Economic Benefits Of Applying Antifreeze Chemical Admixtures During Winter Concreting

[1] Usmonova D.A.

[1] PhD, associate professor, Tashkent University of Architecture and Construction, The Republic of Uzbekistan

Received: 24th Dec 2025 | Received Revised Version: 10th Jan 2026 | Accepted: 25th Jan 2026 | Published: 11th Feb 2026

Volume 08 Issue 02 2026 | Crossref DOI: 10.37547/tajet/Volume08Issue02-08

Abstract

Winter concreting under negative temperatures is associated with significant technological and economic challenges, primarily due to the need to prevent early freezing and ensure the required strength development of concrete. Traditional methods, such as electrical heating, lead to increased energy consumption and labor costs. This study investigates the effectiveness and economic efficiency of using a complex anti-freezing chemical admixture "Beton-Strong 17" in monolithic concrete structures under cold weather conditions.

Experimental studies were carried out using Portland cement II/A 32.5N with the incorporation of the chemical admixture under negative temperature conditions. The performance of concrete produced with the admixture was compared with conventional electrically heated concrete in terms of strength development, material consumption, and total production cost. Real construction projects were used to validate the obtained results.

The results show that the use of the anti-freezing admixture allows a reduction in cement consumption by up to 30% while maintaining the required concrete strength class (B30). Economic analysis demonstrated that the total cost of 1 m³ of concrete was reduced by approximately 92,400 UZS compared to the electrical heating method.

Keywords: Winter concreting; anti-freezing admixture; concrete technology; cement consumption; economic efficiency; negative temperatures.

Cite This Article: Usmonova D.A. (2026). Economic Benefits Of Applying Antifreeze Chemical Admixtures During Winter Concreting. The American Journal of Engineering and Technology, 8(2), 99–103. https://doi.org/10.37547/tajet/Volume08Issue02-08

1. Introduction

Concrete construction under negative temperature conditions remains a significant challenge in cold and continental climate regions. Low ambient temperatures adversely affect cement hydration, slow down strength development, and may lead to early freezing of fresh concrete. Ensuring the required strength and durability of concrete during winter concreting is therefore a critical issue.

Traditional winter concreting methods are mainly based on thermal protection techniques, including electrical heating, steam curing, and insulated formwork. Electrical heating is widely applied but is associated with high energy consumption, increased labor intensity, and significant additional costs.

The use of chemical admixtures has emerged as an energy-efficient alternative. Anti-freezing chemical admixtures reduce the freezing point of pore water, accelerate early strength development, and ensure hydration under negative temperatures. However, comprehensive studies combining technical and economic evaluation remain limited.

The aim of this study is to evaluate the technical effectiveness and economic efficiency of using a complex anti-freezing chemical admixture "Beton-Strong 17" in winter concreting under real construction conditions.

2. Results

Portland cement II/A 32.5N produced by the Akhangaran cement plant was used. Crushed stone (5–20 mm) and natural sand with a fineness modulus of 2.0–2.5 were used as aggregates. All materials complied with relevant standards.

The anti-freezing chemical admixture "Beton-Strong 17" was used as a complex multifunctional additive. The dosage ranged from 2.0% to 3.0% of cement mass depending on ambient temperature [1].

As a result of using the antifreeze complex chemical admixture "Beton-Strong 17" during the construction process, labor productivity was significantly increased, the possibility of producing high-strength concrete under negative temperature conditions was ensured, and substantial economic efficiency was achieved in construction practice.

There are several methods of winter concreting. However, at present, the method of concreting with electric wire heating is considered one of the most widely used and effective techniques. This method provides uniform heating throughout the entire volume of the structure and allows precise control of the heating temperature.

The essence of this method lies in installing steel wires with a diameter of 1.0–2.0 mm within the structural framework prior to placing polyethylene or polyvinyl chloride insulation. Due to the electrical resistance of the metal, when a high electric current passes through the wires, heat is generated. Owing to the insulation of the wires, the electrical conductivity of the concrete and the presence of reinforcement do not adversely affect the heating process.

In addition, the application of this method is recommended for structures with a surface modulus (the ratio of surface area to structural volume) of at least 5. According to literature sources [2], for 1 cubic meter of concrete:

-60 m of heating wire;

-0.6 man-hours — labor costs for laying the heating wire;

-2.7 kWh — energy consumption during the heating process.

