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RESEARCH ARTICLE

COMPARATIVE CALCULATIONS OF FRAME BUILDINGS WITH REINFORCED CONCRETE FRAMES ACCORDING TO STANDARDS SP RK EN 1998-1:2004/2012 AND SP RK 2.03-30-2017*

Y.M. Shokbarov[1], Y.V. Koshcheev[1], U.T.Begaliev[2], M.Bresler[3]

[1]Kazakh Research and Design Institute of Construction and Architecture, 050046, Almaty, Kazakhstan
[2]International Association of Experts on Earthquake Engineering, 720009, Bishkek, Kyrgyz Republic
[3]MAURER SPS GmbH, 80807, München, Deutschland

Abstract. *Kazakhstan has implemented the transition to new building design standards SR RK EN, identical to the Eurocodes, with National Appendices. At the moment, in Kazakhstan, in the field of seismic design, two regulatory documents coexist in parallel. These are SP RK 2.03-30-2017* "Construction in seismic zones" and SP RK EN 1998-1:2004/2012 "Design of earthquake-resistant structures. Part 1. General rules, seismic effects and rules for buildings" and scientific and technical manuals for them. According to 1.4(5) SP RK EN 1990:2002+A1:2005/2011 (the main fundamental document of the Eurocodes), alternative design rules that differ from the EN 1990 rules, may be used if the alternative rules are consistent with the fundamental principles and ensure structural safety, serviceability and durability at least equivalent to those provided for in the Eurocodes. This paper compares the results of calculations of moment reinforced concrete frames of frame buildings obtained according to the design standards SP RK 2.03-30-2017* and SP RK EN 1998-1 to verify the compliance of SP RK 2.03-30-2017* with clause 1.4(5) of SP RK EN 1990. The objective of this study is to compare the results of three-dimensional structural analyses performed in accordance with the provisions of SP RK 2.03-30-2017* with the requirements of Clause 1.4(5) of SP RK EN 1990, based on a comparative assessment of the calculation results for reinforced concrete moment-resisting frame buildings designed according to the current and the new regulatory frameworks. The calculation methodology is based on the numerical modeling of a three-dimensional reinforced concrete frame structure, followed by a comparative analysis of stiffness characteristics, displacements, internal forces, and design parameters of structural elements obtained in accordance with SP RK 2.03-30-2017* and SP RK EN 1998-1. The scientific novelty of the study lies in the comprehensive evaluation of the equivalence of the current and the newly adopted seismic design codes as applied to reinforced concrete frame buildings. The findings contribute to the assessment of the consistency between the existing national seismic design provisions and the Eurocode-based regulatory framework and provide a basis for the further improvement and harmonization of seismic design standards in the Republic of Kazakhstan.*

Keywords: *alternative design rules, structural safety, frame building, reliability, durability, Eurocodes.*

***Corresponding author**
Yeraly Shokbarov, e-mail: eshokbarov@razniisa.kz

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ҒЫЛЫМИ МАҚАЛА

ҚҰРЫЛЫС НОРМАЛАРЫНА ҚР ЕЖ EN 1998-1:2004/2012 ЖӘНЕ ҚР ЕЖ 2.03-30-2017* СӘЙКЕС ТЕМІРБЕТОН ЖАҚТАУЛАРЫ БАР ҚАҢҚАЛЫ ҒИМАРАТТАРДЫҢ ЕСЕПТЕУ НӘТИЖЕЛЕРІН САЛЫСТЫРУ

Е.М. Шокбаров[1], Е.В. Кощеев[1], У.Т. Бегалиев[2], М. Бреслер[3]

[1]Қазақ құрылыс және сәулет ғылыми-зерттеу және жобалау институты, 050046, Алматы, Қазақстан
[2]Жер сілкінісіне қарсы инженерлік мамандардың халықаралық қауымдастығы 720009, Бишкек, Кыргыз Республикасы
[3]MAURER SPS GmbH, 80807 Мюнхен, Германия

Аңдатпа. *Қазақстанда еурокодтарға ұқсас, Ұлттық қосымшалары бар ҚР ЕЖ EN жаңа құрылыстарды жобалау стандарттарына көшу жүзеге асырылды. Қазіргі уақытта Қазақстанда сейсмикалық жобалау саласында екі нормативтік құжат қатар жұмыс істейді. Бұл ҚР ЕЖ 2.03-30-2017* «Сейсмикалық аймақтағы құрылыс» және ҚР ЕЖ EN 1998-1:2004/2012 «Жер сілкінісіне төзімді құрылымдарды жобалау. 1-бөлім. Жалпы ережелер, сейсмикалық әрекеттер және ғимараттарға арналған ережелер» және оларға ҒТҚ (ғылыми және техникалық оқу құралдары) оларға. ҚР ЕЖ EN 1990:2002+A1:2005/2011 (Еврокодтардың негізгі құжаты) 1.4(5) тармағына сәйкес EN 1990 ережелерінен ерекшеленетін альтернативті жобалау ережелері, егер альтернативті ережелер негізгі қағидаттарға сәйкес келсе және құрылымдық қауіпсіздікті, жұмысқа қабілеттілікті және еурокодтарда қарастырылғандарға баламалы ұзақ мерзімділікті қамтамасыз етсе, қолданылуы мүмкін. Бұл жұмыста ҚР ЕЖ 2.03-30-2017* 1990 ҚР ЕЖ EN 1990 1.4(5) тармағына сәйкестігін тексеру үшін ҚР ЕЖ 2.03-30-2017* және ҚР ЕЖ EN 1998-1 жобалау стандарттары бойынша алынған қаңқалық ғимараттардың моменттік темірбетонды қаңқаларын есептеу нәтижелері салыстырылады. Зерттеудің мақсаты қолданыстағы және жаңа нормативтік базалар бойынша жобаланған темірбетон қаңқалы ғимараттардың моменттік рамаларын кеңістіктік есептеу нәтижелерін салыстырмалы талдау негізінде ҚР ЕЖ 2.03-30-2017* ережелерінің ҚР ЕЖ EN 1990 стандартының 1.4(5)-тармағы талаптарына сәйкестігін бағалау. Есептеу әдістемесі кеңістіктік темірбетон қаңқаны сандық модельдеуге негізделген. Зерттеу барысында ҚР ЕЖ 2.03-30-2017* және ҚР ЕЖ EN 1998-1 талаптарына сәйкес алынған қаңқаның қаттылық сипаттамалары, орын ауыстырулары, ішкі күштері және конструкция элементтерінің есептік параметрлері өзара салыстырылды. Жұмыстың ғылыми жаңалығы зілзалаға тұрақты құрылыс саласындағы қолданыстағы және жаңа нормативтік құжаттардың темірбетон қаңқалы ғимараттарға қатысты баламалылығын кешенді бағалауда жатыр. Зерттеу нәтижелері ұлттық және еурокодтық жобалау тәсілдерінің сәйкестік деңгейін анықтауға, сондай-ақ Қазақстан Республикасының сейсмикалық жобалау жөніндегі нормативтік базасын одан әрі жетілдіруге ғылыми негіз қалыптастыруға мүмкіндік береді.*

Түйін сөздер: *альтернативті жобалау ережелері, құрылымдық қауіпсіздік, рамалық құрылыс, сенімділік, ұзақ мерзімділік, Еурокодтар.*

