

GEOTECHNICS AND INFRASTRUCTURE

LIGHTWEIGHT AND STRONG SOLUTIONS
WITH LATERLITE EXPANDED CLAY
AND STRUCTURAL LIGHTWEIGHT CONCRETES

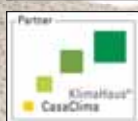


CONTENTS

1st edition

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1. Laterlite Expanded Clay	3
1.1 Geotechnical characteristics	3
1.2 Delivery methods	5
2. Lightweight embankments and fills	6
2.1 Construction of lightweight embankments and fills	6
3. Geotechnical applications	8
3.1 Lightened embankments	8
3.2 Containment structures	11
3.3 Foundations of buildings	12
3.4 Fill for underground structures	13
3.5 Buried tanks and pipes	14
3.6 Fill for below-ground cavities	15
3.7 Water risk management	16
3.8 Tunnels	17
4. Infrastructural applications	18
4.1 Passive impact protection systems	18
4.2 Landscaping management	18
4.3 Noise barriers	19
4.4 Bituminous road surfaces	19
5. Lightweight concretes	20
5.1 Expanded clay for concrete mixes	20
5.2 Lightweight structural concretes	21
5.3 Lightweight non-structural concretes	23

Our company

Laterlite is an Italian company that manufactures and develops lightweight insulating products for construction, civil engineering, geotechnical engineering, industrial uses, agriculture, and landscaping.

Our company history began in 1964 when we first introduced lightweight expanded clay aggregates into Italy. Today we have four Italian manufacturing plants, main offices in Milan, and a network that covers all of Italy. Later on during the 1990s we expanded internationally; we now have a structured presence in France, Switzerland, and Spain and we export to more than 20 countries in five continents.

Our research and development from the beginning was focused on creating innovative products based on the material in which we specialise: expanded clay. Currently our range includes lightweight granular materials of various types, special concretes for structural applications, a range of screeds and mortars, and a wide selection of lightweight insulating blocks that are manufactured by our sister company Lecasistemi.

Over these 50 years we have produced and sold more than 50,000,000 cubic metres of expanded clay products: long experience that has made Laterlite the leader in its field, helping designers and construction professionals to choose lightweight insulating products for use in construction, sustainable renovation projects, and complex engineering projects.

Sustainability

Laterlite Expanded Clay, as well as the rest of our range, are manufactured using the Best Available Technology (BAT) that uses natural resources efficiently, obtaining more than 5 m³ of expanded clay from 1 m³ of our abundant natural local clay. We operate an environmental management system that complies with voluntary international standard ISO 14001:2004, and Health and Safety Management Best Practice that meets British Standard BS OHSAS 18001.

Whilst we are continuing to reduce emissions from our manufacturing plants, for some time we have also been implementing a long-term programme of further development to make them more energy-efficient. At all of our factories we have replaced fossil fuels with alternative recycled combustibles and/or biomass, whilst a significant part of the electrical energy we use is now generated on site from renewable sources.

Laterlite is a partner member of the CASA CLIMA energy certification agency and is actively involved in promoting energy efficiency as a member of the Green Building Council for Italy: promoting the retention and upgrading of existing buildings and encouraging sustainability throughout the construction Industry supply chain. Most of our products are certified by ANAB-ICEA, the Italian Accreditation Institute, for use in sustainable construction.

1 Laterlite Expanded Clay

Laterlite Expanded Clay is a granular lightweight aggregate that is obtained by subjecting special natural clays to a thermal expansion and vitrification (clinkerisation) process at 1200°C.

The granules have a lightweight internal cellular structure with good insulating properties. This is enclosed within a compact, strong external shell that provides an excellent weight/strength ratio, making the product suitable for a wide range of geotechnical, infrastructure, and construction applications.

Laterlite Expanded Clay is also a durable and incombustible material that is fire and frost resistant, thermally insulating, and sound-absorbent.

It is 100% reusable and recyclable.



The raw natural clay.



Rotary kiln.



Firing at 1200° C and expansion.



1.1 Geotechnical characteristics

Expanded clay is the only lightweight aggregate certified for geotechnical uses, and is CE marked as compliant with EN 15732 - *Lightweight fill and thermal insulation products for civil engineering applications (CEA). Expanded clay lightweight aggregate products (LWA)*. This European Standard defines the required characteristics and properties of the product, together with the procedures for testing, marking and labelling it for civil engineering uses.

1.1.1 Grain sizes

Laterlite Expanded Clay is available in a wide range of granulometric sizes. The most suitable sizes for geotechnical use are 3/8, 8/20 and 0/30. Specific granulometric sizes can be prepared to meet particular requirements.



GRAIN 3/8



GRAIN 8/20



GRAIN 0/30

1.1.2 Specific weight

Thanks to its high percentage of voids, the density of Laterlite Expanded Clay is considerably lower than that of traditional aggregates (in the case of granule size 8/20, up to over 6 times lower).

Material	Laterlite Expanded Clay (kg/m ³)			Sand (kg/m ³)
	3/8	8/20	0/30	
Particle density	~ 600	~ 550	~ 700	~ 2.600
Loose bulk density	~ 350	~ 320	~ 390	~ 1.600

Indicative dry density, with $\pm 15\%$ deviation as per EN 13055-1.
For evaluating loadings due to humidity see 1.1.4





Laterlite Expanded Clay.



Up to 6 times lighter than a traditional aggregate.
More than one tonne less per m³.

Laterlite - Geotechnics and infrastructure - 3



Apparatus for triaxial testing.



Angle of repose.



Plate testing apparatus.

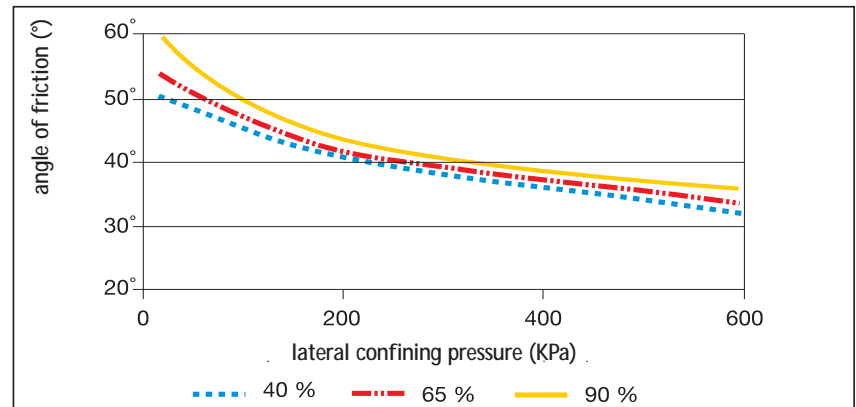
Compaction of light embankments.



1.1.3 Mechanical characteristics

• ANGLE OF INTERNAL FRICTION

The angle of friction of unbounded expanded clay is obtained from triaxial tests by varying the lateral confining pressure of the aggregate and its degree of compaction. For design purposes, with a confining pressure of 200 kPa (which is typical of the most important geotechnical applications), a value of approximately 40° can be assumed.



Trend of the angle of friction as a function of the confining pressure and the degree of compaction.

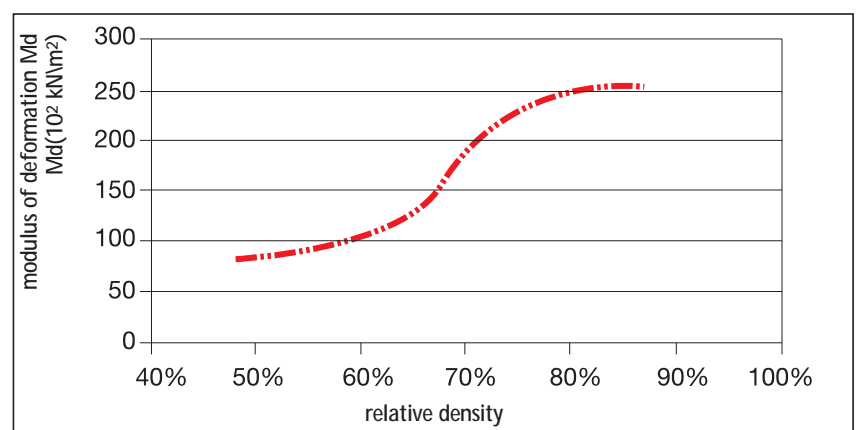
• SURFACE STIFFNESS OF EMBANKMENTS – PLATE LOADING TESTS

The surface stiffness of expanded clay embankments is determined by plate load testing. The stiffness values obtainable will depend on the technical solution chosen, the grain size of the expanded clay, and the degree of compaction.

