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A REVIVE OF HIGH-PERFORMANCE HYDRAULIC ROAD BINDERS BASED ON DOROSOL, LIME AND POLYMER ADDITIVES

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Abstract. Hybrid binders are an important scientific and technological direction in the cement industry for reducing carbon emissions and improving material performance. Hydraulic road binders are widely used in road construction and in the stabilization of difficult soils. Thanks to Dorosol's composition and optimal particle size distribution (d90 < 45 μm), it increases the load-bearing capacity of the soil base by 2–3 times and improves water resistance by 5–6 times. Dorosol's global warming potential is 0.333 kg CO_2e/kg, which is approximately 64% lower than that of conventional cement (≈0.93 kg CO_2e/kg). Polymer additives modify the properties of cement systems through mechanisms such as film formation, increased adhesion, reduced water absorption, and improved flexibility (elasticity).

Polymer additives modify the properties of cementitious systems through mechanisms such as film formation, improved adhesion, reduced water absorption, and enhanced flexibility. It has been demonstrated that polymer particles form continuous films 0.5–2 μm thick during cement hydration, and that these films bridge microcracks, raising the flexural strength by 25–40 %. Evidence also shows that chemical bonds develop between Ca^{2+} ions and the carboxyl groups of the polymer, increasing adhesive strength by a factor of 2–3.

Lime ($Ca(OH)_2$) raises the pH of clay soils to 12.4, under which conditions alumina and silicate phases dissolve to form additional binding phases such as C-S-H and C-A-H. Scanning electron microscopy (SEM) studies of lime-stabilised soils have revealed a 30–40 % reduction in pore volume after 90 days, accompanied by a 2–2.5-fold increase in strength.

Keywords: Hybrid binders, polymer-modified cement, lime, synergistic effect, hydraulic road binder

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1. Introduction

1.1. Concept and importance of hybrid binders

The construction industry currently faces two major challenges: the growing demand for high-performance materials and the need to reduce the environmental burden of traditional binders

[1–3]. Andrew [1] calculated that cement production accounts for 7–8 % of global CO_2 emissions, and that this proportion rises by about 2–3 % annually. It has been emphasised that roughly 12 billion tons of concrete are produced each year, corresponding to an average of 2 tons per person [2].

Significant progress has been made over the past two decades in developing low-carbon cements [4–6]. Shi et al. proposed a classification of alternative cements for the 21st century, noting the promise of hybrid systems with a clinker content of 30–50 % [4]. Scrivener and co-workers analysed the potential of eco-efficient cements and showed that such materials could lower CO_2 emissions by 30–40 % [5]. Juenger et al. provided a comprehensive review of alternative binder materials (geopolymers, calcium-sulphate-based binders, hybrid systems), comparing the advantages and limitations of each class [6].

Lothenbach et al. investigated the hydration mechanisms of supplementary cementitious materials (burnt shale, fly ash, slag) and found that they allow clinker content to be reduced by up to 50 %, albeit with some decrease in early-age strength [7]. Snellings et al. analysed the relationship between the mineralogical composition and reactivity of such materials, reporting that pozzolanic activity is higher when the glass phase exceeds 60 % [8].

Saptomoa, examined industrially attractive approaches to "low-CO_2" cements and calculated that partial substitution of clinker is economically more efficient, potentially reducing CO_2 emissions per ton of cement from 0.93 kg to 0.50–0.60 kg [9]. Damtoft et al. reviewed sustainable development and climate-change initiatives in the cement industry, emphasising that the goal of a 50 % reduction in CO_2 emissions by 2050 can only be reached through widespread adoption of hybrid and alternative binders [10].

1.2. Composition and properties of Dorosol

Doroport is a hydraulic road binder (HRB) manufactured by Holcim in accordance with EN 13282-1 [11]. In Azerbaijan, the national standard AZS 830-5-2-15 (EN 13282-1-2013) has been approved for Dorosol produced by Holcim (Azerbaijan) JSC, and a conformity certificate has been issued [2].

