A REVIEW ON NEW METHODS FOR INCREASING THE AMPACITY OF UNDERGROUND POWER CABLES: COOL AND PHOTOVOLTAIC PAVEMENTS

Dardan Klimenta¹, Miroljub Jevtić¹, Jelena Klimenta² and Bojan Perović¹

¹Faculty of Technical Sciences, University of Priština in Kosovska Mitrovica, Kosovska Mitrovica, Serbia
²Independent consultant in the field of urban and spatial planning, Niš, Serbia
Cement-based grouting materials utilizing recycled ceramic waste powder, high-reflectance pavements and white pavement coatings represent cool pavements.

Temperatures of conventional asphalt-pavements can be up to 48-71.1 °C in summer.

Cool pavements reduces these temperatures by 10-20 °C.

Numerical simulations have shown that these temperatures can be reduced by much more than 20 °C.

There are conventional and new methods.

The uses of special cable beddings, systems for forced cooling, and systems for irrigation represent conventional methods.

The use of a cool pavement represents a new method.
Introduction – 2/2

Effect of the surface radiation properties on the surface temperature of an asphalt road (the source of these images: https://heatisland.lbl.gov/coolscience/cool-pavements).

- The temperature of the light segment is about 17 °C lower than the temperature of the dark segment.
Conventional methods: (a) special cable beddings, (b) systems for forced cooling, and (c) systems for irrigation.
New methods: (a) cool pavement with uncoated surface, and (b) asphalt- or concrete-pavement with white-coated surface.
Other possible methods: (a) conventional photovoltaic pavement combined with a system for forced cooling, (b) solar-pavement and soil-regenerator hybrid energy system, abbreviated as SPSRHES, and (c) conventional photovoltaic pavement or SPSRHES combined with a ventilation channel.
General design of conventional photovoltaic pavements.
Advantages of new methods:

- For the same price of the cables and all the associated equipment, an increase of up to 26.7% in the cable ampacity compared to the corresponding base case can be provided.

- These methods do not have to be too expensive, they can be easily implemented within current practice and they would result in significant economic benefits.

- Any cost for periodic cleaning, maintenance or resurfacing will be quickly paid back by these methods.

- Application of these methods would lead to the elimination of all possible hot spots caused by unfavorable conditions in the soil along a cable line route.

- The cool pavements above the cables can contribute to mitigation of the Urban Heat Island effect.
Disadvantages of new methods:

- These methods will definitely increase the costs of construction and maintenance, i.e. the initial costs. Such methods will require periodic maintenance and cleaning to preserve the pavement surface radiation properties. Compared with the dimensionally-optimized cable bedding, the methods require up to 2.5 times higher volume of the bedding material, and up to 2.5 times higher volume of the native soil must be transported to other places.

- The cool pavements do not produce electricity.

- The life span of cool pavements with white-coated surfaces is the same as the life span of conventional asphalt-pavements.
Advantages of other possible methods:

- These methods can significantly increase the cable ampacity.
- The photovoltaic pavements above the cables can contribute to almost 0.8 °C decrease of the ambient temperature compared to the conventional asphalt-pavements, which could mitigate the effect of Urban Heat Island.
- Electricity produced by a photovoltaic pavement can be capable to cover a part of the energy demand.
- The life span of photovoltaic pavements is 2.5-4.3 times greater than the life span of conventional asphalt-pavements.
- The photovoltaic pavements are modular, so repairs will be much easier and quicker.
- The elimination of all possible hot spots in the soil along a cable line route.
Disadvantages of other possible methods:

- The construction cost of a photovoltaic pavement above the cables is about three times higher than the construction cost of any conventional asphalt-pavement.

- Each method would require proper and regular maintenance services, and therefore also maintenance costs.

- By placing the PV cells between the transparent (a polycarbonate sheet or porous rubber) and isolating (porous rubber) layers, the conventional photovoltaic pavements showed up to 50% reduction in power conversion efficiency.
Selection between the different methods

Factors that should be taken into account in order to select the appropriate method for increasing the ampacity of an underground cable line are as follows.

- The condition of the existing assets;
- The characteristic of the rating constraint;
- The budgetary constraints;
- The time constraints; and
- The transient availability of an underground cable line during outages.
Conclusions

- Different methods for increasing the cable ampacity are presented.
- The construction of new cable lines or reconstruction of existing cable lines using the cool and photovoltaic pavements is described.
- The applications of systems for forced cooling, hybrid energy systems and ventilation channels in combination with the photovoltaic pavements is considered.
- The advantages and disadvantages of the new and other possible methods are listed.
- All the methods are based on the radiation properties of the pavement surface above the cables.
- The factors that determine the selection of the appropriate method are identified and discussed.
- Many different factors must be taken into account in the selection of the appropriate method, and the optimal solution varies from project to project.
THANKS FOR YOUR ATTENTION

THE END