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## **DETERMINATION AND RANGING OF ORGANIZATIONAL AND TECHNOLOGICAL FACTORS THAT DEFINE THE RATIONAL DECISIONS OF RE-BARS CONNECTION**

**Purpose.** The paper proposes: 1) determination and formulation of factors that influence the choice of rational method for joining re-bars of vertical support members of reinforced concrete frame; 2) determination of factor parameters; 3) ranging of factors by the expert evaluation (Delphi) method. **Methodology.** In order to achieve research objectives, it is necessary to carry out analysis of existent rebar connection methods, determination of factors and parameter variation limits for each of the methods. Performing factor ranking by the expert evaluation method. **Findings.** The results of the questioning materials of 14 experts in the area of monolithic construction allowed setting the following: when choosing the rational re-bars connections, the most significant values are the factors that define the time parameters: possibility of carcassing, time of joining the re-bars, length of rebar cage, prior operation run time, operation time of main lifting equipment. Herewith the factors that define the rebar cage parameters have a direct relation to the work performance time, as they determine the amount of bar connections in the course of building erection over wide range. Economic factors – rebar connection cost and quality control cost – have the less value. It is obvious that in the conditions of considerable construction expenses it is advantageous for an investor to increase the rebar joining cost for the work growth rate. Structural and technological factors have the least value: origin of eccentric load transmission between re-bars, possibility of use of the thermally work-hardened re-bars of A500 and higher grades, work category for implementation of works, necessity to use the scaffold and appurtenances for re-enforcement of constructions. The reason is analogical: a contractor is ready to go to complication of technology with the purpose of reduction of the facility erection terms. As the calculated Pearson's matching criterion  $\chi^2 = 47.24$  is higher than the tabular one (22.36203), then the obtained concordance coefficient  $W=0.26$  is not casual value, and that is why the obtained results make sense and can be used in further researches. **Originality.** The author obtained factors that influence the choice of the rational method for re-bars connection the most. **Practical value.** Ranging of factors will allow objective approaching to the problem of choice of re-bars connection method, optimizing the labour and material costs, and also reducing the construction time.

*Keywords:* re-bars; connection; expert evaluation; rank; factor; ranking; concordance coefficient

### **Introduction**

Statistical analysis of buildings and structures in Ukraine found that one of the constructive types of engineering development is monolithic frame systems.

One of the main technological operations of the erection of such buildings is the production of rebar cages. Modern technological methods involve joining reinforcing bars of the cages by welding or lapping. Recently there have been spread mechanical connections of reinforcing bars with the help of

threaded or crimp clutches. The presence of such a large choice of methods complicates the task of finding a rational method of joining re-bars for a particular facility, leads to rise in the construction cost and slows down the construction of the reinforced concrete frame of the building.

### **Problem statement**

In the modern construction in the territory of Ukraine, various types and methods of connections are used to connect the re-bars. The use of this or that method of connection is usually the preroga-

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tive of the contractor and depends only on the equipment available to the customer. It is possible to change the connection method depending on the design requirements of regulatory documents, for example, using a lap joint in areas with seismic activity. When trying to determine the rational way of connecting, a specialist faces a number of factors that influence his choice, but it is difficult to evaluate the factors by significance. The inability to identify a more significant factor complicates the assessment, which results in a waste of resources and shorter construction time. It is necessary to assess the main factors and perform the ranking.

#### Analysis of recent research and identification of unsolved problems.

The method of re-bars connection is an important parameter in the construction of the building frame, but the method of choosing a rational method of connection is practically not covered in the literature. The regulatory documents [2, 3] contain only the list of admissible methods of re-bars connection – lapping, welding, mechanical connections. But there is no method of choosing between them. Traditionally, the designer chooses a necessary connection way based on the design experience, often also taking into account the cost of the connection or the speed of its execution. However, quality control is rarely taken into account, in particular its complexity for welded joints [4-6]. Due to the wide spread of various types of joints, designers and builders often do not take into account the mechanical methods of joining. But their use often leads to a significant acceleration of the process of erecting the building and reducing its cost. Thus, it is necessary to have a methodology for a comprehensive assessment of existing ways of rebar joining and selecting the most rational one for a particular project.

#### Purpose

To determine the factors that influence the choice of the rational method for re-bars connection the most. To perform factor ranking by the expert evaluation method.

