

## Reinforced Earth®, the Value of Experience



LGV Rhin-Rhone (France)

When it was invented almost 50 years ago, nobody could foresee the great success of the Reinforced Earth® technique. It is now recognized as a major innovation in the field of civil engineering. Reinforced Earth® has substantially widened its scope of applications to beyond just roads in the last 30 years, demonstrating its advantages in other markets. Structures associated to railway projects have been designed and supplied by companies of the global Terre Armée Internationale network on five continents since 1973.

For railway owners and engineers Reinforced Earth® simultaneously provides unique key benefits:

- Strength – significant load bearing capacity
- Resilience – effective absorption of vibrations and an exceptional seismic response
- Durability – high quality materials, proven track record and ease of inspection
- Adaptability – to geotechnical, environmental and architectural site conditions
- Low impact – rapid construction, limited land use, no traffic disruption and reduced environmental footprint



Durability samples

Choosing a Reinforced Earth® solution means getting the best of:

- the longest experience in the the field of mechanically stabilized earth structures
- a global network of innovative companies deeply rooted on their markets
- bespoke engineered solutions adapted to complex situations
- the widest range of reliable and sustainable materials with a complete independence from manufacturers



Pilbara (Australia)

With TechSpan® technique, the same philosophy is pursued with the inherent advantages of:

- engineered backfills
- precast construction components



Our goal is to create, design and supply innovative technologies to the civil engineering industry with a strong commitment to excellence in design, service and public welfare.

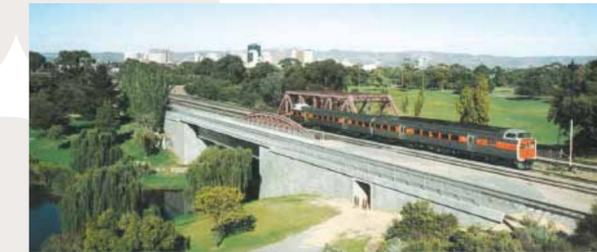
# Sustainable Technology

## Railways

Reinforced Earth® and TechSpan® structures



Shikansen Ohmihachiman-Japan(1987)



Torrens River bridge abutments – Australia (1982)

It was only five years after the introduction of Reinforced Earth® that this technique was first used to build structures near railway lines.

By the mid seventies, the civil engineering community had become more aware of the capabilities of this unique construction method, particularly in terms of mobile and dynamic load bearing capacity.

Engineers and projects owners began using Reinforced Earth® extensively to build structures under railway tracks. Hundreds of such structures have been designed and build since the construction of the first walls supporting a railway line in the USA in 1973. TechSpan®, a precast arch system developed by Terre Armée Internationale from the end of the eighties also has applications for railway projects.

Reinforced Earth® and TechSpan® bring all the answers to the legitimate concerns for safety governing railroad designs and exploitation.

The railway applications use the same technologies as those used for roads. However design is modified to take into account specific requirements concerning the surcharges or coefficients of safety, especially for high speed trains.

Reinforced Earth® and TechSpan® are used for the construction of a wide range of railway related structures...

- retaining walls along railways
- bridge abutments spanning railway lines
- retaining walls and bridge abutments supporting the track beds
- rail tunnels beneath earthen embankments
- arch bridges supporting the track beds
- underpasses and culverts beneath earthen embankments supporting the track beds
- steep embankments for noise and collision protection

... and for all types of trains

- LRT
- MRT
- Regional
- Intercity
- High speed
- Freight



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REINFORCED EARTH  
SUSTAINABLE TECHNOLOGY

## Retaining walls along railways



Daegu (South Korea)



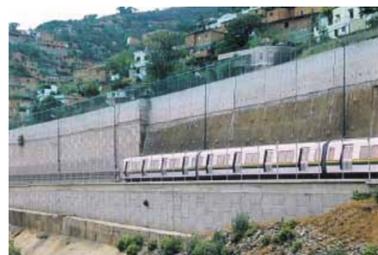
Santa Fe (USA)

In addition to its primary advantages of load bearing capacity, resilience, speed of construction and economy, Reinforced Earth® structures require very little space. This is a very important consideration when building walls parallel to a railway. Structures are not deeply founded, require no footing beyond the front face, and as a result, excavations do not encroach upon rail line beds. A Reinforced Earth® wall is built entirely from the backfill side, without scaffolding and without the necessity of any structure or equipment in front of the wall. It may therefore be placed right up to a clearance line or to a service road without any serious disruption of rail service.

- Limited land use
- Minimal traffic disruption during construction



KyungBu–highspeedtrain(SouthKorea)



CaracasMRT(Venezuela)

## Retaining walls supporting the track beds



Snider Diamond grade separation (Canada)

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 safety requirements, especially for high speed railways. Railways loads differ from highway loads in regards to intensity, frequency and associated vibrations. The 40 year experience of the Reinforced Earth companies worldwide provides an incomparable return regarding highly loaded structures. The inextensibility of the steel strip soil reinforcements, recommended for structures supporting railways, is the guarantee of minimal deformations under high loads. Structures beneath the tracks are designed to accommodate sudden braking decelerations.

