'Intelligent' Reinforcement Geosynthetic For Stabilisation Of Earth Structures And Early Warning System

By: Dr KH Loke

Since the introduction of reinforced soil structures using geosynthetics, their success stories have revolutionised the construction industry for various reasons that resulted in their tremendous growth. Geosynthetic reinforced soil structures are more economically viable, easily and rapidly constructed, provide sound geotechnical engineering solution, flexible for dynamic loading and versatile from architectural viewpoint. Today the reinforced soil system is accepted worldwide with numerous national codes of practice published. However, the development of geosynthetics did not stop there. Monitoring the short and long-term behavior of engineering structures is becoming increasingly important. More so when engineering structures are built to meet the demands of economic growth and in challenging situations such as requirements for higher structures or steeper slopes and construction over soft foundation, as an example. The situation becomes more critical in countries prone to natural disaster such as earthquakes, typhoons, or with heavy rainfall intensity and naturally occurring poor soil conditions.

The use of 'intelligent' reinforcement geosynthetic with monitoring sensors known as 'geodetect' has been adopted in some projects for post construction monitoring of earth structures. The first application of geodetect was for the construction of railway embankment over cavity prone areas for high-speed trains. The geosynthetic was placed at the base of the railway embankment to act as reinforcement in the event a cavity developed below the embankment. Collapsed soil at the base of the embankment was supported by the geosynthetic. The monitoring sensors in the geosynthetic were used to detect the presence and development of cavities. The strains measured by the sensors were

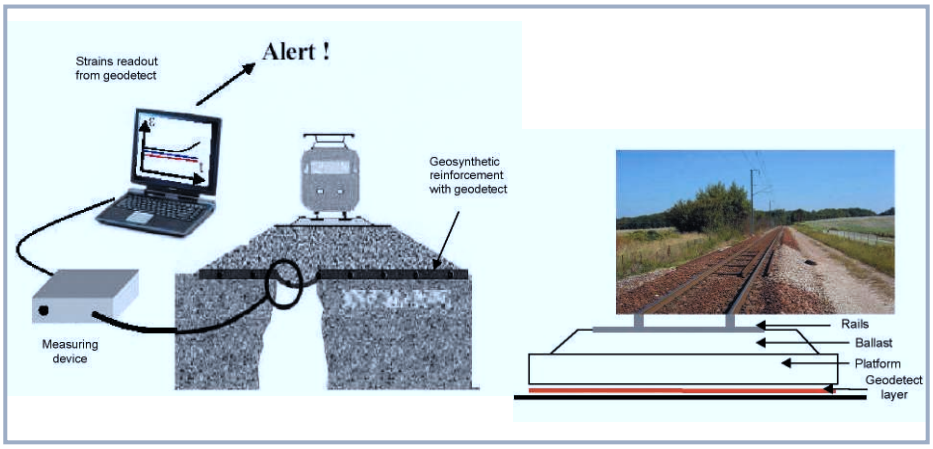

Figure 1: Warning is triggered when strain threshold is reached and train will be stopped