The various methods for constructing an embankment are described in detail in Section 2. In general these include a finishing layer to distribute the loading. The graph shows the trend of the modulus of deformation M_d as a function of the relative density, for an 80 cm thick layer of type 0/30 expanded clay finished with 20 cm of granular mix.

If necessary, an asymptotic value of $M_d = 200 \text{ Kg/cm}^2$ can be considered for design purposes, which corresponds to a degree of compaction of the aggregate that is easy to attain using ordinary ground-compacting machinery (plate vibrators, compaction rollers).

Values for the modulus of deformation M_d as a function of the compaction of individual layers and different granulometries of Laterlite Expanded Clay are available by request.



Trend of the modulus of deformation M_d (measured on the first load for a 30 cm plate load test for variable vertical strain values between 150 and 250 kPa) as a function of the relative density.

1.1.4 Water absorption and drainage

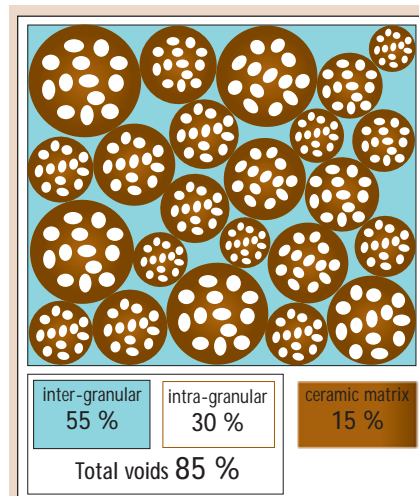
Laterlite Expanded Clay is an inert, vitrified, dimensionally stable material whose volume remains unchanged in contact with water.

When the inter-granular voids (i.e. the voids between the granules, which interconnect with one another) are immersed in water they immediately become saturated; the intra-granular pores (the voids within each granule) only fill more slowly with water by capillary action, and some of them will never become saturated.

The excellent drainage capacity of expanded clay is due to this network of inter-granular pores, whilst the water absorption is due to the intra-granular pores.

In accordance with European Standard EN 13055-2 (par. 4.8), the coefficient of water absorption of expanded clay is determined by immersing a dry sample in water for 24 hours. Comparison of its weight before and after the test (of the drained material) gives the quantity of water that has been absorbed by the granules (this will vary, depending on the grain size).

For design purposes, the coefficient of water absorption of Laterlite Expanded Clay can be conservatively considered as always less than 25% by weight. Laterlite Expanded Clay is also available in the special **Laterlite Plus** dry hydrophobic variant, which maintains its extremely low coefficient of water absorption over time.



Inter-granular voids, intra-granular pores and ceramic matrix in a sample of expanded clay.

1.2 Delivery methods

Expanded clay can be delivered:

In bulk

- In tipper trailer trucks (of bulk cereal side or rear tipping type) up to 65 m³ capacity depending on the denomination and type of material, or in "walking floor" trailer trucks of up to 80 m³ capacity.
- In cistern trailer trucks of up to 60 m³ capacity, fitted with pumping gear of sufficient power to move the material vertically up to 30 m, or 80 m horizontally.
- In containers for sea transport.
- By ship, if very large quantities of the bulk product are required.

A mix of different denominations and sizes can be supplied by request.

In big bags

By request Laterlite Expanded Clay can be delivered in big bags of approximate capacity 1 – 1.5 – 2 – 3 m³.

In bags

Laterlite Expanded Clay is delivered in easy-to-handle 50-litre polythene bags on non-returnable wooden pallets (20 bags/m³).



Tipper trailer truck.



Tanker trailer truck with pneumatic pumping.



Big bag.



50L bag.



2 Lightweight embankments and fills

2.1 Construction of embankments/fills

Depending on the technical and economical constraints, expanded clay embankments and fills can be constructed in the following ways:

1. Embankments/fills consisting of expanded clay only (Figure 1)

Average density after completion: 400 - 600 kg/m³.

Spreading sequence (repeated):

- A geotextile separation layer (if required) is laid in contact with the founding ground
- Expanded clay is laid to a thickness that is variable depending on the means of compaction used (Fig. 3).
- The surface of the expanded clay is compacted directly by multiple passes with a vibrating plate compactor (typical weight 50-140 kg, width 50-80 cm, contact stress < 5 kN/m², frequency 75-100 Hz) or a tracked vehicle (excavator, shovel, bulldozer - Contact stress < 50 kN/m²) The number of passes required will depend on the thickness of the layers and the machine used (Fig. 3).



2. Embankments/fills consisting of alternating layers of expanded clay and granular mix (of gravel or rockfill) (Figure 2)

Average density after completion: 600 - 1200 kg/m³.

The thickness of each layer can be varied depending on the design requirements.

Spreading sequence (repeated):

- A geotextile separation layer (if required) is laid in contact with the founding ground.
- A first layer of expanded clay is laid to a thickness of 20 - 100 cm.
- A geotextile separation layer is laid.
- A layer of granular mix is laid to a thickness of at least 10 cm.
- The top of the granular mix layer is compacted using a vibrating roller, typically weight 15-50 kN.

The total thickness of each sandwich of clay + granular mix must not exceed 120 cm. The final layer of granular mix, on which the finishing layers will be placed, must be at least 30 cm thick (suggested thickness: 40 cm).

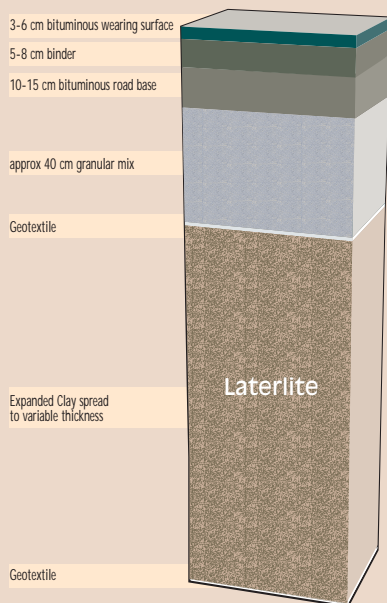


Figure 1: Embankments/fills consisting of expanded clay only (with final capping layers).

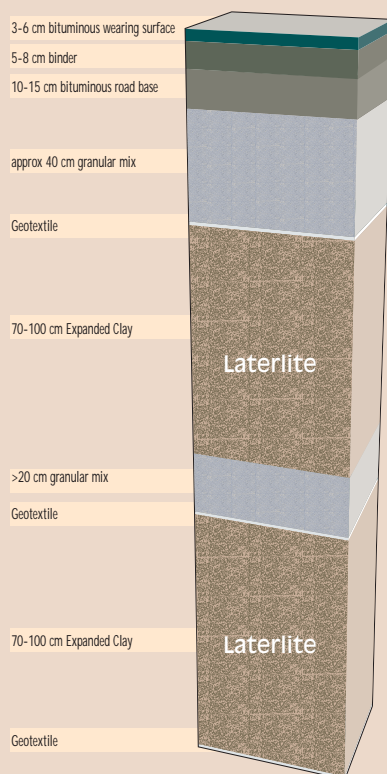


Figure 2: Embankments/fills consisting of alternating layers of expanded clay and granular mix (with final capping layers).

FIGURE 3: COMPACTION DIRECTLY ON EXPANDED CLAY

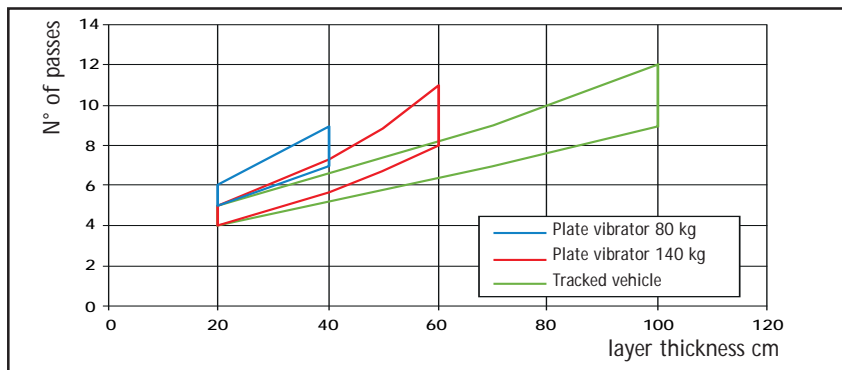
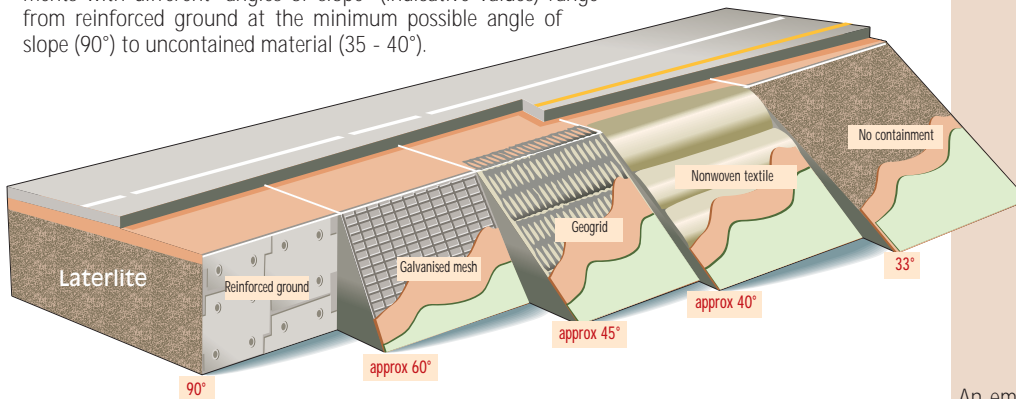


Figure 4: The most commonly used methods for containing embankments with different "angles of slope" (indicative values) range from reinforced ground at the minimum possible angle of slope (90°) to uncontained material (35 - 40°).



