

The Reinforced Earth Company



Reinforced Earth

Sustainable Technology



THIS PAGE: TerraMet® dump walls are the most cost effective in remote sites like the Pilbara.

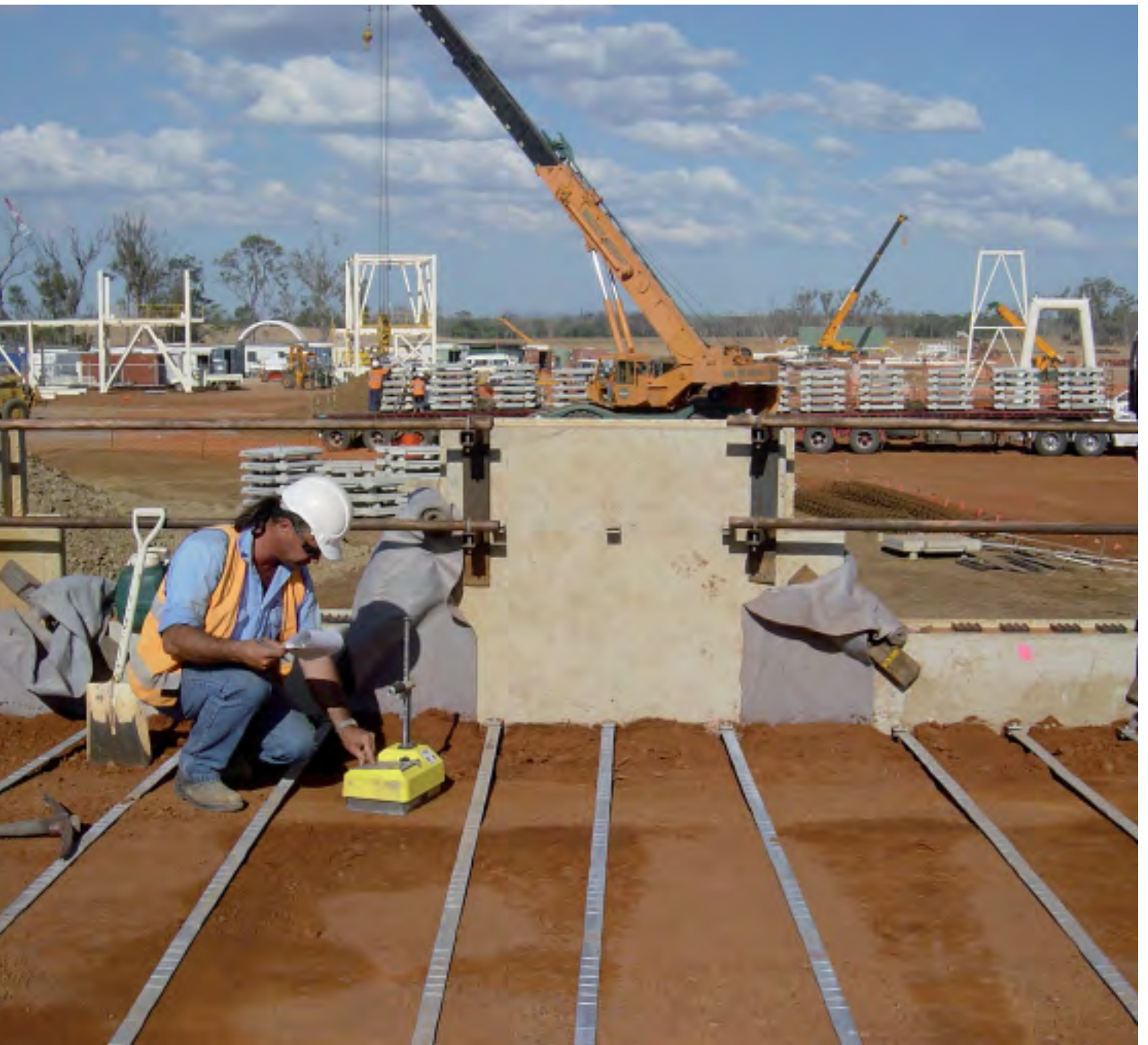
COVER: top left, truck dump wall at Rio Tinto's Yandi JSE iron ore mine in the Pilbara Region of WA. The 20 metre high wall has been designed for 495 tonne Komatsu 930E dump trucks; top centre, the TechSpan® overpass gets started at Millenium Coal in Central QLD; right, 15m tall TerraPlus® Reinforced Earth retaining walls for the twin bridges over Merri Creek in Victoria; bottom left, the TerraClass® Reinforced Earth bridge abutments at Granard Road in Brisbane were duplicated in 2005, sixteen years after the original bridge was constructed.