#### Methodology

Analysis of advantages and disadvantages of the existing connection technology for reinforcing bars. Determination of key factors peculiar for a particular re-bars connection method. Performing factor ranking by the expert evaluation method.

#### Findings

There were selected 14 factors influencing the choice of a rational way of rebar joining. The names and rationales for each of them are presented below.

1. The length of the rebar cage is one of the most important parameters of the erection technology of vertical supporting structures [8, 9]. The cage length influences the total number of bar connections over the building height. The minimum height of the cage is 3 m (when connecting the re-bars with bath welding, and also when connecting with threaded or crimped clutches with reinforcement by individual bars). The maximum length of the cage can be 9 m when reinforcing with frames with a sufficient diameter of the longitudinal bars (32 mm and above).

2. The connection time of the reinforcing bars makes for the total time required to perform the connections. Since the re-bars connection is carried out on the mounting horizon, the connection time determines the early start of the next erection of formwork members. The parameter of this factor varies in the interval from 1 min (lap joint, connection by threaded couplings) to 60 min (bath-welded welding for re-bars of 40 mm in diameter).

3. The time for performance of quality control is also a component of the time required to perform the connections and depends on the quality control method and the connection type [7]. For most types of re-bars connections, a combination of several control methods is used, both for each connection and for a sample. Total time for performance of quality control in terms of one bar can be from 1 to 10 minutes.

4. The cost of the re-bars connection includes the cost of consumables (forgings and bath welding electrodes, threaded and crimp clutches for mechanical connections), as well as the cost of energy resources for making connections. The cost of re-bars connection with lap joint includes the re-bars expenditure for overlapping. The numerical

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value of the parameter is from 60 to 220 UAH, depending on the type of connection and the diameter of the re-bars.

5. The cost of the connection quality control is in the range from 6 UAH (lap joint) to 92 UAH (bath welding).

6. The time for the completion of the preparatory operations (including the manufacture of the cage when reinforcing with cages) is one of the most important parameters for determining the labour costs and the timing required for the re-bars of the structures. Since the preparatory operations can be carried out on the reinforcement pad separately from the main construction process, often using a separate lifting mechanism, conducting operations during the preparatory period is an important way to reduce the time required to perform the connections. When reinforcing with individual bars the preparatory operations include only the cutting of the re-bars for a given length and making the clamps, while the cage assembly is made at the stage of performing the connection.

7. The work category for performing the connection determines the necessary qualifications of the workers. The need to reduce the average work category is evident. It lies in the range from 3 to 6; the latter value is indicated for bath welding of the re-bars.

8. The operating time of the main load-lifting mechanism determines the degree of stoppage of other construction processes performed in parallel with the process of reinforcing of vertical support members. One of the most common methods of joining re-bars in Ukraine with bath welding requires about 5-15 minutes of crane operation for each reinforcing bar in the cage. Often it is these time costs that determine the maximum number of welded bars during the work shift.

9. Ability to mount the cage actually reflects the possibility of making major labour-intensive operations at the stage of preparatory work. Reinforcement with pre-assembled cages significantly reduces labour costs directly on the mounting horizon.

10. The possibility of using the re-bars connection method in seismic areas is a key factor in the design phase of a building. Until recently, in the territory of Ukraine in the seismic regions (Crimea), as well as for dynamically loaded structures,

only the lap joint was used, which led to a significant re-arming of the elements, the appearance of eccentricity in the load transfer between the bars and the reduction of the protective layer [11-13].

11. Occurrence of eccentric force transfer between reinforcing bars. Actual for non-axial bar joints (lapping, some types of welding); it leads to the appearance of eccentricities, an increase in the required number of re-bars [10].

12. The possibility of using thermally work-hardened re-bars of A500 and higher grades is actual for the construction of high-rise buildings with 22 floors and higher. Such re-bars cannot be welded, and the use of low grade re-bars leads to an increase in the cross section of the element. When using thermally work-hardened re-bars of large diameters, the lap joint is economically inefficient. It is also necessary to consider the need for joining non-metallic re-bars [1].

13. The possibility of dismantling the rebar cage and reusing the connecting elements becomes an important parameter when the mounted cage is damaged during quality control or at the stage of the formwork installation. The re-bars lap joining, as well as the connection with threaded couplings, allows quickly dismantling the cage, mounting a new one and conducting further work without delaying the main process of erecting a monolithic frame of the building.