***Автор-корреспондент**
Yeraly Shokbarov, e-mail: eshokbarov@razniisa.kz

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НАУЧНАЯ СТАТЬЯ

СРАВНИТЕЛЬНЫЕ РАСЧЕТЫ КАРКАСНЫХ ЗДАНИЙ С ЖЕЛЕЗОБЕТОННЫМИ РАМАМИ ПО НОРМАМ СП РК EN 1998-1:2004/2012 И СП РК 2.03-30-2017*

Е.М. Шокбаров[1], Е.В. Кощеев[1], У.Т. Бегалиев[2], М. Бреслер[3]

[1]Казахский научно-исследовательский и проектный институт строительства и архитектуры, 050046, Алматы, Казахстан
[2]Международная Ассоциация экспертов по сейсмостойкому строительству, 720009, Бишкек, Кыргызская Республика
[3]MAURER SPS GmbH, 80807 Мюнхен, Германия

Аннотация. *В Казахстане осуществлен переход на новые строительные нормы проектирования СП РК EN, идентичных Еврокодам, с Национальными приложениями. На данный момент в Казахстане в области сейсмического проектирования параллельно сосуществуют два нормативных документа. Это СП РК 2.03-30-2017* «Строительство в сейсмических зонах» и СП РК EN 1998-1:2004/2012 «Проектирование сейсмостойких конструкций. Часть 1. Общие правила, сейсмические воздействия и правила для зданий» и НТП (научно-технические пособия) к ним. Согласно 1.4(5) СП РК EN 1990:2002+A1:2005/2011(основному основополагающему документу Еврокодов) альтернативные правила проектирования, отличающиеся от правил EN 1990, допускается применять, если альтернативные правила соответствуют основным принципам и обеспечивают конструктивную безопасность, эксплуатационную пригодность и долговечность, как минимум, равнозначные, предусмотренным в Еврокодах. В данной работе сравниваются результаты расчетов моментных железобетонных рам каркасных зданий, полученным по нормам проектирования СП РК 2.03-30-2017* и СП РК EN 1998-1 для проверки соответствия СП РК 2.03-30-2017* пункту. 1.4(5) СП РК EN 1990. Целью исследования является сравнение пространственных расчетов согласно с положениями СП РК 2.03-30-2017* требованиям пункта 1.4(5) СП РК EN 1990 на основе сравнительного анализа результатов расчета моментных железобетонных рам каркасных зданий, выполненных по действующими и новой нормативной базы. Методика расчета основана на численном моделировании пространственного железобетонного каркаса с последующим сопоставлением жесткостных характеристик, перемещений, внутренних усилий и расчетных параметров элементов, полученных согласно СП РК 2.03-30-2017* и СП РК EN 1998-1. Научная новизна работы заключается в комплексной оценке эквивалентности действующих и новых норм по сейсмостойкому строительству применительно к железобетонным каркасным зданиям.*

Ключевые слова: *альтернативные правила проектирования, конструктивная безопасность, каркасное здание, надежность, долговечность, Еврокоды.*

***Автор-корреспондент**
Yeraly Shokbarov, e-mail: eshokbarov@razniisa.kz

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1 INTRODUCTION

According to the Concept for the reform of the regulatory framework in the construction sector of the Republic of Kazakhstan, approved by the Decree of the Government of the Republic of Kazakhstan dated December 31, 2013 No. 1509, from 2015 to 2020, a period of "coexistence" of the current and new regulatory frameworks is envisaged. Thus, starting from July 1, 2015, the codes of SP RK EN, identical to the Eurocodes, were put into effect for parallel application with the current standards for the calculation and design of structures of buildings and structures.

The improvement of the regulatory framework of the construction industry in Kazakhstan provided for moving away from the prescriptive method of building rationing to the progressive parametric method. The parametric method of rationing, in contrast to the strict prescriptive one on which the Soviet SNiPs are based, provides freedom in choosing design solutions, building materials and technologies, without limiting designers and builders. The introduction of the Eurocode system and the updating of the regulatory framework of the construction industry in Kazakhstan has certainly allowed for more active and widespread use of innovative technologies and materials in design and construction. In conditions of increased seismic activity in some regions of Kazakhstan, ensuring seismic safety and stability of buildings and structures is one of the key tasks for designers and builders. Monolithic design and construction of frame buildings with reinforced concrete diaphragms are widely used in the construction market of Kazakhstan. As part of the reform of the regulatory framework of the construction industry of the Republic of Kazakhstan, it was assumed to switch to the European standards of SP RK EN 1990-1999 identical to the Eurocodes. In 2017, based on the developed sets of maps, new standards for earthquake-resistant construction and design of SPs of the Republic of Kazakhstan were developed. 2.03-30-2017* "Construction in seismic zones", interacting with the existing standards of the SNiP at that time. This document significantly facilitated the transition to Eurocode standards, as it contained many additional parameters from them [1]. Codes of rules of SP RK EN 1998-1 and SP RK 2.03-30-2017* They have fundamentally different scientific and methodological foundations. Design of buildings and structures in accordance with the provisions of the SP of the Republic of Kazakhstan 2.03-30-2017* It is carried out in compliance with the condition of equal strength of all elements of the structural system involved in the perception of seismic loads. When designing buildings and structures in accordance with the provisions of the SP RK EN 1998-1 and its normative and technical manuals, the rules of the method of additive design are followed, which provides for the planning of damage zones of structural systems during seismic impacts [2]. After the complete transition to the SP RK EN identical to the Eurocodes of the fundamental documents on loads, load impact combinatorics, calculations of reinforced concrete structural elements, it became necessary to verify the relevance of the SP RK 2.03-30-2017* . In addition, in the SP RK 2.03-30-2017* There are still many references in the text to the coefficients of the already canceled snips, which were missing from the Eurocodes [3].

In this regard, it is an urgent task to carry out comparative calculations of frame buildings with reinforced concrete frames according to the standards of the SP RK EN 1998-1:2004/2012 and the SP RK 2.03-30-2017* . Such an analysis makes it possible to identify the relevance in the calculated parameters, to assess the degree of regulatory approaches of the SP RK 2.03-30-2017* and determine the scope of its application.

2 MATERIALS AND METHODS

In this work, the method of comparative-system analysis is used according to the old current design standards of the SP of the Republic of Kazakhstan. 2.03-30-2017* and the new regulatory framework of the SP RK EN 1998-1 for calculations of momentary reinforced concrete frames of frame buildings. As the empirical basis of the study, the calculation is based on the finite element method using the main unknown displacements and rotations of the nodes of the calculation scheme carried out by KazNIISA JSC specialists before the introduction of the new regulatory framework.

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The research methodology also includes the use of modern spectral calculation methods and probabilistic approaches to seismic hazard assessment, taking into account the requirements of the new regulatory framework identical to the Eurocodes. The research materials were the current regulatory documents of the SP of the Republic of Kazakhstan 2.03-30-2017* and SP RK EN 1998-1:2004/2012 and NTP (scientific and technical manuals) [5].

The comparative analysis was performed according to the following key criteria and parameters:

- ✓ values of calculated seismic loads and shapes of response spectra;
- ✓ behavior coefficients and reliability coefficients;
- ✓ requirements for plasticity and structural classes;
- ✓ maximum displacement and deformation restrictions;
- ✓ efforts in the elements;
- ✓ requirements for reinforcement and structural elements of nodes;
- ✓ rules for accounting for nonlinear effects and redistribution of efforts;
- ✓ approaches to load combinations and combination coefficients.