A brief history

It was the invention that revolutionised an entire industry... In the 1960s, noted engineer and architect, Henri Vidal introduced 'reinforced earth technology'. Vidal built the first full scale demonstration retaining walls which quickly became recognised as one of the most significant developments in civil engineering.

To realise his engineering vision, Henri Vidal quickly established companies throughout the world when he formed the Reinforced Earth Group. In 1974, The Reinforced Earth Company (RECO) was set up in Australia. Today, the Reinforced Earth Group is internationally renowned as the leader in mechanically stabilised embankments.

Henri Vidal revolutionised an entire industry when he built the first full scale demonstration retaining walls in the 1960s.



THIS PAGE: RECO's high adhesion, ribbed steel strips deliver superior performance in high dump walls like the 14 metre high Millenium Coal Mine.

OPPOSITE PAGE: left, RECO often develops a site specific architectural finish as was the case for the North Klama Bypass in NSW; centre, Fosterville Gold Mine, NSW; right, Bus Rail Interchange at Shenton Park in WA.

What is the Reinforced Earth System?



Reinforced Earth structures combine selected granular, engineered backfill with steel or synthetic tensile reinforcements and a modular facing system.

This highly adaptable, robust system ensures retaining walls are as strong as they are durable.

Reinforced Earth structures combine selected granular, engineered backfill with steel or synthetic tensile reinforcements and a modular facing system. This unrivalled combination creates a durable, mass gravity retaining wall.

The technique is adaptable to retaining walls of any practical height. What's more, it's capable of supporting its own weight as well as large dead and live loads imposed by associated structures and vehicles.



THIS PAGE: left, TerraClass® dump wall takes shape at the Blackwater CHPP in Central QLD; above, TerraTrel® retaining wall above Myrtle Gully in NSW.

OPPOSITE PAGE: top left, the temporary TerraTrel® Reinforced Earth walls in the background of this photograph enabled Abigroup Contractors to divert traffic on the busy great Western Highway in the Blue Mountains, NSW during the construction of the permanent TerraPlus® walls; top right, RECO's masonry block wall system, TerraMid®, provides strong support and good looks to compliment Multiplex's Wondakiah residential development at Oyster Cove in Sydney; bottom centre, the bridge spanning the Kwinana Freeway in Perth at Rowley Road is supported on reinforced concrete columns behind the full height facing panels. RECO supplied the precast concrete formwork for the columns as well as the TerraTilt® wall system, bottom left, RECO's galvanised REhas® strips are non-extensible and unmatched for structural reliability.

Facing options

Concrete for extended durability.

Concrete panels are offered in a variety of shapes, sizes and architectural finishes. The range includes:

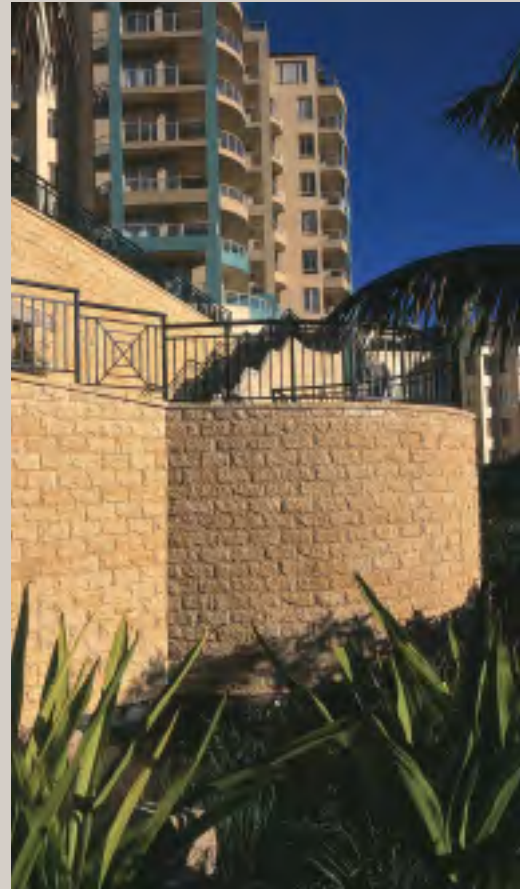
- TerraClass®
The 1.5m x 1.5m cruciform shape first adopted by RECO and still used worldwide. The unique shape makes construction rapid and easily accommodates horizontal curves, also providing the structure with inherent flexibility and accommodating significant foundation settlement.
- TerraPlus®
The 2m x 2m square shape which is popular with architects and designers for its clean-edged appearance.
- TerraTilt®
The full height panel system, that offers additional architectural benefits coupled with rapid and efficient construction processes.

