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Problems Of Updating The Calculation And Design Of Buildings (Structures) Taking Into Account Seismic Loads In Accordance With The Documents Of The Republic Of Uzbekistan

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Problems of Updating the Calculation and Design of Buildings (Structures) Taking Into Account Seismic Loads in Accordance With the Documents of the Republic of Uzbekistan

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Abstract. The article is devoted to the issues of improving calculations and design of buildings and structures in earthquake-prone regions of the Republic of Uzbekistan based on the norms of KMK 2.01.03-19 «Construction in seismic areas». The authors analyze modern approaches to accounting for seismic loads in design, highlighting the features relevant to the conditions of regions with a seismicity of 8-9 points. Proposals for the further development of the calculation methodology aimed at improving the reliability, earthquake resistance and economic efficiency of construction are presented. The advantages of KMK 2.01.03-19 are noted, including the possibility of taking into account various degrees of responsibility of structural elements, the use of dynamic analysis and the calculation of buildings according to the second group of limit state. The applicability of the approach to unique and massive facilities, taking into account operational characteristics and technical conditions, is also shown. Comparative calculations have been carried out using other regulatory documents, which makes it possible to identify the advantages of the Uzbek methodology and ensure its compatibility with international standards. The results obtained demonstrate the high accuracy and practical value of the calculated models. The proposed approaches contribute to improving the efficiency of earthquake-resistant design and may be useful in the context of a national program to improve the safety of buildings and structures.

INTRODUCTION

Ensuring earthquake-resistant construction and reliability of facilities under construction, including the seismic safety of the population, is of paramount importance for the protection of human lives, as well as material and cultural values created by the labor of many generations living in the seismically active regions of Central Asia. Such regions include 78-87% of the Republic of Uzbekistan territory belongs to such regions, where more than 90% of the country's population lives. These areas, especially the 8th and 9th points, account for the largest volume of construction. The share of modern development of earthquake-resistant construction in our country largely determines the main directions for improving methods of their calculation and design, taking into account technical and economic indicators assessing their operational characteristics (reliability, seismic safety, durability, deformability, etc.), with a reasonable compromise between cost estimates and efficiency, largely depending on the regulations of national norms of design through updating and harmonization, which seems to be quite significant because, this, to a certain extent, determines the level of development of construction science and technology [1, 2, 6-9].

Relevance, main tasks and problems. The guarantee of earthquake resistance of construction and reliability of facilities under construction, as well as protection of the population from seismic risks, are the most important elements in the process of improving the national standards of the Republic of Uzbekistan in the field of design, construction and reconstruction of buildings and engineering structures. In accordance with the current Building

Codes and Norms (hereinafter referred to as the "KMK") KMK 2.01.03-19 [1, 2], which take into account seismic loads, the relevance of this topic is determined by the need for further development and harmonization of regulatory requirements.

The results of the present studies [6-9] conducted by the authors aim to fill this gap to some extent by analyzing international experience, since the spectral calculation method, widely used in practice, has both advantages and some disadvantages [2]. In this regard, it is important to systematize and take into account the available materials on the modernization of similar regulatory documents, including Eurocodes, building codes of the USA, Great Britain, Japan, China, South Korea, as well as norms of the Russian Federation and CIS countries, that take already "Updating" to some extent their standards taking into account Eurocode-8 [3-5, 7-9]. But it must be borne in mind that not even all European countries use Eurocodes. For example, European countries prone to earthquake-prone countries such as Italy, Spain, Portugal, Germany, and some others use their own regulatory documents [7-9]. The main objectives of the work are as follows:

- preservation and development of the advantages of the current building codes and regulations (KMK and ShNK);
- minimization of the identified shortcomings;
- comparison of the methodology for calculating seismic impacts on buildings with similar calculations for engineering networks, hydraulic, transport, agricultural and other structures.

Let's consider the key advantages and possible disadvantages of the methodology presented in KMK 2.01.03-19 [2].