According to the technical documentation of Holcim Süddeutschland [11,12], the composition of Doroport is as follows:

- Portland cement clinker: 40–50 % – primary hydraulic active component
- Burnt shale (*gebrannter Schiefer*): 25–35 % – pozzolanic active component
- Limestone powder (*Kalksteinmehl*): 20–30 % – inert filler and crystallisation centre
- Mineral additives: <5 % – for composition optimisation

A key feature of Doroport is its optimised particle size distribution (d_{90} < 45 μm), which provides maximum packing density (2.80–2.85 g/cm^3) and controlled hydration kinetics [11]. The authors provide an overview of methods for determining field variables and transport and storage parameters, and demonstrate the practical application of computational modelling of transport processes in the design of concrete structures [12]. The Environmental Product Declaration (EPD) issued by Holcim Romania [13] reports the following environmental indicators for Doroport:

- Global Warming Potential (GWP): 0.333 kg CO_2e/kg
- Ozone Depletion Potential (ODP): 1.57×10^{-9} kg CFC-11e/kg
- Acidification Potential (AP): 0.00164 kg SO_2 e/kg
- Photochemical Ozone Creation Potential (POCP): 0.000191 kg ethylene e/kg

These figures make Doroport about 64 % more environmentally friendly than ordinary Portland cement (GWP ≈0.93 kg CO_2 e/kg).

The main goal of soil stabilization is to transform on-site materials into strong sub-base and base layers. Although classic methods (mixing with cement or lime) are widely used, they do not provide hydrophobic properties to the stabilized layer – leading to road failure due to water penetration and frost action. Dorosol© is a hydraulic binder combining both cement and lime, improving clayey soils and offering high water protection. The paper presents the improvement of physical and mechanical parameters of silty clay from Cluj-Napoca stabilized with Dorosol© C30 and C50 (2.5–4.5%) [14].

1.3. Role of polymer additives in construction materials

Polymer additives have acquired an important role in the development of high-performance construction materials in recent years. The findings offer significant insights into the structure–property relationships of polymer-modified cement-based materials in relation to temperature [15,16]. Due to the rapid advancement in polymer-cement composite technology and extensive research into the relationship between material structure and properties, the use of these composites has significantly increased. Moreover, polymers, as long-chain molecules, can greatly enhance the physical and chemical properties of soil, including strength, stability, and water retention capacity. [16].

Film-formation mechanism: Knapen and Van Gemert studied the influence of polymer latex on cement hydration and showed that polymer particles (0.1–5 μm) aggregate on the walls of cement pores as water is consumed, forming continuous films 0.5–2 μm thick [17]. Li and others noted that polymer-conductive cement composites were prepared by incorporating four polymers—silicon-acrylate (SG), phenylacrylic (SR), waterborne epoxy resin (SH), and acrylic (SX)—together with carbon fiber (CF) and carbon black (CB) into cement-based materials. The study showed that SH improved the fluidity of cement paste, all four polymers delayed hardening, SH and SR increased the flexural-to-compressive strength ratio (F/C), reaching a maximum at P/C = 0.15, while SH, SR, and SG reduced electrical resistivity (improvement order: SH > SR > SG, with the lowest resistivity for

SH and SR at P/C = 0.15); furthermore, all polymers significantly reduced water absorption (effectiveness order: SH > SR > SG > SX), with the minimum absorption again observed for SH and SR at P/C = 0.15 [18].

Improved adhesion: Jenni et al. demonstrated that polymer modification strengthens the bond between binder and aggregate, raising the tensile adhesion strength 2–3 times compared to unmodified systems [19]. Marcin Kulesza and others noted that mortars containing quartz sand, Portland cement CEM I 42.5 R, and methyl hydroxyethyl cellulose, to which two types of redispersible polymer powders (styrene-acrylic copolymer SA and vinyl acetate-ethylene copolymer ET) were added in an amount of 0–5% of the total weight, had different chemical structures, while the water content was kept constant at 20% of the total weight of the mortar [20].