Steel for lightweight and cost-effective delivery to remote locations:

- TerraMet®
Prefabricated galvanised steel plate that is particularly suitable for use in the mining industry.
- TerraTrel®
Steel mesh facing that can be used for temporary or semi-permanent applications. TerraTrel® is often found in road staging works or other short term applications.

Modular blocks – for attractive yet economical low height applications that require extended durability:

- TerraMid®
Modular dry cast concrete blocks available in a range of colours and textures.



Soil reinforcement options

- **Galvanised steel.**

REhas® (Reinforced Earth High Adhesion Steel) strips are non-extensible and are unmatched for structural reliability and performance. Steel soil reinforcement, when coupled with the complying select fill, can be designed for 100 years service life or more if required.

- **Synthetic.**

Omega® strips are polyester tendons contained in a polyethylene sheath. Polyester is ideal for light to medium loaded structures that may be affected by a corrosive environment (ie acidic or saltwater). Polyester reinforcing is now widely and successfully used all over the world.

RECO collaborates closely with research laboratories and universities all over the world to provide clients with safer, more durable, environmentally conscious solutions.

Why is the Reinforced Earth technique a success?

Since its invention in the 60s, the Reinforced Earth Technique has enjoyed rapid adoption in many applications across all sectors.

The reasons are simple

- Strength by providing significant load-bearing capacity
- Flexibility by providing superior differential settlement on poor foundations
- Resilience by providing exceptional seismic response and effectively absorbing vibrations from both heavy and high speed rail and explosions
- Predictable longevity through the use of reliable and durable materials
- Cost effectiveness in both construction time and materials cost
- Aesthetics by offering a wide range of architectural treatments.



Constant innovation

The Reinforced Earth innovation didn't begin and end in the 60s. New developments have continued, including:

- The internationally recognised cruciform-shaped precast concrete panel (later called TerraClass®).
- The introduction of the hot-rolled, high adherence, ribbed steel strip (or HA strip).
- The balanced capacity steel strip with reinforced end (HAR strip)
- Inclined wall systems for coal storage applications
- Vegetated facing systems for aesthetic benefits
- TerraMid® block wall system with ladder reinforcing strips
- Wall systems engineered for recycling concrete, fly ash and slag sand
- Omega® technology with fully synthetic connections between polyester strips and panel.

RECO provides sustainable engineering solutions with a lower carbon footprint than conventional construction techniques.

OPPOSITE PAGE: left, Cliff Street overpass at Portland, Victoria; top right, the Reinforced Earth bridge abutments at MacKay's Crossing near Wellington in NZ are designed to withstand a ground acceleration of 0.39g without permanent movement and not to collapse in the event of a maximum credible event. The highly skewed bridge taking SH1 over the NIMT near Paekakariki is very close to the active Owharu Fault. Ground dislocation of 4 metre horizontally and 1 metre vertically is expected to occur when a major seismic event occurs on this fault; bottom right, Omega® technology introduces a fully synthetic connection between polyester strips and facing panel.

THIS PAGE: right, Putty Road, NSW; below, the presence of compressible materials at depth under the Reinforced Earth flyover at Blenheim Road in Christchurch, NZ, has resulted in settlements of over 200mm – with more expected over the next few years. TerraClass® facing panels are able to accept significant differential settlements without damage.



THIS PAGE: Many challenges had to be overcome during the construction of the rail tunnel to Homebush Bay Railway Station, near the site of Sydney's 2000 Olympic Games and the main Stadium. The single span TechSpan® tunnel gradually increased in span to 19 metres before bifurcating into twin tunnels near the entry to the underground station.

OPPOSITE PAGE: left, RECO supplied TechSpan® arches for the conveyor tunnel and the emergency escape tunnel. Both tunnels will be buried under an iron ore stockpile almost 40 metres high when Rio Tinto's Brownfields extension of its Tom Price mine is commissioned; centre, unit three goes into place over the Kwinana freight railway line at Port Coogee in WA; right, the iron ore trains did not stop during the construction of the TechSpan® overpass tunnel and TerraMet® head walls near BHP Billiton's Mining Area "C" in the Pilbara Region of WA; right,



TechSpan®, the perfect arch, custom designed



RECO offers custom-designed arches that deliver maximum economy and flexibility with site-specific clearance envelopes.

