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APPLICATION PROSPECTS OF THREADED JOINT OF ARMATURE

Purpose. One of the main technological operations of buildings construction on the basis of monolithic frame systems is the production of mesh reinforcement. The current interest is the new ways specification of advanced bonding armature techniques without reliability weakness and design of the building in whole, as well as the finding of use prospects of screw-threaded joint of armature as the most technological and economic method of re-bars joints. **Methodology.** Advantages and disadvantages analysis of existing rebar compound technologies was implemented by couplings of different types and constructions. The most promising vertical constructions for the vertical bars joints in frameworks were determined. **Findings.** Researches of existing technologies of rebar joints by the couplings of different construction were carried out. The installation method of mesh reinforcement of vertical structural elements with the use of the special catching devices was developed. It allows considerably accelerating installation of mesh reinforcement. **Originality.** Regularity of labor intensiveness change of mesh reinforcement installation of columns at armature joint in vertical position by threaded couplings with the help of catching devices using special construction was determined. This allows substantially reducing the labor expenditures during installation of these elements. Dependency of labor intensiveness and cost of lap welding armature joints, by tub-seam welding and by thread coupling depending on its diameter was designated. Regularity of labor intensiveness changes of installation at armature joints by different methods taking into account preparatory works was defined. **Practical value.** The analysis of mechanical armature joints techniques was conducted. It will allow selecting methods of armature joints to increase the speed of construction works more economical and effective.

Keywords: armature; mechanical joint; cylinder thread; cone thread; coupling, that catches the device; installation

Introduction

Using statistical analysis of buildings and structures in Ukraine it is found that one of the structural types of construction projects are monolithic frame systems.

One of the main technological operations constructions of these buildings is the production of mesh reinforcement. Modern production techniques provide the rebar joint by welding or lap welding. With the continuous increase the cost of armature and energy resources, increasing the number of storeys in buildings it is necessary to define new and promising ways of armature joints without the reliability reduction of structures and buildings in general, as well as to develop the technology of joint execution in construction site conditions.

Problem statement. In modern construction in monolithic reinforced concrete structures 2 ways are used for armature joint: lap-joint and welding of bars. New standards SBN V.2.6-98-2009 [1] and SSTU B V.2.6-156-2010 [2] entered into force and lap length increased up to 1.5–2 times., it makes this type of joint uneconomical for armature of large diameters used in the vertical elements. Welded joint, especially tub-seam welding that appropriate for large diameters armature of vertical elements is energy intensive and requires a lot of labor costs of highly skilled workers. In addition, quality control of this joint type is a complex and expensive procedure. Another shortcoming of armature welded joints is the inability to use heat-strengthened armature of high class. This leads to the increase of element section and rise in the cost of construction [9, 14–16]. One of the solution variants concerning this problem is using a threaded armature joint. But we need to develop an effective technology to ensure the installation speed and quality of work performance.

Analysis of recent research and identification of unresolved issues. Many studies are devoted to the problems of new armature joint types. In particular, they are as follows:

1. Armature joint with crimp couplings. The authors [4] propose the following technology: cyl-

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inder coupling is put on the armature bar so that half of it will close the butt-place in the specified bar. After that, the coupling part, put on the bar, is tighten using a hydraulic press. These operations are performed sequentially for all bars of structure. Next step: a new framework is installed so that the bars get in to the set couplings. Thereafter couplings are crimped sequentially in the top of the newly mounted framework.

Advantages of this method are:

– the use possibility of fitting for the armature of any class, including heat-strengthened one;

– butts finish of bars is not critical;

– high speed of elements installation;

– authors have declared high reliability of a joint;

– quality control for each butt is carried out with the pressure gauge check during reduction performance. Parameters are logged.