The results of comparative calculations are aimed at quantifying and qualitatively assessing the differences between regulatory approaches, identifying critical discrepancies, as well as improving and updating existing regulatory documents with the requirements of the new regulatory framework for earthquake-resistant construction.

3 RESULTS AND DISCUSSION

General information.

The structural scheme of the facility is a framed reinforced concrete frame with hard disks of floors and coatings in the form of a reinforced concrete monolithic slab.

The dimensions of the building in the plan are 24.0 x 12 m. The building has 5 floors with a height of 3.0 m each.

The pitch of the structure between the axes in the longitudinal and transverse directions is 6.0 m.

The rigidity of the frame in the transverse direction is ensured by the rigid pinching of the main columns of the frame in the foundation.

The spatial immutability of the frame elements is ensured by a system of longitudinal and transverse metal beams and monolithic reinforced concrete slabs 200 mm thick made of concrete of class C20/25.

Reinforced concrete columns 450x450 mm in size.

Reinforced concrete beams measuring 400x600(h) mm. Floor slabs and coatings with a thickness of 200 mm.

Calculation scheme.

General characteristics of the calculation scheme.

The calculation was performed in a spatial setting with elastic stiffness characteristics of materials for the action of basic and special combinations of loads.

The calculation scheme was created and all calculations were performed using the LIRA-CAD 2022 R2 software package.2.

The calculation is based on the finite element method using the main unknown displacements and rotations of the nodes of the calculation scheme.

In this regard, the idealization of the design is made in a form adapted to the use of this method, namely: the system is represented as a set of standard-type bodies (rods, plates, shells, etc.), called end elements and attached to the nodes of the design scheme.

The calculation scheme includes structures whose operation is essential and decisive for this system; all other structures that have little effect on the scheme of the system and its operation are excluded from the calculation scheme.

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For a more correct inclusion of metal beams in the work when transmitting the calculated effects of impacts from loads, the bending stiffness of reinforced concrete slabs has been reduced without changing the shear stiffness.

The angular end elements of the floor slabs are also calculated to exclude the transfer of residual bending moments from them for a more correct influence of the frame beams on the columns [6] (Figure 1).

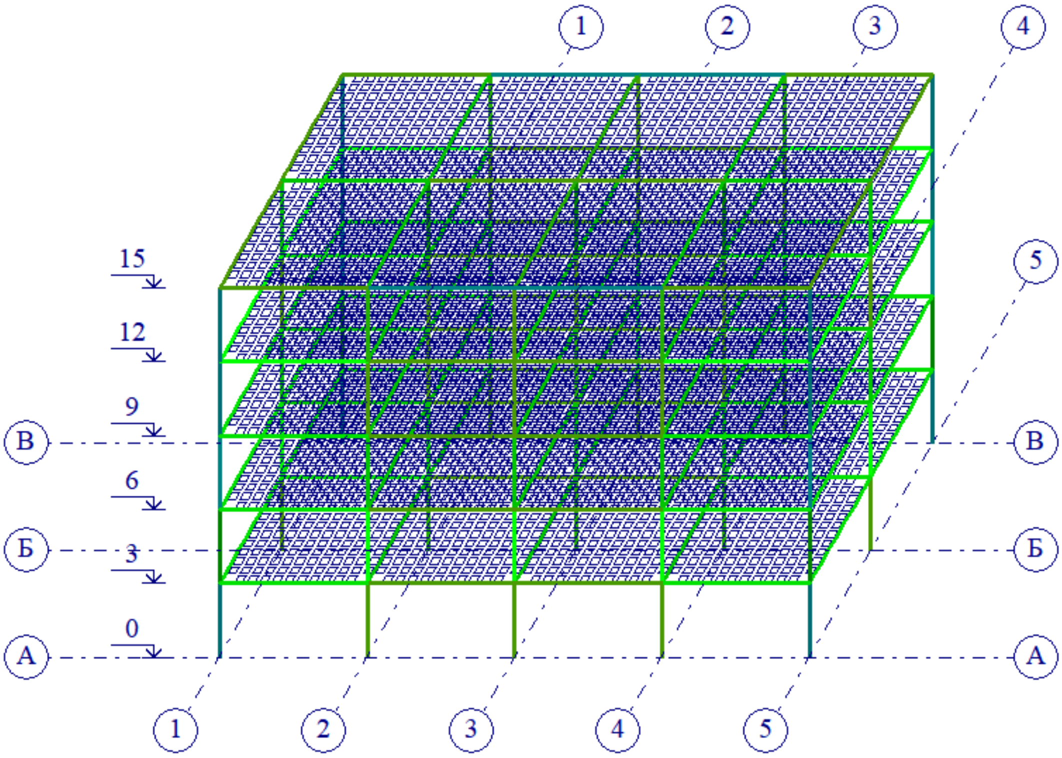

Figure 1 - Design scheme of the building. [Authors' material]

In this way, the direct transmission of bending moments from the floor slabs to the frame columns is minimized. When creating the finite element model, the finite element "Type 10 - universal spatial core CE", "Type 44 - universal quadrangular CE" was used.

The bearing capacity of the cross-sections in terms of the strength of reinforced concrete elements was determined in accordance with SP RK EN 1992-1-1:2004/2011.

The calculated load combinations are the same as when calculating the metal frame.

The design combinations of loads (RSN) are performed in accordance with SP RK EN 1990:1002+A1:2005/2011 and NP to SP RK EN 1990:2002+A1:2005/2011.The calculated combinations of loads (RSN) were performed according to Table "B" using the formulas (6.10a) and (6.10b) as amended by the NP dated 12/30/2021. Additional coefficients 1.3 for column moments were applied only for calculations according to SP RK EN 1998-1 [7].

The results of comparing the calculated data obtained

Mosaics of the results of checking the percentage of reinforcement of the assigned column cross-sections according to the ULS (load-bearing capacity) of the building, calculated according to the standards of the SP of the Republic of Kazakhstan 2.03-30-2017* shown in Figure 2.

Mosaics of the results of checking the percentage of reinforcement reinforcement of the assigned column sections according to the ULS (load-bearing capacity) of the building, calculated according to the standards of the SP RK EN 1998-1 are shown in the figure 3 [8].