RECO introduced the TechSpan® precast concrete arch system to Australia in 1989. It was developed by the Reinforced Earth Group through its Spanish subsidiary. The technique utilised the Group's knowledge of soils and finite element analysis to develop the perfect arch. TechSpan® is a three-pin, two-piece, funicular curve shaped arch.

TechSpan® is the leader in precast concrete arch systems available in Australia and New Zealand.

Its unique benefits have actually expanded the market for TechSpan® arches. These include:

- Enhanced concrete durability at competitive cost due to:
 - reduced tensile stresses
 - reduced shear forces
 - minimised bending moments in the completed structure which improves resistance to overload
- Lower footing costs due to reduced horizontal reactions at the arch base
- Rapid installation
- Open to through traffic during construction
- Optimised traffic clearance envelopes
- Any practical arch span and height
- Increased load-bearing capacity – high fills, high live load, steep slopes
- Design for special geometry requirements.

Top level service – our promise

The RECO goal is simple: to offer an unsurpassed level of service in a timely and cost-effective manner – across all projects.

When we embark on our Reinforced Earth and TechSpan® projects we have one goal – to offer our clients an unsurpassed level of service in a timely and cost-effective manner.

RECO is committed to meeting our clients' project needs. Our engineers and technicians liaise with owners, consultants and contractors at each stage, from initial conceptual discussions to a successfully completed structure.

At all times we ensure care, reliability and excellence in the quality of the service that we provide, in the implementation of our techniques and in the approachability and organisation of our teams.



Left, a member of RECO's team of highly experienced specialist site technicians and project managers inspects the construction of a dump wall at Xstrata's Rolleston coal mine in Central QLD; top, a RECO project manager offers some advice during the construction of the TechSpan® coal reclaim tunnel at Blakefield South coal mine in the Hunter Valley, NSW. The coal stockpile will rise to 30 metres above the tunnel; above, short lengths of reinforcing strips are weighed and labelled before installation into the dump wall at Saraji coal mine in Central QLD. Should the owner wish to extend the wall past its nominal design life in the future the strips can be extracted through the front of the wall and used by RECO to determine the condition of the wall.

A work ethic that's focussed on you – our client

Our experienced team of engineers and technicians will offer assistance at every stage in the project.



RECO Australia provides engineering services and construction materials for TechSpan® and Reinforced Earth structures throughout Australia, New Zealand, Papua New Guinea and the South Pacific.

Conception and feasibility

We'll meet to discuss concepts, options, and budget. Our aim is to provide you with all the information necessary to determine the right solution for your project. This includes technical specifications and construction methodologies.

Tendering

During the tender phase we will produce a preliminary design that will provide more detail on how RECO's solution will be applied. Detailed drawings, estimates on quantities, supply programs and firm pricing can be provided at this stage.

Design

On award, we take the project to a final certified design. Critical final details are added to the drawings. And once we have client approval, the manufacture of specialised materials can begin.

Manufacture

Materials are manufactured at various locations throughout Australia or overseas. We monitor production to ensure programs are maintained and, through our independently certified ISO 9001 quality system, we ensure that products comply with all relevant codes and client specifications.

Construction

We schedule materials to arrive on-site as the construction program dictates. We remain on-site to help the construction team identify the materials and educate them on the best construction practice. We return to the site as and when is required by the client.