14. The need to use scaffolds (reinforcement of vertical supporting members with individual bars) and additional lifting mechanisms (rebar connection with crimp clutches) leads to an increase in labour costs and the time required to carry out work, as well as to the occurrence of dangerous factors associated with longer periods of people's presence at altitude. It is especially important when reinforcing elements located at the edges of the building, in particular for external reinforcing bars.

The ranking of factors will be carried out by the expert assessment method. For the assessment there were selected 14 experts in the field of monolithic construction: scientists, engineers, superintendents and heads of construction organizations. Each specialist received a questionnaire, where 14 factors were indicated. For each factor, the dimensionality and the parameter variation limits were given for better understanding of the factor value. The list of factors and their parameters is given in Table 1.

Table 1

**Factors influencing the choice of rational rebar connection method**

№	Factors	Dimension	Parameter variation limits	Rank
1	Length of rebar cage	m	3 – 9	
2	Rebar connection time	min	1 – 60	
3	Connection quality control time	min	1 – 10	
4	Rebar connection cost	UAH	60 – 220	
5	Connection quality control time	UAH	6 – 92	
6	Execution time for preparatory operations (including the fabrication of the cage)	min	1 – 20	
7	Work category for connection execution		3 – 6	
8	Working time of the main lifting mechanism	min	1 – 30	
9	Possibility of carcassing	–	Yes/No	
10	Possibility of application in seismic regions	–	Yes/No	
11	Occurrence of eccentric load transfer between re-bars	–	Yes/No	
12	Possibility of using thermally work-hardened re-bars of A500 and higher grades	–	Yes/No	
13	Possibility of dismantling the rebar cage and reusing the connecting elements	–	Yes/No	
14	Need to use scaffolds and additional lifting mechanisms for reinforcing the structures	–	Yes/No	

Experts were asked to rank factors by assigning a rank to each factor, where rank 1 has the most significant factor, and rank 14 has the least significant one. In addition, the experts were asked, if necessary, to add factors that, in their opinion, are not available in the table, and to conduct the ranking taking into account the additional factors.

Based on the questionnaire data, a consolidated

ranking matrix was compiled (Table 2). The consolidated ranking matrix includes all 14 factors proposed by experts for the assessment. None of the experts added their own factor, which indicates a complete and universal coverage of the parameters. The ranking matrix with deviations is shown in Table 3.

Table 2

**Consolidated ranking matrix**

№ of sub-item. Experts	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	9	6	8	8	2	5	4	1	3	3	2	1	14	8
2	1	7	3	3	3	6	8	7	4	4	4	4	2	4

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End of table 2

№ of sub-item. Experts	1	2	3	4	5	6	7	8	9	10	11	12	13	14
3	6	10	6	2	10	12	12	5	7	8	7	5	10	3
4	5	8	13	14	9	9	15	3	11	1	8	2	1	5
5	7	14	2	1	8	11	13	10	12	9	9	7	3	6
6	2	9	4	4	4	8	5	6	1	5	13	3	4	9
7	3	13	14	7	11	7	11	4	8	11	14	8	9	14
8	4	11	1	5	5	10	6	9	9	6	1	6	7	7
9	8	5	5	6	6	4	2	2	2	7	3	9	5	1
10	12	3	12	13	12	3	10	13	14	2	10	10	11	11
11	11	1	11	12	13	2	3	8	13	13	6	11	12	2
12	13	2	10	11	7	1	7	12	10	10	5	12	13	10
13	14	4	9	10	14	14	14	14	6	14	12	13	6	13
14	10	12	7	9	1	13	9	11	5	12	11	14	8	12

Table 3

## Matrix of ranks

Factors / Experts	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Rank sum	d	d2
x <sub>1</sub>	9	6	8	8	2	5	3	1	3	3	2	1	14	8	73	-32	1024
x <sub>2</sub>	1	7	3	3	3	6	7	7	4	4	4	4	2	4	59	-46	2116
x <sub>3</sub>	6	10	6	2	10	12	11	5	7	8	7	5	10	3	102	-3	9
x <sub>4</sub>	5	8	13	14	9	9	14	3	11	1	8	2	1	5	103	-2	4
x <sub>5</sub>	7	14	2	1	8	11	12	10	12	9	9	7	3	6	111	6	36
x <sub>6</sub>	2	9	4	4	4	8	4	6	1	5	13	3	4	9	76	-29	841
x <sub>7</sub>	3	13	14	7	11	7	10	4	8	11	14	8	9	14	133	28	784
x <sub>8</sub>	4	11	1	5	5	10	5	9	9	6	1	6	7	7	86	-19	361
x <sub>9</sub>	8	5	5	6	6	4	1	2	2	7	3	9	5	1	64	-41	1681
x <sub>10</sub>	12	3	12	13	12	3	9	13	14	2	10	10	11	11	135	30	900