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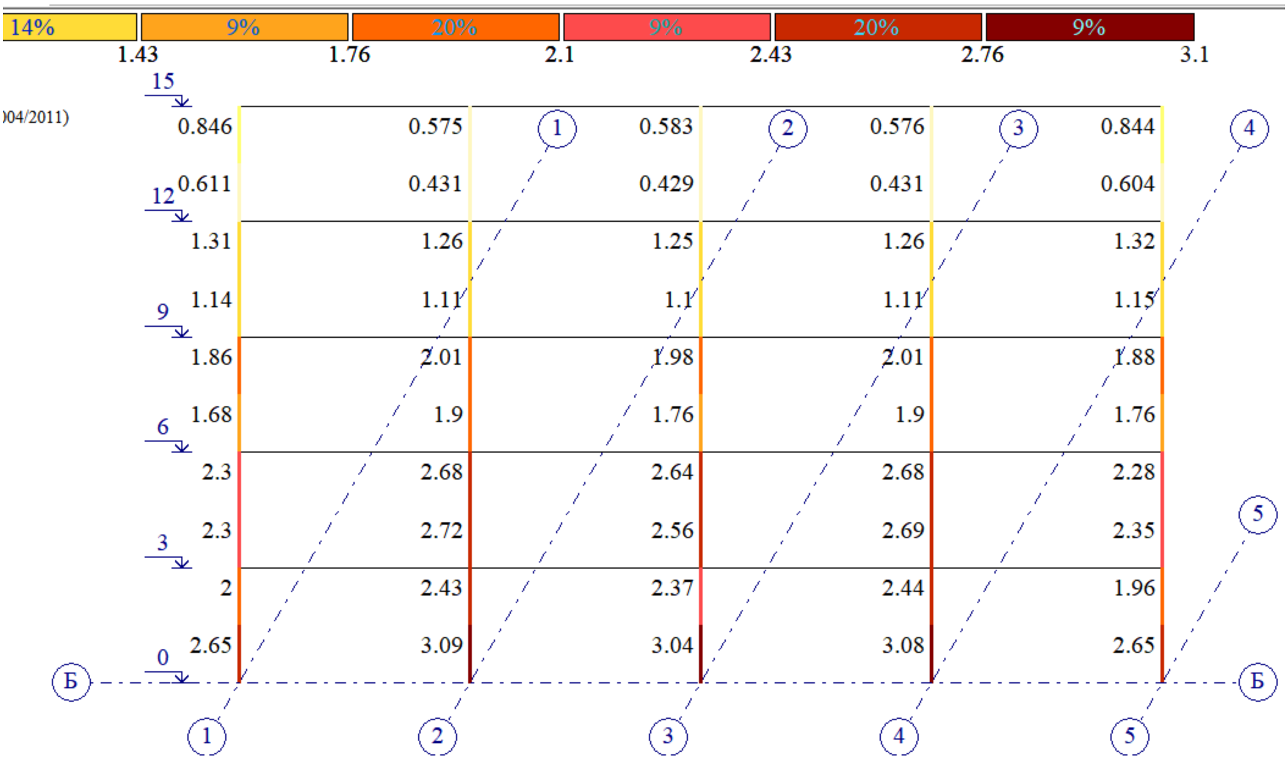

Figure 2 - Mosaics of the results of checking the percentage of reinforcement of column reinforcement according to the SP of the Republic of Kazakhstan 2.03-30-2017*. [Authors' material]

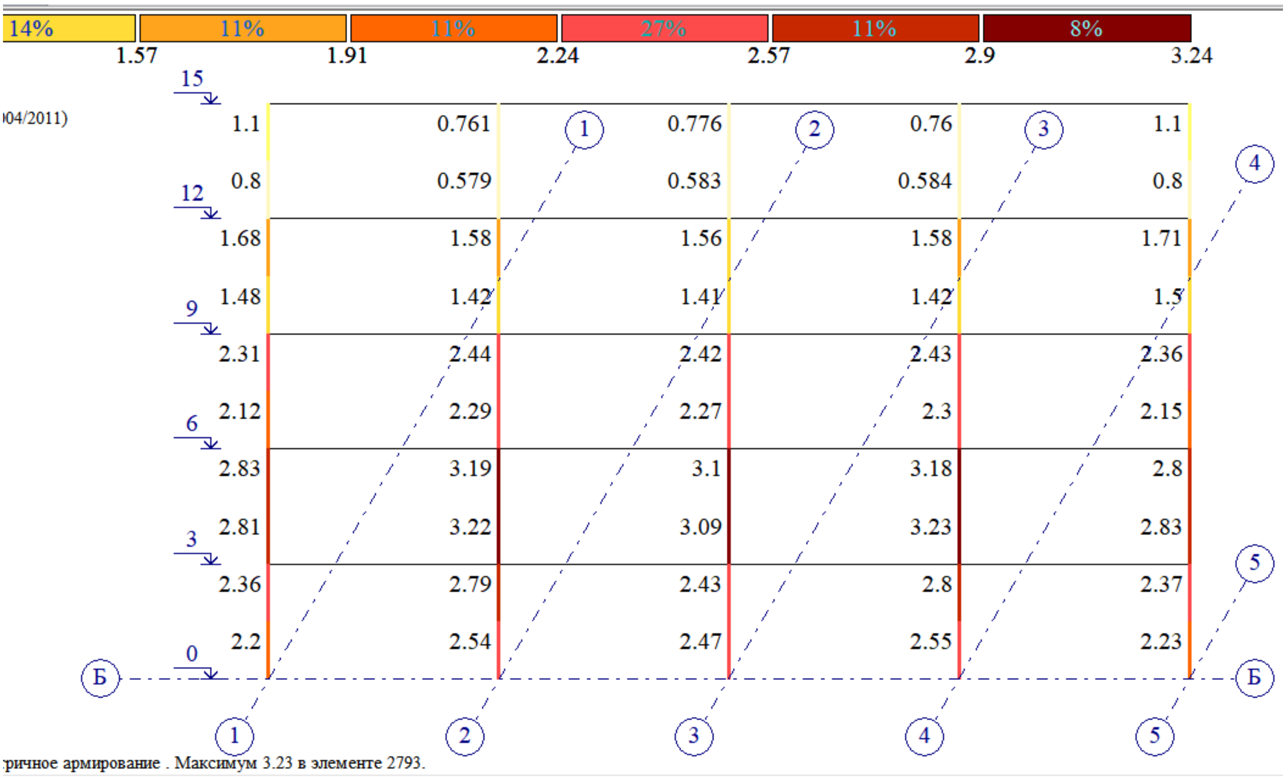

Figure 3 - Mosaics of the results of checking the percentage of reinforcement of column reinforcement according to SP RK EN 1998-1. [Authors' material]

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As can be seen from the comparative results, the difference in the percentage of column reinforcement is also quite large [9]. Even if we take only the most loaded columns of the 1st and 2nd floors, the difference reaches its maximum on the 2nd floor and amounts to 18.728% for the outermost columns and 14.839% for the inner columns, shown in Table 1.

Table 1 - Comparative results of column reinforcement percentage. [Authors' material]

№	Floor number	Naming of axes	The result of the SP RK EN 1998-1, in %	The result of the SP of the Republic of Kazakhstan 2.03-30-2017* , in %.	Difference in results
1	1	«1, Б»	2.36 %.	2 %.	15.254 %.
2	2	«1, Б»	2.83 %.	2.3 %.	18.728 %.
3	3	«1, Б»	2.31 %.	1.86 %.	19.481 %.
4	4	«1, Б»	1.68 %.	1.31 %.	22.024 %.
5	5	«1, Б»	1.1 %.	0.846 %.	23.091 %.
6	1	«3, Б»	2.43 %.	2.37 %.	2.469 %.
7	2	«3, Б»	3.1 %.	2.64 %.	14.839 %.
8	3	«3, Б»	2.42 %.	1.98 %.	18.182 %.
9	4	«3, Б»	1.56 %.	1.25 %.	19.872 %.
10	5	«3, Б»	0.776 %.	0.575 %.	25.902 %.

The biggest difference is obtained on the columns of the upper floors [10]. For the extreme columns of the 4th floor it is 22.024%, for the middle column it is 19.872%. And for the extreme columns of the 5th floor it is 23.091%, for the middle column it is 25.902%.