Maintenance

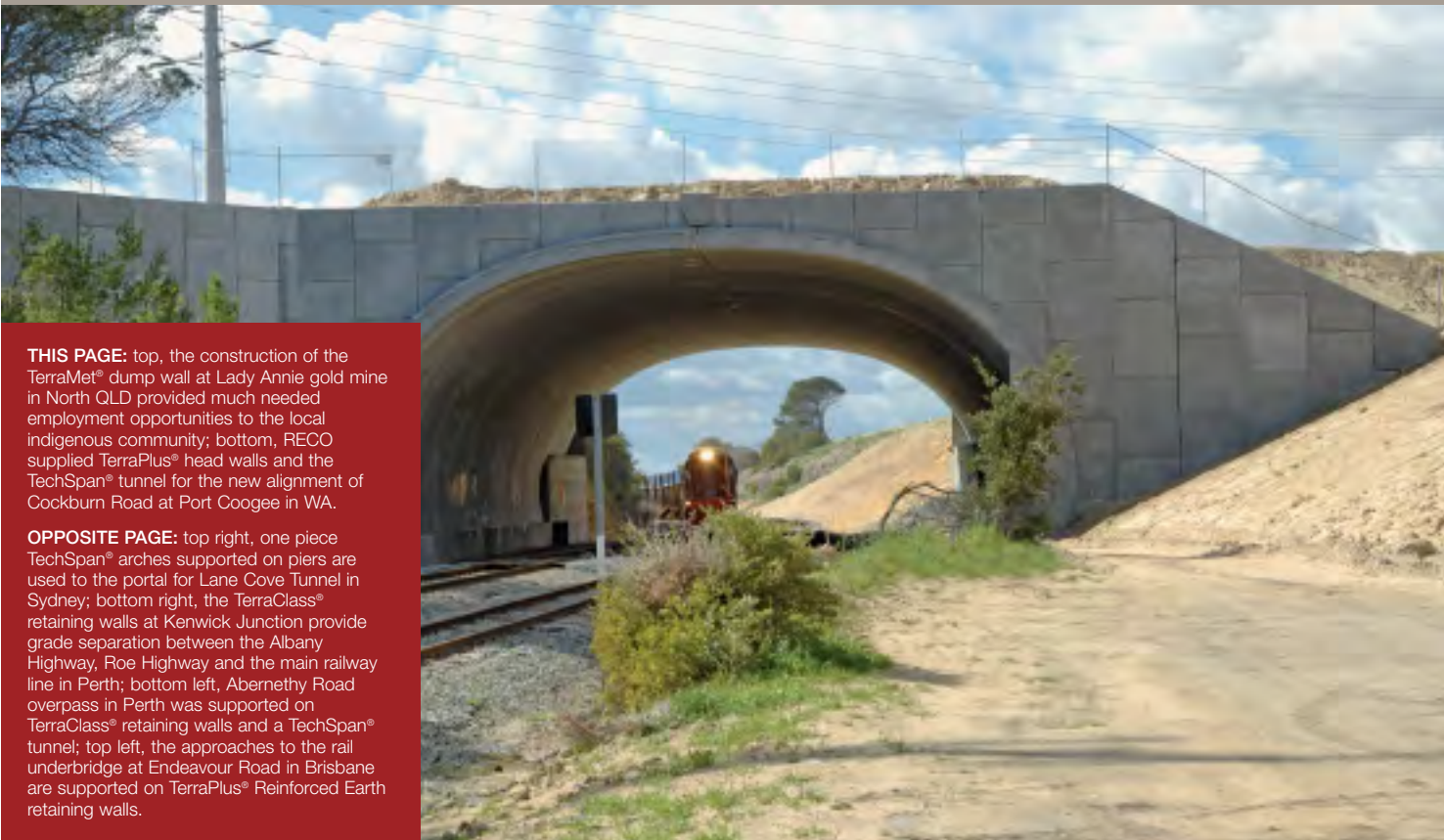
We can give advice on a maintenance program to ensure the ongoing performance and durability of your structure is in line with the design intent.

Performance and upgrades

We have industrial and mining structures in Australia that are nearing the end of their original design life. We can provide condition inspections and report on structural performance. Occasionally, structures are asked to do more than originally designed – whether it be an increased loading or extended life. In these cases, we investigate and provide the necessary guidance.



Reinforced Earth and TechSpan® technologies have applications in roadways, railways, mining, industrial,

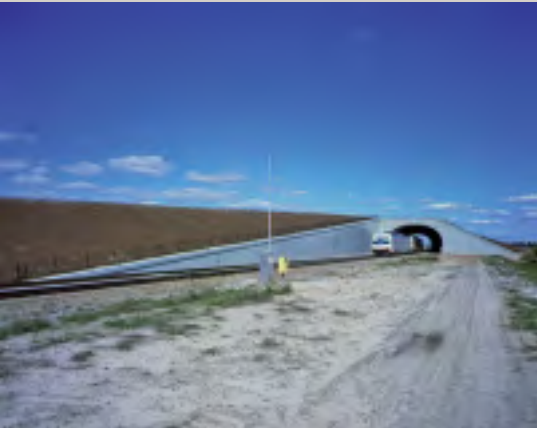
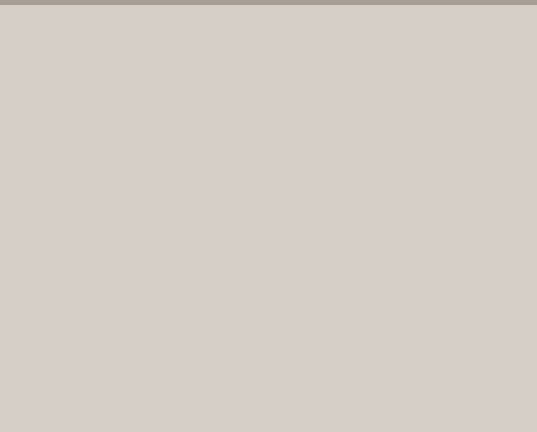


