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***Research paper***

# Improving the Efficiency of Construction of High-Rise Monolithic Reinforced Concrete Buildings with the Introduction of Innovative Technologies and Technologies

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**Abstract**

Innovations' application of techniques and technologies to modern construction production, along with the reduction of manual labor, also boosts its technical and economic performance. Construction production is one of the fields in the country that plays the most important role and reflects the dynamics of the development of the economy in itself. In our country, the issue of organizing a cheap housing market has an importance among a number of socio-economic issues. The programmes adopted in this direction and the initiatives dealing with the improvement of housing conditions for people from a number of categories are evident proof of this. And this, in its turn, requires the solution of a number of organizational and technological problems of construction work carried out by monolithic reinforced concrete structures before both the designers and builders. The article explores the ways of timely commissioning of high-rise monolithic reinforced concrete buildings, improving the organization of work, and increasing the technological efficiency to reduce the cost of construction products. It was determined that during the reinforcement of monolithic reinforced concrete structures, automation of works will reduce labor costs, material consumption, product cost and construction time, while technological efficiency is increasing.

***Keywords***: *automation of concrete works, construction period, labor trafficking, product cost, technological efficiency*

## 1 Introduction

Automation of construction production, along with organizational and technological issues, also increases the efficiency of resource utilization. It shows itself in the construction of multi-storey buildings with monolithic reinforced concrete structures. In our Republic, the construction of monolithic reinforced concrete buildings began mainly in the 2000s. Technological processes of construction of monolithic iron-concrete are very complicated, as well as many factors. And this, in its turn, requires the solution of a number of organizational and technological problems of construction work carried out by monolithic reinforced concrete structures in front of both the designers and builders. Since these problems are not resolved, the cost of construction products in our republic is very high and the construction period is longer than the normative period. The solution to this problem is not only a technological issue, but it is also a socially necessary economic issue.

Thus, reducing the cost of construction products due to timely commissioning of facilities, improvement of the organization of work with high quality remain relevant for all construction industry participants and and this should be solved by applying innovative techniques and technologies in construction.

In the capital of our Republic Baku and in large cities such as Sumgait, Ganja, Zagatala, Mingachevir and others the construction of high-rise monolithic reinforced concrete buildings are widely carried out. Constructive solutions and locations of all constructed high-rise monolithic reinforced concrete buildings are of different character. Researches in Baku and Sumgayit show that the highly developed construction companies in the construction industry use a wide range of technological solutions to select an efficient construction method for the construction of high-rise monolithic reinforced concrete buildings. All this depends on the specific construction machinery, mechanism and materials that the construction company which will conduct the construction has.

## 2 Overview of Problem

For this purpose, the technology issues of construction of high-rise monolithic reinforced concrete buildings in 10 construction sites in Baku and Sumgayit were visually studied. The study was conducted with the application of modern efficient technologies; transportation of concrete by means of concrete carrier motor transport, transportation of the solution by means of stationary concrete pumps to concreting sites, fast mounted and demounted encasing systems. The main objective of the research was to reduce the number of technological breaks by reducing the cost of reinforcing steel and reinforced concrete structures, preventing loss of excessive tile material and increasing the efficiency of the use of concrete carrier motor transport, concrete, crane and other machine - mechanisms by studying the experience of the construction of high-rise monolithic reinforced concrete buildings. As a result of studies conducted in Baku and Sumgait cities, the positive and negative aspects of the construction of high-rise

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monolithic reinforced concrete buildings were studied. As a positive aspect, the following can be noted the following:

- since the reinforced concrete is used in full (without interruption), the consumption of concrete is lower than norm;
- constructions do not have intersections that need further reinforced concrete;
- rigid connections in the volume and planning solutions of buildings, structures and individual structures are reduced;
- one-time consumption to the preparation of the construction is carried out;
- one-time usage of the transport is carried out to bring the materials to make of the construction;
- volume-planning solutions of a building and an installation to create architectural forms with different optimal parameters are widely allowed;
- acceleration of the start of the work on the reduction of the production of the production base of the building and the material and the layout of the basic construction.

In addition, monolithic reinforced concrete constructions have some of the following disadvantages:

- a large amount of labor expenditure on the construction site while creating it;
- lack of effective method for early tension of monolithic reinforced concrete structures;
- the presence of technological break spent on drying to achieve the given strength of the construction;
- absence of stable production conditions;
- to carry out drying works.

Currently, the evaluation of the technology of monolithic reinforced concrete constructions is done by comparing the technical-economic indicators of the "etalon" design or other variants of the same construction. Comparison of feasibility indicators in many design and construction organizations is done according to the single dimensions of the design (1m3 of construction, 1m2 of the tile area, etc.). The technological effectiveness of the monolithic reinforced concrete constructions is carried out in the following system of indicators: *b)*

• labor expenditure spent on the created construction;
• material capacity of metal and cement consumption;
• estimated construction cost;
• duration of the tissue;
• amount of capital investment;
• purchase price - the amount of cost per unit of finished product.