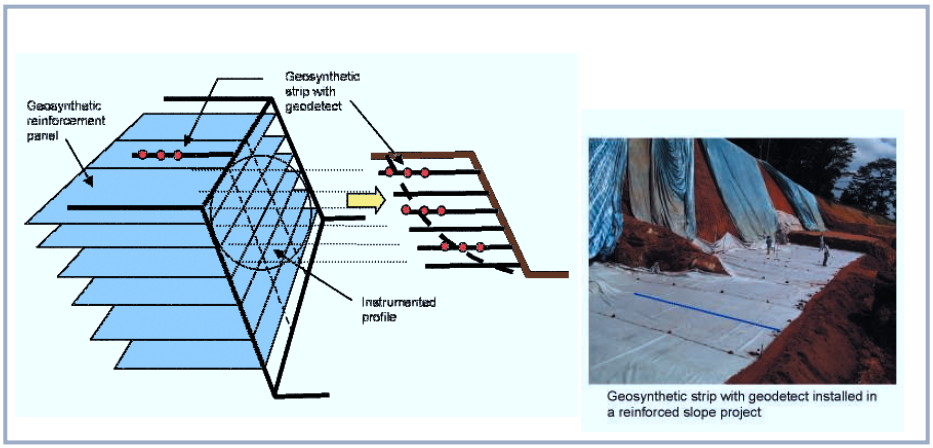

Figure 2: Geodetect application on engineered slope behaviour

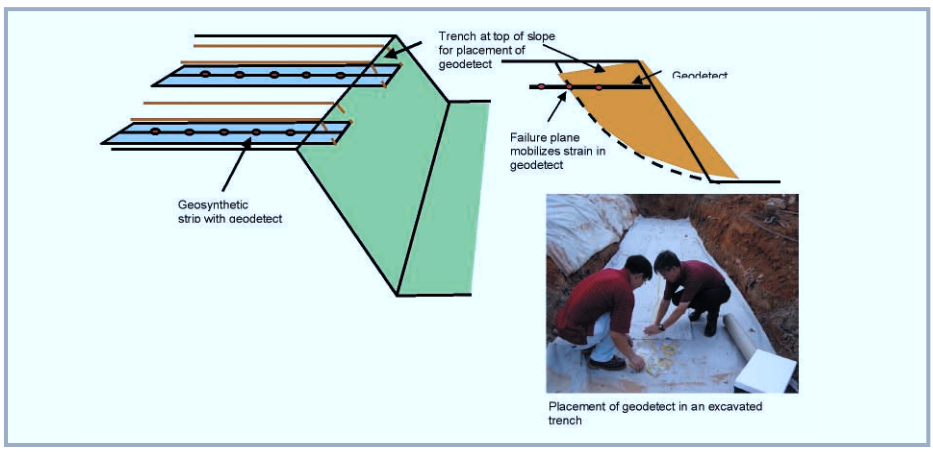

Figure 3: Trench excavation along top of slope to map horizontal profile of slope movement

related mathematically to the size of the cavity that develops with time. Depending on the size of the cavity, an early warning system was implemented by setting a strain limit exerted in the geosynthetic. Once the strain threshold is reached, a warning will be triggered and the train operation will be stopped before significant settlement at the top of the embankment occurred (Figure 1).

The application of geodetect was also employed to monitor the behaviour of engineered slopes as shown in Figure 2. Geosynthetic panels with strain sensors were placed at pre-designed locations to determine the development of strains in the structure. In this application, geodetect provides both reinforcement and strain monitoring system to the structure.

Geodetect was also used to monitor movements of existing slopes in landslide prone areas. In such application, several trenches were excavated along the top of the slope for the placement of geodetects to map the horizontal profile of the slope movement as shown in Figure 3.

Geodetect comprises of nonwoven geotextile incorporated with high strength reinforcing yarns that provides reinforcement to stabilise earth structures. Within the bundle of multifilament reinforcing yarns, optical fibre is inserted as shown in Figure 4. The nonwoven geotextile provides protection against damage of the reinforcing yarns and the optical fibre. The nonwoven geotextile also provides in-plane drainage capability and therefore helps dissipate pore water pressures within the soil.

Using state-of-the-art technology, build-in sensors were incorporated in the optical fibre to detect strains. The optical fibre is connected to a measuring device that measures changes in wavelength versus real time. Any stresses exerted in the geosynthetic will cause a wavelength shift in the sensor that can then be related to a corresponding strain.

Constant monitoring and management of a particular structure can be implemented using telemetry for remote data acquisition and early warning system. Once the change in wavelength or strain limit threshold is reached, a warning system will be activated prior to failure of the structure as illustrated in Figure 5.

The versatility of geodetect as a reinforcement and monitoring geosynthetic provides vast applications in civil engineering structures such as roads and railway embankments constructed on foundation prone to excessive settlements, piled embankments reinforced with geosynthetics, monitoring of soil subsidence, ground sinkholes and cavities, engineered walls and slopes and existing cut slopes and other structures such as underground pipelines and bridges.

