

HENRI VIDAL & LA TERRE ARMÉE

By **Laura Kerner**, young member of the French Society for Soil Mechanics and Geotechnical Engineering (CFMS Jeunes), April 2022

In this report, the invention of *Terre Armée* by Henri Vidal, together with the worldwide development of the company is presented. An outstanding reinforced earth structure in India and an interview with Nicolas Freitag, Europe Zone Manager for *Terre Armée* are also presented.

Henri Vidal and reinforced earth retaining walls

The inventor, Henri Vidal



Henri Vidal (1924 – 2007) was a French engineer and architect, he received his engineering degree from *Ecole Polytechnique* (1944). He was also an engineer from *Ecole Nationale des Ponts et Chaussées* (1949) and an architect from *Ecole des Beaux Arts*, Paris.

Henri Vidal started his career in the French electric company *EDF*, then in the *Fougerolle* company, where he was involved in the construction of dams and bridges. He left *Fougerolle* in 1962 to devote his full time to his invention, a new material called *Terre Armée*.

In 1957, Henri Vidal invented *Terre Armée* on a beach in Ibiza by considering a mix of sand and pine needles which showed much better mechanical properties than the sand alone. He worked on this project alone for a few years, making reduced scale models in his kitchen with sand and paper. He studied the properties of the material, developed practical methods to design and build *Terre Armée* structures... and kept it all secret!

Henri Vidal spend a lot of time and effort in the development of his technique, the patent application and a great research campaign with full scale experimental walls to validate his work. Research started in 1966 with the department of soil mechanics of LCPC (Laboratoire Central des Ponts et Chaussées, Paris) under the enthusiastic guidance of François Schlosser. With the help of Maurice Darbin, he simultaneously developed a worldwide company.

According to François Schlosser, Henri Vidal was a brilliant inventor and a pioneer in soil reinforcement who conceived *Terre Armée* with very few experimental results. His invention is one of the main ones in Civil Engineering during the 20th century.

The technique

Terre Armée (Reinforced Earth) is a composite material made up of the combination of a granular backfill and strips. The stability of structures is ensured by friction between strips and the backfill. Hence, the soil contributes to its own stability.

At the very beginning, the implementation of *Terre Armée* consisted of alternating a layer of reinforcements with a layer of backfill, up to the desired height. But the principle subsequently evolved by binding the reinforcements to a skin made up of concrete plates or "shells". The latter thus improved aesthetics while strengthening the structure. Because of the resulting lightness and low-cost, *Terre Armée* is often used for retaining walls. The main advantage of the technique is that it needs little maintenance and is aesthetically neat.

The constitutive elements of *Terre Armée* are:

- **A Granular backfill**

Backfilling consists of filling a ditch by adding all types of construction materials or inert waste. But for reinforced earth walls granular material is usually used.



- **The strips**

At the beginning, the shape of the reinforcements was round and smooth, but other shapes were gradually used. Subsequently, more complex shapes such as galvanized flat steel with ribs and twisted welded mesh steel were invented. This is what is currently used. Non-corrosive synthetic materials are also considered.

- **The shells**

Shells are a generally prefabricated made up of reinforced concrete and/or steel. The concrete shell consists of:

- a facing which is the visible face of the shell;
- hooks intended to receive the reinforcements;
- connecting sleeves in which an iron rod (stud) is anchored for the assembly of the shells;
- stops to support the movements of the shells.

This ideal combination creates a long-lasting gravity retaining structure. This technology can be adapted to build retaining walls of any height.

Maurice Darbin and the company

Maurice Darbin is a French engineer, he received his engineer degree from Ecole Nationale des Ponts et Chaussées (1955).

During his wedding, he met Henri Vidal for first time in July 1955. After more than two years of military service in Algeria and Morocco, he started to work for the company *Fougerolle*, where Henri Vidal was also working.

In 1968, Henri Vidal wanted to start his own company and asked Maurice Darbin to join him in the adventure. Quitting his steady and interesting job for a thrilling but uncertain future was a difficult decision that he took in January 1969. The company was settled in a tiny 60 m² office in Paris without any tables, chairs or furniture. This first year was a great challenge for Maurice Darbin: he had to deal altogether with:

- two major issues of the invention: the structure had a poor look and a high cost;
- rapidly find money in a short term to pay for the construction of the first retaining walls;
- start the first development of the company abroad.

This first year ended well: there was no longer enough space in their office for the new employees!