3. Embankments/fills in expanded clay bound with cement

Densities ranging from 500 - 800 kg/m³ and strengths from 1 - 4 MPa, depending on the type of expanded clay and the quantity of cement used.

To increase the stiffness of fills or embankments or to resolve problems of lateral containment, or to deal with other requirements, they can be constructed using cemented expanded clay (permeable concrete – open pore structure).

Each layer must not be more than 50 cm thick and compaction must be carried out with a plate vibrator.

Cemented expanded clay can be manufactured in various ways:

- **Continuous on-site manufacture:** expanded clay is delivered to site in tanker trucks equipped with suitable pumping gear. At the same time a cement slurry is manufactured on site using suitable machinery, and continuously injected into the pump hose as the expanded clay is delivered. The mixing takes place at this stage.
- **Off-site manufacture in a batching plant,** with delivery in concrete mixer trucks.
- On-site mixing (if small quantities are required)
 - using bulk expanded clay and cement.
 - using bagged premixes (Latermix Cem Classic or Maxi).



CAPPING LAYERS

The upper part of an embankment or fill made from expanded clay can be constructed in various ways depending on its intended use, the loads carried, and the finishing materials: from growth substrates for a planted top surface, granular mix layers interspersed with bituminous layers (as shown on the previous page), and reinforced concrete slabs for various types of top finish. Specific technical solutions can be developed to meet particular design requirements.

An embankment of expanded clay mixed with cement.

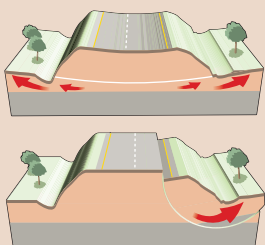


Compaction using a plate vibrator.



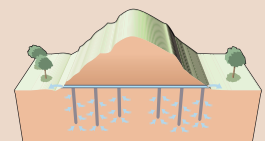
3 Geotechnical applications

PROBLEMS ASSOCIATED WITH TRADITIONAL EMBANKMENTS

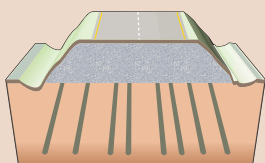


Traditional embankments constructed on poor supporting ground may lead to settlement and loss of stability.

TRADITIONAL TECHNIQUES

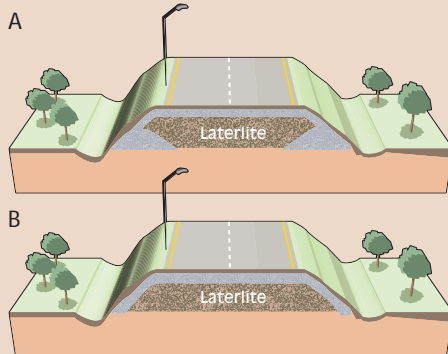


Preloading founding ground with vertical drains and quarry mix, prior to construction of an embankment.

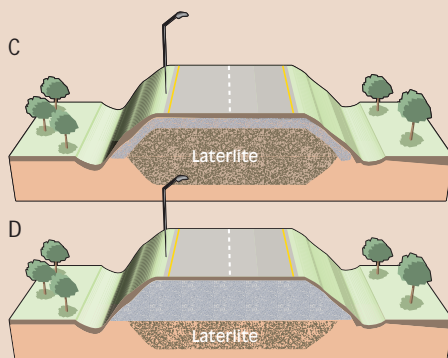


Piling used to consolidate an embankment constructed on ground with poor load-bearing capacity.

TYPES OF LIGHT EMBANKMENT CONSTRUCTED USING LATERLITE EXPANDED CLAY



Embankments without load compensation.



Embankments with load compensation.

3.1 Lightened embankments

3.1.1 Embankments on soft ground

The loads generated by a traditional embankment can cause instability and differential settlement if the supporting ground has poor mechanical properties. These problems can usually only be avoided by means of costly, technically complex preliminary stabilisation works (preloading and drainage, piling, etc.).

The use of Laterlite Expanded Clay as the nucleus significantly reduces the weight of the embankment (up to 80 %), enabling the cost of stabilising the founding ground to be partly or completely avoided.

By constructing the embankments using the load compensation method (replacing a volume of the ground below the embankment with an equivalent volume of expanded clay) the loading on the ground is not increased (or is only increased by an extremely small amount), maintaining the original state of stress, even in embankments of considerable height.

Advantages

- Reduced absolute and differential settlement of the embankment.
- Simple and rapid construction using ordinary site equipment.
- Increased safety coefficient at the ultimate limit state of the embankment.
- Possible to construct in technically or logistically complex situations.

Types

Light embankments in Laterlite Expanded Clay can be:

- uncompensated (Figs. A and B): on foundation ground with poor bearing capacity, the distributed load is reduced by exploiting only the beneficial effect of the lower specific weight of the material itself.
- compensated (Figs. C and D): if foundation ground with poor bearing capacity is partly replaced with expanded clay, this improves its mechanical characteristics and compensates either partly or completely for the imposed load of the new embankment.

Densification

A light embankment constructed with expanded clay can be compacted in various ways, depending on the construction method (see section 2):

- After a load distribution layer has been spread:
 - Spreading a load distribution and capping layer (of gravel or rockfill) followed by compaction with a roller.
 - Interposing a geogrid, followed by compaction with a roller.
- Directly on the layer of expanded clay:
 - Using a plate compactor.
 - By passing over it with a tracked vehicle (excavator/shovel).



3.1.2 Bridges abutments and alignment ramps

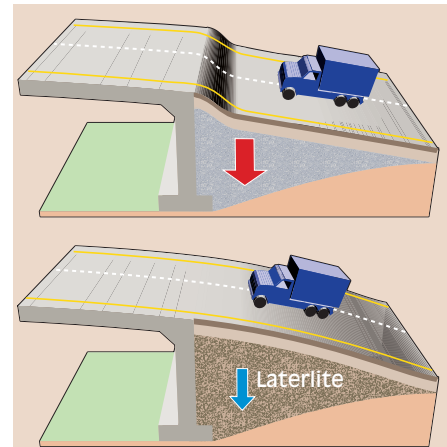
When embankments are constructed connecting to “rigid structures” such as viaducts, bridges or other concrete works, any drop in the level of the approach ramp would be particularly problematic, since it would result in a step that could make the infrastructure unusable.

The lightweight nature of expanded clay, its optimised granulometric size, and its other properties, which are determined and controlled at the manufacturing stage, make it ideal for resolving this problem or preventing it from occurring, because it densifies much more easily than traditional aggregates, reduces in volume to a much lesser extent, and avoids settlement by reducing the imposed loading on the supporting ground.

Advantages

- Reduces and simplifies compaction.
- Reduces the load on the supporting ground.
- Reduces settlement over time.
- Reduces horizontal thrust on the containing structure (e.g. a bridge shoulder) (see 3.2).

Alignment ramp on railway infrastructure.



The use of expanded clay in the construction of alignment ramps connecting to rigid structures gives the system a high degree of rigidity, reducing problems due to differential settlement.



Bridge alignment ramp
Port of Barcelona - Spain.

3.1.3 Widening existing embankments

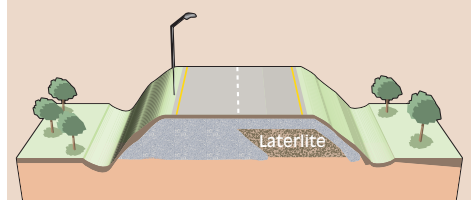
When existing embankments are widened, particular care must be taken to avoid settlement in the new part, as over time this could bring about a dangerous level difference. The use of expanded clay minimises this risk due to its ease of compaction, its low volumetric reduction as compared to normal aggregates, and the minimum load it imposes on the supporting ground.

