Enhanced medium voltage cable ratings by improving cable trench design and thermal conditions

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ABSTRACT

Due to increasing power demand in Dubai, DEWA investigated ways to increase the current ratings of their medium voltage grid. One solution is the application of backfill material around the cables. In this contribution, the study conducted to define and specify such backfill material with a value of 1 Km/W at a moisture content of 2% is described. It is shown that local available materials can be used to reach this thermal resistivity value. As a result, the current rating of existing cable circuits can be increased by 9%. The improved thermal behaviour of the cables in backfill material was confirmed in a pilot project.

KEYWORDS

Soil thermal resistivity, backfill, current rating

INTRODUCTION

Due to increasing power demand, Dubai Electricity and Water Authority (DEWA) is experiencing higher loading of their medium voltage (MV) cable network. Expansion of the cable network is restricted mainly due to space limitations in the city of Dubai. Therefore, other means to increase the current rating of the MV cable network are required.

The cable current rating depends on different aspects, such as the cable arrangement in the cable trench and the soil surrounding the cables. In particular, the value of the thermal resistivity of the backfilling material is of utmost importance. At the moment, DEWA is using soft sand as backfilling material, with a thermal resistivity of 1.6 Km/W at a moisture content of 2%. DEWA and DNV GL have investigated possibilities to reduce the value of the soil thermal resistivity to 1.0 Km/W or less by using special backfilling materials. This value should be obtained at a moisture content of 2%. Moreover, the backfilling material should be made from local available materials. If successful, this will result in a significant improvement in medium voltage cable ratings.

This contribution describes the performed soil investigations and the optimized cable trench arrangement and lay-out.

To confirm the backfill material behaviour and efficiency, an existing cable trench was selected as pilot project to partly replace the existing backfilling material by the proposed backfilling material. Temperature measurements have been conducted for over one year in a part of the trench with the original sand and in a part with the backfill material. The thermal influence of the proposed backfilling material was investigated. After one year, soil samples have been taken in both parts of the cable trench. The results from the investigation will be further described and discussed in the following sections.

CHARACTERISATION OF SOIL

The cable environment plays an important role with respect to the current rating of cable systems. To characterise the soil, different properties are used. Several properties are characteristics of the soil itself, other properties characterise the external influences on the thermal behaviour of the soil. The following important characteristics are typically used to describe soils: the thermal resistivity, the dry density, the particle size distribution, the proctor density and the moisture content.

Thermal resistivity

Soil is a mixture of solid soil particles, water and air, see Fig. 1.

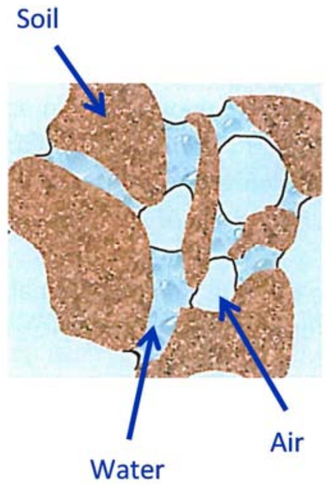

Fig. 1: Typical composition of soil: soil, water and air

There are three major heat transport processes of which heat conduction is the dominating one in soil [1]:

1. Heat conduction: Conduction of heat through soil involves transfer of kinetic energy at molecular level. Molecules in warmer areas vibrate more rapidly, resulting in collisions with, or excitation of, their colder "neighbours". In this way, they lose part of their heat and the heat is transferred to the surroundings. Heat is also conducted by water bridging soil particles. Conduction is considered to be the primary mode of heat transfer in soils and is the basis of the IEC 60287 models.
2. Heat radiation: Heat is emitted by molecules in form of electromagnetic waves. According to the Stefan-Boltzmann law, all materials with temperatures above 0ºK emit energy by electromagnetic waves. Typically radiation occurs between surfaces of particles. Because in compacted backfill material, the surfaces of particles are close to each other and even