

**METHODOLOGY FOR THE EXPERIMENTAL IMPLEMENTATION OF LIME-WASTE-BASED GYPSUM CONCRETE**

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**Abstract**

The present study investigates the methodology for the production of gypsum concrete based on lime waste and Redispersible Polymer Powder (RPP), together with the assessment of its technical and economic efficiency. Experimental gypsum concrete compositions containing different amounts of lime waste and RPP were prepared and tested under controlled curing conditions. The introduction of lime waste and RPP made it possible to reduce gypsum consumption by up to 25% while maintaining high strength and density of the gypsum concrete products. The optimum preparation procedure included sequential mixing of lime waste, RPP additive, and G-6 grade gypsum under controlled mixing speeds and curing conditions. Economic analysis showed that the modified gypsum concrete has a lower production cost compared with conventional gypsum concrete. The economic benefit from producing 1 m<sup>3</sup> of gypsum concrete under industrial conditions amounted to 91,940 UZS, while the projected annual economic effect reached 1,654,920,000 UZS. The developed composition was successfully tested under the production conditions of Ferghana Ceramics Industry LLC and demonstrated improved durability, reduced binder consumption, and enhanced structural performance.

**Keywords:** Gypsum concrete, lime waste, Redispersible Polymer Powder, RPP, gypsum binder, industrial waste, energy-efficient technology, economic efficiency, production methodology, durability, strength, density, construction materials.

**Introduction**

The growing demand for energy-efficient and cost-effective building materials requires the development of new gypsum-based composites with improved physical and mechanical properties. One of the promising approaches is the partial replacement of gypsum binder with industrial by-products and polymer additives. Lime waste, generated as a secondary industrial material, can be effectively utilized in gypsum concrete production, thereby reducing raw material consumption and minimizing environmental impact. At the same time, the incorporation of Redispersible Polymer Powder (RPP) contributes to improved bonding between particles, enhanced hydration processes, and increased strength of the final product.

This study is aimed at developing a methodology for the production of gypsum concrete based on lime waste and Redispersible Polymer Powder (RPP), as well as evaluating its technical and economic efficiency under industrial conditions. Special attention is paid to the optimization of the composition, technological parameters of preparation and curing, and the possibility of reducing gypsum consumption

while maintaining high strength characteristics. The obtained results demonstrate that the use of lime waste and RPP makes it possible to produce durable and economically efficient gypsum concrete products suitable for large-scale industrial application.

During the scientific research related to the production of gypsum concrete products based on lime waste, a methodology for the manufacture of gypsum concrete products was developed.

The implementation of gypsum concrete products produced from gypsum, lime waste, and Redispersible Polymer Powder (RPP) additives is described below.

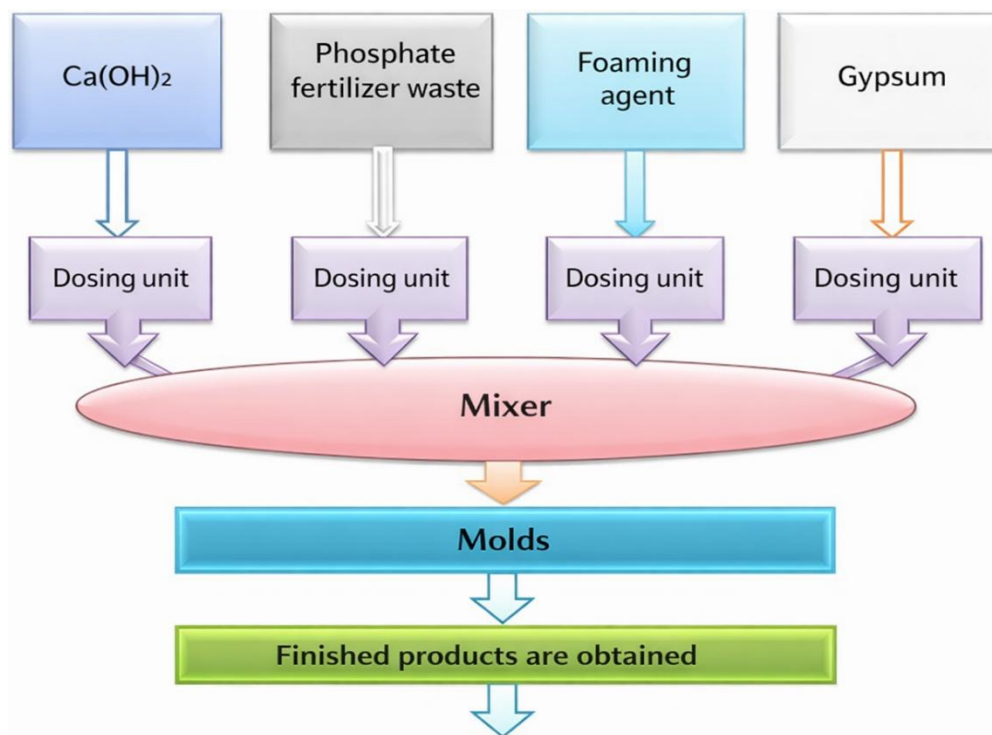
The optimum amount of Redispersible Polymer Powder (RPP) additive contributes to an increase in the density and strength of gypsum concrete (Table 1).