3.1.4 Embankments on landfill

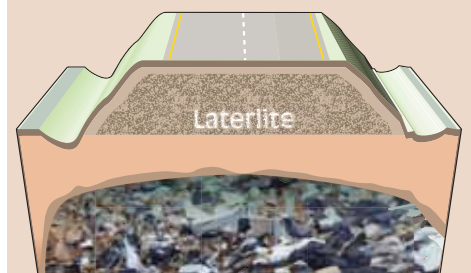
Designing and constructing an embankment, or any other type of construction, on landfill, is particularly complex because of the poor loadbearing capacity of landfill, the likelihood that it will be incoherent and variable in its mechanical behaviour, and because these factors are difficult to quantify at the design stage. Since traditional probing and strengthening techniques such as piled foundations (which would risk contaminating the ground) cannot be used on landfill, it is crucially important to minimise the loads imposed by the new embankment. This can be achieved in technically and economically advantageous ways by using expanded clay, and following the methods described in the preceding paragraphs.

Advantages

- No disturbance to the landfill layers (which are not perforated).
- Minimised loading.
- Improved safety, including in cases where preliminary investigations cannot be thorough.

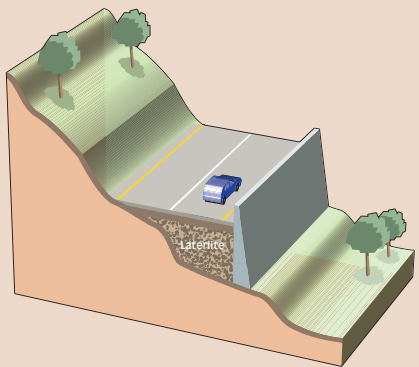


Widening an existing embankment.



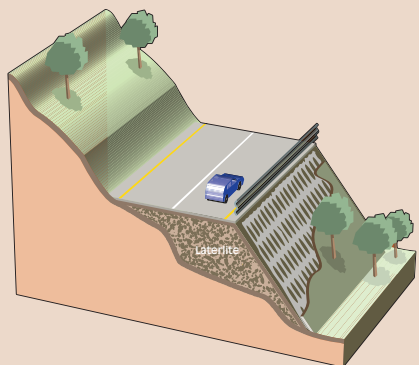
A light embankment on a landfill.

3 Geotechnical applications



Light slope embankment with retaining wall.

Slope embankment constructed from expanded clay reinforced with geogrids.



Slope embankment with "ground strengthening" technology.

Slope embankment constructed from expanded clay reinforced with geogrids.



3.1.5 Embankments on potentially unstable slopes

The use of Laterlite Expanded Clay is strongly advantageous in the construction of new slope embankments, or the reinstatement of existing slope embankments, thanks to its lightness and static functionality (i.e. its internal stability), which reduce the load on the slope, avoiding movement due to landslide or the risk of reactivating any pre-existing landslide.

If the embankment is contained by a retaining wall, the use of expanded clay has the further advantage of reducing lateral thrust on the wall (see 3.2.1).

Advantages

- Minimal disturbance to the load state of the slope.
- Improved control of landslide risk.
- Reduced need for complementary support and containment works.
- Greater flexibility at the design stage.
- Optimised drainage.

Light slope embankment with retaining wall –A1 motorway - Italy.



Strengthened ground, reinforced ground, geogrids.

Laterlite Expanded Clay is compatible with the reinforcement systems that are widely used in the construction of slope embankments - strengthened earth, reinforced earth, and geogrids. If layers of expanded clay are spread in a sequence, these adapt easily to the modularity of the containing system adopted. Despite the lightweight of the expanded clay, very high friction (i.e. extraction) values can be attained at the interface where it comes into contact with the reinforcement, enabling the dimensions of the reinforcement to be calculated efficiently.

Light slope embankment in "reinforced ground" – A1 motorway - Italy.



3.2 Containment structures

3.2.1 Retaining walls

The dimensions of ground containment structures are determined by the horizontal thrust of the contained ground. Expanded clay is particularly useful as a replacement for traditional aggregate fill behind existing or new containment structures, because it reduces the thrust and offers various other advantages.

Advantages

- Drastic reduction (up to 80%) of the thrust of the ground on the wall
- Optimal, continuous drainage
- Structural economy in the construction of new retaining walls (slimmer structure, simpler foundations)
- Simplification of the process for making safe existing retaining walls (both gravity and non-gravity)
- Ideal for widening existing slope embankments (see 3.1.5).
- Reduced differential settlement (see 3.1.2).



Thermal insulation in earth retaining walls

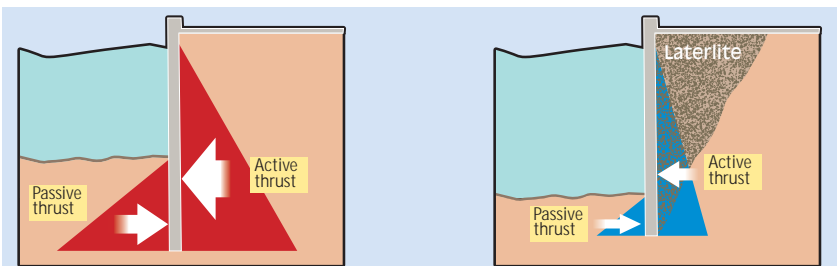
Laterlite Expanded Clay also gives effective thermal insulation (λ value 0.09 W/mK) in earth retaining walls that surround habitable rooms, tanks, or swimming pools. Recommended product: Laterlite Plus hydrophobic expanded clay.

3.2.2 Piers and waterfronts

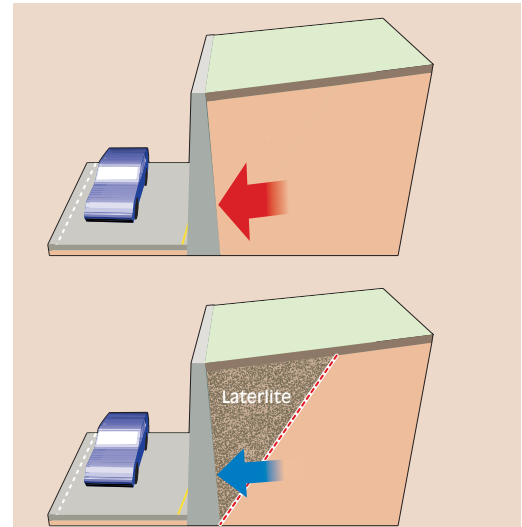
For constructing or enlarging piers, artificial islands, and the banks of watercourses, expanded clay can be used as fill behind the supporting structures (sheet piling, retaining walls, etc.) as a replacement for traditional aggregates.

Advantages

- Reduced thrust on the containing structure.
- Reduction in the depth of sheet piling.
- Resistance to freeze-thaw cycles, and aggressive substances in the water.
- Drains rapidly when the water level changes.
- Can be placed directly in water (expanded clay saturated with water does not float).
- Controlled differential settlement (since the weight of saturated clay immersed in water is similar to that of water itself).



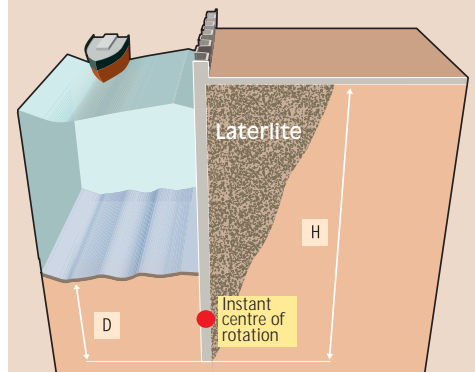
Thanks to its lightweight nature, expanded clay enables the active thrust to be reduced to $\frac{1}{4}$ that of a traditional aggregate.



Backfilling with Laterlite Expanded Clay reduces the thrust on the retaining wall.



Lightweight fill behind historic containment walls: the 16th century walls of the city of Lucca - Italy.



Constructing retaining walls and backfilling with expanded clay enables the underground depth D to be reduced (and therefore the relationship H/D to be increased).



3.3 Foundations of buildings

3.3.1 Compensated foundations

For constructing new buildings on ground of poor loadbearing capacity (where traditional foundations would cause an unacceptable amount of settlement) compensated foundations can be constructed using Laterlite Expanded Clay, which is sufficiently strong to support the whole load of the building.

A compensated foundation consists of replacing a volume of the ground below the foundations with an equivalent volume of expanded clay (which has a much lower density) thereby reducing the weight and partly or wholly compensating for the loads imposed by the new building.