Factors / Experts	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Rank sum	d	d2
x <sub>11</sub>	11	1	11	12	13	2	2	8	13	13	6	11	12	2	117	12	144
x <sub>12</sub>	13	2	10	11	7	1	6	12	10	10	5	12	13	10	122	17	289
x <sub>13</sub>	14	4	9	10	14	14	13	14	6	14	12	13	6	13	156	51	2601
x <sub>14</sub>	10	12	7	9	1	13	8	11	5	12	11	14	8	12	133	28	784
Σ	105	105	105	105	105	105	105	105	105	105	105	105	105	105	1470		11574

The sums over the matrix columns are equal to each other and to the checksum; therefore, the matrix is correctly formed.

Next, we place the factors by significance (Table 4).

Table 4

## Location of factors by significance

Factors	Rank sum
x <sub>2</sub>	59
x <sub>9</sub>	64
x <sub>1</sub>	73
x <sub>6</sub>	76
x <sub>8</sub>	86
x <sub>3</sub>	102
x <sub>4</sub>	103
x <sub>5</sub>	111
x <sub>11</sub>	117
x <sub>12</sub>	122
x <sub>7</sub>	133
x <sub>14</sub>	133
x <sub>10</sub>	135
x <sub>13</sub>	156

Now we will assess the average degree of consistency of opinions of all experts. To do this, we

calculate the matching factor using the following formula:

$$W = \frac{12S}{m^2(n^3 - n)},$$

where  $S = 11574$ ,  $n = 14$ ,  $m = 14$ .

$$W = \frac{12 \cdot 11574}{14^2(14^3 - 14)} = 0.26.$$

$W = 0,26$  indicates a weak degree of consistency between the opinions of experts.

Next, we estimate the significance of the matching factor. For this purpose, we calculate the Pearson's matching criterion:

$$x^2 = \frac{12S}{mn(n+1)},$$

$$x^2 = \frac{12 \cdot 11574}{14 \cdot 14(14+1)} = 47.24.$$

The computed  $x^2$  is compared to the tabulated value for the number of degrees of freedom  $K = n - 1 = 14 - 1 = 13$  and for a given significance level  $\alpha = 0.05$ .

Since  $x^2$  is estimated 47.24 more than the tabular one (22.36203), then  $W = 0.26$  is not a random variable, and therefore the obtained results make sense and can be used in further studies.

On the basis of obtaining the rank sum (Table 4), we can calculate the weight indices of the parameters considered. The polling matrix is trans-

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formed into the matrix of transformed ranks according to the formula:

$$s_{ij} = x_{\max} - x_{ij},$$

where  $x_{\max} = 15$ . The matrix of transformed ranks is shown in Table 5.

Table 5

Matrix of transformed ranks

№ of sub-item. Experts	1	2	3	4	5	6	7	8	9	10	11	12	13	14	$\Sigma$	Weight $\lambda$
1	6	9	7	7	13	10	11	14	12	12	13	14	1	7	136	0.0934
2	14	8	12	12	12	9	7	8	11	11	11	11	13	11	150	0.103
3	9	5	9	13	5	3	3	10	8	7	8	10	5	12	107	0.0735
4	10	7	2	1	6	6	0	12	4	14	7	13	14	10	106	0.0728
5	8	1	13	14	7	4	2	5	3	6	6	8	12	9	98	0.0673
6	13	6	11	11	11	7	10	9	14	10	2	12	11	6	133	0.0913
7	12	2	1	8	4	8	4	11	7	4	1	7	6	1	76	0.0522
8	11	4	14	10	10	5	9	6	6	9	14	9	8	8	123	0.0845
9	7	10	10	9	9	11	13	13	13	8	12	6	10	14	145	0.0996
10	3	12	3	2	3	12	5	2	1	13	5	5	4	4	74	0.0508
11	4	14	4	3	2	13	12	7	2	2	9	4	3	13	92	0.0632
12	2	13	5	4	8	14	8	3	5	5	10	3	2	5	87	0.0598
13	1	11	6	5	1	1	1	1	9	1	3	2	9	2	53	0.0364
14	5	3	8	6	14	2	6	4	10	3	4	1	7	3	76	0.0522
Total															1456	1

Now we transform the original table for expert assessment of the significance of factors influencing the choice of a rational rebar connection method, taking into account the transformed ranks. To do this, we put the resulting transformed ranks for

each factor in the initial table (Table 5). Next, we sort the factors by the rank value, from higher to lower one. Thus, we get a list of ranked factors, where the ordinal number of the factor determines the degree of its importance.