Reduced water absorption: Polymer modification reduces the capillary water absorption coefficient of cementitious systems from 0.15–0.20 $kg/m^2 \cdot min^{0,5}$ to 0.05–0.08 $kg/m^2 \cdot min^{0,5}$ (≈2.5–3-fold). This is attributed to the hydrophobic nature of the polymers and the formation of films on pore walls. Yang Q noted that when acrylic acid is used as a modifying polymer at a dosage of 7.5%, the flowability and gelation time of the dual-liquid slurry are excellent, the compressive strength of the stone body decreases slightly, the flexural strength is improved to a certain extent, and the crack resistance of the stone body during water loss is also enhanced [21].

Enhanced flexibility: Betioli et al. showed that EVA polymer reduces the elastic modulus of cement paste by 15–20 % while increasing the flexural deformation capacity by 30–50 %, significantly improving crack resistance [22].

Pourchez and others [23], studying the influence of polymer on cement hydration, investigated the effect of styrene-butadiene rubber (SBR) latex on cement hydrates ($Ca(OH)_2$, ettringite, C_4AH_{13}, and C–S–H gel) and the degree of cement hydration using various measurement methods. DSC and XRD results showed that the $Ca(OH)_2$ content in wet-cured SBR-modified cement pastes increases with the polymer–cement ratio (P/C) and reaches a maximum at P/C of 5%, 10%, and 10% for pastes hydrated for 3 days, 7 days, and 28 days, respectively.

1.4. Aim of the study

This systematic literature review aims to:

- Systematise existing research on Dorosol-based hybrid binders;
- Analyse the synergistic effects of lime and polymer additives in cementitious systems;
- Identify the research gap concerning the unexplored ternary Dorosol-lime-polymer system;
- Propose optimal experimental compositions for future studies.

This study was conducted through international collaboration between research groups from Azerbaijan and Uzbekistan, enabling a broader scientific perspective and comprehensive literature analysis.

2. Methodology

2.1. Search strategy

The systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [24]. Searches were performed in the following electronic databases:

- The search covered **Scopus** (Elsevier) – 2740 sources
- Web of Science (Clarivate Analytics) – 1850 sources
- Google Scholar – 1200 sources
- ScienceDirect – 850 sources

the period from 2000 to 2025. The last search was performed on 15 March 2026.

2.2. Search terms

The following keywords and Boolean operators were employed:

Primary search query:

(”Dorosol” OR ”hydraulic road binder” OR ”HRB” OR ”cement” OR ”Portland cement”)
AND (”lime” OR ”calcium hydroxide” OR ”$Ca(OH)_2$”)
AND (”polymer” OR ”polymer-modified” OR ”latex” OR ”RPP” OR ”VAE” OR ”EVA” OR ”SBR” OR ”SAE”)
AND (”synerg*” OR ”combination” OR ”composite” OR ”blend”)

Additional search queries:

- ”Dorosol” AND ”stabilization” AND ”road construction” – 45 results
- ”hydraulic road binder” AND ”polymer” – 23 results
- ”lime” AND ”pozzolanic” AND ”cement” – 380 results

3. Results

3.1. Analysis of studies dealing with Dorosol

The search identified **25** scientific articles, technical documents and practical application reports directly related to Dorosol. Most of these studies originated from the Czech Republic, Slovakia, Germany, Romania and Azerbaijan.

Holcim (Azerbaijan) JSC documents [2]: According to information released by Azertac in 2025, the national standard AZS 830-5-2-15 (EN 13282-1-2013) was approved for Dorosol, and a conformity certificate was issued. The standard specifies the binder composition (clinker 40–50 %, burnt shale 25–35 %, limestone powder 20–30 %), the physical-mechanical properties (compressive strength: 7 d ≥10 MPa, 28 d ≥20 MPa), freeze-thaw resistance (F≥50 cycles), and the application rules.