The results of checking the complete reinforcement of columns AS1, AS2, AS3, AS4 of column sections according to the ULS (load-bearing capacity) of the building, calculated according to the standards of the SP of the Republic of Kazakhstan 2.03-30-2017* shown in Figure 4. Mosaics of the results of checking the complete reinforcement of columns AS1, AS2, AS3, AS4 of column sections according to the ULS (load-bearing capacity) of the building calculated according to the standards of the SP RK EN 1998-1 are shown in Figure 5.

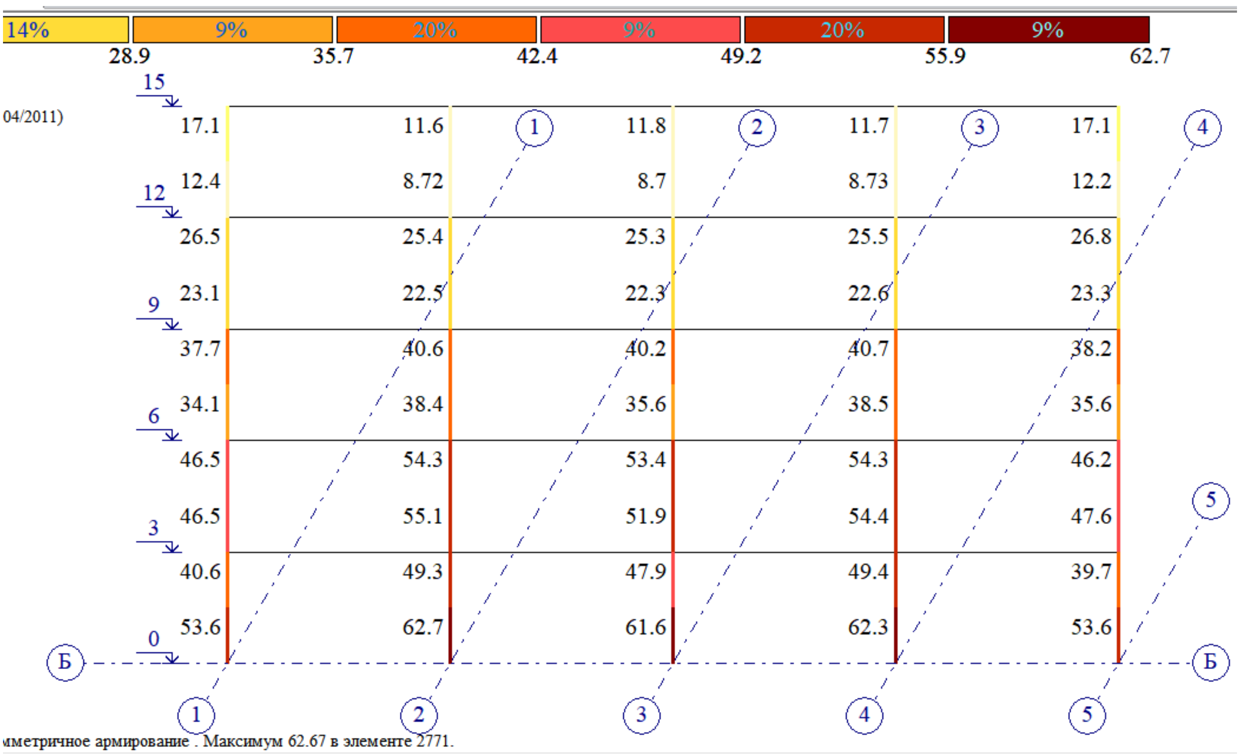

Figure 4 - Mosaics of the results of checking the reinforcement of columns AS1, AS2, AS3, AS4, according to the SP of the Republic of Kazakhstan 2.03-30-2017*. [Authors' material]

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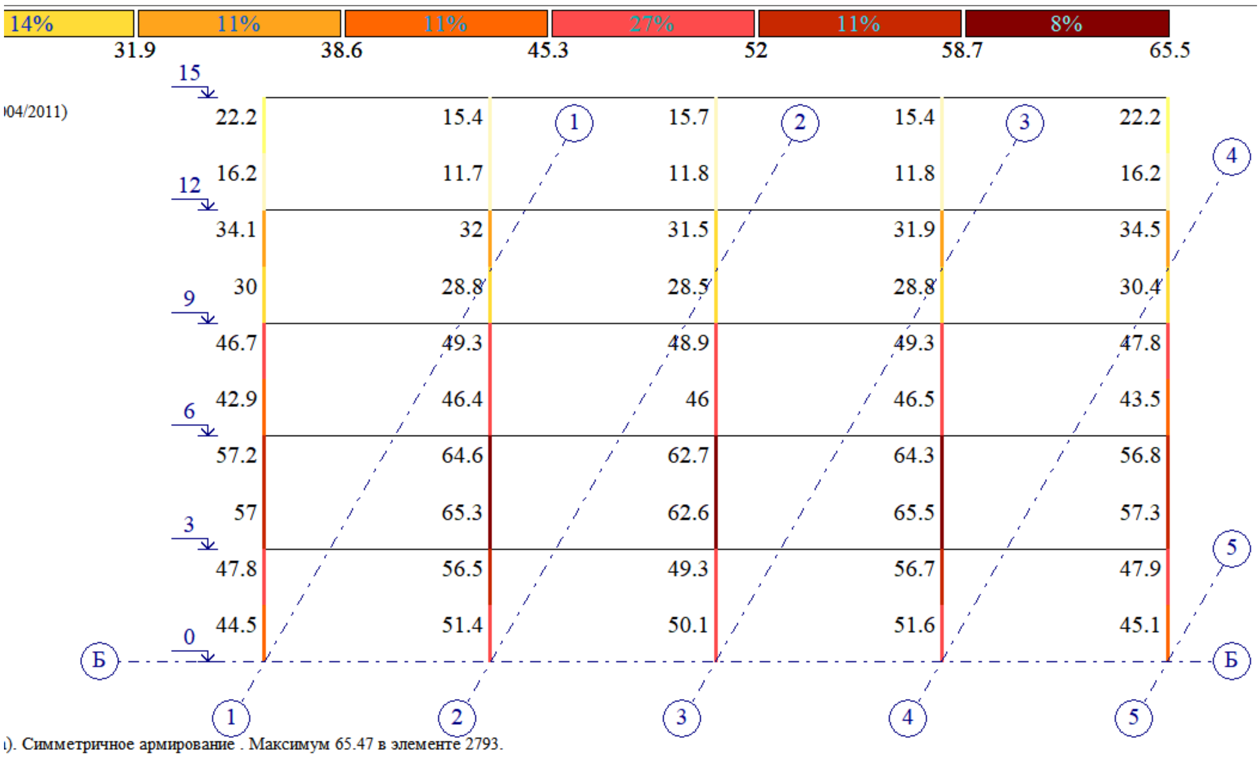

Figure 5 - Mosaics of the results of the inspection of columns AS1, AS2, AS3, AS4, according to SP RK EN 1998-1. [Authors' material]

Comparative results show that the difference in the percentage of column reinforcement is also quite large.

If we take only the most loaded columns of the 1st and 2nd floors, then the difference reaches a maximum on the 2nd floor for the outermost columns is 18.706%, for the inner columns 14.833%. There is a big difference on the columns of the upper floors.

For the extreme column of the 4th floor, it is 22.287%, for the middle column it is 19.683%.

The results are shown in Table 2.

For the extreme column of the 5th floor, it is 22.973%, for the middle column 24.841%. The difference data in Table 2 is almost identical to Table 1.

