TECHNICAL SCIENCES

OPERATIONAL CHARACTERISTICS OF ROAD MARKING PAINTS BASED ON LOCAL RAW MATERIALS: CURRENT STATUS, CHALLENGES, AND TRENDS

Khakimov R.
Cand. Sc., professor
of the Tashkent State Transport University
Republic of Uzbekistan, Tashkent
Ayrapetov D.
Assistant of Tashkent State Transport University,
Republic of Uzbekistan, Tashkent
Omonkulov T.
of Tashkent State Transport University,
Republic of Uzbekistan, Tashkent
https://doi.org/10.5281/zenodo.14169146

Abstract

The purpose of this work is to study existing paint and coating materials (PCM) for road markings, as well as to develop and produce high-performance coatings based on local raw materials to improve the quality, durability, and environmental safety of road markings. In laboratory conditions, PCM samples were created for road marking applications, and laboratory and field tests were conducted to evaluate key quality indicators of the coating, such as adhesion, color, and wear resistance. Observations over a two-month period showed that alkyd-based PCM retains its properties during the observed period, making it suitable for recommendation as a road marking coating.

Keywords: road marking, marking materials, composition, coatings, polymer, enamel, properties, tests, composition, adhesion, abrasion resistance, drying time, polymer, enamel, paints and varnishes.

In recent years, the flow of road traffic in the Republic of Uzbekistan has significantly increased. As a result, organizing traffic flow plays a crucial role in ensuring road safety. The use of technical means for traffic management allows for enhancing traffic speed, road capacity, and safety in a short time and with minimal costs, while also reducing the number of traffic accidents by more than 20% [1].

The application of horizontal road markings, such as dividing lines between opposing traffic flows and lanes for organizing vehicle positioning, as well as highlighting pedestrian crossings and specialized zones, effectively structures the movement of both vehicles and pedestrians, significantly improving overall safety [2].

Today, road markings have become an essential and familiar element of roadways, coordinating and organizing traffic flows while ensuring the safety of vehicles, freight, and pedestrian routes.

The materials used for road markings are subject to high standards. They must possess durability, excellent adhesion, resistance to weather conditions, including low temperatures, resistance to fuels and lubricants, as well as lightfastness and good visibility at any time of day and in all weather conditions. An important criterion is also ensuring reliable traction with vehicle tires. In addition, special attention is given to the environmental safety of the paint materials.

The development and production of such paints and coatings for road markings are actively being researched by many scientists [3-9].

The selection of materials, products, and designs for road markings is determined by a variety of factors, including the following key aspects: — type and condition of the road surface; — traffic flow intensity; — type and placement of the horizontal markings; — availability of technical equipment; — climatic and weather conditions; — budgetary constraints [1].

Many countries are actively developing new, more effective technologies for applying road markings [10].

A variety of materials are used for road markings, including special paints, spray plastics, thermoplastics, cold plastics, thermoplastic tapes, and in some cases, porcelain chips, ceramic and clinker paving stones, elements made of white polymer or cement concrete, marking blocks, colored asphalt concrete, and others. The largest share of materials used consists of thermoplastics and paints.

Paints and coatings for road markings vary in chemical composition, application technology, and service life. The chemical composition directly affects the application technique and the durability of the markings. Typically, these coatings contain between 4 to 6 components, including pigments, fillers, polymers, plasticizers, special additives, and solvents.

Each component serves its specific function, but the polymer binder plays a key role in determining the stability and strength of the structure. Modern plastics and paints for road markings are highly filled systems. According to European standards, the "dry residue" content should be at least 75% for paints and at least 97% for plastics. The temperature of the air and the road surface during application should be between 5 to 35°C.

The effectiveness of road markings is determined by their excellent visibility at any time of the day and in any weather conditions, regardless of the season, as well as reliable traction with vehicle tires. The condition of the markings throughout their service life must meet high standards, with international norms requiring

the durability of the coating to be at least one year. Additionally, an important requirement for paints and coatings is their environmental safety [11-12].