The advantages of KMK 2.01.03-19 [2] include:

- the features have been taken into account and a methodology for designing buildings and structures in the Republic of Uzbekistan has been developed, taking into account the characteristics of areas with a seismicity of more than 9 points (for soils of the third category in the 9 point zone) and 9* points (in areas where seismic sources are likely to occur);
- a methodology has been developed for calculating unique buildings (structures) with a height of more than 40 m, as well as for mass buildings with a height of up to 40 m, using dynamic analysis conducted with the participation of specialized research organizations in the field of earthquake-resistant construction;
- the opportunity is used to take into account the varying degrees of responsibility of structural elements for the ultimate condition of buildings and structures, which significantly increased the economic efficiency of construction;
- the probability of significant deformation of buildings in the initial stage of an earthquake (in the elastic stage) is estimated, which can lead to significant distortion of objects. Post-seismic surveys confirm the possibility of increased displacement of buildings (structures) during in real earthquakes;
- a methodology for designing buildings (structures) according to a second group of limit states (LST-2) has been developed, taking into account the distortions of buildings and floors under the influence of seismic loads.

This allows you for the correct determination of displacement for the assignment of the width of antiseismic joint. This approach, applied in the Republic of Uzbekistan, has already been taken into account in the regulatory documents of other Commonwealth of Independent States (CIS) countries;

- one of the advantages of KMK 2.01.03-19 [2] is the ability to determine, within the framework of a single calculation both the displacements in the initial (conditionally elastic) stage of an earthquake for assigning the width of antiseismic joints, and as well as the combination of efforts in the elements, taking into account their different degrees of responsibility for the limiting state of buildings and structures, which is necessary for optimal selection and checking their cross-sections. This approach may be of interest to other countries as well.

Some disadvantages of KMK 2.01.03-19 [2] include the following:

According to subclause 2.21 of KMK 2.01.03-19 [2], when calculating buildings (structures) in accordance with subparagraph 2.6b, to check that the limiting state of LST-1 has not occurred, the calculated forces in the structural system elements from a special combination of loads, taking into account seismic impacts, are determined by the [2, formula (2.8)]. When applying the [2, formula (2.8)] of the reduced reduction ratio before the radical expression r, the calculation is based on the assumption, according to which the efforts in the elastic system, with the subsequent introduction of reduction coefficients. These coefficients, regulated by the standards, depend on the type of structural system, of the material used, as well as the degree of responsibility of the elements for the transition of the system to the limit state.;

- the use of a spectral method for calculating buildings and structures, which takes into account the degree of responsibility of the elements for the transition to the limiting state, leads to an imbalance in the nodes of the system. This makes it difficult to compare the results with the standards of other countries and limits the possibility of using foreign regulatory documents (manuals, recommendations, guidelines) to verify calculations, which may increase the risk of errors;

- the calculation features related to taking into account the reduction coefficient in [2, formula (2.8)] rather than in [2, formulas (2.3) and (2.4)] of KMK 2.01.03-19 make it difficult to compare the data obtained with international standards. This also complicates the coordination of methods for designing structures in earthquake-prone areas within the KMK itself, since [2, section 4] is based on the methodology of the former USSR with minor adjustments [7-9];
- the dynamic calculation method is not intended for mass use, since its use is limited by references to special technical conditions that are inaccessible to most designers;
- there are no methodological manuals explaining the key aspects of spectral and dynamic calculation methods, as well as practical recommendations for calculating and verifying results obtained using computers, and therefore it is necessary to develop and issue a series of manuals explaining the main provisions of the KMK and simplifying its application in practice.

ANALYSIS OF THE CALCULATION RESULTS

A comparative analysis of the calculations of the building (structure) using the methodology KMK 2.01.03-19 [2], SNIP (Building codes and regulations) 2.7-81* (USSR) [3] and SP (Building regulations) 14.13330.2014 (Russia) [4]. The study revealed certain shortcomings of regulatory documents that make it difficult to obtain unambiguous calculated results.

As an example, a design scheme of a 6 m frame with a span of 6 m for a single-span four-storey building (residential, public or industrial) made of reinforced concrete with a height of 12,0 m (height of each floor 3,0 m) is adopted. The cross section of the columns and crossbars is 400×400 mm, concrete of class B30 ($E_b = 33{,}1\times10^3$ MPa). The frame is loaded with two types of loads: the 1st load - horizontal dynamic loads (seismic); the 2nd load - vertical static loads. The following coefficients were used to calculate seismic loads according to KMK: $\alpha = 1$ [2, subparagraph 2.16]; $K_p = 1$ coefficient of regularity; $K_o = 1$ coefficient of responsibility; $K_{эт} = 1$ coefficient depending on the number of storeys of the building (structure), determined to [2, paragraph 2.17]; $K_п = 1$ coefficient of earthquake recurrence factor [2].