THIS PAGE: top, the construction of the TerraMet® dump wall at Lady Annie gold mine in North QLD provided much needed employment opportunities to the local indigenous community; bottom, RECO supplied TerraPlus® head walls and the TechSpan® tunnel for the new alignment of Cockburn Road at Port Coogee in WA.

OPPOSITE PAGE: top right, one piece TechSpan® arches supported on piers are used to the portal for Lane Cove Tunnel in Sydney; bottom right, the TerraClass® retaining walls at Kenwick Junction provide grade separation between the Albany Highway, Roe Highway and the main railway line in Perth; bottom left, Abernethy Road overpass in Perth was supported on TerraClass® retaining walls and a TechSpan® tunnel; top left, the approaches to the rail underbridge at Endeavour Road in Brisbane are supported on TerraPlus® Reinforced Earth retaining walls.



revolutionised construction with wide-ranging energy, hydraulic, military and protective structures.



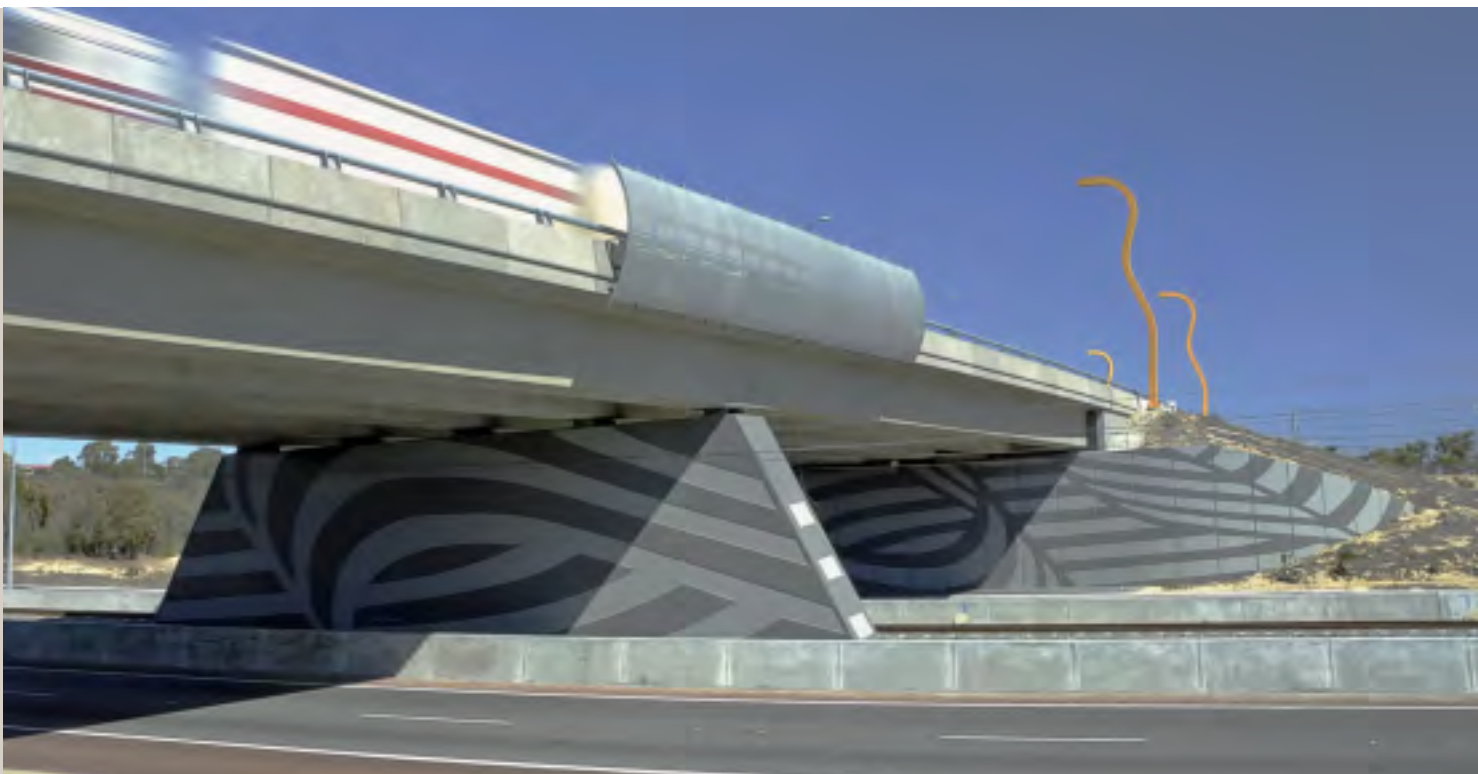
Transport infrastructure

The Reinforced Earth and TechSpan® techniques are widely used in public infrastructure projects.

Most applications are for the construction of retaining walls and bridge abutments supporting roadways. However, the versatility of the technology means a wide variety of geometrical and aesthetical high-level-engineering solutions are available.

What's more, Reinforced Earth projects require only a short construction time and minimum right-of-way so the disruption to traffic is considerably reduced.

- Single or tiered carriageway retaining walls
- Bridges supported directly on abutment walls
- Bridges supported on columns within retaining walls
- Reinforced Earth bridge headstock restraints
- Slip roads and embankment support
- Underpass and flyover arches
- Cut and cover tunnels.



Reinforced Earth retaining walls are used in many countries to support high speed and heavy railways, as well as metro and light rail transit lines. The technology is similar to roadway applications except the design of the retaining structures is adapted to comply with the heavy load and safety requirements – especially for high-speed railways.

Reinforced Earth structures absorb the vibrations created by passing trains. A great benefit of building a Reinforced Earth retaining wall along a road or railway is that it doesn't need scaffolding or any structural footing in front of the facing. As a result, the wall can be built from the rear without interruption to traffic.

TechSpan® arches are frequently used for the construction of railroad tunnels beneath earthen embankments. They can be constructed over existing railway tracks without closing the line.