Table 6

Significance of factors influencing the choice of rational method for joining longitudinal re-bars

№	Factors	Dimension	Parameter variation limits	Rank
1	2	3	4	5
1	Rebar connection time	min	1 – 60	0.103
2	Possibility of carcassing	–	Yes/No	0.0996
3	Length of rebar cage	m	3 – 9	0.0934

End of table 6

№	Factors	Dimension	Parameter variation limits	Rank
4	Execution time for preparatory operations	min	1 – 20	0.0913
5	Working time of the main lifting mechanism	min	1 – 30	0.0845
6	Connection quality control time	min	1 – 10	0.0735
7	Rebar connection cost	UAH	60 – 220	0.0728
8	Connection quality control cost	UAH	6 – 92	0.0673
9	Occurrence of eccentric load transfer between re-bars	–	Yes/No	0.0632
10	Possibility of using thermally work-hardened re-bars of A500 and higher grades	–	Yes/No	0.0598
11	Work category for connection execution	–	3 – 6	0.0522
12	Need to use scaffolds and additional lifting mechanisms for reinforcing the structures	–	Yes/No	0.0522
13	Possibility of application in seismic regions	–	Yes/No	0.0508
14	Possibility of dismantling the rebar cage and reusing the connecting elements	–	Yes/No	0.0364

### Originality and practical value

The ranking of factors that significantly influence the choice of the rational method for re-bars connection was carried out. The ranking was performed by specialists in the design and construction of multi-storey reinforced concrete frames of buildings.

The factors influencing the choice of the rebar connection method the most are determined. The time of the connections, the length of the rebar cage, the possibility of mounting the cage are the most important from the point of view of experts.

### Conclusions

Based on expert evaluation of the significance of factors affecting the choice of a rational rebar connection method, it is determined:

– the most significant factors are those that determine the connection speed. These are the factors of time, possibility of carcassing, length of rebar cage;

– cost factors have less importance. Experts are ready to increase the cost of rebar connections in favour of reducing construction time;

– the least significant are the connection complexity factors – the need for additional devices, as well as work category. Experts are ready to increase the amount of equipment and complicate the work while reducing the construction time.

It is recommended to conduct additional studies with the development of a comprehensive methodology for selecting a rational method of re-bars connection.

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## ВИЗНАЧЕННЯ ТА РАНЖУВАННЯ ОРГАНІЗАЦІЙНО-ТЕХНОЛОГІЧНИХ ЧИННИКІВ, ЩО ОБУМОВЛЮЮТЬ РАЦІОНАЛЬНІ РІШЕННЯ З'ЄДНАННЯ АРМАТУРИ