The disadvantages of this are as follows:

– joint is non-detachable. That is, in case of installation error it is necessary to destroy the joint elements with the possibility of armature damage;

– during crimp of couplings there is a need to use a hydraulic press or other crimp device. Accordingly press jaws or gripping devices have to pass between adjacent bars freely. This imposes design complexities:

– the minimum distance between the bars should be limited, it often interferes with the optimal selection of the diameter and the number of bars in the structure;

– it is necessary to use additional expensive equipment (hydraulic press);

2. Armature joints with threaded couplings. Authors [3, 6, 8, 10–13] have proposed the following technology: before placing in to the structure both bars, which will be connected afterwards, are subjected to special treatment: the bars ends are trimmed, and then they rolled thread using a special machine. Joint of bars is operated as follows: a female coupling is screwed on one of the bars with a torque wrench, and then the second bar is inserted and screwed in accordance with the specified in the technical documentation force.

The advantages of this method are as follows:

– the use possibility of a joint for armature of any class;

– high speed of elements installation;

– authors have declared high reliability of a joint;

– setting accuracy of the bars in to the vertical position of the project is not critical, since while screwing the coupling, displacement of bars on height and more accurate positioning occur (using couplings with many-sided thread). In another option, the bar is lowered until it contacts the other one, whereupon the coupling, winding on it, does not change the distance between the bars (in case with positional couplings, or using locknuts);

– thread use increases the contact area surface in several times, it reduces the overall dimensions of the butt, and thus use such joint in more complex structural elements;

– the joint is detachable. In the case of installation errors or other situations one can spin couplings and dismantle the joint for 1–2 minutes. At the same time the coupling can be operated as secondary;

– it is easy to control proper joint operation using the number of threads, which remains outside the coupling and the force of coupling tightening mounted on the torque wrench;

– works on the machines are operated before armature installation at the stage of its manufacture. This allows you to perform all the preparatory work in a convenient location concurrently with the implementation of the remaining construction and installation works, which are carried out on the critical path. The framework is installed very quickly – it needs 30–60 seconds for tightening of one coupling, the tool is only a torque wrench;

– use of threaded armature joint technology allows performing operations by workers of lower qualifications, compared with tub-seam welding.

The disadvantages of this method are as follows:

– it is necessary to use additional expensive equipment (cutting machine, thread rolling machine);

– processing accuracy of bar butt is critically important (for thread rolling one needs clean cut that perpendicular to the longitudinal axis of the bar) and the bar length compliance (the butts of the bars in the fabricated part must be coplanar);

– difficulties with framework bars mounting may arise in the conditions of quick installation, that is being installed in to the couplings, fixed on the bars of structures. That is why one needs additional research to accelerate and simplify the installation process.

There is a variant of a threaded armature joint with tapered thread, both on the bars and couplings. But such thread imposes restrictions on the installation methods (in particular, it is impossible to screw the coupling with the lock nut on the 1st bar, after that to screw on the 2nd. It is possible to use only one variant with position coupling), because the use is not reasonable.

Many questions should be solved:

1) Determining the most technologically advanced and cost-effective types of mechanical armature joints with the possibility of heat-strengthened armature;

2) Development an effective technology to ensure the speed of installation and quality of operations.

Purpose

Determining the use prospects of a threaded armature joints as the most technologically advanced and cost-effective method of armature rebar joints. Comparative analysis of the existing armature joints methods on a construction site. Determination of the most efficient, cost-effective and technologically advanced methods of armature joints among existing ones. Determination and solving problems related to the armature joints on the construction site.

Methodology

Advantages and disadvantages analysis of the existing rebar compound technologies using couplings of different types and constructions. Determination the most promising technologies for the vertical bars connection in the frames of the vertical structures.

Findings

The threaded joint of armature using the couplings with cylindrical thread seems to be the most technological. Currently at the market of connecting elements are presented the following types of the couplings:

1) Standard connecting couplings. The connection technology is as follows: Preliminary the thread is rolled on the bars, which are being connected. Then, the coupling is screwed onto the bar so that the bar takes a half of its length. Thereafter, the second bar is screwed into a coupling from the free side to the necessary effort using the torque wrench. Such couplings are the simplest and cheapest to manufacture. But they can be used only in cases where at least one of the bars can freely rotate.

2) The adaptor connecting couplings that joint the bars of different diameters. Joint technology is the same as that of the standard couplings.