Table 2 - Comparative results of reinforcement AS1, AS2, AS3, AS4 column reinforcement. [Authors' material]

№	Floor number	Naming of axes	The result of the SP RK EN 1998-1, in %	The result of the SP of the Republic of Kazakhstan 2.03-30-2017* , in %.	Difference in results
1	1	«1, Б»	47.8	40.6	15.063 %.
2	2	«1, Б»	57.2	46.5	18.706 %.
3	3	«1, Б»	46.7	37.7	19.272 %.
4	4	«1, Б»	34.1	26.5	22.287 %.
5	5	«1, Б»	22.2	17.1	22.973 %.
6	1	«3, Б»	49.3	47.9	2.84 %.
7	2	«3, Б»	62.7	53.4	14.833 %.
8	3	«3, Б»	48.9	40.2	17.791 %.
9	4	«3, Б»	31.5	25.3	19.683 %.
10	5	«3, Б»	15.7	11.8	24.841 %.

When taking the column size of 400x400 mm, it can be seen that we are slightly exceeding the permissible percentage of column reinforcement, equal to 4%.

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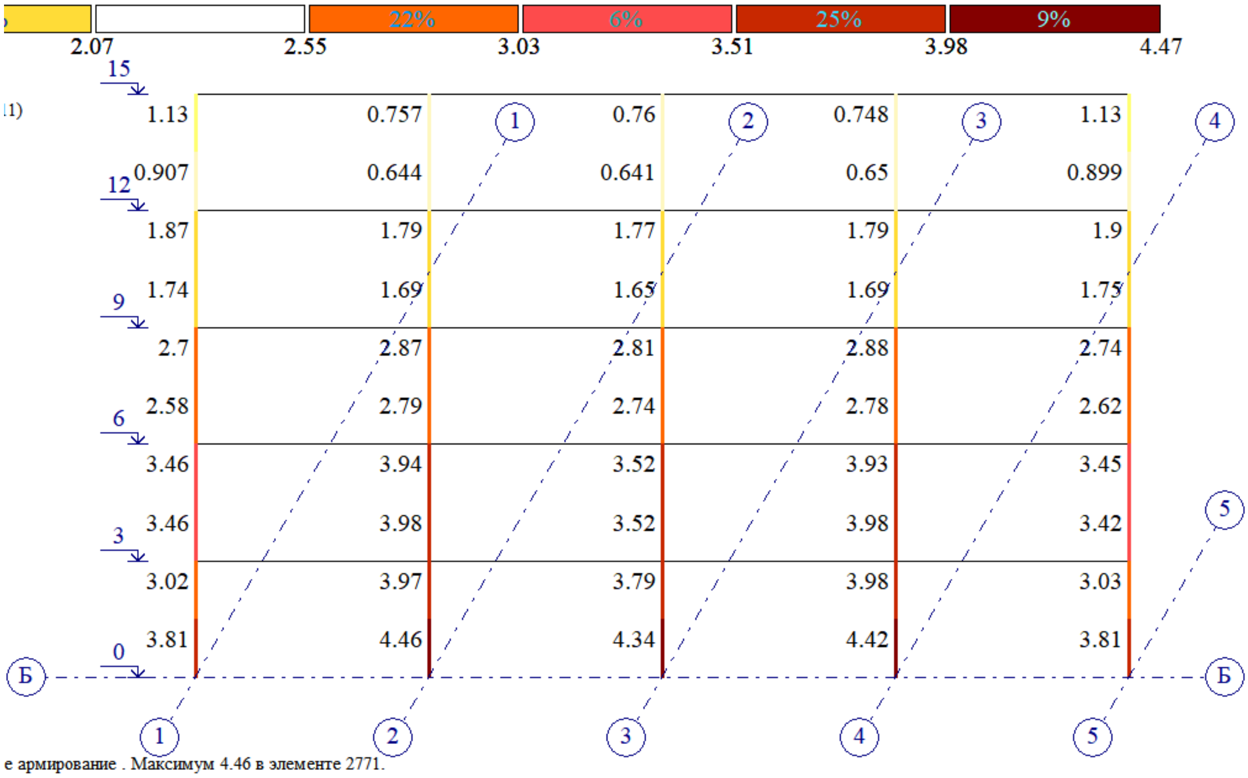

Figure 6 - Mosaics of the results of checking the percentage of reinforcement of column reinforcement according to the SP of the Republic of Kazakhstan 2.03-30-2017*. [Authors' material]

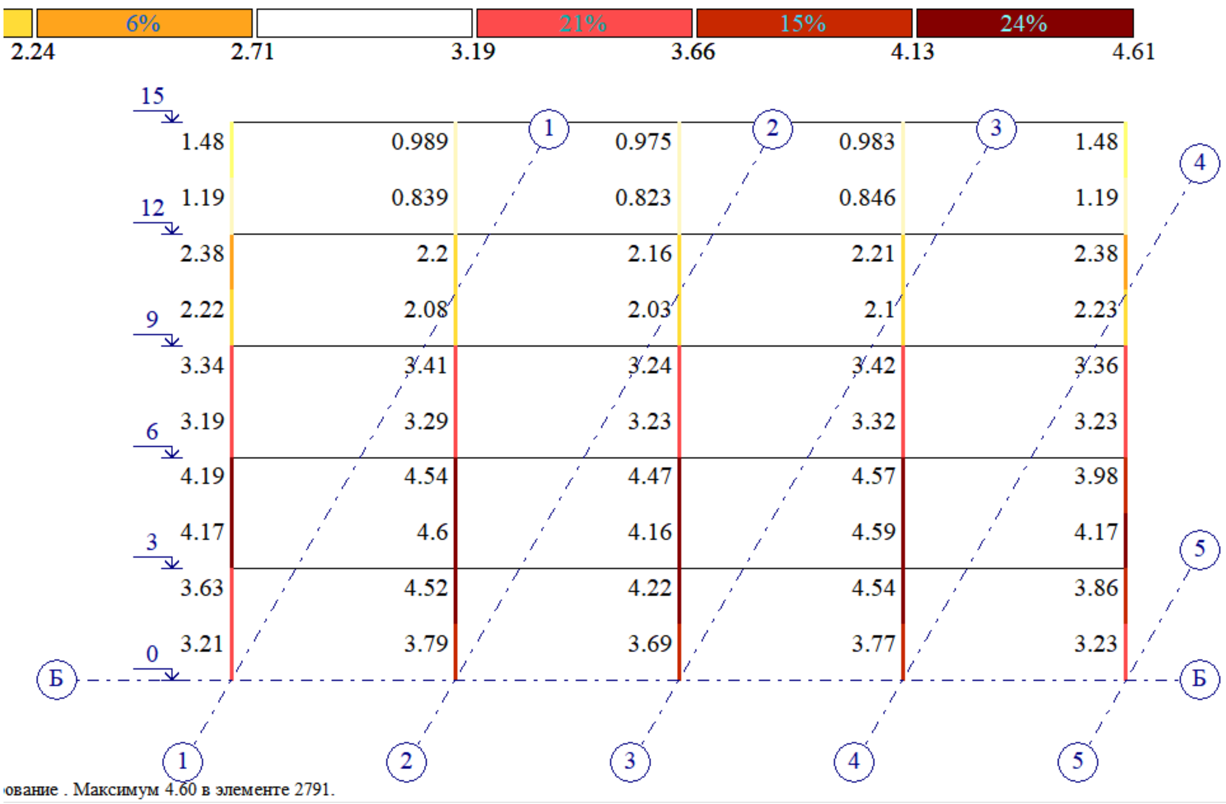

Figure 7 - Mosaics of the results of checking the percentage of reinforcement of column reinforcement according to SP RK EN 1998-1. [Authors' material]

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However, Figures 6, 7 and Table 3 show the comparative results of these calculations [11].