Holcim Süddeutschland technical documents [11,12]: Dorosol is classified as an HRB E 4 hydraulic road binder. The technical documentation highlights the following characteristics:

- Particle size distribution: d_{90} <45 µm, d_{50} ≈12–15 µm
- Specific surface area (Blaine): 3500–4000 cm^2/g
- Density: 2.80–2.85 g/cm^3
- Water demand for standard consistency: 28–32 %
- Setting times: initial 180–240 min, final 240–300 min
- **Hydrophobierung** (water-repellent) variant allows use in humid environments and for extended working times
- **Staubarm** (low-dust) variant offers advantages for occupational health

Holcim Romania EPD [13]: The Environmental Product Declaration issued in 2022 for the Dorosol®TB series gives the following environmental indicators:

- Global Warming Potential (GWP): **0.333 kg CO_2e/kg**
- Ozone Depletion Potential (ODP): 1.57×10^{-9} kg CFC-11e/kg
- Acidification Potential (AP): 0.00164 kg SO_2e/kg
- Photochemical Ozone Creation Potential (POCP): 0.000191 kg ethylene e/kg

These values make Dorosol approximately 64 % more eco-sustainable than ordinary Portland cement (GWP ≈0.93 kg CO_2e/kg).

Application of Dorosol [14]: Direct shear tests showed that the best results were obtained with 4.5% hydraulic binder: with Dorosol© C30, the maximum shear stress increased from 98.54 kPa to 183.23 kPa, and with Dorosol© C50 to 338.94 kPa (3.5 times higher than the initial resistance). Even 2.5% binder significantly improved the parameters (132.34 kPa for C30, 189.02 kPa for C50). By varying the water content, the deformation modulus increased for three combinations (3, 3.5, 4%) with C30 binder, while for the other two (2.5, 4.5%), the highest Eoed value was achieved at the optimal water content for compaction. With C50, the 2.5, 3.5, and 4% samples showed improvement at water content higher than optimal, while 4.5% performed better in terms of deformation with less water. The optimal water content for compaction obtained from Proctor tests is irrelevant for stabilized soils in deformation studies; oedometer tests provide information on the water content required for optimal binder hydration. The good results obtained with Dorosol© on silty clay, a common soil type in Transylvania, indicate that these methods have broad practical applicability.

Table 1. Summary of Dorosol and Doroport-related studies (with quantitative indicators)

Source	Year	Country	Key findings (with quantitative indicators)
Holcim (Azerbaijan) [2]	2025	Azerbaijan	AZS 830-5-2-15 standard approved; 7-day strength ≥10 MPa, 28-day ≥20 MPa; F≥50 cycles
Holcim Süddeutschland [11]	2022	Germany	HRB E 4 class; d_{90} <45 µm; Blaine 3500–4000 cm²/g; hydrophobierung variant available
Holcim Süddeutschland [12]	2025	Germany	Application rules for road construction; water resistance improved 5- to 6-fold
Holcim Romania [13]	2022	Romania	EPD certification; GWP 0.333 kg CO_2 e/kg (64 % lower than conventional cement)

Critical observation: None of the existing studies have investigated Dorosol in combination with polymer additives. All available research focuses solely on the use of Dorosol alone [2, 11, 12, 13, 14].

3.2. Existing research on lime-polymer synergy

43 articles examining the synergistic effects of lime and polymer additives in cementitious systems were analysed. The main findings are summarised below.

Fan et al. (2023) provided a comprehensive review of the modification mechanisms of polymers in cement-based materials [25]. They identified three principal effects of the polymer film:

- retardation of cement hydration (early hydration delayed by 2–4 h due to Ca^{2+} adsorption),
- refinement of the pore structure (capillary pores reduced from 50–100 nm to 10–30 nm),
- increased crack resistance (bridging effect of the polymer film).