The charismatic, charming and smart Henri Vidal was not parsimonious. Like in the tale, the *Terre Armée* team was therefore directed by the Ant and the Grasshopper. And the Ant was in charge of the bank account! Maurice Darbin was CEO of *Terre Armée* until 1991, spending 23 years in the company.

1957

1st experiment by Vidal

1963

1st patent application

1965

1st retaining wall Pragnères, France,

1968

Creation of *Terre Armée Inc*

1970 - 1974

Research program with LCPC

1971

Creation of *RECO*, USA

1972

Creation of *Tierra Armada*, Spain

1974

Agreement with Sumimoto & Kawasho, Japan

1979

1st design recommendations LCPC/Sétra

1992

10⁷ m² of *Terre Armée* structures in the world

1998

Terre Armée part of Freyssinet Group (Solétanche Freyssinet since 2009)

2013

50th anniversary of *Terre Armée* patent

2014

5·10⁷ m² of *Terre Armée* structures in the world

According to Pierre Segrestin (another director of *Terre Armée*), Maurice Darbin was always bringing constancy and serenity. The way he behaved helped people to keep the conviction that the group will keep going safe. Resisting to all issues and difficulties, he personified the most capital notion among all: durability.

The development of the Company

The Company started in 1968 in Paris in a tiny office with 4 employees, with a great development in France between 1971 and 1975, reaching the milestone of 100 000 m² of *Terre Armée* structures built in 1975.

In the 70s also occurred the worldwide development of the Company with the start of the Reinforced Earth Company in USA in 1971, *Tierra Armada* in Spain in 1972 and the signature of agreements with Sumimoto and Kawasho in 1974 in Japan. In the early 80s, the Company had already developed in 25 countries.

In the 80s, the Company enjoyed a sustainable growth worldwide. In 1980, *Terre Armée* had 250 employees, with 80 % of the new projects outside France. 1980 was also the year of the start of *Terre Armée Internationale*.

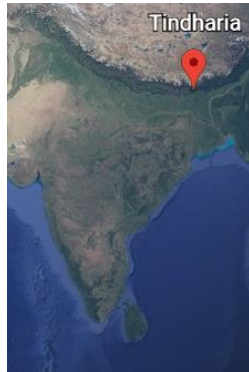
Maurice Darbin retired in 1991 and Henri Vidal had health issues in the 90s. He had to hand over *Terre Armée Internationale* to Freyssinet group.

The group kept expanding in the world with the creation of Reinforced Earth India in 2006.

World's tallest reinforced earth structure, *Tindharia, India*

In September 2011, Tindharia, a picturesque town located on the historic Siliguri-Darjeeling hill cart road, in West Bengal, India experienced massive landslide following an earthquake of 6.9 magnitude and heavy rainfall.

Terre Armée India was able to provide a solution for the 3 locations (S1, S2, S3) where landslides occurred. The solution for the S2 location is shown on the figure below.



Initial situation (landslide)

After completion

Main challenges of this project

- **Inclement weather:** Tindharia receives approximately 185 cm of average rainfall annually. Monsoon is active from end of May to beginning of October. Work got either suspended or very limited activities could be carried out during this period.

- **Unfavorable geology:** The geological strata of this area are susceptible to weathering and fracture.

- **Presence of ground water:** The strata was almost saturated due to continuous percolation of water during monsoon or presence of natural aquifer.

- **Safety:** Working in such a height was also a key challenge from safety point of view for men and machineries.

Solution

- **Stabilization of failed slope:** The design of the structure was done in such a way that it stabilizes

the collapsed slope (landslide area) and also fulfills the requirement of road widening.

- **Design of tall structure in high seismic zone:** the project is located in Darjeeling Himalayan region and falls under seismic zone IV. The maximum height of the proposed structure was also very significant (102.8 m). Thus, the design had to be robust to take care of high seismic load, local and global deformation due to such height during as well as after construction and moreover the stability of the slope and the proposed structure.

- **Drainage solution:** For the sub-surface drainage, multiple layers of semi perforated PVC pipes wrapped with non-woven geotextile were inserted into the slope to drain out the sub-surface water and reduce the hydrostatic pressure. For the surface drainage, catchment drains, and drops and guide drains were designed and constructed to guide the water in a systematic manner so that the structure does not remain unprotected against severe water flow during monsoon.

- **Minimum environmental impact:** Reduction of backfill and boulder quantity, usage of steel mesh fascia instead of reinforced cement concrete panel, limited use of heavy machineries reduced the carbon foot print significantly in this project.

