Enhancing the efficiency of rebar use in reinforced concrete products’ manufacturing

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Abstract. The article analyzes the state of rebar use in the conditions of construction enterprises of the Republic of Kazakhstan (RK). As a result of the research, it was found that today the domestic industry of construction materials is able to satisfy just a part of the needs of the Republic of Kazakhstan’s construction complex, and as a result, a significant share of the market is occupied by imported products, preventing a shortage of virtually all types of construction materials. The current situation has a negative impact on the prime cost of construction products’ manufacturing. It was also established that there is a high consumption of rebar for wastes, which exceeds the standards defined by State Standard and is about 2%. The consumption of rebar in this ratio also leads to an increase in the prime cost of reinforced concrete products’ manufacturing. For the effective use of reinforcing bars, which are the main components in reinforced concrete products’ manufacturing, it is proposed to separately use wastes of reinforcing bars, rods and wires to manufacture certain types of reinforced concrete products.

1. Introduction
A major component of the modern economy of any country is the industry of construction materials, products and structures. Being the main material base for construction, it significantly influences growth rates in other sectors of the economy and the social condition of society as a whole. The modern construction of various objects is due to the rapid growth of population, its needs and objective desires to coexist in the modern world. Construction has a global impact on the development of many industries such as metallurgy, mining, transportation of construction materials, production of construction equipment and materials, which undoubtedly gives a great economic effect and provides millions of jobs worldwide. Also, the need for construction is driven by an important effect, i.e., the construction of modern shopping centers, health centers and comfortable housing for the convenience, recreation and health of people [1,2].

2. Main part
Reinforced concrete products (RCP) are the main construction materials and enjoy the deserved attention of scientists and civil engineers all over the world [3]. Figure 1 shows pictures of some reinforced concrete products.
Reinforced concrete products’ manufacturing enables to obtain products of any shape and size, both in factory environment and at the site of objects construction. Efforts to construct structures made of reinforced concrete is significantly lower than to build similar structures from other construction materials. Also, the time to construct objects has been significantly reduced. Due to its structure, concrete remarkably resists moisture impact, temperature changes, aggressive environment impacts such as strong acids, alkalis, etc. These properties enable to use reinforced concrete products to manufacture open structures, constructions exposed to constant moisture.

Reinforced concrete is an excellent material, withstanding dynamic and static loads without destruction. This property is used when roadbeds are laid, using road slabs, and when bridges’ spans are made. High seismic resistance and excellent ability to work under compression enables to use reinforced concrete as piles, arches of tunnels’ overlaps. The nomenclature of reinforced concrete products is diverse. These are parts of foundations, walls, overlaps, beams, etc. One of the main elements of reinforced concrete products is rebar [3,4].

In factory production, the share of rebar accounts for about 20% of the prime cost of reinforced concrete products, therefore organization issues of rebar works at precast reinforced concrete plants are the most important both technically and economically.

Figure 2 shows the classification of rebars by types [4,5].
By functional purpose rebar can be divided into the working and structural (distributional) and for installation. The main one is the working reinforcement designed to withstand tensile and sometimes compressive forces. The purpose of structural reinforcement is primarily to ensure the integrity of a structure that is taken into account during strength calculation (for example, structural transverse reinforcement increases the adhesion of concrete with longitudinal working reinforcement, prevents longitudinal compressed rods from buckling and serves as a coupling element of stretched and compressed areas of sections), and also, in the distribution of the action of concentrated forces or shock load on a large area and in taking over (to prevent cracks formation in concrete) temperature and shrink stresses [5].

Assembling reinforcement have no direct static value. It is necessary to create a rigid (and, therefore, transportable) frame from working and structural rods. Working and structural reinforcement at the same time can perform installation functions. For reinforcement of reinforced concrete structures, reinforcing steel must be used that meets requirements of relevant state standards and specifications. Depending on mechanical properties rebar is divided into the following types and classes [6]. Figure 3 shows the classification of reinforcing steel.
thermally and thermomechanically strengthened - periodic profile of classes Ат-IIIC, Ат-IV, Ат-IVC, AT-IVK, AT-V, AT-VK, AT-VCK, AT-VI, AT-VIK и AT-VII;
• hard-drawn - periodic profile of a class А-IIIб (with stretching and stresses control or with only stretching control),
• Wire reinforcement [6,7,8,9];
• cold-drawn wire reinforcement - ordinary periodic profile of a class Бп-I; high-tensile plain class B-II; high-tensile periodic profile of a class Бп-II;
• prestressing strand - spiral seven-wire class К-7 and nineteen-wire class К-19.

It should be noted that in the previous design standards plain cold-drawn wire of B-II a class was provided. For embedded items and junction plates rolled carbon steel of ordinary quality is used.

Rebar grids and frames are produced in a reinforcement workshop equipped with cutting, bending and welding machines.

The manufacturing process is based on the principle of a single technological flow, from the preparation of reinforcing steel to the production of a finished product. Rebar grids and frames are manufactured in accordance with the working drawings, which indicate the length and diameter of rods, their number, the distance between them, the place of welding of embedded parts and the location of installation hinges. During frameworks installation and unfastening in the form, high accuracy is needed, since the size of a protective layer of concrete in a product depends on it, otherwise corrosion of reinforcing steel may occur.