OPPOSITE PAGE: The architectural treatment of the TerraTilt® wall panels provides an attractive appearance for Kwinana Freeway commuters as they pass under the Roe Highway in Perth.

THIS PAGE: top, RECO's design team developed an elegant solution to the technical challenges presented by the low clearance height of the North Kiama Bypass route and the tight radius of the rail line to the nearby Bombo Quarry. Contractor John Holland engaged RECO to supply temporary TerraTrel® walls so that the construction of the TechSpan® tunnel and the permanent TerraClass® retaining walls could be staged to keep the Princes Highway open to traffic at all times; centre right, Springwood Interchange in Brisbane; bottom right, the construction of the tunnel for the Hawkeswood Deviation in NZ took just two days. This was a vital factor in the selection by Works Civil of the TechSpan® tunnel and TerraClass® retaining walls as the SIMT railway line had to remain open to traffic at all times; bottom left, TerraPlus® retaining walls form the exit ramps for the Inner City Bypass in Brisbane.



Mining infrastructure

Reinforced Earth structures are resistant to vibrations and can support the extreme live loads associated with fully loaded mine vehicles. The versatility of the facing technology means that concrete panels, steel sections or wire mesh can be used to conform to the required geometry (face inclination, straight or curved alignment).

Choice of facing also depends on the required design life of the structure and factors such as site location.

- Dump walls
- Retaining walls
- Bridge abutments
- Ore storage silos and reclaim bunkers for coal, iron ore, etc
- Covered arch tunnels for conveyor and reclaim tunnels
- Haul road overpasses
- Rail and road tunnels



TechSpan® arches have enjoyed rapid acceptance in the mining industry. The custom designed arch gives great flexibility to both designer and mine owner to optimise clearance envelopes. RECO is able to design the arch for the high fills and live loads associated with bulk materials handling. Importantly the reduced bending moments inherent in the funicular curved arch improves resistance to overload. TechSpan® arches have been widely used for reclaim conveyor tunnels below coal and iron ore stockpiles, some up to 40 metres high.



OPPOSITE PAGE: Turn-key specialist, Sedgman Pty Ltd, engaged RECO to design, supply and construct the TerraPlus® dump wall in this photograph. This wall duplicated an existing Reinforced Earth dump wall enabling New Acland Coal in QLD to quickly increase production.