Key figure

Area	7724 m ²
Maximum height	102.8 m
Live load	24 kPa
Seismic co-efficient	0.24 g (zone IV)
Design life	100 years



Interview with Nicolas Freitag, Europe Zone Manager, Terre Armée



Laura: What is your point of view on the premise of Terre Armée?

Nicolas: *Terre Armée*, it's the name of a technique, but also the name of a group, a company. One word for two sides. *Terre Armée*, as a technique, is a major invention for infrastructure:

it allowed to reduce costs and environmental impacts of linear infrastructures for the French highway network in the first place and later at an international level. The success of the technique, it's **Vidal**. The quick set-up of the company *Terre Armée*, with a handful of colleagues, no money, and the feeling that everything is possible, it's **Maurice Darbin**. Together, they will successfully start the company in many countries: Canada, Spain, USA, Japan, etc. They signed in the 70s partnerships that are still going on today, in 2022. The 70s were incredible years with a great opening-up of innovation, thirst for new challenges and many needs in Western Europe.

Laura: Did you have the opportunity to meet Henri Vidal and Maurice Darbin?

Nicolas: Maurice Darbin retired in the early 90s and Henri Vidal, I saw him once, from far! The company was sold to Freyssinet in 1998 and I started to work there in 1999. I arrived for the new chapter of *Terre Armée*, after them. Two of my mentors had worked with them since the 70s and had participated in developing the fundamentals that everyone is using nowadays. These fundamentals were an extraordinary scientific work which were never disproved. If you want to design a Reinforced Earth retaining wall in 2022, you can use the recommendations¹ that were written in 1979! This research is now part of the common design practice at a world scale. Many people worldwide have no idea that it is a French technique, yet it's part of the French intellectual standing!

Laura: What is the distinctive feature of Terre Armée as a company?

Nicolas: It is a company with quite a particular way of working. Usually in the construction business, there are people who handle the design of the structure,

¹ Les ouvrages en terre armée, recommandations et règles de l'art, Ministère des transports, direction générale des transports intérieurs, LCPC, 1979.

others supplying the materials and finally people who assemble everything (construction company). The idea of Maurice Darbin was that the company should be in charge of the design and also the materials. It was a visionary choice and it allowed the company to grow, stay light, strong and able to handle the ups and downs.

There is also a great network between all the *Terre Armée* firms of the group. We do the same work in different countries with different cultures. One of the particularities since the beginning is to develop each firm with local workers. The American company started with an American CEO, in Brazil, a Brazilian CEO and so on. They didn't want any expatriate to be in charge, which is usually the way French companies work abroad. Today, it's still the same. All the workers are locals in one firm. It is quite clever because our clients are local general contractor, our prescribers are local engineering and design companies.

Laura: The sustainability of Terre Armée technique seems to have been questioned over the past few years.

Nicolas: The problematic infrastructures have been perfectly identified for 20 years. A reference document², written in 1994 by Sétra, specifies the structures that need a particular surveillance. The structures built before 1976 need to be monitored and many awareness campaigns are conducted to inform administrators. Some of them don't consider this information and this is how incident like the bridge of Gennevilliers in Paris region in 2018 happen. All the structures built after 1979 show a very good long-term performance. When the design and construction rules are followed, everything goes well. The company developed also solutions such as the use of geosynthetics for difficult applications.

We used to build those structures for 50 years, not 100 years. So, the eldest *Terre Armée* retaining walls are now more than 50 years old and of course need reinforcements and a close monitoring. Our company is always trying to be pro-active and offer the best suited technique for a specific need.

Laura: Nowadays, in which countries is the Terre Armée group the strongest?

Nicolas: The USA is from far our largest setting up in the world. The country with the highest growth for many years now is India. We have also a very strong

² Les ouvrages en terre armée – guide pour la surveillance spécialisée et le renforcement, Sétra, 1994

activity in Canada and Australia. The group is still growing!

Laura: What is the future of Terre Armée?

Nicolas: These days, we started a phase of diversification for *Terre Armée*. For the moment, this technique represents 80 % of our activity but we know that it is not our future. This type of activity will still grow in countries where there are a lot of infrastructures' development. Nevertheless, for countries with a strength structure network with new challenges towards the mobility of the future, we are

developing various techniques: geosynthetics, protection of the environment (regarding natural hazards). These days, we are developing protection structures against avalanche in Iceland, optimising *Terre Armée* structures to resist to rock falls, etc. The idea is to be part of innovative projects and applications where *Terre Armée* was not known before.



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