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On-site follow up of the characteristics of controlled backfill, using the TDR moisture-measurement method

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The electricity sector in Belgium has since many years generalised the use of controlled backfill for underground high-voltage transmission links.

The value adopted as standard in Belgium for the controlled backfill's thermal resistivity is 1 K.m/W for correctly placed materials (specified degree of moisture and specified minimal density).

In the scope of an important project involving supply of traction power to the high-speed trains between Brussels and the German border, Elia (Belgium's Transmission System Operator) has imposed very strict transmission capacity requirements, particularly in degraded situations. The envisaged 150 kV link was initially planned with 3 cables per phase, laid in a horizontal configuration, with cross-bonding, the third cable being installed only to face the situation in which one circuit failed.

However, we felt it would be advisable to envisage a more dynamic approach and investigate, for a system having two cables per phase, what would be the answer to the question: How long will the remaining circuit be able to sustain the total load of the degraded situation if it had been operating in steady regime prior to the incident ?

The calculations showed that, for certain conditions of cable depth and spacing, the solution of installing two cables per phase can ensure sufficient transmission capacity to sustain the loss of one circuit during one week (the average time necessary for repairs). However, in this case the controlled backfill's thermal resistivity value considered should be 0.7 K.m/W (instead of the standard 1 K.m/W).

Although this value is relatively conservative compared to a value of 0.4 K.m/W recorded when the moisture content that is present corresponds to that used during backfilling in order to achieve the highest density of compaction, we felt that in view of the importance of this assumption in the results, it was essential that it should be confirmed by a number of experimental field measurements.

In order to verify the evolution in thermal behaviour of the backfill around the high-voltage cables in service, we called in the department of Agronomy, Economy and Development of the Agricultural University of Gembloux (Belgium).

Tests were organised and performed in a trench that reproduced most realistically the site conditions. With judiciously located sensors, the evolution in the degree of moisture content was measured at various levels of the trench. The TDR (Time Domain Reflectrometry) method was chosen in order to measure the moisture profiles.

This technique measures the propagation time of a signal in a transmission line composed of the sensors inserted into the soil. The longer is the propagation time, the higher is the moisture in the soil. The propagation time, correlated with the length of the sensor, the dielectric constants of the soil and the water, and the type of sensor, is directly converted into a percentage of volumetric moisture.

The paper describes the organisation and implementation conditions of these tests, and discusses the results, which are found extremely encouraging.

The hypothesis of a thermal resistivity of 0.7 Km/W is proven fully acceptable.

Finally, the paper illustrates that the TDR method has proved effective and now provides a simple, original and innovative means of performing moisture content checks in situ.