Advantages

- Consolidation settlement is controlled or eliminated.
- Simple construction with minimal impact and disturbance to neighbouring buildings.
- Can be integrated with other works in more complex situations (piling, etc.).
- Provides thermal insulation, drainage, and protection from rising damp (see 3.3.2)



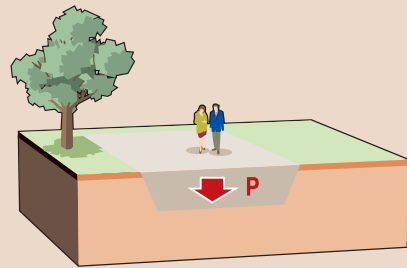
3.3.2 Ground insulation

Incorporating a layer of expanded clay below the base structures of a building, tank, or swimming pool (the base slab and foundations) provides an extremely durable, stable, robust layer of thermal insulation that is free of interruptions and is easy to spread. If special Laterlite Plus hydrophobic expanded clay is used, this provides effective additional control of rising damp.

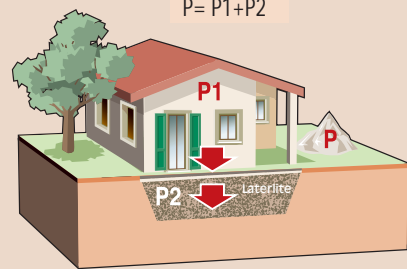
Advantages

- Excellent thermal insulation (lambda value 0.09 W/mK).
- Elimination of thermal bridging.
- Ease of incorporating service distribution runs into the construction.
- Stable and durable support for the building.
- (With Laterlite Plus) control of rising damp from the ground due to capillary action.

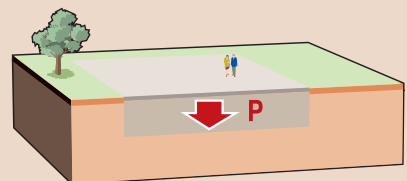
Thermal insulation in contact with the ground between foundation ground beams.



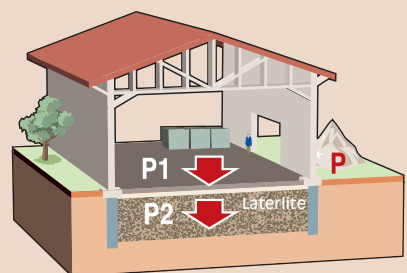
$$P = P_1 + P_2$$



The load compensation principle: replacement of a volume of the founding ground with the same volume of much lighter expanded clay.



$$P = P_1 + P_2$$



A compensated expanded clay foundation can replace or collaborate with a piled foundation.

Load compensation of a single-family house and insulation in contact with the ground.



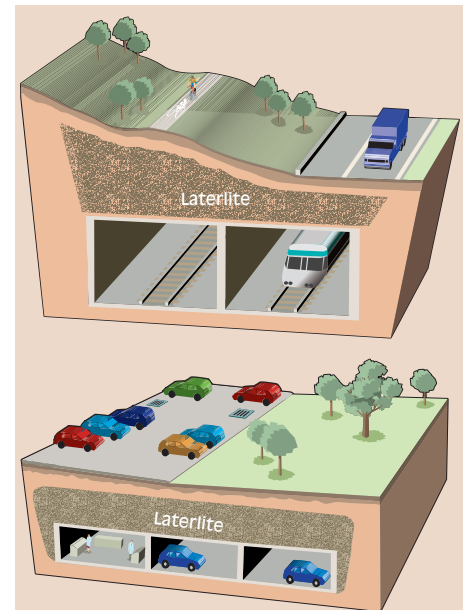
3.4 Fill for underground structures

Traditional aggregates used as fill above underground structures (tunnels, parking garages, etc.) impose a high permanent load that restricts the possibilities of re-using the existing structures and requires new structural elements to be oversized to take the extra load.

Laterlite Expanded Clay drastically reduces the weight of the fill layers, and its high strength enables maximum flexibility in how the spaces above are used.

Advantages

- Reduced dead loading on the below-ground structure.
- Economy of construction in new-build structural elements (which can be slimmer).
- Greater freedom for modifying and re-using any existing structure.
- Can be laid to deep thicknesses.
- Maximum freedom in the use of the spaces above, including by vehicles.
- High drainage capacity.
- Freedom from risk in case of fire (expanded clay is a 100% mineral material).
- Simplicity of construction.



Intermodal station – El Prat de Llobregat – Barcelona – Spain.



Promenade du Paillon – Nice – France.



Casino Gardens – Monte Carlo.

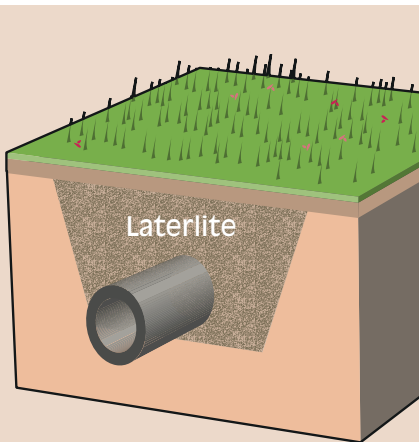


Underground parking – Tortosa – Spain.

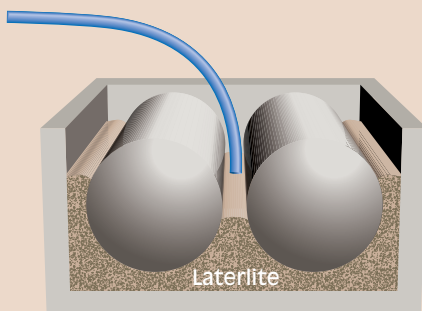


Turin-Milan high-speed railway – Italy.





Bedding for a gas pipeline – Shakalin - Russia.



Bedding and making safe tanks.



3.5 Buried tanks and pipes

3.5.1 Bedding and insulation for pipelines

The use of expanded clay as bedding and fill for underground pipelines or for pipelines that are integrated into engineered structures (bridges, tunnels, etc.) brings technical and practical advantages.

Advantages

- Simple to lay without any need for compaction, without risk of damage to pipework.
- If access to the pipeline is required for maintenance, it is easy to identify and the aggregate is easy to remove.
- Thermal resistance: the low heat dispersion and reduced risk of freezing enable the excavation to be shallower.
- Protection from vibration and thrust caused by settlement, seismic events, landslip, etc.
- Ability to support significant loading.
- Drainage and elimination of stagnating water.

3.5.2 Tank burial

Tanks that are buried underground, particularly when they are used for storing dangerous flammable liquids, reduces the risk of accident or damage and is frequently required for compliance with national and international standards. The properties of Laterlite Expanded Clay make it the perfect material for burying all types of tank.

Advantages

- Lower imposed loads on the ground and foundations. Prevention of settlement (which could compromise the usability of the tank).
- Durability, including in acidic or basic environments.
- Resistant to weather and freeze/thaw cycles.
- Incombustibility and resistance to fire.
- Thermally resistant, with lower heat loss and reduced risk of freezing.
- Drainage and elimination of stagnating water.
- Easy to spread.
- Extremely high percentage of voids (the volume of the voids between the granules, added to the volume of the voids within the granules, is approximately 85% of the total).



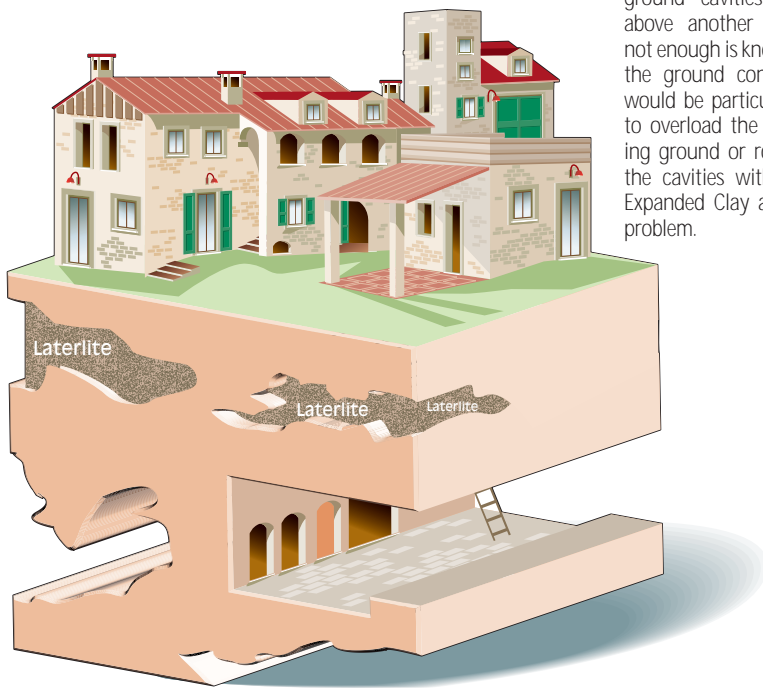
3.6 Fill for below-ground cavities

Natural or artificial underground cavities are frequently encountered below historic cities or in particular regions. These cavities can often put at risk the stability of structures; a tried and tested technique for making them safe is to fill them with Laterlite Expanded Clay.