Let's compare the obtained values of seismic loads and forces in the elements of this frame building located on a site with a seismicity of 9 points and soils of the 2nd category in terms of seismic properties. The oscillation period of the first tone is $T_1 = 0.9852$ seconds (according to computer calculations), and the weight of the floor assigned to the point “K” is equal to $Q_k = 500$ kN (without taking into account the loads of the main combination). The comparison is based on the following regulatory documents: SNIP (Building codes and regulations) 2-7-81* (paragraphs 2.5-2.10) [3], SP (Building regulations) 14.13330.2014 [4] and KMK 2.01.03-19 – by limit state of LST-1, taking into account the requirements of [2, paragraphs 2.22 and 2.24]. In this case, the reduction coefficient r is taken into account, corresponding to different values of the relative inelastic deformation of the elements μ (according to [2, table 2.11]), as well as r = 1.0 under the assumption of elastic deformation of structures [2].

When calculating buildings and structures in accordance with paragraph 2.6 b to check that the limit state has not occured LST-1, the calculated forces in the elements of the structural system arising from a special combination of loads taking into account seismic forces are determined by the [2, formula (2.8)]. And to take into account the seismic force, the second part of this [2, formula (2.8)] is used, which was disclosed by the authors of the article in the radical expression. Four forms of oscillations are taken into account in this expression [7-10].

For columns at μ = 5, the value of r calculated by [2, formula (2.9)] is -4.27. [2, condition (2.10)] is not fulfilled, since $r = -4.27 \geq r_1 = 1.951$. In this case, according to [2, formula (2.11)], the value of r is $0{,}85\mu^{-0{,}67} = 0{,}289$.

For crossbars at μ = 7.5, the value of r according to [2, formula (2.9)] is also -4.27. [2, condition (2.10)] is not fulfilled, since $r = -4.27 \geq r_1 = 1.951$. Therefore, according to [2, formula (2.11)], r is $0{,}85\mu^{-0{,}67} = 0{,}222$.

According to KMK 2.01.03-19 [2, for formulas (2.3) and (2.4)] the following coefficient values were adopted: $K_o = 1.0$ – coefficient of responsibility according to [2, table 2.3]; $K_p = 1.0$ - coefficient of earthquake recurrence according to [2, table 2.4]; $K_{et} = 1.0$ – coefficient depending on the number of storeys and structural solutions of buildings and structures according to [2, Table 2.10]; $K_p = 1.0$ – coefficient regularity according to [2, table 2.12]; $K_\delta = 1.0$ is the dissipation coefficient according to [2, formula (2.5)] at $\delta = 0.3$ according to [2, table 2.9]; $\alpha = 1.0$ during seismity of 9 points according to [2, table 2.7]; $W_i = 0.48$ at $T_1 = 0.9852$ sec according to [2, table 2.8]; $\eta_{1k} = 1.278495$, for example, for the first form of natural oscillations.

According to SNIP (Building codes and regulations) 2-7-81* [3], the following coefficient values are accepted for [3, formulas (1) and (2)]: $K_1 = 0.25$ is a coefficient taking into account permissible damage to buildings and structures, is taken from [3, table 3]; $K_2 = 1.0$ is a coefficient taking into account the structural solutions of buildings and structures, adopted according to [3, table. 4]; $K_\psi = 1.0$ – according to the [3, table. 6]; A = 0.4 – with 9 points; $\beta_I = 1.1/T_1 = 1.1/0.9852 = 1.1165$; coefficient $\eta_{1k} = 1.278495$, for example is for the first form of oscillations.