THIS PAGE: top right, the 37 metre high TerraMet® dump walls at Freeport Indonesia's Grasberg gold and copper mine in Irian Jaya are one of the highest walls ever built using the Reinforced Earth technology. The walls have been designed for the next generation, 700 tonne dump trucks; centre, for Newpac coal mine in the Hunter Valley, NSW, RECO designed and supplied TechSpan® arch units specially manufactured to form voids in the roof of the tunnel to take the coal feeder units. This generates significant savings in materials cost and construction time compared to cast-in-place construction of the coal feeder chambers. The installed coal feeder unit is shown on page 23; bottom, the TechSpan® reclaim tunnel and TerraPlus® headwalls at Mt Arthur North are designed for a coal stockpile height of almost 30 metres. However the more significant challenge for RECO's design team is that the shape and location of the stockpile changes continuously, generating unbalanced loading onto the tunnel below.



Industrial, energy, military and hydraulic infrastructure

Reinforced Earth technology and TechSpan® are ideal systems for all types of industrial applications. Structures can withstand impact, explosion, flood and fire.

Reinforced Earth has been used in coal and secondary storage applications and as blast protection in military applications. TechSpan® has applications in military shelters and ammunition bunkers.

Reinforced Earth technologies are commonly used along rivers, lakes and coastal areas. The technology shows great resistance to severe loading conditions such as flooding and draw down, tidal fluctuations, storms and ice.

- Secondary containment walls for oil and LNG tanks
- Blast walls for civilian, industrial and military protective structures
- Covered arch tunnels for underground shelters and explosive ordinance storage
- Quay walls (marinas, fishing ports, etc)
- Dam walls
- Tailrace walls
- River training walls
- Drainage tunnels.



Rapid construction can take place for works carried out in the tidal range due to the simultaneous placement of fill, reinforcement and facing.

TechSpan® also has applications in culvert and other water crossings. The adaptability of the arch shape allows optimisation of the section while respecting the anticipated water flow.

TechSpan® is the solution of choice for these applications as the prefabricated durable concrete units used are cost-effective and construction can take place without diverting the stream.



OPPOSITE PAGE: Belmore Crossing in NSW.

THIS PAGE: top, TechSpan® explosive storage bunkers have been approved by the Explosive Safety Board of the US Department of Defense and are widely used by the US Army Corps of Engineers. TechSpan® bunkers incorporate a patented lightning protection system; centre, The Reinforced Earth technique has been widely used to construct coal storage bunkers such as this one at Callide 'B' Power Station in Central QLD; far right, tests have proven that Reinforced Earth retaining walls can withstand the extremes of temperatures associated with an accidental discharge from LNG and oil storage tanks. The photograph shows the TerraClass® secondary containment walls at Santos' LNG tank farm at Stony Point in South Australia; right, RECO has supplied the RAAF with blast walls and gun missile barriers for several air bases in Australia. The Reinforced Earth technique gained widespread acceptance for this type of application following full scale blast overpressure tests at Woomera in South Australia.



Introducing the Freyssinet Group... A new parent and partner

In late 1998 Freyssinet acquired the Reinforced Earth Group worldwide followed by Ménard in 1999.

The expanded Freyssinet Group brings together a prestigious group of brands and expertise in structures and soils. This knowledge and experience is unequalled in specialised civil engineering fields.

The Freyssinet Group of companies

- Freyssinet, the world leader in prestressing, stay cables and strengthening of structures.
- The Reinforced Earth Company, the world leader in mechanically stabilised embankments (MSE).
- Ménard, the world leader in foundation strengthening and soil improvement.

The future outlook

Innovation will play an important role in the future of RECO's strategic development. The group currently allocates 1.5% of its turnover to innovation worldwide.

As well as in-house research, RECO collaborates closely with research laboratories and universities all over the world. The goal? To provide clients with safer solutions that are both durable and environmentally sound.

Award-winning innovation

In 2006, the Reinforced Earth Group was given the French Ivor Award for the development of the Omega® technology – a fully synthetic connection for its Reinforced Earth wall systems.

When there are no metallic elements between facing panels and polyester reinforcements, the Group offers sustainable retaining solutions for aggressive environments such as marine and acidic backfills.

The Freyssinet Group combines a prestigious group of brands and expertise unrivalled in specialised civil engineering fields.



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View of the coal feeder unit inside the TechSpan® reclaim tunnel at the Newpac coal mine in NSW.

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