

# Reinforced Earth® the Value of Experience

When it was invented 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 widened its scope of applications to beyond just roads in the last 30 years, demonstrating its advantages in other markets. Protective structures have been designed by companies of the global network of Terre Armée Internationale to mitigate risks either natural or from human origin, thus contributing to a better environment.

Choosing a Reinforced Earth® solution allows owners and engineers to benefit from:

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



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.

# Risk Mitigation

Reinforced Earth® protective structures

# Sustainable Technology





## Natural disasters



Izmit earthquake (Turkey)



Avalanche barrier - Neskaupstaður (Iceland)



Tunnel extension - Hyeongok (South Korea)



Avalanche barriers - Seydisfjörður & Ísafjörður (Iceland)



Sea wall - Gaspé (Canada)

Throughout history Nature's forces have proven to be overwhelmingly dangerous causing heavy loss of life, injuries and extensive damage to property. The Reinforced Earth® techniques can help mitigate the consequences of such natural disasters. Reinforced Earth® provides such protection through its intrinsic characteristics.

### Earthquakes

An effective way for a structure to resist strong motions due to seismic activity is to exhibit sufficient flexibility in order to dissipate the applied energy while not attracting detrimental loads on critical structural elements. The inherent ductility and resilience of Reinforced Earth® justify its high degree of acceptance in regions exposed to earthquakes. There are many documented examples of excellent performance during seismic events.

### Avalanches

With the same philosophy of resilience and flexibility, Reinforced Earth® structures are commonly used to protect properties and commodities against avalanches. Using steel mesh facings of systems such as TerraTrel® or GeoTrel® provides additional flexibility while allowing easier logistics and construction in remote areas or sites with difficult access.

### Rockfalls and slope failures

TechSpan®, a precast arch system developed by Terre Armée Internationale, provides protective solutions to mitigate the risk of rockfalls and slope failures at the extremities of tunnels. TechSpan® arches can be designed to fit exactly to the shape of the tunnel and can be installed without disrupting the flow of traffic.

### Floods, tsunamis, mud and lava flows

Due to its lower use of construction materials compared to regular embankment and its suitability to build vertical and battered walls, as well as steepened slopes, Reinforced Earth® is a perfect solution for protection dikes or channeling walls against a variety of potentially hazardous naturally aggressive events such as water in case of floods or tsunamis, but also debris flows and even lava.

### Land slides

By minimizing the quantity of building materials, Reinforced Earth® is a flexible and easy-to-build technique which has been used in some specific cases to provide active protection against potentially hazardous landslides.



Lava flow channeling wall - Izu-Oshima Island (Japan)



Stabilisation of landslide - Cairmuir (New Zealand)

## Industrial hazards

Within an increasingly regulatory framework regarding the potential for industrial explosions, fire and pollution, the use of Reinforced Earth® for vital structures designed to protect against such hazards has been a logical extension of the technology after its performance has been established in other applications.

### Containment

Reinforced Earth® is used to construct safety dikes around large tanks of liquefied natural gas (LNG) or other volatile liquid petroleum products. In the event of a rupture in one of these tanks, the function of a Reinforced Earth® dike is twofold: containment of the escaping fluid and prevention of damage to nearby tanks and facilities.

### Fire and thermal shocks

Reinforced Earth® with steel soil reinforcements is an ideal material for the construction of industrial protective structures since its components: earth, steel soil reinforcement and concrete facing are substantially non flammable and resistant to thermal variations. Tests conducted at Gaz de France have shown that Reinforced Earth® could withstand the drastic impact of a fire following the leakage and ignition of a cryogenic fluid. The thermal resistance of Reinforced Earth® has been also proven in real situations such as the oil tank fire at Tacoa (Venezuela) and in addition it can be easily repaired after an accident.

### Explosions

Experience has shown that Reinforced Earth® is a highly stable explosion barrier that impedes the propagation of a blast at ground level and absorbs high levels of energy due to its tolerance for deformation. Because it is resistant to multiple fracturing, Reinforced Earth® minimizes the dispersal of debris during an explosion. The positive results of early studies and experiments have subsequently been confirmed by the performance of structures in service.

### Spills

Actual Reinforced Earth® structures have proven to be virtually impermeable despite the fact that they are composed of small, discontinuous elements. Combined with appropriate and adequate waterproofing, Reinforced Earth® provides a convenient solution for the storage of waste outputs from industrial processes with a wide range of chemical aggressivity.

### Mineral dust

With increased mining production capacity, live storage coal slot facilities were developed in the 70's and 80's using Reinforced Earth® techniques due to its flexibility and ease of construction. Large span roof structures covering these live coal storage facilities prevents dust migration and thus reduce the negative impact on health and environment.



LPG tanks - Stony Point (Australia)



Containment dikes for ammonia tanks - Montoir (France)



Blast barrier - Townsville (Australia)



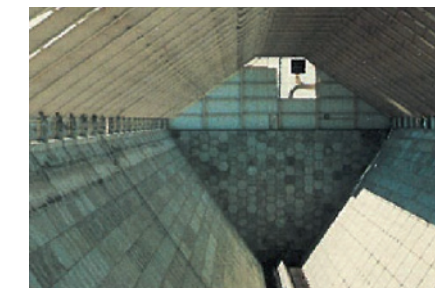
Explosion testing (USA)



Ammunition shelters (USA)



Trekkopje reservoir (Namibia)



Coal storage - Wyoming (USA)

## Reinforced Earth® protective structures for risk mitigation

- Economy of materials
- Low land use and site impact during construction
- Lower CO<sub>2</sub> impact than conventional solutions
- Use of natural or recycled materials
- Suitability of reinforcing materials to environmental and site conditions
- Durability
- Ease of inspection, maintenance and upgrading
- Ease of dismantling

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