3) Position couplings with the multidirectional thread. On the bars, which are being connected, the right and the left-hand thread is rolled. When connecting the bars the coupling is put on the both bars at the same time, and then it is screwed, pulling the bars together. The same number of windings on different sides ensures precise and uniform connection bars. The use of such couplings is complicated by the need of rolling the different types of threads on the bars.

4) Position connecting couplings with unidirectional thread. When installing the framework the both parts are screwed onto the corresponding bars simultaneously or in succession. Such couplings can be used for any joints without limitations, but they are rather expensive due to the manufacturing complexity.

It was developed a method using the standard connecting couplings for positional joints where none of the bars, which are being connected can not rotate. It consists in the fact that initially the thread of greater length is rolled on the bars. The length of the rolled thread should make it possible to screw the locknut and coupling on the each bar completely. First on the connection bar is screwed the locknut and then the connecting coupling, completely. After that, the second bar is lowering on the coupling face until it touches the first bar. Thereafter, the coupling is screwed onto the second bar twisting from the first one. When the coupling is in the middle position and the both bars are evenly screwed into the coupling, the locknut clamps it, ensuring its spatial position. At this the twisting effort of the locknut should be in accordance to the technical documentation for the technology of the armature connection provided by the supplier.

The most appropriate solution to provide the speed and adaptability of installation is the use of special catching devices [7, 8]. One of the variants of such device is shown in Fig. 1.

The operation principle is as follows. Catching device (1) consists of two halves connected by the articulated joint on the one side and the closures (2) on the other side. The connecting coupling (3) on which the device is put, is being screwed on the connecting bar (4).

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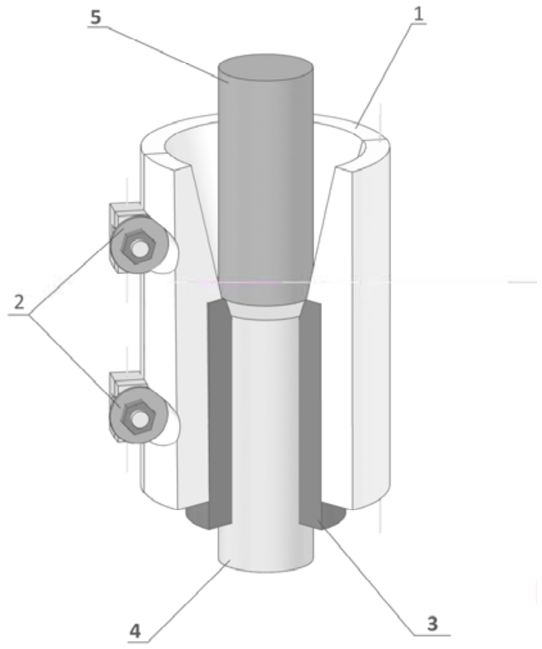

Fig. 1. Catching device

The bar of the framework (5), which is being installed at the lowering of the framework should fall into the accepting bowl at the top of the device (1). After that it slides down under the action of gravity until it reaches the coupling (3), its axis is a continuation of the axis of the lower bar (4). Once all the bars are in the design position, the closures (2) are being untwisted and unlocked and the catching devices (1) are removed. Another possible variant to facilitate the installation of elements is to use a special jig plate that will hold the bars, providing the design distance between them. Such jig plate should be manufactured and installed into the column framework at the stage of manufacture. But the use of such jig plate will complicate the framework production; it will not compensate possible deviations of the bar lengths during production, as well as it will lead to the waste of armature. So, this option requires additional technological and economic research.

Using the technology of threaded joint of the armature will solve another important problem – reducing the amount of waste products of armature during manufacture of the mesh reinforcement. During the manufacturing process of mesh reinforcement there is a lot of waste – residues of the bars up to 2 m length, which is almost impossible to apply in the future work. It is connected with the inability to determine the optimal bar cutting, delivery to the construction yard of the bars of different lengths, and many other factors. The estimated values of armature residues depending on the diameter are shown in the Table 1.