## ТРАНСПОРТНЕ БУДІВНИЦТВО

**Мета.** В роботі передбачається знайти: 1) визначення та формулювання факторів, які впливають на вибір раціонального способу з'єднання арматури вертикальних несучих елементів монолітних залізобетонних каркасів; 2) визначення параметрів факторів; 3) ранжування факторів методом експертного оцінювання. **Методика.** Для досягнення мети дослідження необхідно провести аналіз існуючих способів з'єднання арматури, визначення чинників та меж зміни параметрів для кожного зі способів. Ранжування чинників виконано методом експертного оцінювання. **Результати.** За даними обробки матеріалів експертного опитування чотирнадцяти експертів в області монолітного будівництва встановлено наступне: найбільше значення при виборі раціонального з'єднання арматури мають чинники, які обумовлюють параметри часу: можливість монтажу каркасами, час з'єднання арматурних стержнів, довжина арматурного каркаса, час виконання підготовчих операцій, час роботи основного вантажопідйомного механізму. При цьому чинники, що обумовлюють параметри арматурного каркаса, мають пряме відношення до часу виконання робіт, оскільки вони визначають кількість арматурних стиків по мірі зведення будівлі в широких межах. Менше значення мають економічні чинники – вартість арматурного з'єднання та вартість контролю якості. Очевидно, що в умовах значних матеріальних витрат на зміст будівництва інвестору вигідно збільшити вартість з'єднань арматури для росту темпів робіт. Найменше значення мають конструктивні та технологічні чинники: виникнення позацентрової передачі навантаження між арматурними стержнями, можливість використання термічно зміцненої арматури класів А 500 і вище, розряд для виконання робіт, необхідність використання риштувань та додаткових пристосувань для армування конструкцій. Причина аналогічна: підрядник готовий йти на ускладнення технології з метою скорочення термінів зведення об'єкту. Оскільки розрахунковий критерій узгодження Пірсона  $\chi^2 = 47,24$  більше табличного (22,36203), то отриманий коефіцієнт конкордації  $W = 0,26$  – величина не випадкова, а тому отримані результати мають сенс та можуть використовуватися в подальших дослідженнях. **Наукова новизна.** Авторами визначені чинники, що в найбільшій мірі впливають на вибір раціонального способу з'єднання арматури. **Практична значимість.** Ранжування чинників дозволить об'єктивно підходити до проблеми вибору способу з'єднання арматури, оптимізувати витрати праці та ресурсів, а також скоротити терміни будівництва.

*Ключові слова:* арматура; з'єднання; експертне оцінювання; ранг; чинник; ранжування; коефіцієнт конкордації

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## ОПРЕДЕЛЕНИЕ И РАНЖИРОВАНИЕ ОРГАНИЗАЦИОННО-ТЕХНОЛОГИЧЕСКИХ ФАКТОРОВ, ОБУСЛОВЛИВАЮЩИХ РАЦИОНАЛЬНЫЕ РЕШЕНИЯ СОЕДИНЕНИЯ АРМАТУРЫ

**Цель.** В работе предполагается найти: 1) определение и обозначение факторов, которые влияют на выбор рационального способа соединения арматуры вертикальных несущих элементов монолитных железобетонных каркасов; 2) определение параметров факторов; 3) ранжирование факторов методом экспертного оценивания. **Методика.** Для достижения цели исследования необходимо провести анализ существующих способов соединения арматуры, определение факторов и пределов изменения параметров для каждого из способов. Ранжирование факторов выполняется методом экспертного оценивания. **Результаты.** По итогам обработки материалов экспертного опроса четырнадцати экспертов в области монолитного строительства установлено следующее: наибольшее значение при выборе рационального соединения арматуры имеют факторы, которые обуславливают параметры времени: возможность монтажа каркасами, время соединения арматурных стержней, длина арматурного каркаса, время выполнения подготовительных операций, время работы основного грузоподъемного механизма. При этом факторы, которые обуславливают параметры арматурного каркаса, имеют прямое отношение ко времени выполнения работ, поскольку они определяют количество арматурных стыков по мере возведения здания в широких пределах.

## ТРАНСПОРТНЕ БУДІВНИЦТВО

Меньшее значение имеют экономические факторы – стоимость арматурного соединения и стоимость контроля качества. Очевидно, что в условиях значительных материальных расходов на содержание строительства инвестору выгодно увеличить стоимость соединений арматуры для роста темпов работ. Наименьшее значение имеют конструктивные и технологические факторы: возникновение внецентровой передачи нагрузки между арматурными стержнями, возможность использования термически упрочненной арматуры классов А 500 и выше, разряд для выполнения работ, необходимость использования подмостей и дополнительных приспособлений для армирования конструкций. Причина аналогична: подрядчик готов идти на осложнение технологии с целью сокращения сроков возведения объекта. Поскольку расчетный критерий согласования Пирсона  $\chi^2 = 47,24$  больше табличного (22,36203), то полученный коэффициент конкордации  $W = 0,26$  – величина не случайная, а потому полученные результаты имеют смысл и могут использоваться в дальнейших исследованиях. **Научная новизна.** Авторами определены факторы, в наибольшей мере влияющие на выбор рационального способа соединения арматуры. **Практическая значимость.** Ранжирование факторов позволит объективно подходить к проблеме выбора способа соединения арматуры, оптимизировать расходы труда и ресурсов, а также сократить сроки строительства.

*Ключевые слова:* арматура; соединение; экспертное оценивание; ранг; фактор; ранжирование; коэффициент конкордации

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