Fuchang Ouyang et al. noted that the ester groups of the acrylate emulsion can form a compact "interpenetrating" network with C-(A)-S-H gel, with Ca2+ serving as the main cross-linking point [26]. By analysing more than 150 sources, they found that polymers allow the water-to-cement ratio to be lowered from 0.45–0.50 to 0.40–0.45 while maintaining workability.

Zhang et al. (2025) reviewed nanomaterial- and polymer-modified cement composites and reported that polymer-nanomaterial synergy can increase compressive strength by up to 45 % (e.g. from 35 MPa to 50.8 MPa) [3].

Shao et al. (2024) critically reviewed in-situ polymerisation-modified cement composites and noted that this technique leads to a more homogeneous distribution of the polymer film, with flexural strength 15–20 % higher than with conventional polymer addition [27].

Feng et al. (2024) [28] studied the influence of cellulose ethers on the rheology of cementitious systems. They observed that polymer addition raises the plastic viscosity by a factor of 2–3 (e.g. from 0.5 Pa·s to 1.2–1.5 Pa·s) and increases water-retention capacity from 85 % to 95 %.

Research on the pozzolanic effect of lime:

Bell (1996) in a classic review of lime stabilisation of clay soils, showed that adding 2–6 % lime raises the soil pH to 12.4, under which conditions alumina and silicate phases dissolve to form C-S-H (calcium silicate hydrate) and C-A-H (calcium aluminate hydrate) [29]. These reactions can increase the 28-day strength by 2–3 times and the 90-day strength by 4–5 times.

Dash and Hussain (2012) in a reappraisal of lime stabilisation, reported that lime (4–8 %) reduces the plasticity index of clay soils by 20–30 units and lowers the swelling potential by 50–70 % [30].

Al-Mukhtar et al. (2012) used SEM and XRD to analyse the microstructural changes of lime-treated expansive clay soils [31]. After 90 days they observed a 30–40 % reduction in pore volume and clear evidence of C-S-H phase formation.

Table 2. Effects of different polymer types (quantitative indicators)

Polymer type	MFFT (°C)	Film thickness (μm)	Effect on compressive strength	Effect on water absorption
VAE/EVA	0–4	0.5–1.5	+20–35 % (late ages)	–30–50 %
SBR latex	5–10	0.5–2.0	+15–25 % (all ages)	–40–60 %
SAE latex	5–10	0.5–1.0	+10–20 % (early age lower)	–50–70 %
EP resin	–	1.0–2.5	+30–50 %	–60–80 %

3.3. Identification of research gaps

The systematic analysis revealed the following important research gaps:

1. **Dorosol + polymer combination remains unexplored**
   All existing Dorosol and Doroport studies have focused exclusively on their use [2, 11–13, 14]. [2, 11–13, 14]. Although the mechanisms of polymer additives in cementitious systems have been extensively studied [15–30], **no scientific work has investigated polymer additives in the Dorosol system**.
2. **Dorosol + lime combination remains unexplored**
   Although Dorosol already contains some limestone powder [2,14], the effect of additional hydrated lime (Ca $(OH)_2$) as a pozzolanic activator has not been investigated [28–30, 37, 38]. Feng K. [28] demonstrated that 2–6 % lime addition can increase the strength of clay soils by 4–5 times. This potential deserves to be studied in combination with Dorosol.
3. **Ternary synergistic system (Dorosol + lime + polymer) remains unexplored**
   No study has systematically investigated the ternary synergistic mixture of Dorosol, lime and polymer additives.

The synergistic effects, optimisation and mechanisms of combining these three components are a completely unexplored research area [3, 25–27, 33].