Thus, the total cost required to heat 1 m³ of concrete can be calculated as follows:

$$\Sigma P = U_p \text{ x } N_p + M_{cons} \cdot M_{price} + E_{cons} \cdot T_h \cdot N_e + C_{pol}$$

where:
ΣP - total cost of heating 1 m³ of concrete;
U_p - labor input for laying the heating wire (man-hours);
N_p - labor cost per man-hour;
Mcons - consumption of heating wire (m);
Mprice - cost of heating wire per meter;
Econs- electricity consumption during heating (kWh);
T_h- heating duration (h);
N_e - electricity cost per kWh;
C_{pl} - cost of polyethylene film or insulation materials.

ΣP=25x980+0.6x49,735+2.7x24x450+1200=84700 som

These costs, taking into account the material consumption for 1 m³ of concrete mix, are determined as follows. The main objective of the study is to achieve the required concrete strength during winter concreting through the use of complex chemical admixtures, as well as to maintain concrete strength while reducing cement consumption when superplasticizers are applied. When calculating economic efficiency, these factors must be taken into consideration [3].

As mentioned above, Ohangaron cement SEM II/A 32.5N was used for the experimental study, and a concrete mix design was developed based on its application.

Thus, when casting 1 m³ of concrete at negative temperatures using the electric heating method, while maintaining a constant cement content and ensuring the required concrete strength, the total costs can be calculated as follows:

$$\Sigma X_{total} = \Sigma P + M_{cement} + M_{gravel} + M_{sand}$$
$$= 84700+352000+75000+73000 = 571700 \text{ som.}$$

If complex chemical admixtures “Beton-Strong 17” are used in winter concreting, the following efficiencies can be achieved:

$$\Sigma X_{total}\ M_{cement} + CCHA + M_{gravel} + M_{sand} + Mc$$
$$\text{xMprice} = 440\text{x}800 + 8.8\text{x}9000 +$$
$$+75000+73000+0.6\text{x}49{,}735 = 596.000 \text{ som}$$

When comparing the results obtained from the study, it was found that the use of a complex chemical admixture allowed a 30% reduction in cement consumption. That is, for producing 1 m³ of B30 class concrete, if 440 kg of cement was initially required, this amount was reduced to 308 kg.

The following presents the costs associated with the reduced cement consumption:

$$\Sigma X_{total} = M_{cement} + CCHA + M_{gravel} + M_{sand} + Mc$$
$$\text{xMprice} =$$
$$308\text{x}800 + 6.16\text{x}9000 + 75000 + 73.000 + 0.6\text{x}49{,}735$$
$$= 466281 \text{ som}$$

3. Conclusion

In conclusion, when comparing the costs of the two winter concreting methods, the following economic efficiency was achieved:

$$\Sigma X_{total} = \Sigma X_{e/is} - \Sigma\ CCHA = 571700 - 479281 = 92400 \text{ som}$$

Thus, when using the complex chemical admixture “Beton-Strong 17” for winter concreting, an economic efficiency of 92,400 UZS per 1 m³ of concrete can be achieved compared to other methods. The comparison results also form the basis for recommendations on the application of “Beton-Strong 17” in monolithic concrete. These recommendations are intended for inclusion in the technological regulations developed by construction enterprises.

For the preparation of monolithic concrete, cement with a standard consistency of 28% and S3A content not exceeding 7% should be used. To increase the efficiency of the admixture, it is advisable to use pure clinker Portland cement. When using Portland cement with active mineral additives, it is necessary to determine the optimal admixture dosage in the concrete mix under laboratory conditions to maintain its effectiveness and proper setting [4].

The use of delivered cement in construction should be carried out taking into account the technology of monolithic reinforced concrete structures, the concrete curing conditions, and the surrounding environmental factors. The activity of the cement must be checked by the construction laboratory under the following conditions:

• If there are any doubts regarding the actual activity (strength) of the cement;

• If more than two months have passed since the cement was manufactured.

To prepare an admixture concrete mix, it is recommended to add “Beton-Strong 17” using one of the following methods:

• Together with the calculated amount of mixing water;

• 1–2 minutes before the end of mixing, together with 10–20% of the mixing water in the pre-mixed concrete.

