IMPROVING THE AUTONOMOUS LIGHTING SYSTEM AND EQUIPPING PEDESTRIAN CROSSINGS

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Abstract. *The aim of this study is to improve the developed autonomous energy-efficient lighting system for a pedestrian crossing. The implementation of new elements and solutions based on the latest research and materials has been justified. Increasing efficiency and functional capabilities is relevant for the energy crisis situation in Ukraine. The methodology of this work involves the use of a new ecological material to increase the wear resistance of the light-emitting coating. The modernization of the solar panel design to improve energy supply efficiency. The introduction of a structural element - a charging module - to expand the functionality of the lighting system. Due to significant damage to Ukraine's energy infrastructure, pedestrians have found themselves in a high-risk accident zone, and the proposed modernization is largely aimed at creating safe conditions for them. The creation of a three-component mixture for the road surface and painting will allow obtaining durable and reliable road marking. The mixture consists of paint, luminescent material, and "basalt scaly." The 3D model of this lighting system has been improved with changes in the design of solar panels and the addition of charging elements. The conclusion justifies the expediency of the changes made.*

Key words: *luminophore, basalt fiber, solar panels, charging elements, road marking, environmental design.*

1. INTRODUCTION

The rapid development in the field of researching new materials and technologies has made it possible to comprehensively improve existing components and introduce new ones into previously created street lighting projects. Since the situation in Ukraine remains quite crisis-ridden, there is a need to create autonomous lighting systems with high energy efficiency. An analysis of the situation has demonstrated the need to adapt the existing complex by expanding its functionality, which will ensure greater stability in the country's energy sector.

Previously, an autonomous pedestrian crossing lighting system was developed that used components such as solar panels, ultraviolet light sources, and luminescent coatings [1]. Due to the development of the proposed technologies, there is a need to improve this project. Changes are proposed to be made to the structural components, which will ensure greater efficiency and durability and make the system more innovative.

2. EXPERIMENTAL OR METHODOLOGICAL PART

Earlier it was suggested to add only a luminescent component to the lacquer-paint coating for pedestrian crossings. In Ukraine, luminescent materials, as an innovative additive, have been widely used on pedestrian crossings for several years to improve road safety and reduce accident rates. Today, luminescent materials are used to mark

pedestrian crossings in many cities of Ukraine, including Kyiv, Odesa, Kharkiv, Lviv, and others.

Luminescent materials have the property of glowing in the dark, which makes them more noticeable in conditions of poor visibility. Additionally, luminescent materials are environmentally friendly since they do not contain lead or other harmful materials. To select the optimal luminescent material, it is important to consider the local operating conditions, such as climate and traffic intensity [2].

Pedestrian crossings are an essential part of urban infrastructure that ensures pedestrian safety on roads. The use of luminescent paint with basalt components is one of the methods to increase safety at pedestrian crossings.

The natural substance known as basalt additive is obtained from basalt rock. Modern composites with the addition of basalt fiber are often used to reinforce road surfaces. This provides long-term road operation without additional reconstruction due to the strength and resistance of such materials to mechanical and chemical damage. An analysis has shown that basalt fibers have the best cost-to-quality ratio among other inorganic fibers [3]. Any form of road surface, including concrete and asphalt, can be colored using luminescent paint based on basalt to create bright and visible road markings.

As a significant percentage of waste is generated during the production of basalt thread, there is a need to consider the rational use of these waste materials. Grinding produces "basalt flakes" that can be used as an additive for other materials.

Luminescent paint based on basalt is applied using specialized tools to create pedestrian crossing markings. To ensure optimal adhesion, the surface must be thoroughly cleaned and prepared before applying the paint.

The application of basalt-based paint on pedestrian crossings is effective due to its numerous advantages. It has light-reflective properties that enhance the visibility of road markings at night and in poor lighting conditions. Traditional road marking paints are less durable than basalt-based paint due to its high resistance to abrasion and ultraviolet radiation.

The advantages of using basalt-based luminescent coatings for pedestrian crossings are their high effectiveness in low visibility conditions, which is particularly important at night, during rain, or in fog. The light-reflective properties of basalt-based paint enhance the visibility of road markings for drivers, reducing the likelihood of accidents involving pedestrians at pedestrian crossings.

The basalt component in luminescent coatings for pedestrian crossings has the following advantages:

- Durability: the use of basalt prolongs the service life of pedestrian crossings, reducing maintenance and repair costs.
- Eco-friendliness: the basalt additive is safe for the environment as it is made of natural materials and does not contain toxic chemicals.
- Resistance to environmental influences: the basalt additive is not susceptible to corrosion, does not deteriorate under ultraviolet radiation, and does not change its characteristics at high temperatures [4].