Thanks to its high compressive strength in fact, expanded clay (either loose or bound with cement), enables stresses on the ground to be redistributed throughout the subsoil, eliminating dangerous load concentrations and attenuating and redistributing them over time. As compared to filling with a traditional aggregate, this significantly reduces the additional load and the lateral thrust, avoiding the risk of settlement.

This technique is also used for making safe disused underground tanks, by filling them with expanded clay and leaving them in place.

In situations where below-ground cavities are one above another or where not enough is known about the ground conditions, it would be particularly risky to overload the surrounding ground or rock. Filling the cavities with Laterlite Expanded Clay avoids this problem.

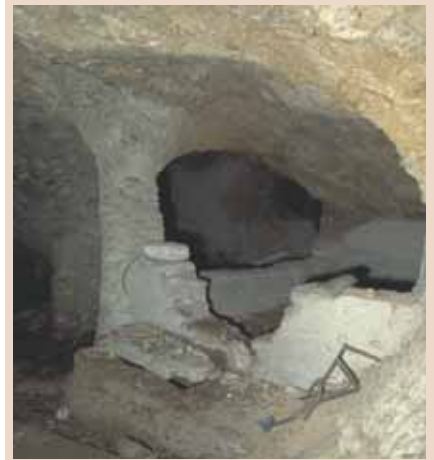


Advantages

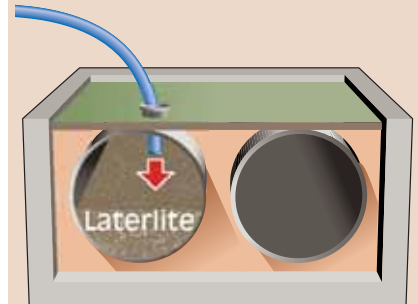
- Positive load redistribution in the parent rock.
- Reduced additional loading and minimal alteration of the tension state of the ground below the filled cavity and surrounding it (minimised lateral thrust).
- This technique can also be used in multiple cavities superimposed one above another.
- Ease of execution.
- No alteration of water flows within the ground.
- Safe in the event of fire.
- Can be carried out as temporary works that are easy to remove at a later stage.

Tensioning the fill

After a cavity has been filled with expanded clay, the effectiveness of the procedure can be maximised by injecting an expanding polyurethane resin into the cavity, applying a predetermined amount of precompression to the cover above the cavity. This resin injection system is denominated "Cavity Filling" and was developed by Laterlite in collaboration with Uretek.

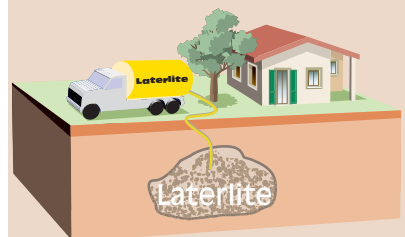


Natural underground grottoes or mines used to excavate construction material can compromise the stability of buildings



Fill for disused cisterns.

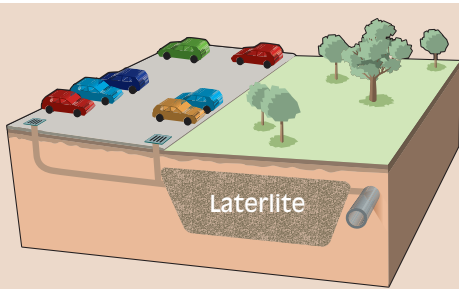
Laterlite & URETEK CAVITY FILLING



Phase 1: filling the empty space with expanded clay.

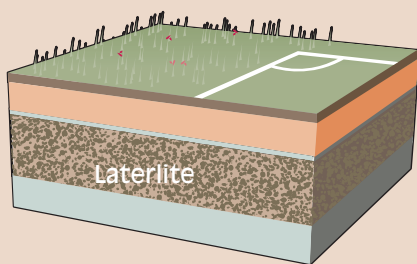
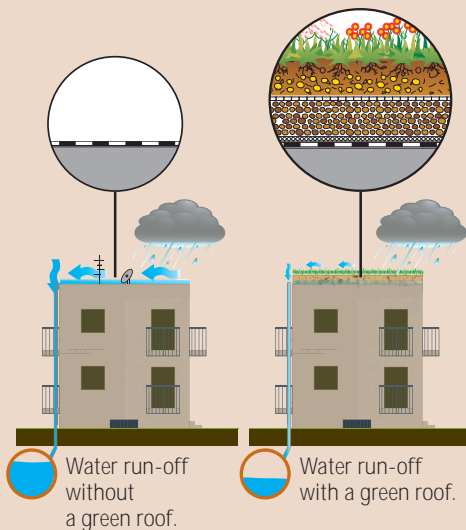


Phase 2: injecting expanding resin into the cavity to pre-compress the cover layer.



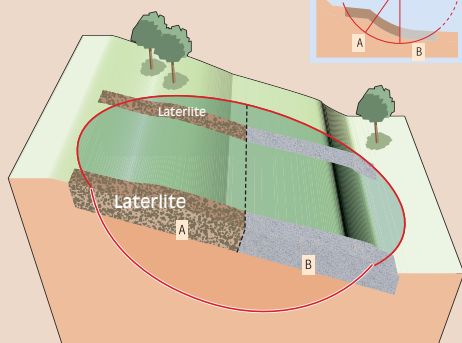
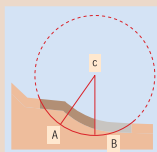
Underground infiltration reservoirs.

Advantages of the green roof system.



Drainage for playing fields.

Zone A: expanded clay
Zone B: traditional aggregates
with high drainage capacity



Drainage trenches in expanded clay.

3.7 Water risk management

Climate change is bringing about ever more frequent and more intense rainfall, with peak water flows that exceed the capacity of drainage networks and surface watercourses, resulting in overflows and flooding of inhabited areas and agricultural zones.

3.7.1 Underground accumulation - infiltration reservoirs

To regularise peak storm water flows, a simple underground accumulation and infiltration reservoir can be constructed by burying a volume of expanded clay, suitably contained within a geotextile or geomembrane.

Thanks to the inherent strength of the expanded clay there is no need for a complex covering structure. The ground layers above the reservoir can bear directly on the expanded clay and can take the load of any type of activity (parking, roads, sports grounds, gardens, etc.).

Advantages

- Excellent water storage and drainage capacity thanks to the 90% intragranular and intergranular void content of expanded clay.
- Can be integrated into existing construction works to give a usable surface at ground level.
- Adapts to fill excavated volumes of any shape.
- Enables existing excavations to be reused.
- Minimal need to construct complementary structures.
- Stability and mechanical strength over time.
- Enables the stored water to be potentially reused.

3.7.2 Green roofs

The use of expanded clay in the layers of a correctly designed green roof (consisting of a drainage, a substrate, and a mulching layer) improves plant health and significantly reduces peak water discharge into the public drain during intense rainfall. For further information see the specific documentation.

3.7.3 Drainage below playing fields

The use of expanded clay in the drainage systems below playing fields prevents flooding, allows the field to be used in adverse weather conditions, and prevents the ground from settling. For further information contact the technical support.

3.7.4 Drainage trenches

Expanded clay is used for trenches in various situations to construct drainage, particularly for stabilising slopes that consist of silty clay material.

If the drainage trench follows the line of maximum slope, this decreases the water pressure in the slope, consequently increasing the safety coefficient.

In these cases if expanded clay is used to construct the upstream part of the trench, its low density provides additional mechanical stabilisation by reducing the weight of the trench at a point where this might otherwise become a factor leading to collapse.

3.8 Tunnels

Fill behind lining segments in tunnels

3.8.1 excavated by TBM (full face tunnel boring machinery)

Mechanically excavated tunnels in rock or rock masses with high convergence (i.e. where the rock has a strong tendency to expand, thereby reducing the cross-section excavated) require special care at the design stage and during construction, to ensure that there is no excessive thrust from the rock on the tunnel lining segments.