At present, the use of indicators such as material consumption, labor efficiency, duration of the construction and the estimated cost of construction is used to select the form and solutions of monolithic reinforced concrete structures in construction production. The specific condition for evaluating the technology of monolithic reinforced concrete structures is made by comparing one or more of the key data [1].

The minimum or maximum limits for these indicators, although not a general criterion for the cost-effectiveness of the design, help to make optimal decisions in specific cases. That condition of constructive solutions is considered to be the most optimal which meet technology and economic efficiency.

Thus, the total quality characteristics of the design and technological efficiency of the constructions should be taken into account. The minimum cost indicator is considered to be the most efficient. Investigations carried out in buildings constructed with the application of monolithic reinforced concrete structures, scientific research shows that the composite is more efficient than reinforced concrete structures [2].

## 3 Proposed Methods

Let us consider the features of the research of the technology of some of the structures of high-rise monolithic reinforced concrete buildings.

*a) Basement*

Although there are many different constructive, architectural and planning solutions, the conducting methods of the construction of the underground section.of high-rise monolithic reinforced concrete structures are similar. However, the requirements for the receiving of concrete, its technological development, the strength and the technology of its carrying out are very important.

Numerous observations made during the construction of high-rise monolithic reinforced concrete buildings in Baku and Sumgayit show that the underground part is constructed using 100% monolithic reinforced concrete. During the observations, special attention was paid to the technological construction of monolithic reinforced concrete basements. It has been established that the main lack of technology for the construction of monolithic reinforced concrete basements is the high labor costs in the construction site. From this constructive point of view, this depends on the factors such as the organization of mold and reinforcement work, the method of detonating, the level of mechanization, the concrete care and so on.

In the 1980s, it was believed that the role of molding in the reduction of the consumption of labor and its cost in monolithic iron-concrete works was very significant. Approximately this allows to reduce labor consumption by 40-50% and 20-25% cost estimate in complex concrete work. Also, it was found that 0.7-1.3 man-day was spent on on average on the average 5$m^2$ mold for 1 $m^3$ of monolithic iron-concrete construction .

The conducted surveys show that increasing the efficiency of the technology of reinforced concrete structures, the reduction of the cost of labor, material, the time of construction depend on a number of factors such as high quality concrete mixes, automation of armature carcass preperation, application of efficient molding systems, quality of concrete transportation, high-speed pumping of concrete to the construction sites, the use of high-quality squeezing equipment,proper mixing of concrete for the purpose of getting concrete strength the monolithic reinforced concrete structures and so on.

*Column and cover pan.*

In the study of 10 high-rise monolithic reinforced concrete buildings built in Baku and Sumgayit, the technology of the monolithic reinforced concrete columns and cover pans was studied.

In these buildings, the columns in sizes 0.4x0.4 m and cover pans of 0.6x0.8 m were used. By our suggestions, some of the columns in most buildings were accepted as 0.2x0.7 ... 0.8 m. Then the steps of these columns were brought to 6,6x6,6 m. Subsequently, appropriate alterations were made in the installation of the constructions. In the reinforced reinforced concrete structures, concrete was found to be 6-8 cm in thickness and 20 mm in thickness, with a density of 4-6 cm and a filling depth of 40 mm in density armature. It is advisable to make necessary changes to the technology of welding the armature on the construction site. Welding of classic hand and reinforcement with mechanical or automated methods has been carried out. The classification of wires used at this time was studied [3]. BP-1 and BP-2 type wiring were used. The diameter of the wires is 0.12 kg in diameter and the diameter of 2 mm is 0.025 kg. These are reflected in Figure 1.



a) b) c) d)

**Fig. 1:** Armature crochet tools and materials: a) wire net, b) welded crochet instrument by hand, c) automated reinforcing crochet device, d) wire winding ball

The efficiency of the KW-0038, RG-400T, RB-398 automated reinforcement crochet instrument was investigated. The technical and economic indicators of these instruments are given in Table 1.

**Table 1**

| Series | Brand of armature crochet tool | Diameter of crocheted armature (mm) | Diameter of wire to use (mm) | Length of the wire winding used once (m) | The number of nods crocheted with a ball of winding (pieces) | The time spent on crocheting one node (second) |
|---|---|---|---|---|---|---|
| 1 | KW-0038 | 4-28 | 0,8-1,0 | 95 | 330 | 0,8 |
| 2 | RG-400T | 4-40 | 0,8-1,2 | 75 | 320 | 0,8 |
| 3 | RB-398 | 4-68 | 0,8-1,5 | 45 | 280 | 0,8 |

To know the amount of wire required, it is necessary to know its weight and its length in 1 kilogram. This is set out in Table 2.

