Reinforced soil walls over compressible soils

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In the early 1960's Henri Vidal, introduced the Terre Armée (Reinforced Earth®) construction technique. Henri Vidal conceptualized this method and built the first full scale demonstration. For 50 years since, Terre Armée has set the standards for reinforced soil structures and has been involved in more than 50,000 projects all over the world, accumulating knowledge and experience in the field of engineered backfills.

Figure 1

Terre Armée structures can be built on compressible subsoil. The settlements have to be accounted for in the design.
Conventional Reinforced Earth walls with precast concrete facing panels can be used in areas where the anticipated differential settlements are within the tolerable limit for the precast panel system. The limit depends of the width of the joints, but typically less than 1%, or 1 metre of differential settlement along a 100 metre wall length.
At locations where greater differential settlements are expected, for example a two stage construction or an obstacle in the subsoil, special provisions like a vertical joint can be applied.

In many projects limitations to the acceptable differential settlements are set by project requirements, like aesthetics or a superstructure. Most often, common geotechnical solutions can be applied: preloading, soil improvement, light backfilling materials or consolidation methods. Preloading can be done before, during or after construction of the Terre Armée walls.
Over compressible or poor quality soils where preloading or soil improvement cannot be used, piles combined with basal reinforcement or rigid inclusions like Menard's Controlled Module Columns (CMC™) can be used to control both stability and settlement of the structure. Menard's Controlled Module Columns (CMC™) is a technique where grout is installed in the foundation soil to both densify the soil and to provide additional support.
On numerous projects over the world Terre Armée structures have been built on piles with basal reinforcement or rigid inclusions. Based on theoretical models additional soil reinforcing strips were added to account for potential additional loading due to stress concentrations caused by arching around the top of the inclusions.
In 2012, in order to understand more clearly and demonstrate the behaviour of the combined system during and after construction, extended theoretical studies and a full scale instrumentation was performed on a structure, constructed along the Garden State Parkway in Bass River (USA). Data was recorded over 5 months during construction and 2 months after construction.

Figure 3 shows the instrumentation. Stress gauges to measure the stress in the reinforcing strips; gauges to measure soil pressures and settlements at the bottom of the reinforced soil block and gauges to measure stresses in the rigid inclusions.

Based on the analysis of the recorded instrumentation data, it was shown that the strains within the reinforcing strips did not exceed in the very lowest levels of the MSE wall mass the conventional design values. As a result, there is no need for increasing the density of soil reinforcing strips in the lower levels of reinforcement. The location of the top of the rigid inclusions is an important aspect of the design to prevent the soil reinforcement within the Reinforced Earth being overloaded. If the distance is too small, the stresses in the reinforcing strips may increase due to differential movement around and in between the rigid inclusions. A vertical distance of 0.55 m has proven sufficient.

In some cases, additional reinforcing geosynthetics are used in the LTP where the loading is further spread out and the concentration of stresses is reduced. Geosynthetics have been found to be ineffective in the LTP for steel reinforced RE walls, since steel is relatively inextensible and will engage loading before geosynthetics can be effective.

Studies and build structures have proven that the combination of two techniques: Terre Armée and rigid inclusions, is an economical and efficient solution that has the potential to accelerate construction and limit long term settlement. This solution gives designers, owners and contractors a valuable tool to design Reinforced earth over compressible soils, that can be used next to more conventional methods like soil improvement, preloading, LPTs or using light backfilling materials.

Figure 2

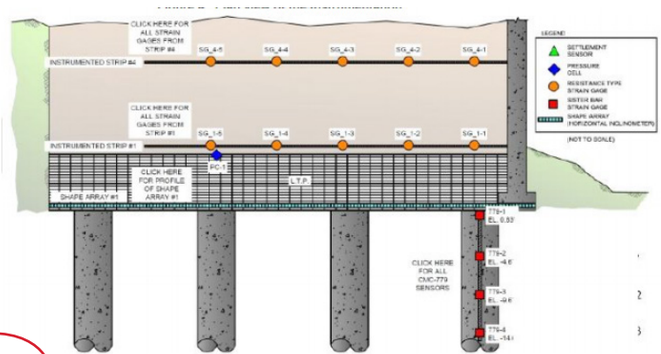

Figure 3