**Table 1 Composition of gypsum concrete containing lime waste and Redispersible Polymer Powder (RPP)**

No.	Raw Material Name	Composition of gypsum concrete			
		Unit	No. 1	No. 2	No. 3
1	G-6 grade gypsum	kg	755	750	745
2	Lime waste	kg	245	250	255
3	Redispersible Polymer Powder (RPP) additive	L	0.06	0.10	0.12
4	Water	L	550	600	650

The preparation of gypsum concrete was carried out as follows. Initially, the specified amount of lime waste was placed into the mixer and mixed for 1 minute until a uniform state was achieved. After that, the Redispersible Polymer Powder (RPP) additive was introduced, and mixing was continued for  $15 \pm 5$  s. At the next stage, G-6 grade construction gypsum was added to the mixture and mixed for 20 s until a homogeneous plastic mass was formed. During the mixing process, the rotational speed of the mixer drum was maintained at  $140 \pm 5 \text{ min}^{-1}$ , while the rotational speed of the counter-rotating blades was  $62 \pm 5 \text{ min}^{-1}$ . This regime ensured uniform distribution of the mixture and effective bonding between the components.

Before pouring the prepared mixture into the molds, the inner surfaces of the molds were coated with a special oil, which ensured easy demolding of the specimens and prevented surface damage. After the mixture was poured into the molds, the surface was leveled, and after  $9 \pm 2$  min, when the initial setting stage had been completed, the specimens were removed from the molds. The specimens were marked and placed in a curing chamber at a temperature of  $23 \pm 2^\circ\text{C}$  and a relative humidity of at least  $50 \pm 5\%$ . The curing process continued until the testing period, which ensured the stable progression of hydration and structural formation processes. The finished gypsum concrete products were then tested and stored in warehouses (Figure 1).



**Figure 1. Scheme of the energy-efficient technology for gypsum concrete production**

**Figure 1 Scheme of the energy-efficient technology for gypsum concrete production.**

The consistency of the gypsum concrete mixture shall be within the standard limits established for each type of gypsum concrete mixture in accordance with the construction material standards of SNiP. During the preparation and molding of gypsum concrete containing lime waste and Redispersible Polymer Powder (RPP), it is necessary to comply with the requirements of QMQ, as well as the relevant safety regulations for the use of machines, mechanized equipment, and tools.

Service personnel operating mechanized equipment and tools must complete industrial training courses, undergo safety instruction, and possess the appropriate electrical safety qualification category.

**Economic Efficiency of Gypsum Concrete Product Manufacturing**

Improving the physical and mechanical properties of gypsum concrete, as well as reducing the gypsum content by 25% through the incorporation of lime waste and Redispersible Polymer Powder (RPP), became the basis for the production of high-strength gypsum concrete products.