Bar reinforcing steel with a diameter of up to 10 mm is delivered to a factory in coils, and with a diameter of 10 mm or more in bars with a length of 6 ÷ 12 m or measuring length specified in orders.

Figure 4 shows pictures of bar reinforcement.

Reinforcing wire is delivered in coils, and each coil consists of one piece of wire. Rebar manufacturing consists of the following steps: preparation of wire and rod steel, cleaning, straightening, cutting, splicing, bending; assembling steel rods in the form of flat grids and frames; manufacture of bulk reinforcement frames, including welding of installation hinges, embedded parts, clamps.

Preparation of rebar arriving at a factory in coils consists in their unwinding, straightening, cleaning and cutting into separate rods of a given length. Straightening and cutting of reinforcing steel is carried out on a straightening machine.

Today, the domestic industry of construction materials is able to satisfy just a part of the needs of the Republic of Kazakhstan’s construction complex, and as a result, a significant share of the market is occupied by imported products, preventing a shortage of virtually all types of construction materials.

Despite the fact that in recent years, the production of ceramic tiles, plastic pipes, metal tiles, joinery made of plastic, dry mixes and other products appeared in Kazakhstan, almost all products of the construction materials industry of Kazakhstan are not competitive on a foreign market.

Another one of the most important objectives of the modern construction industry is the development and introduction of resource-saving technologies, which provide for the wide use of industrial waste and
local natural materials, enabling to rationally use raw materials and fuel and energy resources. The optimal solution of the problem is to develop and introduce low-waste technologies into production, which is undoubtedly relevant.

The results of the research [10,11,12,13,14,15,16] conducted in the conditions of construction manufactures of the Republic of Kazakhstan, in particular in the conditions of LLP “Paurbeton” (Prishakhtinsk city), LLP “NORD Prom NS” (Temirtau city), LLP “ZBI-5” (Aktas city), JSC “Remstroytekhnika” (Almaty city), LLP “Temirbeton-1” (Almaty city), showed that depending on the organization of production and on the productive capacity of reinforced concrete products manufacturing, waste make up about 2% of reinforcing steel.

Figure 5 shows rebar waste in the conditions of construction enterprises of the Republic of Kazakhstan.

![Figure 5](image1.png)

**Figure 5.** Rebar waste in the conditions of construction enterprises of the Republic of Kazakhstan. a,b – in the conditions of LLP “ZBI-5”; c,d,e - in the conditions of JSC “Remstroytekhnika”; e - in the conditions of LLP “Temirbeton-1”; I,II,III,VI,V,VI – zoomed.

Figure 6 shows rebar waste at a scrap yard.
Conducted researches in the conditions of the given enterprises have shown that up to 2% of the used rebar is spent on waste and scrapped.

Figure 7 shows bar charts of construction enterprises’ productive capacity and the percentage ratio of rebar consumption to waste. The bar chart shows (see figure 7 a), that the productive capacity of the given construction enterprises over three years is 774 th.t. At the same time, the consumption of rebar on waste is 1.7-1.9%, i.e. 13.2 - 14.7 thousand tons (see figure 7 b). Preliminary calculations showed a high efficiency of waste use in the manufacture of frames for non-critical reinforced concrete products such as fencing walls, wells, lintels, etc. Since the scrapping of rebar waste along with the low cost of metal, is also followed by additional costs, such as loading, transportation and unloading.

To implement the effective use of reinforcing bars, rods and wires wastes to manufacture reinforced concrete products, it is necessary to solve the following main objectives:

- development of a resource-saving effective method of connecting dimensional wastes of reinforcing bars, rods and wires in the conditions of construction enterprises;
- finding reinforced concrete products and building structures for the effective use of rods made from wastes of homogeneous and heterogeneous, non-dimensional rebars, rods and wires;
- research, development and manufacture of a special device for the implementation of the welding method of connecting non-dimensional rebar wastes in the conditions of construction enterprises;
• organization and carrying out tests (for breaking, tensile, etc.) of reinforcing bars made of homogeneous and heterogeneous, non-dimensional reinforcement bars, rods and wires for compliance with the requirements of CSaR and State Standart.

It should be noted that rebar and rod wastes are also found in other mechanical engineering industries and the solution of these problems may lead to the effective use of rebar and rod wastes not only by construction enterprises. And in the future it is possible to create a separate production to manufacture reinforcing bar rods from wastes for certain types of reinforced concrete products.

3. Conclusion
The research of the current state of Kazakhstan’s construction industry has shown that the domestic industry of construction materials (in particular, reinforcing bars) is currently able to meet only part of the needs of Kazakhstan’s construction industry, and as a result, imported products occupy a significant market share. This current situation has a negative impact on the prime cost of construction products manufacturing.

The results of the research in the conditions of construction enterprises of the Republic of Kazakhstan have shown that there is a high consumption of rebar on wastes, which exceeds the standards specified by State Standart and is about 2%. The consumption of rebars in this ratio leads to an increase in the prime cost of reinforced concrete products’ manufacturing, which plays an important role in the current state of the construction industry of Kazakhstan.

To effectively use reinforcing bars, which are the main components in reinforced concrete products manufacturing, it is proposed to create a separate production to use reinforcing bars, rods and wires wastes to manufacture certain types of reinforced concrete products.

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