Comparative results show a fairly large difference in the percentage of column reinforcement. Even if we take only the most loaded columns of the 1st and 2nd floors, the difference reaches its maximum on the 2nd floor, for the outermost columns it is 17.422%, for the inner columns 21.253%, are shown in Table 3.

The difference is greatest in the columns of the upper floors. For the extreme column of the 4th floor, it is 21.429%, for the middle column 18.056%. The extreme columns of the 5th floor are 23.649%, for the middle column 22.051% [12].

When comparing the results in Tables 1, 2 and 3, although there is a slight variation in the calculated parameters, there is a general trend in the differences in calculations according to SP RK EN 1998-1 and SP RK 2.03-30-2017* saved.

Table 3 - Comparative results of column reinforcement percentage according to SP RK EN 1998-1. [Authors' material]

№	Floor number	Naming of axes	The result of the SP RK EN 1998-1, in %	The result of the SP of the Republic of Kazakhstan 2.03-30-2017* , in %.	Difference in results
1	1	«1, Б»	3.63 %.	3.02 %.	16.804 %.
2	2	«1, Б»	4.19 %.	3.46 %.	17.422 %.
3	3	«1, Б»	3.34 %.	2.7 %.	19.162 %.
4	4	«1, Б»	2.38 %.	1.87 %.	21.429 %.
5	5	«1, Б»	1.48 %.	1.13 %.	23.649 %.
6	1	«3, Б»	4.22 %.	3.79 %.	10.19 %.
7	2	«3, Б»	4.47 %.	3.52 %.	21.253 %.
8	3	«3, Б»	3.24 %.	2.81 %.	13.272 %.
9	4	«3, Б»	2.16 %.	1.77 %.	18.056 %.
10	5	«3, Б»	0.975 %.	0.76 %.	22.051 %.

Analysis of comparative calculations of reinforced concrete frame

When calculating the SP of the Republic of Kazakhstan 2.03-30-2017* the conditions of equal strength of all elements of the structural system involved in the perception of seismic loads were observed. This technique was inherited from previous SNiP documents as in the assignment of external loads to the structure (effects of impacts) This is also the case when calculating the cross-sections of the elements of this structure [13].

When designing buildings and structures in accordance with the provisions of the SP RK EN 1998-1 and its normative and technical manuals, the rules of the method of additive design are followed, which provides for the planning of damage zones of structural systems during seismic impacts.

Several methods are used to create plastic joints in beams (the strong column-weak beam concept) in the SP RK EN 1998-1 and regulatory and technical manuals.

1. Application of formula (4.29) according to SP RK EN 1998-1 or formula (7.3) according to NTP RK 08-01.2-2021 ($\Sigma MRc \geq 1.3\ \Sigma MRb$). When applying these formulas, the sum of the calculated values of the moments of resistance of columns in the zones of nodal joints should exceed the sum of the calculated values of the moments of resistance of beams in the zones of nodal joints by 1.3 times [14].

This increases the rigidity of the columns in the areas of nodal joints and makes it possible to form plastic joints in the joints of the beams with the columns, i.e. in the beams, not in the columns.

2. The use of various additional structural reinforcement methods for columns and beams for the favorable formation of plastic joints.

From the obtained comparative calculations of column cross-sections according to ULS (load-bearing capacity), calculated according to the standards of SP RK EN 1998-1 and SP RK 2.03-30-2017* (Tables 1 and 2) it can be seen that the difference in the results in terms of the percentage of reinforcement and full reinforcement in ULS (1PS) sections for columns of the 1st and 2nd floors is from 2.469% to 18.728%.

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Results for the SP of the Republic of Kazakhstan 2.03-30-2017* lower than according to SP RK EN 1998-1, which means that when calculating for SP RK 2.03-30-2017* less reinforcement of columns can be obtained than according to SP RK EN 1998-1 and its regulatory and technical manuals [15].

This difference in the calculation results indicates that the reliability of the accepted cross-sections calculated according to the SP RK 2.03-30-2017* lower than those calculated according to the SP RK EN 1998-1 and its regulatory and technical manuals.

The revealed differences indicate the need to verify the compliance of the considered approaches with the requirements of paragraph 1.4(5) of the SP RK EN 1990:2002+A1:2005/2011, which stipulates that alternative design rules should ensure a level of safety, serviceability and durability not lower than that established in accordance with the requirements of the SP RK EN, identical to the Eurocodes [16, 17].

The difference in the results when calculating columns with a smaller cross-section (Table 3) also has a similar trend (from 10.19% to 21.253%).

This is the difference in the calculations of column cross-sections according to ULS, calculated according to the standards of SP RK EN 1998-1 and SP RK 2.03-30-2017* due to the fact that in the SP of the Republic of Kazakhstan 2.03-30-2017* there is no increase in column moments by 1.3 times in relation to beams, as in SP RK EN 1998-1 and regulatory specifications

There are no allowances for it, and there is no increase in the coefficient α_{cc} from 0.85 to 1.0 with seismic effects on structures. The coefficient α_{cc} takes into account the effect of long-term processes on compressive strength and adverse effects as a result of the method of applying the load [18].

Another important difference between these design standards is the difference in the anchoring of the beam reinforcement in the body of the middle columns. Based on P.5.6.2.2(1), p.5.6.2.2 and formulas (5.50a) and (5.50b) of SP RK EN 1998-1 it turns out that if the beams have longitudinal fittings with a diameter above 16 mm, then an increase in the column cross-section over 40x40 cm is required. (depending on the diameter of the longitudinal bars of the beam) [19]. These conditions of the SP RK EN 1998-1 further increase the reliability of reinforced concrete momentary frame structures in relation to the SP RK 2.03-30-2017* [20].

4 CONCLUSIONS

1. Analysis of the performed comparative calculations of frame buildings with reinforced concrete frames according to the requirements of the norms of the SP of the Republic of Kazakhstan 2.03-30-2017* and SP RK EN 1998-1:2004/2012 shows that the regulatory documents under consideration, with a general focus on ensuring the seismic resistance of buildings, implement various methodological approaches to determining calculated seismic impacts and evaluating the work of structures.

2. It has been established that with comparable initial impacts, calculations for the SP of the Republic of Kazakhstan 2.03-30-2017* In some cases, they lead to the adoption of smaller column cross-sections compared to the results obtained according to NTP RK 08-01.5-2013. This discrepancy indicates differences in the level of conservativeness of the calculation approaches and requires additional assessment in the context of reliability requirements regulated by the SP RK EN 1990:2002+A1:2005/2011.

3. The results of the comparative calculation analysis show the need for further updating of the provisions of the SP of the Republic of Kazakhstan 2.03-30-2017* "Construction in seismic zones" in order to ensure a comparable or higher level of reliability in relation to the requirements of the NTP RK 08-01.5-2013, as well as alignment with the principles laid down in the SP RK EN, identical to the Eurocodes.