According to SP (Building regulations) 14.13330.2014 [4] were accepted the following values of the coefficients for [4, formulas (1) and (2)]: $K_0 = 1.0$ is a coefficient taking into account the purpose of the structure and its responsibility according to [4, table 3]; $K_1 = 0{,}35$ is a coefficient taking into account the permissible damage to buildings and structures is adopted according to [4, table 4] for reinforced concrete frame buildings (when calculating deformations, the value of $K_1 = 1.0$ – see [4, note 2 to Table 4]; $K_\psi = 1.3$ is a coefficient taking into account the ability of buildings and structures to dissipate energy, according to [4, table 5]; $A = 0.4$ m/s^2 is acceleration at the base level at 9 points; $\beta_I = 2.5(0.4/T_1)0.5$ is the dynamic coefficient at $T_i > 0.4$ s; the coefficient $\eta_{1kj} = 1.278495$, for example, is for the first form of oscillations.

Based on the calculation results, it was found that the values of efforts from the seismic loading in the sections of elements adjacent to the nodes, assuming elastic deformation of structures according to KMK [2], SNIP [3] and SP [4], are in equilibrium.

However, in KMK [2], instead of the coefficient K1 [3, 4], which takes into account the permissible damage to buildings and structures for the entire object, different reduction coefficients r (according to [2, subparagraph 2.22) are used for different elements. These coefficients depend on the period of natural oscillations of the first tone T1 and the permissible relative inelastic deformation of the elements μ, determined by [2, Table 2.11].

At the same time, different reduction coefficients are used for different elements when calculating combinations of efforts from the seismic load. This approach takes into account the assumed varying degrees of responsibility of the elements for the transition of the building to its limit state, but at the same time violates the basic principles of structural mechanics and strength of material, since it leads to a violation of the equilibrium in the section of elements adjacent to the nodes. For example, if you set different coefficients $\mu = 5$ for columns and $\mu = 7.5$ for crossbars, and calculate them using the KMK method, the balance of efforts in the sections of elements adjacent to the nodes is immediately distured [7-10].

If instead of a single coefficient $[\mu_k] = 5$ or 7.5 for all elements (columns and crossbars) - in the KMK [2, formula (2.3)], additionally take into account the correction factor $K_r = 0.289$ or $K_r = 0.222$ (equal to the reduction coefficient r), for $\mu = r = 1.0$, then the balance of forces in the elements adjacent to the nodes is fulfilled.

In reality, when exposed to seismic stress or operational overloads, defects and cracks may appear in the elements, both in normal and especially in inclined sections of the support zones, which leads to a decrease in their rigidity. If in this way we take into account the possibility of reducing the rigidity of the crossbars in the first place, then we can consider what will happen to the combinations of forces in the frame elements, both in individual structures and in the entire structure as a whole. In this example, a single coefficient $[\mu_k] = 5$ should be set for all frame elements (for columns and crossbars). However, the modulus of elasticity of the concrete crossbars must be reduced by an amount equal to the ratio of the coefficients of reduction of the crossbars to the coefficients of reduction of the columns: $0{,}222/0{,}289 = 0{,}768 \cdot (33{,}1 \cdot 10^3) = 25{,}42 \cdot 10^3$ MPa.

This allows us to take into account the varying degrees of responsibility of the elements for achieving the ultimate condition of the building. With this approach, the balance of forces is maintained in the nodes, but at the same time the forces themselves change, their combinations in the sections of the elements under consideration, as well as the movement of the nodes. It is important to note that changing the rigidity of the crossbars affects the forces and their combinations not only in the sections under consideration, but also at full load, including the loads of the main combination, which is not taken into account by the KMK methodology. In general, there is a redistribution of efforts in the framework system while maintaining the balance of efforts and their combinations in the nodes. The resulting combinations of forces can be used to select sections of the elements. Thus, we can be concluded that changing the rigidity of the crossbars leads to a redistribution of forces, which does not correspond to the standard methodology adopted in the KMK [2, 7-10].