In order to determine the reduction in gypsum consumption resulting from the addition of lime waste and Redispersible Polymer Powder (RPP), a series of experiments was carried out by introducing different amounts of lime waste and gypsum into the composition of gypsum concrete specimens. Gypsum concrete products of various compositions, cured in a curing chamber at a temperature of  $23\pm 2^{\circ}\text{C}$  and a relative air humidity of not less than  $50\pm 5\%$ , exhibited high strength. The use of lime waste and Redispersible Polymer Powder (RPP) in gypsum concrete production made it possible to reduce gypsum consumption by up to 25%.



**Table 2 Consumption and cost of materials used under industrial conditions for the production of 1 m<sup>3</sup> of D900 grade gypsum concrete products**

Material name	Unit	Standard consumption per 1 m <sup>3</sup>		Price (UZS)	Cost, UZS	
		Without additive	With additive		Without additive	With additive
Gypsum G-6	kg	1000	750	400	400000	300000
Lime waste	kg	0	250	30	0	7500
Redispersible Polymer Powder (RPP)	g	0	10	56000	0	560
Water	m <sup>3</sup>	0.600	0.600	2600	1560	1560
Technical oil	kg	0.008	0.008	8000	64	64
Electricity	kWh	2	2	1000	2000	2000
Labor	person	2	2	36000	72000	72000
Total					475624	383684

The technical and economic efficiency of using lime waste and Redispersible Polymer Powder (RPP) additive, as well as the evaluation of this efficiency under production conditions, involves comparing the production cost of modified gypsum concrete with the cost of analogous gypsum concrete produced without the proposed lime waste and Redispersible Polymer Powder (RPP) additive.

At the Ferghana Ceramics Industry LLC enterprise, a composition of tongue-and-groove gypsum concrete products with increased strength and reduced binder consumption was developed by incorporating lime waste and Redispersible Polymer Powder (RPP). The composition of raw materials used in gypsum concrete production under industrial conditions and the results of calculating the production cost of gypsum concrete products are presented in Table 4.7.

Under the production conditions of Ferghana Ceramics Industry LLC, the expected economic benefit from using the investigated additives in the production of 1 m<sup>3</sup> of gypsum concrete amounts to 91,940 UZS. If the enterprise produces 20 m<sup>3</sup> of gypsum concrete in one shift using the investigated additives, the economic benefit will amount to 1,838,800 UZS. If the enterprise produces 60 m<sup>3</sup> of gypsum concrete per day (three shifts), the economic benefit will reach 5,516,400 UZS. The expected annual economic benefit from gypsum concrete production over one year (300 working days, three shifts) amounts to 1,654,920,000 UZS.

The concentrations of lime waste and Redispersible Polymer Powder (RPP) additive obtained through the research were successfully tested under the production conditions of Ferghana Ceramics Industry LLC. Experimental results demonstrated that the use of Redispersible Polymer Powder (RPP) additive is advisable for increasing the durability and service life of gypsum concrete.

### Conclusions

1. The incorporation of lime waste and Redispersible Polymer Powder (RPP) into gypsum concrete made it possible to reduce gypsum consumption by up to 25% without reducing the strength of the material.
2. The optimum composition of the gypsum concrete mixture ensured improved density, strength, and durability of the finished products.



3. The developed production methodology, including the sequence of component introduction, mixing regime, molding, and curing conditions, ensured the formation of a homogeneous and structurally stable gypsum concrete.
4. The addition of Redispersible Polymer Powder (RPP) improved the interaction between the components of the mixture and increased the service life of gypsum concrete products.
5. The use of lime waste as a secondary raw material contributes to resource conservation and reduces the environmental impact of gypsum concrete production.
6. The modified gypsum concrete produced under the conditions of Ferghana Ceramics Industry LLC showed a reduction in production cost from 475,624 UZS to 383,684 UZS per 1 m<sup>3</sup> of product.
7. The expected economic effect from the use of the proposed additives amounts to 91,940 UZS per 1 m<sup>3</sup> of gypsum concrete, which confirms the high economic efficiency of the developed technology.
8. Under industrial conditions, the annual economic benefit of producing gypsum concrete with the proposed additives may reach 1,654,920,000 UZS, which demonstrates the feasibility of implementing this technology on a large scale.

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