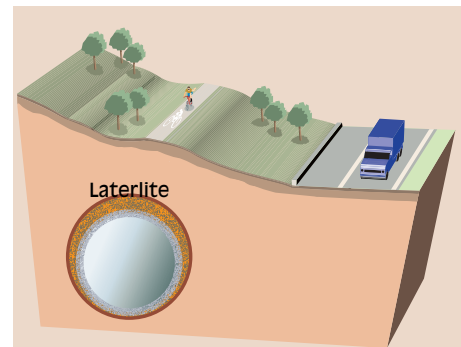
This phenomenon can be kept under control by inserting a “collapsible” material between the rock mass and the lining. The material used must be sufficiently rigid to ensure that the tunnel lining ring remains stable, but must also be able to collapse when a predetermined level of stress is reached, deforming plastically to reduce the thrust on the lining.

Laterlite Expanded Clay is ideal for this type of application because:

- It can be placed using the pumping systems normally available at tunnel construction sites.
- It contains a high percentage of voids.
- Its excellent mechanical characteristics have been tried and tested in civil and geotechnical applications.
- It has a relatively low peak strength.
- It can be “designed” by using various different granulometries combined with other construction materials to obtain the desired performance.

This process was developed for the Gran San Bernardo Tunnel under the Alps, between Italy and Switzerland, and won the Best Technological Solution of the Year award at the 2012 World Tunnel Congress.

Precast concrete tunnel lining segments following passage of the TBM.



Tunnel excavation using a full section tunnel boring machine (TBM) - Gran San Bernardo tunnel Switzerland/Italy.



Filling tunnel cavities.



3.8.2 Other fill types in tunnels

Expanded clay is widely used to fill various types of cavity between the rock and the lining of new and existing tunnels, whether or not the rock is convergent.

4 Infrastructural applications



Reinforced concrete cover / trench filled with expanded clay as protection for the road.



A bed of expanded clay effectively slows falling rocks.



Escape roads at the Imola racing circuit - Italy.



Filling traffic islands with expanded clay prior to planting.

Expanded clay used for renaturising the ground at the edges of transport infrastructure.



4.1 Passive impact protection systems

Loose expanded clay is an excellent means for dissipating the kinetic energy of a sudden impact. In fact the low specific weight of the granules means that the material is highly deformable and for that reason much more effective than heavy granular materials such as gravel. Thanks to these characteristics, expanded clay is used for various purposes in road and infrastructure construction.

4.1.1 Landing beds and roofs for rockfall protection

In structures that protect roads or railways below slopes where there is a risk of falling rocks, expanded clay is used as a landing bed for boulders. These will tend to sink into it and be absorbed without re-emerging.

Compared to gravel, expanded clay imposes a significantly lower static load, and thanks to its efficient energy dissipation it reduces the dynamic action transmitted to the supporting structures, enabling concrete roofs to be thinner with less reinforcement.

4.1.2 Emergency road escape lanes

Escape lanes are often provided on long steep road descents, for vehicles in difficulty that need to escape. These routes terminate in a bed of expanded clay, ensuring that any residual kinetic energy is dissipated as the vehicle sinks into the expanded clay and comes to a stop.



4.1.3 Emergency run-off areas at racing circuits

At racetracks all over the world, expanded clay is used in the run-off areas at the most dangerous bends, to reduce the speed of cars and motorcycles.

4.1.4 Road restraint at danger points

Laterlite Expanded Clay is used in various impact protection and road restraint systems (compliant with EN1317) at danger points of road infrastructure such as exit ramp crash cushions, piers, parapets, openings in guard rails, and buildings (toll booths, cabins, etc.).

4.2 Landscaping management

In the particularly harsh conditions close to infrastructure (e.g. central road reservations) and in roof gardens or newly landscaped areas, Laterlite Expanded Clay makes a valuable contribution to simplifying the management and long-term health of planting. It is also an extremely durable material that is non-combustible, and in the event of fire prevents it from spreading.

Principal uses:

- Drainage and water retention: prevents water from stagnating whilst ensuring a water reserve for the planting.
- As a substrate improver it ensures good protection for the plant root apparatus, aerates the soil, and has good water retention.
- Used in mulch, it protects roots from sudden temperature changes and gusts of wind from passing vehicles, and slows down the germination of weeds.

4.3 Noise barriers

Sound-absorbent noise-insulating acoustic panels and barriers are widely used to protect residential areas from the noise of roads and railways, factories, etc.. The particular structure of Laterlite Expanded Clay makes it an ideal component for prefabricated porous concrete acoustic elements of various sizes and aesthetic appearance, for use as:

- sound-absorbent noise-insulating acoustic barriers.
- sound-absorbent facings for existing walls.

Advantages:

- Very good sound absorption at medium and high frequencies.
- Wide variety of aesthetic treatments.
- Durable and maintenance-free.
- Excellent static and mechanical behaviour.
- Totally incombustible.
- Easy to transport and erect thanks to the lightness of expanded clay.

4.4 Bituminous road surfaces

Laterlite Expanded Clay used as a component in the mix design of bituminous conglomerates improves their technical characteristics. Specifically it can be used for:

- **sound-absorbent road surfaces** - a variable percentage of expanded clay included in the mix, from 11% - 13% by weight, significantly increases the sound absorption (by 3 dB).
- improving the transversal attrition coefficients and reducing wear on **anti-skid road surfaces, including on drained anti-skid surfaces**, as compared to the best basalts.

Noise-absorbent road finishes for urban locations. Monza - Italy



Acoustic barriers.



Railway noise barriers –Milan-Bologna high-speed railway.



Noise-absorbent facing.

Draining road surfaces on motorways.



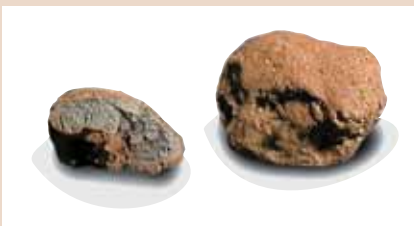
5 Lightweight concretes



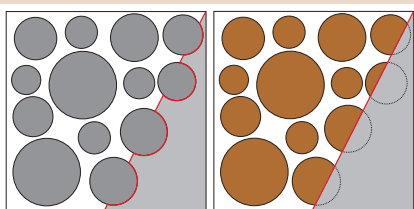
Cube test for determining compressive strength.



Laterlite Expanded Clay.



Structural Laterlite Expanded Clay (high strength).



Failure behaviour in a traditional concrete and a lightweight concrete (LWAC): the mechanical strength of the aggregate is critical for achieving a high mechanical performance of the concrete.



20 - Laterlite - Geotechnics and infrastructure

The mechanical strength of Laterlite Expanded Clay (both standard and structural) in relation to its lightness makes it the ideal aggregate for structural and non-structural lightweight concrete and enables the self-weight of structures to be significantly reduced, as well as giving other structural and geotechnical advantages.

If traditional aggregates are partly or wholly replaced with Laterlite Expanded Clay the properties of the concrete can in fact be varied to give a wide range of densities and strengths.

Laterlite Expanded Clay is specifically manufactured and tested as an aggregate for use in concrete, and is CE marked as compliant with European Standard EN 13055-1. It can be used both for in situ and precast concrete.

The various mix designs are usually determined in relation to the final design requirements and the aggregates that are locally available.

5.1 Expanded clay for concrete mixes

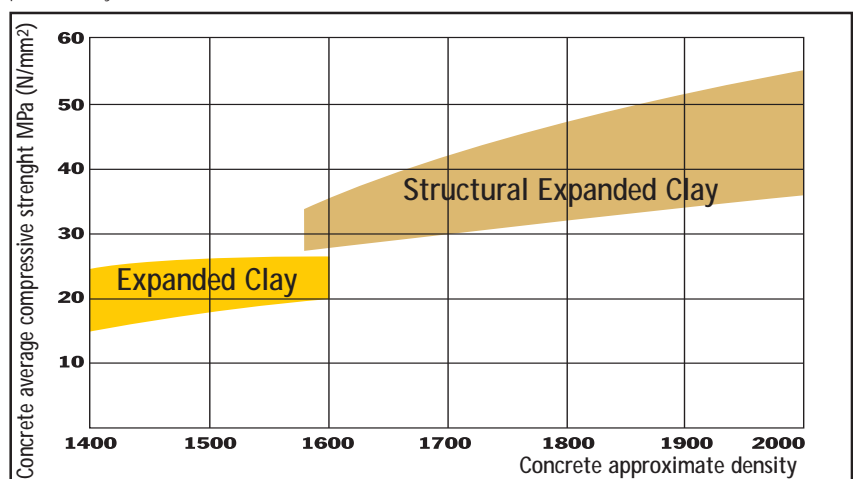
Standard and structural Laterlite Expanded Clay can both be used for the preparation of concrete mixes. Structural expanded clay has less expanded internal nucleus and a thicker, more tenacious vitrified external shell that enable particularly high compressive strengths to be attained.

An aggregate with good strength characteristics is crucial for achieving the mechanical performance of a concrete; the fracture mechanics of concrete based on lightweight aggregate differ significantly from those of a concrete made with heavy aggregate.