In conclusion, geodetect combines the function of geosynthetic reinforcement and monitoring system into one to enable the construction of safer earth structures and management of the structure after construction. This is made possible through the innovative method using state-of-the-art technology of optical sensors. Geodetect is easy to install and robust even as a stand-alone strain measurement geosynthetic. The inclusion of telemetry for remote data acquisition further enhance the application of geodetect in that it provides early warning system on the critical state of the structure to enable preventive maintenance and avoid potential failures. This is of paramount importance to reduce economical lost and possibly save lives. ■

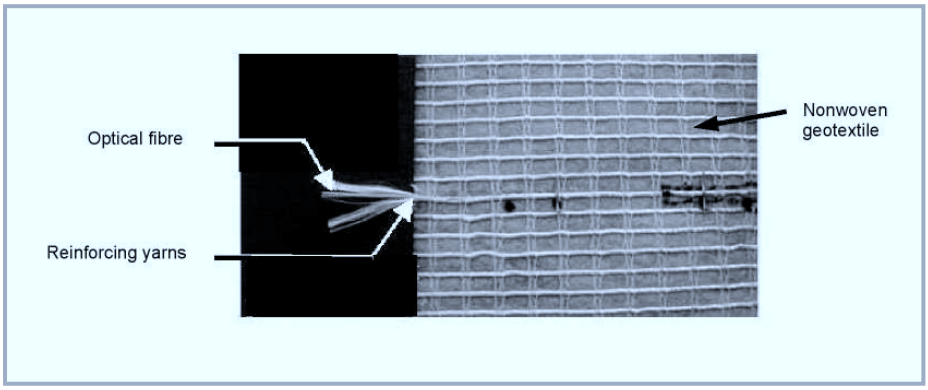

Figure 4: Geodetect with optical fibre inserted

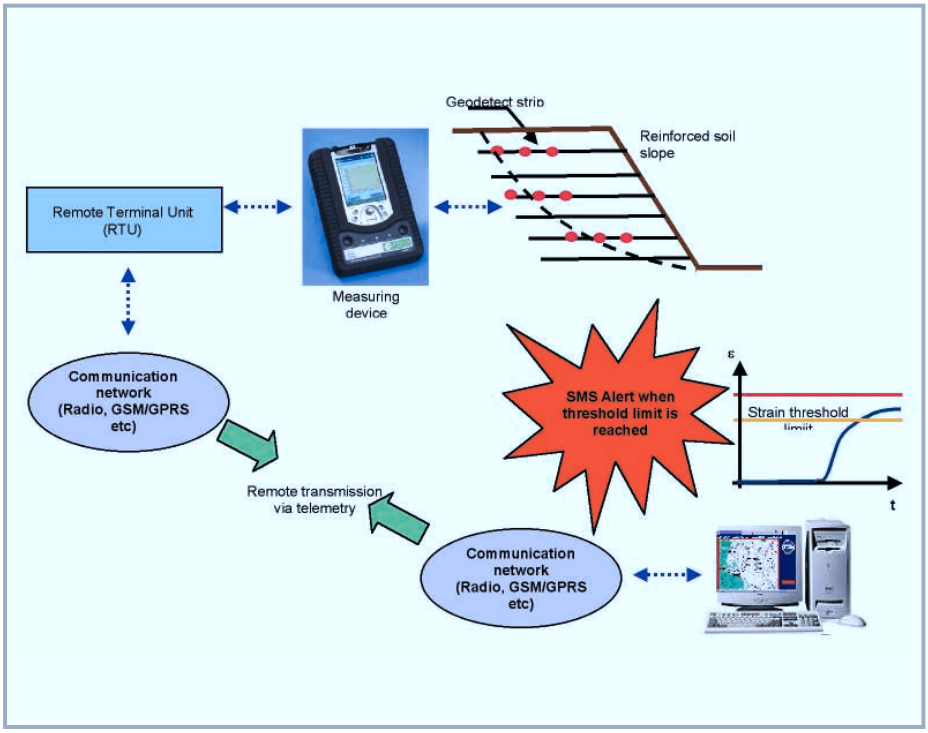

Figure 5: Monitoring on reinforced soil structure via telemetry for remote data acquisition and early warning system.