Reinforced Earth® structures absorb the vibrations induced by passing trains inherently well as evidenced by numerous tests conducted in the USA, France and Germany.

Reinforced Earth® structures have often been used, particularly in Japan, for widening railway embankments. Since the system is versatile and built in successive layers, the Reinforced Earth® technique is well suited for the construction of new structures against, and even above existing embankments.

- Absorption of vibrations
- Minimal deformations under high load



Charlotte LRT (USA)



Whiskey Island Marina (USA)

## Bridge abutments supporting the track beds

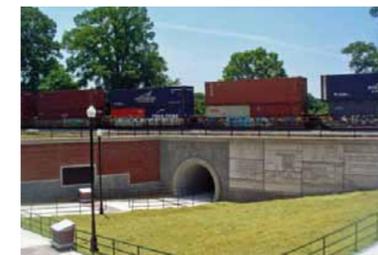


Gautrain-Gauteng (South Africa)

Among its many earth-retaining and load-supporting applications, Reinforced Earth® has gained world wide acceptance as an economical and technically superior construction method for bridge abutments. Reinforced Earth® bridge abutments reduce highly concentrated superstructure loads to acceptable uniform bearing pressures at the foundation level. This eliminates the need for pile supports or other costly foundation improvements.

Reinforced Earth® railroad bridge abutments have been built in several countries since 1975. These are designed to withstand the heavy bearing pressure and breaking stresses transmitted through the track bed. A significant feature is that, even on poor foundation soils, the profile and cross section of track over Reinforced Earth® abutments is level and regular, so long as the reinforced volume is placed in a continuous manner with the approach embankments and is carefully compacted.

- High load bearing capacity
- Uniform bearing pressure at foundation level



Kennesaw (USA)



Saint Etienne de Montluc (France)

## Site integration functionalities



Haan Gruiten (Germany) – Reinforced Earth walls with sound absorbing facing

The most successful civil engineering projects are those which combine excellent performance with attractive appearance. Even on smaller scale projects, owners, architects, engineers and landscape architects are interested in demonstrating their professional capabilities by designing structures which aesthetically integrate into their environments and enhance their surroundings. Reinforced Earth® structures offer limitless aesthetic possibilities, this construction method being a unique combination of high level engineering, straight forward constructability and architectural versatility.

To facilitate the integration of railways into populated areas, Reinforced Earth® structures have been built with sound absorbing facings.

- Architectural flexibility
- Attractive appearance combined with technical performance



San Carlos, Ralston-Holly (USA)

## Bridge abutments spanning railway lines



Bozuyuk-Mekece (Turkey)



Vierzon (France)

The advantages of Reinforced Earth® walls are also obtained in Reinforced Earth® bridge abutments built on either side of existing railways. Traditional abutments often require rather deep foundations, the footing of which must be set within an excavation protected by steel shoring at the cost of slowing trains running alongside the excavation. These constraints are even more burdensome when the project is built on piles due to the space required for the drilling or driving equipment. By contrast, a Reinforced Earth® abutment, even one built on relatively poor soil, will typically be founded at a shallow depth, enabling the construction contractor to work outside the area influenced by the railway. Thus the construction of overpasses combining Reinforced Earth® abutments and bridge deck of prefabricated girders or beams create a minimum of inconvenience for train traffic. Depending on the sites conditions and owners' requirements the Reinforced Earth® structures can be pure or integral load bearing abutment, or mixed abutments.

- Rapid construction
- Economy in foundation works

## Rail tunnels under earthen embankments and cut and covers



Mandurah (Australia)



CTRL (United Kingdom)



North Kyama (Australia)

TechSpan® arches are frequently used for the construction of railway tunnels in earthen embankments or in cut and covers. This construction method, involving a strong soil-structure interaction, associates three-pin prefabricated concrete arches to a select backfill. The main advantages of TechSpan® technique are the material and structural quality, the rapidity of installation and the adaptability to the specific requirements of each project.

TechSpan® method is especially efficient when building the structures over existing rail tracks under traffic when closure is not an option. Reinforced Earth® is a logical complementary technique for the construction of the spandrel walls.

- Optimized traffic clearance envelopes
- Custom designed



Hörselgau (Germany)

## Protective embankments

Reinforced Earth® can be used to build embankments along railways to provide protection against environmental nuisances such as noise or visual pollution. This type of structure can also be an efficient safety barrier against collisions especially in the case of corridors combining high speed railways and highways, due to the inherent resilience of Reinforced Earth®. To optimise the land use and consumption of materials the faces of the embankments can be vertical or steepened, with mineral or vegetalized facings.

- Shock absorbing capacity
- Ease of construction