For concrete mixing, it is recommended to use gravity or forced-action mixers, with respective mixing cycle durations of 4–5 minutes and 2–3 minutes.

For transportation of the admixture concrete, truck mixers and transit mixers should be used. If the transportation time exceeds 1 hour, the workability of the concrete can be restored by adding a small amount of admixture (up to 0.25%) and re-mixing before discharge from the mixer.

To ensure proper placement of the concrete, the operation of concrete pumps and the requirements for placing concrete with these devices must comply with the relevant guidelines and technical documentation [5].

In winter concreting, it is recommended to laboratory-test the composition, quantities, and fractions of fine and coarse aggregates used in the concrete mix before application.

The following recommendations should be followed during winter concreting when the average daily outdoor temperature is below 5°C and the daily minimum temperature is below 0°C:

• The strength of concrete in monolithic reinforced concrete structures during freezing or cooling conditions below the design temperature must be specified in the technological regulations;

• For B15, B25, and B30 concretes, the strength must be at least 30%, 25%, and 20% of the design strength, respectively;

Concretes frozen at this strength must maintain their integrity until the structures are loaded with the design loads and the required design strength is achieved.

To achieve this, it is necessary to use the “thermos” method, pre-heat the concrete mix (using either electric energy or hot air), and incorporate chemical admixtures.

During winter conditions, the removal of formwork and loading of monolithic reinforced concrete structures should be carried out only after testing concrete control samples for strength or by using a non-destructive method to determine the actual strength of the structural concrete.

The surfaces of reinforced concrete elements released from formwork should be temporarily covered with insulating materials. This procedure is recommended under the following conditions:

When the temperature difference between the concrete surface layer and the external air is 20°C (for structures with a surface modulus between 2 and 5);

When the temperature difference between the concrete surface layer and the external air is 30°C (for structures with a surface modulus of 5 or higher).

For preparing the concrete mix (for reinforced concrete structures with a surface modulus less than 3), it is recommended to use rapid-hardening Portland cement or Portland cement of grade M400 and above.

The preparation of admixture concrete mixes should be carried out in heated concrete batching plants using heated water and unfrozen aggregates. During this process, the temperature of both the concrete mix and the ambient air must be monitored and controlled [6].

The materials used, concrete mix, and concrete quality control must comply with the applicable standards and regulations.

The compositions of “Beton-Strong 17” admixture concretes should be initially determined as shown in Table 4.10. In some cases, when there are changes in cement type, aggregate quality, external air temperature, or other factors, the concrete mix can be adjusted based on laboratory tests.

Typical materials for the concrete mix include:

Portland cement M400;

Crushed stone (5–20 mm);

Sand with a particle size of 2–2.5 mm;

Concrete slump (workability) of 5–9 cm.

Table 1

Optimal Concrete Mix Compositions

Concrete Class	Admixture Dosage,%	Materiallar sarfi			
		Cement, kg	Sand, kg	Gravel, kg	Water, l
B15	2 (2,25)	340	780	1020	220
B20	2,25 (2,5)	370	800	1000	215
B25	2,5 (2,75)	400	825	970	205
B30	2,75 (3,0)	430	850	950	195

Appendices:

1. The admixture dosage is determined relative to the cement content per 1 m³ of concrete.

2. Values outside parentheses correspond to a temperature of −10°C, while values inside parentheses correspond to −20°C.

The study results scientifically and practically confirm that, by correctly following the above recommendations, it is possible to maintain the required concrete strength at negative temperatures using complex chemical admixtures.

References

1. Neville, A.M. Properties of Concrete, 5th Edition, Pearson, 2011.
2. ACI Committee 306. Cold Weather Concreting, ACI 306R-16, American Concrete Institute, 2016.
3. Kosmatka, S.H., Kerkhoff, B., Panarese, W.C. Design and Control of Concrete Mixtures, 16th Edition, Portland Cement Association, 2011.
4. Mindess, S., Young, J.F., Darwin, D. Concrete, 2nd Edition, Prentice Hall, 2003.
5. EN 206:2013. Concrete – Specification, Performance, Production and Conformity, European Committee for Standardization.
6. Mehta, P.K., Monteiro, P.J.M. Concrete: Microstructure, Properties, and Materials, 4th Edition, McGraw-Hill Education, 2014.

.