Table 1

Estimated values for residues valves depending on the diameter

Diameter, mm	Residue value, %
6–12 mm	0–1.5%
14–20 mm	1.5–7%
22–32 mm	3.5–12%
36–40 mm	15–33%

These residues accrue to the bars of such length that it is practically impossible to use them in the construction process when connecting using the standard method. Shortening of the column framework for the purpose of rational cutting of the rebar increases the butt number, which leads to high costs of labor and time, as well as slows down the construction process.

Using a threaded joint of armature creates a technology of continuous bar. The technology is as follows. When cutting the standard 12-meter rebar the residues using the threaded coupling are attached to the new bars. After that comes cutting for the set length and manufacture of the frames. As compared to the combination of residues into the bars of the set length the following advantages are obtained:

– 1 bar up to 12 m length contains no more than 1–2 butts. This makes it possible to distribute the butts evenly along the construction length and ensure its higher reliability;

– the possible difference in time for bars preparation from the armature residues and of the logs is compensated. It allows one to design more efficient process for the armature preparation.

A disadvantage of this technology is only production complicating. It is necessary the careful measuring and cutting the armature to obtain the desired length of the bars. But these works are carried out in parallel with the main process, without affecting the duration of the works, which are carried out in the critical way.

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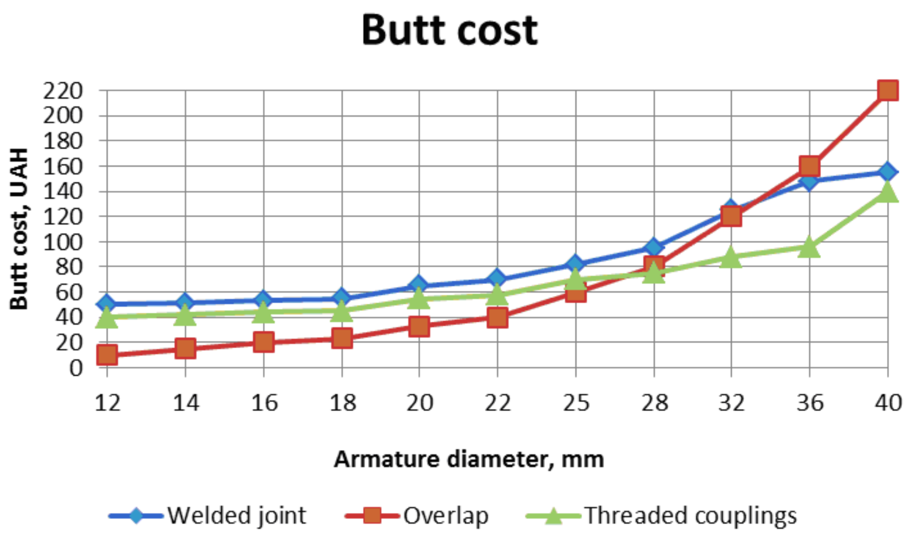

Fig. 2. Costs for butt armature of different types

The Fig. 2 shows the relative values of one butt for different types of armature junction. The calculations were performed for the reinforcement of the brand A400S. The position couplings BARTEK produced by the corporation DEXTRA were taken as the threaded couplings. For the armature of A500 class the tub-seam welding is not applied. And the cost of overlap will increase due to the increased cost of the armature itself. Cost of works taking into account the wages and material cost as of 01/01/2014 were taken according to the software package AVK-5 version 2.12.2 (recommended for use by all participants in the building, the letter of the Ministry of Regional Construction of Ukraine no. 9/10-1306 from 31.12.2008). Time to install the butt by the threaded couplings was taken on the basis of study of the video materials presented by the company DEXTRA.

Cost of the threaded couplings was taken on the basis of the catalog of DEXTRA Company excluding depreciation of equipment to cut the armatures and rolling of the thread. The following prices for materials and resources were taken into account:

– armature A400S and A500 – cost 8 000 UAH/tn;

– tubs for welding – 16 UAH/kg;

– electrodes for welding, diameter 4 mm, mark E50 – 12.85 UAH/kg;

– costs for 1 person/hr for the worker constructor (welder) of the 6 category – 28 UAH;

– costs of 1 person/hr for the worker constructor of the average category 4.6 – 22.76 UAH; (the calculation of the cost of the workers labor include the average monthly salary of 3 400 UAH for the category 3.8).