The rational use of basalt additive in pedestrian crossings luminophore lighting is explained by its functional properties, which include:

- Improved illumination of the crossing.
- Slip resistance: The basalt additive enhances the adhesion between the

surface and pedestrians' footwear, reducing the likelihood of falls and accidents.

- Reduced noise level: Basalt additive can reduce road noise from passing vehicles, making the area more comfortable for local residents and pedestrians.

Environmental resistance: Basalt component has a high level of resistance to environmental influences, allowing it to maintain its qualities over an extended period.

Manufacturers offer ready-to-use luminophore paints based on basalt. Typically, such paint consists of a basalt component, an acrylate or epoxy resin-based lacquer, and luminophore (phosphorescent pigment).

In general, adding a basalt component to the surface of luminophore pedestrian crossings is an innovative and effective way to enhance road safety. It can be used on various types of roads or pedestrian zones and has several advantages over other types of surfaces. Although luminophore surfaces with a basalt element have not yet been encountered in Ukraine, it is quite likely that they will begin to appear soon due to initiatives aimed at enhancing road safety.

Thus, there are numerous opportunities for the dissemination and utilization of basalt additives in the luminophore coating of pedestrian crossings in different cities and countries. In the previous design of solar panels, the focus was on the ergonomics and aesthetics of the placement. However, such placement of solar panels, oriented in all four directions, led to uneven load distribution on each panel and insufficient efficiency of their individual parts.

In the proposed new placement variant, greater efficiency has been achieved through optimal load distribution among all panels. The number of panels has been reduced to three, as depicted in Fig. 1.

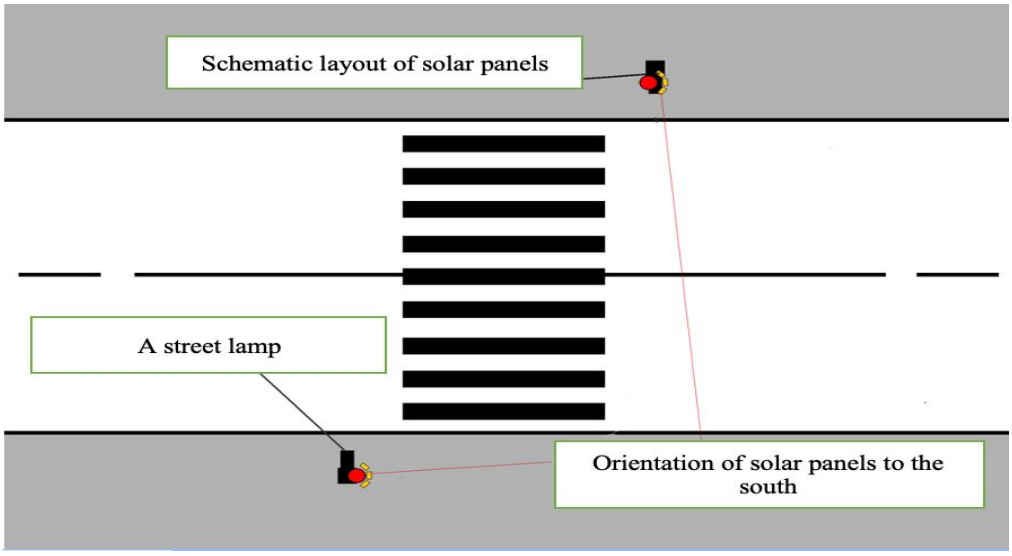

Figure 1: Schematic image of the system (top view)

Based on research on determining the optimal angle for the placement of solar panels [5], the battery system design has been upgraded. Factors such as atmospheric

phenomena, air temperature, solar energy generation potential, the need for solar panel cleaning, and geographic location were taken into account. The optimal angle for installing solar panels in Ukraine, which has an average latitude, was found to be between 30 and 45 degrees from the horizon. For Kyiv specifically, the optimal angle was found to be 40 degrees [6].

However, in order to achieve optimal efficiency and productivity, solar panels on lampposts should be positioned at an angle according to the trajectory of the sun, with an orientation towards the south.

In addition to lighting, additional opportunities have been proposed for the more functional use of the generated energy. Since the previously selected ultraviolet sources are low-powered, all the energy may not be spent only on lighting, and its remains will be redistributed to the function of charging external devices. Power modules, also known as charging stations, are devices that allow various gadgets, such as smartphones, tablets, laptops, and other electronic devices, to be charged. They are currently widely installed in public places, such as parks, squares, shopping centers, airports, train stations, and other places where people often gather.