Type of Laterlite Expanded Clay	0/2	2/3	3/8	8/20
Bulk density (EN 13055-1) [Kg/m ³]	680	480	380	330
Granule crushing strength (EN 13055-1) [N/mm ²]	≥ 5,0	≥ 3,0	≥ 1,5	≥ 1,0

Type of Structural Laterlite Expanded Clay	0/5	5/15	0/15
Bulk density (EN 13055-1) [Kg/m ³]	720	600	650
Granule crushing strength (EN 13055-1) [N/mm ²]	≥ 12,0	≥ 5,0	≥ 9,0

Evolution of the concrete compressive strength in function of his density and of the type of Expanded Clay used.



5.2 Lightweight structural concretes

Ideal for use in loadbearing reinforced concrete structures.

Approximate densities 1,400 kg/m³ - 2,000 kg/m³.

Compressive strengths 15 - 60 MPa (150 - 600 kg/cm²).

Advantages:

- **Reduced self-weight of loadbearing structures** by up to 40%: 1,000 kg (1 tonne) per m³ lower than traditional concretes (2,400-2,500 kg/m³).
- **Reduced loading transmitted to the founding ground.**
- **High levels of mechanical performance** under compression, from 15 - 60 MPa (150 - 600 kg/cm²). Traction, bending, and pull-out strengths in line with those of traditional concretes in the same class.
- **Calculation, structural testing, manufacture and control can be carried out in compliance with international reference standards** (European Standard EN 206, Eurocode 2, etc.).
- Thanks to the insulating and refractory properties of Laterlite Expanded Clay, **it responds better than traditional concretes in the presence of fire.**
- **The mixing process is similar to that of ordinary concrete.** Most mixes (particularly those of density greater than 1,650 kg/m³) can be pumped.
- **Thermal insulation and reduced thermal bridging**, thanks to the low thermal conductivity, which is up to 4-5 times less than that of an ordinary concrete.
- Thanks to the lower density of the concrete, **transportation is more efficient and handling is simplified**, particularly in precast elements of large size.

A large-span bridge cast in situ.

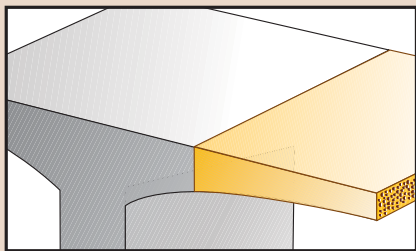


NET tower – Padua – Italy
Arch. A. Galfetti, L. Schiavon.

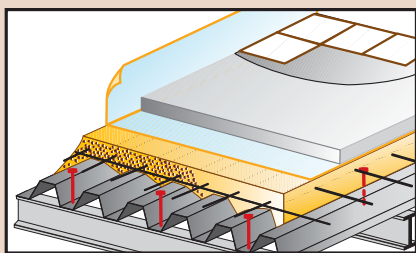
City Life Residences – Milan – Italy
Arch. D. Libeskind.



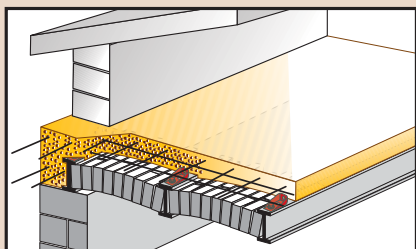
5 Lightweight concretes



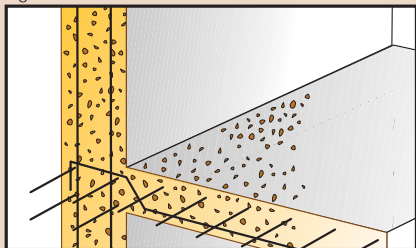
Major infrastructure projects (bridges, etc).



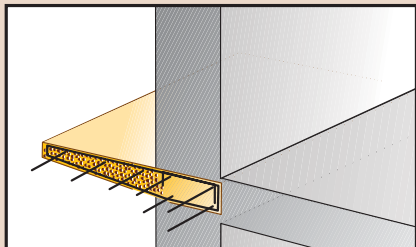
Composite slabs.



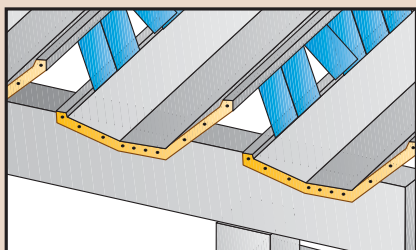
Earthquake-resistant renovation and strengthening works.



Reduction of thermal bridging.



Cantilevered structures.



Precast structures.

AREAS OF APPLICATION

- **For construction on ground of poor bearing capacity.**
- For reducing the complexity and cost of foundations, even in the most difficult ground conditions. Enables larger structures to be built for the same load transmitted to the ground.
- **For structures whose self-weight exceeds the loads they carry.**
Lightweight structural concrete enables long-span bridges, precast roofing slabs, large precast components, large-span slabs, etc. to be slimmer, with aesthetic and economic advantages.
- **Construction and refurbishment works in seismic zones.**
The use of lightweight structural concrete to reduce the inertial mass of structures lessens seismic stresses, simplifies the design, and ensures that buildings are safer in the event of an earthquake.
- **Complex architectural projects.**
Reducing the weight of concrete elements enables structures to be slimmer with fewer structural constraints, making possible greater design freedom and more adventurous architectural solutions.
- **Refurbishment.**
For avoiding excessive loads on existing structures and foundations when floor slabs are strengthened or when extra floors are added to existing buildings, and in all refurbishment works where concrete can be used (columns, loadbearing walls, edge beams, slabs, staircases, balconies, etc.).
- **Reducing thermal bridging in the building envelope.**
Thermal bridging due to structural elements that pass through the external enclosure (facades, roofs, foundations...) is reduced by up to 4-5 times. This also reduces heat loss and the risk of building pathologies, and facilitates compliance with the most demanding regulations and certification protocols.
- **In prefabricated structures and components.**
Lightweight precast concrete structural components are easier to manoeuvre, more economical to transport, can be made slimmer, and have better insulating properties and improved fire resistance as compared to ordinary concrete.

MIX PREPARATION

Laterlite Expanded Clay structural concretes are mixed in batching or precasting plants. For traditional pouring (using a chute or bucket) the process is the same as that for traditional concrete. Pump pouring requires correct mix design. Specifically, the following processes can be used:

- SCC (Self Compacting Concrete) technology.
- Pre-wetting the expanded clay.

For more specific information and mix designs, contact Laterlite Technical Support. For small projects, lightweight structural concretes can be mixed using bagged premixed products in the Latermix Beton range.

Examples of lightweight structural concrete mixes (see also p. 20 - diagram).

STRUCTURAL CONCRETES	GRANULATES % in volume			CEMENT [kg/m³]	Indicative density [kg/m³]	Average resistence [N/mm²]
	Sand	Expanded clay				
	type 0/3 30%	type 0/2 30%	type 2/3 40%	(type 42,5) 350	1400	20
	type 0/3 20%	type Structural 0/15 80%		(type 42,5) 350	1600	30
	type 0/3 40%	type Structural 0/15 60%		(type 42,5) 400	1800	40

5.3 Lightweight non-structural concretes

Levelling layers, support layers, and fills spread on loadbearing layers can have:

- **An open structure** (porous - no fines concrete) of density 600 - 1000 kg/m³ and strength of 1 - 3 MPa.
- **A closed structure** of density 1000 - 1400 kg/m³ and strength of 3 - 15 MPa.

Advantages:

- Dead loads on loadbearing structures are reduced by 75% or more
- Loads transmitted to loadbearing structures and the founding ground are reduced.
- Stability over time .
- Incombustibility.
- Thermal insulation.
- Rapidity of execution and adaptability for a very wide range of situations.

Areas of application

- Alignments and inclines on viaducts.
- High strength/high rigidity when used in fills and embankments.
- Reduced loading on loadbearing structures.
- Screeds on slabs.

For small projects, lightweight structural concrete can be mixed using bagged premixed products in the Latermix Cem range.

Examples of non-structural lightweight concrete mixes with closed structure - for specific needs contact Laterlite Technical Support.

STRUCTURAL NON CONCRETES	GRANULATES % in volume			CEMENT [kg/m³]	Indicative density [kg/m³]	Average resistance [N/mm²]
	Sand	Expanded clay				
	type 0/3 25%	type 3/8 75%		(type 32,5) 350	1000	7,5
	type 0/3 15%	type 2/3 35%	type 3/8 50%	(type 32,5) 350	1200	13



Concrete production in a batching plant.



Delivery to site and pumping.



Laterlite
lightweight insulating solutions

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