The Fig. 2 shows that the lap joint is the most economical for the armature diameter up to 25 mm. But at this the area of the framework reinforcement in the junction area is doubled that leads to complications when laying the concrete mix and overreinforcing of the element.

In addition, during overlap the armature is not connected coaxially, and this leads to the appearance of unaccounted calculations of eccentricities and eccentric work of rebars.

The Fig. 3 presents the comparative time expenditures for rebar junctions of different types provided the work of 1employee. Connection of armature by the threaded coupling allows one to perform the prior operations in parallel with the basic construction and installation operations that are performed using the critical path. As a result, the speed of direct installation of the mesh reinforcement approaches to the speed of installation with the armature overlap. It should also be noted that for connection by the threaded couplings are needed the workers of much lower qualification than, for example, for connection by tub-seam welding.

Change regularity of installation labor input of the mesh reinforcement columns under armature joints in a vertical position by the threaded couplings with the help of special designed catcher was determined. This will significantly reduce labor costs for installation of these items.

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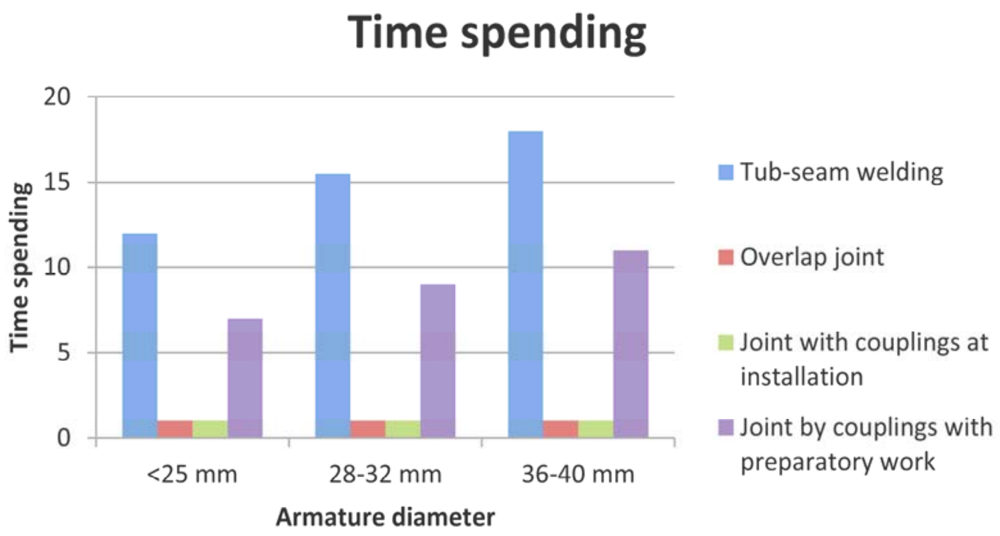

Fig. 3. Average time expenditure for butt installation for different types of joints

The dependence of the labor input and cost of the overlap armature joints using tube-seam welding and by means of threaded couplings, depending on its diameter was defined.

Change regularity of the installation labor input of the framework under joint was defined. Fig. 3. Average time spending for the butts system for different types of armature joints by different methods, taking into account the preparatory work was also determined.

Originality and practical value

The installation of the mesh reinforcement columns under armature joints in a vertical position by the threaded couplings with the help of special designed catcher was designed. This will significantly reduce labor costs for installation of these items.

The most economically and technologically advantageous joint methods of mesh reinforcement columns in a vertical position, depending on the diameter and the armature class were determined.

Conclusions

Threaded armature joint with the use of couplings with cylinder thread is the most promising type of armature joint for today. But further research and developments of operation technology are necessary. In particular, it requires the development of a production line for maximum adaptability in the performance of preparatory operations (rebar cutting, trimming, and thread rolling).