Additionally, charging modules can be connected to street lighting systems, enabling them to use energy generated by the structure. This method of powering charging stations is efficient and environmentally friendly, reducing electricity costs.

To improve pedestrian crossing lighting systems, it is proposed to use power modules to charge devices through built-in USB ports. This system consists of the following components:

1) Solar panels are semiconductor-based plates that efficiently capture solar energy due to their strategic placement.
2) Battery - a device that stores electrical energy generated by solar panels during the day. Batteries are usually used to provide electricity at night or during periods of insufficient solar activity.
3) Charge controller, which regulates the flow of electrons from solar panels to the battery. The charge controller prevents overcharging of the battery and ensures its maximum operating life.
4) Inverter - a device that converts direct current from the battery to alternating current, which can be used to charge devices.

When the sun shines, solar panels collect solar energy and convert it into electrical energy, which is stored in a battery with the help of a charge controller. So, when the user connects their device to the system, the inverter converts the stored energy from the battery to alternating current [7].

The proposed solution for using power modules is a relevant and useful step towards stabilizing the energy situation in Ukraine or during unforeseen situations.

3. RESULTS

Due to changes in the design elements of the system, its 3D model has been improved. The visualization was carried out using modern software, namely the Blender program. During the modernization of the project, the energy and functional components were significantly improved, and the design change did not worsen the aesthetic appearance of the complex.

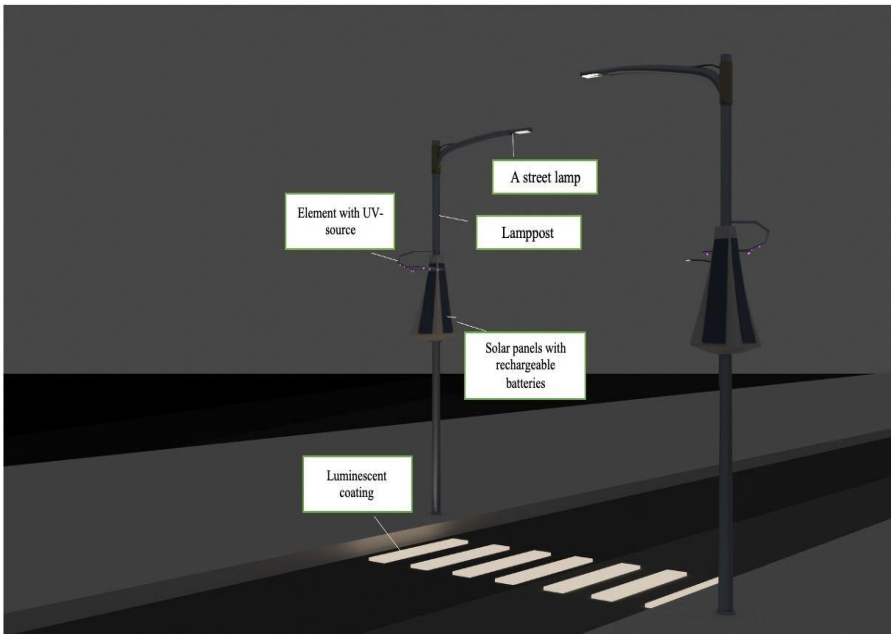

Figure 2: General view of the pedestrian crossing lighting system

4. DISCUSSION

This design is quite advanced, but there is room for further development. This is because the optimal tilt angle for different regions of Ukraine may vary, and the panel structure can be made movable, but this may compromise the strength of the structure, as moving parts have less wear resistance.

5. CONCLUSIONS

An autonomous lighting system for pedestrian crossings is an effective solution for use in Ukraine. Its advantages are primarily due to its energy independence, as the system does not require connection to the general power grid thanks to the use of solar panels. Such a solution is particularly important in conditions of unstable energy supply.

Rational use of excess electricity by connecting additional elements in the form of power modules for charging gadgets will be an economically advantageous solution. The issue of environmental preservation will be addressed not only by using environmentally friendly sources of energy but also by adding absolutely safe "basalt flakes" to road marking paint.

The autonomous system is also characterized by durability as it is composed of robust elements such as solar panels and road surfacing. This system creates a safe environment for all road users, not only through general high-quality lighting but also through light-emitting luminescent elements.

The proposed innovative solutions of the system provide universality and attractiveness for a wide range of society.

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