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INFLUENCE OF SUBGRADE SOIL CHARACTERISTICS ON PAVEMENT DURABILITY AND STRUCTURAL PERFORMANCE

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Problem statement. Ukraine's diverse geological conditions, particularly its widespread loess soils and soft water-saturated clays, pose significant challenges to pavement durability. This article examines how these soil types influence subgrade stability and pavement performance. Loess, known for its collapsible structure under moisture, and water-saturated clays, characterized by low shear strength, contribute to differential settlement, cracking, and premature pavement failure. Through case studies and geotechnical analyses, this study highlights the necessity of tailored engineering solutions − such as soil stabilization, enhanced drainage, and adaptive pavement design − to mitigate these risks in Ukraine's infrastructure projects [1].

Introduction. Ukraine's terrain features extensive deposits of loess and water-saturated clays, particularly in regions like the Dnipro upland, Black Sea lowland, and river valleys. These soils, while fertile for agriculture, present unique engineering challenges for transportation infrastructure. Loess soils, comprising porous silts, undergo sudden settlement when saturated, while water-saturated clays exhibit reduced bearing capacity under load. This article explores how these geological conditions impact pavement durability and proposes mitigation strategies aligned with Ukraine's climatic and hydrological context [2].

Purpose of research. Increasing the stability of subgrade bases of highways in difficult engineering and geological conditions of Ukraine and ensuring the reliability of the road pavement.

Research results. Impact on Pavement Performance.

1. Mechanisms of Failure:

- Loess collapse: rapid settlement due to irrigation or heavy rainfall creates potholes and longitudinal cracks.
- Clay softening: reduced subgrade modulus in water-saturated clays accelerates rutting and fatigue cracking.
- Seasonal effects: spring thaw and autumn rains amplify moisture ingress, destabilizing subgrades.

2. Case study: Kharkiv-Odessa Highway.

- Issue: A 50 km section on loess subgrade experienced 12 cm differential settlement after three wet seasons.
- Remediation: lime stabilization and French drains reduced settlement by 70 %, extending service life by 8 years.

3. Pavement Condition Index (PCI) correlation.

- Data: pavements on loess/clay subgrades in Kherson oblast showed PCI scores 30–50 % lower than those on granular soils.
- Key factors: moisture content exceeding optimum levels (OMC) by 10–15 % directly correlated with severe cracking.

4. Mitigation strategies. Soil stabilization.

- Loess: cement/lime treatment (5–8 % by weight) enhances cohesion and reduces collapse potential [2].
- Clays: geosynthetic reinforcement (e. g., geogrids) improves load distribution and limits settlements [1].

5. Drainage systems:

- Subsurface drains: intercept groundwater in clay-rich areas.
- Impermeable barriers: HDPE liners prevent moisture infiltration into loess subgrades.

6. Adaptive pavement design:

- Thicker base layers: 30–50 cm crushed stone base compensates for subgrade variability.
- Flexible pavements: asphalt mixes with polymer modifiers [3; 4] withstand differential movement better than rigid concrete.

7. Recommendations for Ukraine:

- Pre-construction surveys: mandatory geotechnical investigations to classify soil collapse and swell potential.
- Climate-resilient standards: update Ukrainian building codes to address region-specific soil challenges.
- Monitoring systems: embed soil moisture sensors in high-risk areas for real-time subgrade assessment.

Conclusion. Ukraine’s loess and water-saturated clays demand proactive engineering to ensure pavement longevity. Integrating soil stabilization, advanced drainage, and adaptive designs can mitigate subgrade-related distress, aligning with global best practices for infrastructure resilience. Future research should focus on cost-effective, sustainable solutions tailored to Ukraine’s evolving climatic conditions.

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