4. The results obtained indicate the need for further clarification of the scope and individual design provisions of the SP of the Republic of Kazakhstan 2.03-30-2017* , in order to ensure consistency of calculation results and increase comparability with alternative regulatory approaches.

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REFERENCES

1. **SP of the Republic of Kazakhstan 2.03-30-2017*** "Construction in seismic zones". Committee for Construction and Housing and Communal Services of the Ministry of Industry and Construction of the Republic of Kazakhstan. Astana 2025.
2. **SP RK EN 1998-1:2004/2012** "Implementation of system security. Part 1. General rules, seismic impacts and rules for buildings". Committee for Construction and Housing and Communal Services of the Ministry of Industry and Construction of the Republic of Kazakhstan. Astana 2016.
3. **National annexes to the SP RK EN 1998-1:2004/2012** "Implementation of system security". Part 1: General rules, seismic impacts and rules for buildings". Committee for Construction and Housing and Communal Services of the Ministry of Industry and Construction of the Republic of Kazakhstan. Astana 2017.
4. **NTP RK 08-01.1-2012** "Design of earthquake-resistant buildings and structures. Part. General provisions. Seismic impacts". Committee for Construction and Housing and Communal Services of the Ministry of Industry and Construction of the Republic of Kazakhstan. Astana 2017.
5. **NTP of the Republic of Kazakhstan-08-01.2-2021** "Designing earthquake-resistant buildings. Part: Design of civil buildings. General requirements". Committee for Construction and Housing and Communal Services of the Ministry of Industry and Construction of the Republic of Kazakhstan. Astana 2017.
6. **NTP of the Republic of Kazakhstan-08-01.3-2021** "Designing earthquake-resistant buildings. Part: Monolithic reinforced concrete buildings". Committee for Construction and Housing and Communal Services of the Ministry of Industry and Construction of the Republic of Kazakhstan. Astana 2017.
7. **NTP of the Republic of Kazakhstan-08-01.5-2013** "Designing earthquake-resistant buildings. Part 1. Design of earthquake-resistant buildings made of steel structures". Committee for Construction and Housing and Communal Services of the Ministry of Industry and Construction of the Republic of Kazakhstan. Astana 2017.
8. **Itskov, I. E.** Calculation provisions of the new norms of the Republic of Kazakhstan of the SP of the Republic of Kazakhstan 2.03-30-2017 "Construction in seismic zones". [Text]/ I.E. Itskov//Bulletin of the International Association of Experts on Earthquake-resistant Construction. – 2018. – № 1 (5). – Pp. 41-45.
9. **Michael N. Fardis** «Seismic design, assessment and retrofitting of concrete buildings». ISBN 978-1-4020-9841-3, DOI 10.1007/978-1-4020-9842-0.
10. **George G. Penelis and Gregory G. Penelis** «Concrete Buildings in Seismic Regions». https://doi.org/10.1201/b16399
11. Design of Steel Structures for Buildings in Seismic Areas. Eccs Eurocode design manuals. 2016. ISBN (ECCS): 9789291471348.
12. **A. Zhanabayeva, Sung-Woo Moon, J.I. Ocheme, E. Shokbarov, V. Khomyakov, J. Kim, A. Satyana** «Comparison analysis of Seismic design codes for shallow foundation adhering to the Kazakhstani and European approaches». Sustainability 2023, 15, 615. https://doi.org/10.3390/ su15010615
13. **S. Muhammad, Z. Dichuan, M. Sung-Woo, Y. Shokbarov, D. Sarkulova1, J. Kim** «Macro-Seismic Assessment for Residential Buildings Con-structed in the Soviet Union Era in Almaty, Kazakhstan». Buildings 2023, 13(4), 1053. https://doi.org/10.3390/ buildings 13041053.
14. **U. Begaliev, M. Abdybaliev** «The approaches to define seismic hazard and demand for building design in Kyrgyz Republic» 3rd European conference on earthquake engineering & seismology Bucharest, Romania, 2022-09-04. https://3ecees.ro/3ecees-publications/.
15. **A. Abdykalykov, E. Boronbaev, U. Begaluev, K. Holmatov, N. Zhyrgalbaeva** «Building wall corner structures, its microclimate and seismic resistance». E3S Web of Conferences

https://doi.org/10.51488/1680-080X/2026.2-03

2021. https://doi.org/10.1051/e3sconf/202126304051.

16. **A.N. Tuleyev, T.D. Abakanov, V.A. Lapin, U.T. Begaliev** «Effect of the number of storeys on seismic resistance of high-rise monolithic buildings in Almaty» Bulletin of Kazakh Leading Academy of Architecture and Construction, No4 (94), 2024-12-30. Pp. 183-192. https://doi.org/10.51488/1680-080X/2024.4-14.
17. **A.T. Tuleyev; T. Abakanov; U.T. Begaliev; V.A. Lapin** «Seismic response of A 22-story monolithic building based on instrumental acceleration records», Bulletin of Kazakh Leading Academy of Architecture and Construction. No4 (98), 2025-12-30. Pp. 241-255. https://doi.org/10.51488/1680-080X/2025.4-15.
18. **R. Mels, R. Shults** «Multicomponent seismic assessment of A 16-story building in Almaty using Eurocode 8», Bulletin of the Kazakh Leading Academy of Architecture and Civil Engineering. No1 (99), 2026. Construction. Pp. 233-248. https://doi.org/10.51488/1680-080X/2026.1-16.
19. **N.V. Surovtseva, T. Abakanov, G.M. Nigmetov** «Experimental studies of the seismic vulnerability of A building model strengthened on soils», Bulletin of the Kazakh Leading Academy of Architecture and Civil Engineering. No1 (99), 2026. Construction. Pp. 311-325. https://doi.org/10.51488/1680-080X/2026.1-21.
20. **A.S. Shadkam, E.T. Bessimbayev, U.T. Begaliev, S.E. Niyetbay** «The comparison of deformation calculation results of structures under seismic impact using Mohr-coulomb and hardening soil small (HSS) soil models», Bulletin of the Kazakh Leading Academy of Architecture and Civil Engineering. No4 (94), 2024. Pp. 193-202. https://doi.org/10.51488/1680-080X/2024.4-16.

https://doi.org/10.51488/1680-080X/2026.2-03

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The authors state that there is no conflict of interest.

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Information about authors:
Yeraly Shokbarov – Candidate of technical sciences, managing director of production Kazakh Research and Design Institute of Construction and Architecture, Almaty, Kazakhstan, Eshokbarov@kazniisa.kz
Yevgeni Koshcheev – Head of the Dynamics and Structures Calculations Sector, Kazakh Research and Design Institute of Construction and Architecture, Almaty, Kazakhstan, Ekoshcheev @kazniisa.kz
Ulugbek Begaliev – Doctor of Technical Sciences, President of the International Association of Earthquake Engineers, Bishkek, Kyrgyz Republic, utbegaliev@mail.ru
Mark Bresler – Sales Director, MAURER SE, Munich, Germany, m.bresler@maurer.eu

Author Contributions:
Yeraly Shokbarov – supervision, concept development, methodology, research, in-depth analysis, writing-original draft.
Yevgeni Koshcheev – conducting spatial calculations, analysis, writing-original draft.
Ulugbek Begaliev – scientific supervision, methodology, validation, interpretation of results, writing-review and editing.
Mark Bresler – consultation, supervision, methodology, validation, writing-review and editing.

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