**Table 2**

| Series | Wire diameter (mm) | The weight of 1m wire (kg) | The length of 1 kg wire (m) |
|---|---|---|---|
| 1 | 0,6 | 0,002 | 450,45 |
| 2 | 0,8 | 0,004 | 253,17 |
| 3 | 1,0 | 0,006 | 162,0 |
| 4 | 1,2 | 0,009 | 112,6 |
| 5 | 1,4 | 0,012 | 82,6 |
| 6 | 1,6 | 0,015 | 65,4 |
| 7 | 1,8 | 0,022 | 50,0 |
| 8 | 2,0 | 0,028 | 40,5 |

In the absence of these indicators, the weight of the falling wire may be calculated as usual.

$$M = q \times S \times L \quad (1)$$

Where: q- density of wire, S - the width of the wire (m2), L - wire length (1 m)

As a result of the research, labor productivity increased by 10 times compared to the work done by the equipment used. It is also mentioned in the technical passport of the welding equipment that it can be used instead of 10 workers. This indicates that all interruptions that may arise during the execution of the armature work are eliminated altogether. It is clear from the above mentioned that, while using monolithic reinforced concrete, automation of reinforcing work will reduce labor costs, material consumption, product cost and construction time, and the efficiency of the technology will increase.

## 4 Research and Calculations

Techniques of concrete works were also studied during the construction of a high-rise monolith concrete constructions built in Baku and Sumgayit. In this case, the efficiency of the machine-mechanisms used in the transportation, transportation and conveying of concrete was considered. The majority of concrete works carried out by observation have been reported to be carried out by distributors with concrete pumps. Investigation of concrete pumping by concrete through concrete has been carried out by a number of scientists. It has been determined that the cement-sand-gravel mixture, which forms the flow of concrete through the concrete pumps via concrete through concrete. Also, the amount of air contained in the concrete plays a role in the transfer of the solution [4,5]. Thus, when it is required to have 1-2% air with inertial pressure, it will reach up to 30% in concrete. In order to increase the distance of the concrete, it is necessary to reduce the motion of the concrete mixture at the expense of the maximum velocity of the concrete mixing and the loss of the resistance of the concrete in the tube [6].

Our country uses concrete pumps, which are a manufacturer of many countries. These concrete pumps are used by construction companies in many cases. Use of concrete pumps is selected depending on the purpose of use. They differ from each other by their technical parameters. Using concrete pumps, both electric and diesel fuel, use only concrete diesel fuel pumps in our country's construction industry. Some of their brands and their characteristics are given in Table 3.

**Table 3**

| Series | Technical specifications | The brand of concrete pumps | | | |
|---|---|---|---|---|---|
| | | putzmeister bsa 1408 e | putzmeister bsa 1407 d | sany hbt 60 e | sany hbt 80 d |
| 1 | Productivity-m3/hr | 79/53 | 71/47 | 60/37 | 85/50 |
| 2 | Transmission pressure - bar | 71/106 | 71/106 | 78/130 | 100/180 |
| 3 | Transmission distance to height | 100 | 100 | 200 | 320 |
| 4 | Transmission distance to length | 250 | 250 | 700 | 1000 |

As can be seen from the table, there are concrete pumps with different technical parameters, which can be successfully applied in the raising of the efficiency of the construction of high-rise monolithic reinforced-concrete buildings.




**Fig. 2:** Putzmeister BSA 1407 D concrete pumps

Studies have shown that, with the introduction of Putzmeister BSA 1407 D concrete pumps in high-rise monolithic iron frame buildings, labor costs are falling compared to labor costs as set out in norms and rules. The cost of $1m^3$ concrete works is 3 times lower. Compared to the floors, the labor cost per 1 $m^3$ concrete is given in Figure 3

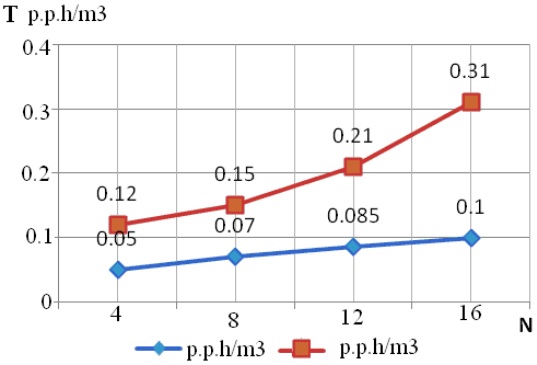



**Fig.3:** Work schedule (T) of $1m^3$ concrete, depending on the number of floors (N)

It is clear from the graph that the total pumping time for the concrete pumping process from 4 to 16 floors is shortened to 2.5 - 4.0 months. Thus, it seems that monolithic reinforced concrete structures are used for automation of concrete work, labor costs, product cost and construction.

## 5 Conclusion

1.Studies carried out in high-rise monolithic buildings in Baku and Sumgayit show that automation of hand-held works enhances technological efficiency.

2.As a result of the studies, it was determined that labor productivity at the expense of automation of reinforcement in monolithic reinforced concrete works increased by 10 times, the total work capacity of concrete works by concrete pump decreased by 4 times and the value of $1m^3$ concrete fell 3 times.

3.Thus, it seems that the automation of works during the reinforcement of monolithic reinforced concrete constructions will reduce labor costs, material consumption, product cost and

construction time, and the efficiency of the technology will increase.

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