Currently, composite polymers such as polyepoxides, polyacrylates, polyvinyl chlorides, and others are actively used for road markings, with reinforcing components added to improve strength. To achieve this, solid particles (ceramic, porcelain, diamond chips) or thin, durable fibers, as well as various additives and special compounds, are used [13,14].

The main directions in the development of road marking materials include:

• Increasing the use of materials with high durability, such as thermoplastics and cold plastics;

• Developing new methods to improve the functional stability of markings through the use of modern technologies and composite materials;

• Creating paints and coatings that are suitable for conditions where conventional materials and methods are less applicable;

• Enhancing the environmental safety of materials used for road markings.

Based on international standards (EN 1436, B 2440) and scientific research, specialists from Tashkent State Transport University and LLC TNIIT "Chemical Technology" have developed a domestic road marking paint that is comparable in quality to foreign analogs.

During laboratory research, coating materials were developed based on various film-forming substances such as AK-101 (polyacrylates), alkyd varnish FX-042 with reduced cottonseed oil content, and a cellulose nitrate (NC) varnish modified with "lean" alkyd. The main components of these materials were local resources, including products from JSC "NavoiAzot", cottonseed oil, and petroleum solvents produced at the Fergana and Bukhara refineries. The total share of local raw materials in the components of the coating materials amounted to 76.5%.

Table 1.

Quality Indicators of Coating Materials.

Designation of quality indicators	**Paint based on organo-soluble acrylic.**	**Nitrocellulose-based paint.**	**Alkyd-based paint (enamel).**	**GOST R 51256-2018 — "Road Marking Paints. General Specifications."**
Appearance of the coating	According to the control sample			
Color of the paint coating	White, shade not standardized			
Mass fraction of non-volatile substances, %, not less than	57	40	55	70
Conditional viscosity according to the viscosimeter BZ-246 with a nozzle diameter of 4 mm at a temperature of (20.0 ± 0.5) °C, sek	60 - 80	60 - 80	60 - 80	40-120
Degree of grinding, μm, not more than	60	50	60	50-60
Drying time to degree 3 at a temperature of (20 ± 2) °C and relative humidity of (65 ± 5)%, minutes, not more than	30	20	30	30
Adhesion of the coating, points, not more than	1	1	1	1-2
Resistance of the coating to static exposure, not less than: a) water at a temperature of (20 ± 2) °C b) 3% aqueous solution of sodium chloride at a temperature of (0 ± 2) °C.	72 72	72 72	72 72	48 48

Road paint is used for road markings. The enamel should be applied to a dry, clean surface free from oils and grease. If necessary, the paint can be diluted with solvent P-646, and the dilution ratio depends on the initial viscosity, ranging from 6 to 12%. Application is carried out using specialized road service equipment or

manually with a spray gun, brush, or roller. The air temperature should range from +5 to +35°C, and the relative humidity should not exceed 85%. At a temperature of 18-22°C, the paint dries within 20 minutes, but at temperatures below 15°C, the drying time increases. The paint consumption is between 200 and 300 g/m² for a coating thickness of 100 to 200 μm, although actual consumption depends on the type of equipment and the skill of the workers.

As shown in Table 1, the quality characteristics of the examined paints are almost identical. The drying time was 20-30 minutes, the film thickness was 250 μm, and the ambient temperature was 20-22ºC. The width of the stripes was 33 cm, and the length was 108 cm.

In conclusion, it should be noted that within the framework of this work, existing paints and coatings (PCM) used for road markings were studied and analyzed. An overview of current trends in this field was conducted, aimed at improving road surface quality, extending their service life, and enhancing environmental safety. In laboratory conditions, samples of PCM based on acrylic, nitrocellulose, and alkyd were developed for use as road markings. The level of imported components in the paints was significantly reduced to 23.5%.

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