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ПЕРСПЕКТИВИ ЗАСТОСУВАННЯ РІЗЬБОВОГО З’ЄДНАННЯ АРМАТУРИ

Мета. Однією з основних технологічних операцій спорудження будівель на основі монолітних каркасних систем є виготовлення арматурних каркасів. Актуальним при цьому є визначення нових перспективних способів з’єднання арматури без зниження надійної конструкції та будівель у цілому. Важливим також є знаходження перспектив використання різьбового з’єднання арматури як найбільш технологічного й економічного способу з’єднання арматурних стрижнів. **Методика.** Аналіз переваг і недоліків існуючих технологій з’єднання арматурних стрижнів здійснювали за допомогою муфт різного типа й конструкцій. Визначались найбільш перспективні для з’єднання вертикальних стрижнів у каркасах вертикальні конструкції. **Результати.** Проведено дослідження існуючих технологій з’єднання арматурних стрижнів за допомогою муфт різної конструкції. Розроблено спосіб монтажу арматурних каркасів вертикальних конструктивних елементів із використанням спеціальних уловлюючих пристроїв, що дозволяє значно прискорити монтаж каркасів. **Наукова новизна.** Визначено закономірність зміни трудомісткості монтажу арматурного каркаса колон при з’єднанні арматури у вертикальному положенні різьбовими муфтами за допомогою уловлювача спеціальної конструкції, що дозволяє істотно понизити витрати праці на монтаж цих елементів. Визначено залежність трудомісткості та вартості з’єднань арматури внапуск, ванношовною зваркою й за допомогою різьбових муфт залежно від її діаметру. Визначено закономірність зміни трудомісткості монтажу каркаса при з’єднанні арматури різними методами з урахуванням підготовчих робіт. **Практична значимість.** Проведено аналіз механічних способів

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з'єднання арматури, визначено способи підвищення швидкості монтажу арматурного каркаса при використанні різьбового з'єднання арматури муфтами з циліндровим різьбленням.

Ключові слова: арматура; механічне з'єднання; циліндрова різьба; конусна різьба; муфта, що уловлює пристрій; монтаж

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ПЕРСПЕКТИВЫ ПРИМЕНЕНИЯ РЕЗЬБОВОГО СОЕДИНЕНИЯ АРМАТУРЫ

Цель. Одной из основных технологических операций возведения зданий на основе монолитных каркасных систем является изготовление арматурных каркасов. Актуальным является определение новых перспективных способов соединения арматуры без снижения надежности конструкции и здания в целом. Важным также является нахождение перспектив использования резьбового соединения арматуры как наиболее технологичного и экономичного способа соединения арматурных стержней. **Методика.** Анализ преимуществ и недостатков существующих технологий соединения арматурных стержней осуществлялся с помощью муфт различного типа и конструкций. Определялись наиболее перспективные для соединения вертикальных стержней в каркасах вертикальные конструкции. **Результаты.** Проведены исследования существующих технологий соединения арматурных стержней с помощью муфт различной конструкции. Разработан способ монтажа арматурных каркасов вертикальных конструктивных элементов с использованием специальных улавливающих устройств, что позволяет значительно ускорить монтаж каркасов. **Научная новизна.** Определена закономерность изменения трудо-емкости монтажа арматурного каркаса колонн при соединении арматуры в вертикальном положении резьбо-выми муфтами с помощью улавливателя специальной конструкции, что позволяет существенно снизить затраты труда на монтаже этих элементов. Определена зависимость трудоемкости и стоимости соединений армату-ры внахлестку, ванношовной сваркой и с помощью резьбовых муфт в зависимости от ее диаметра. Определена закономерность изменения трудоемкости монтажа каркаса при соединении арматуры разными методами с уче-том подготовительных работ. **Практическая значимость.** Проведен анализ механических способов соеди-нения арматуры, что позволит более экономично и эффективно подбирать способы соединения арматуры для повышения скорости выполнения строительных работ.

Ключевые слова: арматура; механическое соединение; цилиндрическая резьба; конусная резьба; муфта, улавливающее устройство; монтаж

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