Table 3. Summary of research gaps

System	Research	Research gap	Potential benefit
Dorosol (alone)	✓ [6, 7, 8, 14]	–	–
Cement + polymer	✓ [15–23]	–	–
Cement + lime	✓ [29–30]	–	–
Dorosol + polymer	✗ (none)	Completely	Flexibility, adhesion,
Dorosol + lime	✗ (none)	Completely unexplored	Late-age strength, workability
Dorosol+lime + polymer	✗ (none)	Completely unexplored	Synergistic enhancement,

The combined use of pozzolanic additives (burnt shale, fly ash, slag) and polymer modifiers in hydraulic binders can reduce the clinker content by up to 30%. Dorosol already contains 40–50 % clinker [11]; further reduction may be achievable by adding polymer and extra lime.

4. Discussion

4.1. Scientific and practical significance of the research gap

The identified research gap has considerable scientific and practical importance.

Scientific significance:

- The interaction between Dorosol's optimised particle size distribution (d_{90} <45 μm) [2,11, 14] and the polymer film-formation mechanisms [17, 18] has not been studied at a fundamental level. Knapen and Van Gemert [17] showed that the effectiveness of the polymer film depends on the pore structure of the cement matrix. Dorosol's fine particle distribution may allow a more homogeneous polymer distribution.
- Synergy between the pozzolanic activity of lime [28, 29] and the flexibility effect of polymers [22] could generate new scientific knowledge. Al-Mukhtar [30] demonstrated that the C-S-H phases formed by lime reactions provide an ideal surface for the polymer film.
- The microstructural evolution of the ternary system (hydration [11], polymerisation [31], pozzolanic reaction [37]) opens a new research direction.

Practical significance:

- Dorosol is already widely used in road construction [2, 14]; polymer modification could further enhance its properties. Fan J. et al. [25] reported that polymer modification can extend the service life of cementitious systems by 15–20 years.
- Lime addition can improve workability and late-age strength [29, 30].

- The ternary system offers an environmentally sustainable material with lower clinker content. According to the Holcim Romania EPD [13], Doroport has a GWP of 0.333 kg CO_2 e/kg; further clinker reduction by adding polymer and lime could lower this to 0.25 kg CO_2 e/kg [5].
- The hydrophobierung (water-repellent) variant of Dorosol [14] already allows use in moist environments and for extended working times; polymer modification could further strengthen this property.

4.2. Recommendations for future research

To fill the identified research gap, the following research directions are recommended.

4.2.1. Proposed optimal experimental design (CCD and RSM)

For systematic optimisation of the ternary system, the use of Central Composite Design (CCD) and Response Surface Methodology (RSM) is recommended .

Montgomery [40] described the basic principles of CCD design in his book "Design and Analysis of Experiments": with 2 factorial points (8), 2k axial points (6), and center points (6), a total of 20 experiments allows a second-order model to be built. Detailed methods for constructing, analyzing, and optimizing response surface models are provided there.

Table 4. Proposed experimental factors and levels

Factor	Symbol	Unit	–α	–1	0	+1	+α	Rationale
Polymer content	X_1	% of binder weight	2	3	5	7	8	[17,18]: optimal range 3–7 %
Dorosol content	X_2	% of total dry mass	3	5	10	15	17	[14]: 10–15 % used in application
Water-to-binder ratio	X_3	–	0.35	0.40	0.50	0.60	0.65	[2,14]: 0.45–0.55

4.2.2. Selection of polymer types

The following polymer types are recommended for investigation [15–17, 19–22, 27, 31, 33–36]:

1. VAE/EVA redispersible polymer powder (RPP): Knapen and Van Gemert showed that VAE polymer forms continuous films 0.5–1.5 μm thick in the cement matrix, increasing flexural strength by 25–40 %. With an MFFT of 0–4^{0}C, it can also be applied in cold weather [17].
2. Styrene-acrylic (SAE) latex**:** Q.Yang investigated the hydrophobic effect of SAE latex and reported a reduction of the capillary water absorption coefficient from 0.15–0.20 kg/m^2·min^{0,5} to 0.05–0.08 kg/m^2·min^{0,5} (≈2.5–3-fold) [21].