Combinations of efforts according to the KMK methodology were determined for several options:

- according to the existing standard methodology, where the coefficients μ and r take into account the different degrees of responsibility of the frame elements in [2, formula (2.8) [2];
- with coefficients μ and r corresponding to the same degree of responsibility of all frame elements in [2, formula (2.8)], separately for $\mu = 5$ and $\mu = 7.5$ [2];
- within the framework of the proposed approach of the methodology, the option of setting the coefficient $\mu = r = 1$ in [2, formula (2.8)] was considered with the simultaneous introduction of the correction factor K_r in [2, formulas (2.4)]. This coefficient took into account the different degrees of responsibility of the frame elements, but was set separately for more and less responsible elements during the repeated calculation;

- options for specifying sections of reduced rigidity in columns and crossbars on the length of (1.5...2)h were also considered, where h = 400 mm is the cross-section size of the crossbar or column. This was done by reducing the modulus of elasticity in proportion to the reduction coefficients in the sections of the elements adjacent to the nodes, separately for crossbars, columns and simultaneously for both types of elements.

RESEARCH RESULTS

It was established that when different values of μ are simultaneously specified for elements with different degrees of responsibility according to the KMK methodology, the combinations of forces in the sections of the elements adjacent to the nodes turn out to be unbalanced. For example, in the upper node in the column (section 4-2), the moment is M = ±97.34 kNm, whereas in the adjacent crossbar (section 12-1), the moment is equal to M = ±74.19 kNm.

In the case of sitting the same values of μ for all elements during repeated calculations (separately for the elements with greater and lesser responsibility), the combinations of forces in the considered sections of adjacent elements become balanced and similar to the previous results. However, the analysis of such data must be carried out separately for crossbars and separately for columns.

When calculating according to the proposed approach to the KMK methodlogy, using the coefficient K_r = 0.2892 (which corresponds to μ = 5) in [2, formula (3)] and when setting the same values of μ = r = 1 for all elements in [2, formula (2.8)], the combinations of forces in the sections of the elements adjacent to the nodes are balanced. For example, in the upper node, the moment in the column (section 4-2) is M = ±97.34 kNm, and in the adjacent crossbar (section 12-1) – M = ±97.34 kNm. In this case the analysis of these results should be carried out separately for crossbars and columns, specifying the required values of the coefficient K_r separately for each type of element for columns and crossbars during the repeated calculation.

When analyzing various options for setting sections of reduced rigidity in columns and crossbars at a length of (1.5... 2)h, where h = 40 cm (the cross-section size of the crossbar or column), by reducing the modulus of elasticity in proportion to the reduction coefficients in the sections of elements adjacent to the nodes (separately in crossbars, columns and simultaneously in both elements), it is established that in all cases there is a redistribution of combinations of efforts. However, in the sections of the elements adjacent to the nodes, the combinations of forces remain in balance. With a slight decrease in the rigidity of the crossbars, the bending moments in the columns remained virtually unchanged compared to the calculated data according to the KMK method, while the moments in the crossbars, on the contrary, increased rather than decreased. In addition, the displacement of the frame and the distortion of the floors at the elastic stage increased slightly, amounting to 153.44 mm compared to 147.76 mm.

With a further decrease in the rigidity of the crossbar and column sections, the combinations of forces in these elements are significantly reduced, remaining balanced at the nodes. However, the sharply increases the displacement of the frame and the distortion of the floors, reaching 234.9 mm, as well as the oscillation periods increase. A similar redistribution is observed for longitudinal and transverse forces [2].

It is interesting to note that when comparing the calculated results performed according to Russian standards, a significant increase in the combinations of forces in the frame elements calculated according to SP 14.13330-2014 [4] was revealed. In particular, the displacements of the upper part of the frame at the elastic stage amounted to 255.33 mm, which significantly exceeds the values obtained according to SNIP 2.7-81 [3] and KMK 2.01.03-19 [2].

CONCLUSIONS

Despite the significant amount of research conducted, this issue remains relevant, requiring further research aimed at designing and examining the technical condition of buildings and structures, taking into account seismic impacts in accordance with KMK 2.01.03-19 [2], with an emphasis on economic efficiency, reliability, seismic safety, durability and deformability.

1. The standard methodology for determining seismic loads and combinations of forces in cross-sections of building elements and structures, taking into account the varying degrees of responsibility of the elements for achieving the limiting condition, in addition to saving, may lead to a decrease in the reliability of the design of certain types of buildings and structures. This is especially relevant for structures with large periods of natural oscillations, if we compare their calculation with the standards of other CIS countries, Russia, Ukraine, Belarus, Kazakhstan and others.

2. This method, in which coefficients [μ] and r are set for all elements, taking into account the reduced rigidity of individual elements (for example, by reducing their modulus of elasticity, taking into account the assumed different

responsibilities of the elements for achieving the limiting condition of the building), allows to take into account the redistribution of efforts when defects occur in individual elements. It gives results similar to the KMK method and eliminates its main drawback – the lack of balance of combinations of forces in the sections of the elements adjacent to the nodes [6-10].

3. It is necessary to review and clarify the provisions of KMK 2.01.03-19 concerning the location of the reduction coefficient r used in calculating the design forces for a special combination of loads. The simplest solution to this problem may be to introduce a single reduction coefficient r in [2, formulas 2.3-2.4] of KMK, and taking into account the varying degrees of responsibility of the elements of the structural system can also be carried out by using the coefficients of responsibility when selecting their sections.

4. The analysis of the stress state of the elements of the structural system of buildings (structures) for seismic loads when calculated using the spectral method can be carried out according to the methodology used in the CIS countries, while the degree of responsibility of the elements can be taken into account through repeated calculations with the corresponding values of the reduction coefficient r. It will also be necessary to check the calculation programs that take into account the provisions of the KMK for compliance with these clarifications. Regulatory documents should be sufficiently reliable, easy to understand for specialists using these documents, have results comparable to the results of documents from other countries, with results easily verifiable by manual calculations, which in general should help to eliminate possible errors when using regulatory documents.

The conducted approach will make it possible to apply the results of calculations according to the norms of other countries, as well as to use regulatory documentation (manuals, recommendations, instructions) as analogues, if necessary, to verify their own calculations. This, in turn, will reduce the number of errors, speed up the correction of KMK deficiencies and simplify the work of designers, especially in areas with seismicity of 8 and 9 points. In addition, the use of this method in seismic loads calculation will not only increase the authenticity and reliability of calculations, but also the efficiency of construction, but also represents the independent scientific and practical interest from the point of view of ensuring earthquake-resistant construction and seismic safety of the population of the Republic of Uzbekistan and will facilitate the international exchange the construction ideas and effective constructive solutions for earthquake-resistant construction.

REFERENCES

1. Decree of the President of the Republic of Uzbekistan "On measures to increase the seismic resistance of buildings and structures, as well as to improve seismic hazard monitoring activities", dated 17.04.2024, № PP-161 https://lex.uz/uz/docs/6887055.
2. KMK 2.01.03-19. *Construction in seismic areas* (Ministry of construction of the Republic of Uzbekistan, Tashkent, 2019), pp. 1-110.
3. SNiP 2.07.81*. *Construction in Seismic Areas* (Stroyizdat, Moscow, 1982), pp. 1–48.
4. SP 14.13330.2014. *Construction in Seismic Areas* (to SNiP 2.07.81*) (Ministry of Construction of the Russian Federation, Moscow, 2014), pp. 1-131.
5. . G. Tyapin, *Seismic-Resistant Construction. Safety of Structures* **5**, 15–18 (2019).
6. M. N. Ubaydulloyev, G. S. Strigo, N. G. Sayfulova, O. Ubaydulloyev, and N. Ubaydulloyeva, *Earthquake Safe Constructions with Lightweight Steel Structures (Book of Abstracts)* (Knauf, Tashkent, 2015), p. 28.
7. M. N. Ubaydulloyev, O. Ubaydulloyev, and N. Ubaydulloyeva, *Problems of Architecture and Construction* **4**, 134–138 (2020).
8. M. N. Ubaydulloyev, O. Ubaydulloyev, N. Ubaydulloyeva, and L. Nasrullayev, *Bulletin of the International Association of Experts on Earthquake-Resistant Construction* **14**, 69–74 (2022).
9. M. Ubaydulloyev and O. Ubaydulloyev, in *Proceedings of the International Conference "Ensuring Seismic Safety and Seismic Stability of Buildings and Structures: Applied Problems of Mechanics"*, AIP Conf. Proc. **3265** (AIP Publishing, New York, 2025), pp. 030010-1–030010-6.