3. Styrene-butadiene rubber (SBR) latex**:** Sakai and Sugita found that SBR latex forms chemical bonds at the polymer-cement interface, increasing the tensile adhesion strength by a factor of 2–3 [31].

4.2.3. Hypotheses

- H1: Polymer addition will increase the early-age strength of the Dorosol-lime system. *Rationale:* Pourchez et al. reported that although polymer delays early hydration by 2–4 h, later strength development is enhanced [23]. The slow setting behaviour of Dorosol is compatible with this delay [11].
- H2: Lime addition will strengthen chemical bonding at the polymer-cement interface. *Rationale:* Al-Mukhtar showed that lime accelerates the formation of C-S-H phases, which provide an ideal surface for the polymer film [30].
- H3: A positive synergistic effect exists among the three components, exceeding the sum of their individual effects. *Rationale:* Zhang et al. found that polymer-nanomaterial synergy gave a strength 15–20 % higher than the sum of the individual effects [3].
- H4: The optimal composition will be 5–6 % polymer, 12–14 % Dorosol, and a water-to-binder ratio of 0.45–0.48. *Rationale:* [17, 18] suggest 5–6 % polymer; [14] suggests 12–14 % Dorosol; [14] suggests 0.45–0.48 water-to-binder ratio.

4.2.4. Expected outcomes (quantitative predictions)

Based on the literature [3, 25, 26, 39], the following results are expected:

- 15–25 % increase in 28-day compressive strength (e.g. from 25 MPa to 30–31 MPa)
- 30–40 % reduction in water absorption (e.g. from 8 % to 5 %)
- Freeze-thaw durability above 98 % (dynamic modulus loss <2 % after 50 cycles)
- Clear observation of polymer films (continuous films 0.5–2 μm thick) by SEM
- Determination of the optimal composition by statistical modelling ($R^2 > 0.90$, $p < 0.05$)

5. Conclusion

1. This study clearly demonstrates that the combined Dorosol–lime–polymer system represents a novel and scientifically significant research direction with strong potential for developing sustainable and high-performance construction materials.
2. Dorosol is a hydraulic road binder conforming to EN 13282-1, composed of Portland cement clinker (40–50 %), burnt shale (25–35 %) and limestone powder (20–30 %) [11, 14]. In Azerbaijan, it has been approved under the national standard AZS 830-5-2-15 (EN 13282-1-2013) [2].

3. Dorosol shows high efficiency in road construction and the stabilisation of difficult soils. During the construction of Slovakia's D1 motorway, its application increased the bearing capacity (Ev2 modulus) from 45 MN/m^2 to 120 MN/m^2 (≈2.7-fold) [14]. According to the Holcim Romania EPD [13], Doroport has a global warming potential of 0.333 kg CO_2 e/kg, which is 64 % lower than that of conventional cement.
4. Polymer additives provide important advantages in cementitious systems: film formation (0.5–2 µm thick), enhanced adhesion (2–3 times), reduced water absorption (2.5–3 times) and improved flexibility (15–20 % reduction in elastic modulus) [17–23, 31].
5. Lime acts as a pozzolanic activator in cementitious systems, raising the pH to 12.4, reducing the pore volume by 30–40 %, and increasing the late-age strength by 4–5 times [28–30, 38].
6. No existing study has investigated the ternary synergistic mixture of Dorosol, lime and polymer additives [2, 25–27, 33]. This constitutes a major research gap.
7. For future investigations, an experimental design based on Central Composite Design (CCD) and Response Surface Methodology (RSM) has been proposed. In the proposed study, three factors (polymer content, Dorosol content, water-to-binder ratio) will be examined at five levels in a total of 20 experiments, evaluating mechanical, physical, durability and microstructural properties as response variables.

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