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## **Determination of the load-bearing capacity of reinforced concrete columns**

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*Abstract. Reinforced concrete structures, when properly maintained, are reliable and retain their original (design) characteristics throughout the entire life of the building. Even after dismantling, they can be reused, provided that their load-bearing capacity has been verified beforehand. The load-bearing capacity of existing building structures must also be determined during the reconstruction of buildings and structures, their superstructure, changes in the structural design, increases in payload due to the modernization of technological processes, changes in the purpose of the facility, for quality control of the completed building structure, etc.*

*The aim of the study is to develop an algorithm for calculating the load-bearing capacity of reinforced concrete columns operating with random eccentricities, based on a deformation model.*

*Reinforced concrete columns are considered as eccentrically compressed elements with random or calculated eccentricities, operating according to the first or second form of equilibrium.*

*The paper presents cross-section diagrams, deformation distribution, stress diagrams, and formulas for determining the load-bearing capacity of reinforced concrete columns under various possible conditions of compressive force application and corresponding deformations in the cross-sections of eccentrically compressed elements. An algorithm has been developed for calculating the stability of reinforced concrete columns operating with random eccentricities. All initial data are obtained as a result of instrumental inspection of existing structures, using normative literature. The load-bearing capacity of the reinforced concrete column on the first floor of a public building scheduled for reconstruction with the addition of a third floor was determined using a specially developed algorithm. This value is compared with the calculated compressive load according to the reconstruction project, and a conclusion is made about the adequacy of the load-bearing capacity or the need to reinforce the column.*

*Keywords: load-bearing capacity, non-destructive testing, calculation, compression, reinforced concrete column, equilibrium form.*

## **Introduction**

Reinforced concrete is a very durable material due to its strength, surface hardness, high density, weather resistance, biological resistance, water resistance, frost resistance, etc. Under proper operating conditions, reinforced concrete structures are reliable and retain their initial (design) characteristics throughout the entire life of the building.

When, due to various circumstances, it becomes necessary to dismantle the entire building or part of it, a project is developed according to which the existing reinforced concrete structures are to be dismantled, stored and possibly reused in new design solutions.

Before reuse, it is necessary to inspect the dismantled structure, take measurements, identify all existing defects, determine the strength of the concrete, the quantity and strength of the existing working reinforcement using instrumental research methods, and, as a result, determine the load-bearing capacity of the dismantled reinforced concrete structure.

The load-bearing capacity of existing building structures must also be determined during the reconstruction of buildings and structures, their superstructure, changes in the structural design, increases in payload due to the modernisation of technological processes, changes in the purpose of the facility, for quality control of the completed building structure, etc.

**The aim of the study:** determination of the stability of reinforced concrete columns.

**Research objectives:** develop an algorithm for calculating the stability of reinforced concrete columns operating with random eccentricities.

**Research methodology.** The calculation of the stability of reinforced concrete structures is based on a deformation model. Reinforced concrete

columns are considered as eccentrically compressed elements with random or calculated eccentricities, operating according to the first or second form of equilibrium.

When using a simplified concrete deformation diagram, two forms of cross-section equilibrium are considered:

- the first form of equilibrium (Figs. 1, 2, 3) is observed when the entire cross-section is compressed and the conditional height of the compressed zone  $x$  exceeds the height of the cross-section  $h$ ;

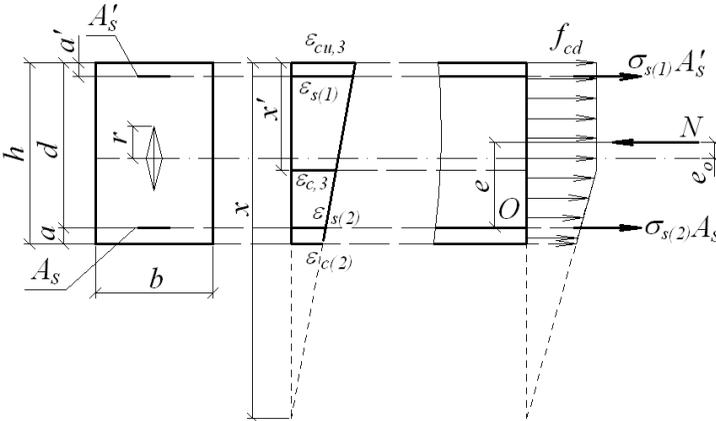


Fig. 1. The first form of equilibrium of a compressed element, general case

- the second form of equilibrium (Figs. 4, 5) is characteristic of cases where part of the cross-section of the element is compressed and the other part is stretched, i.e., the height of the compressed zone  $x$  is less than the height of the cross-section  $h$ .

Let us consider the deformation model (Fig. 1). Deformations in concrete are distributed proportionally:  $\frac{\epsilon_{cu,3}}{x} = \frac{\epsilon_{c(2)}}{x-h}$ , where  $x = h \frac{\epsilon_{cu,3}}{\epsilon_{cu,3} - \epsilon_{c(2)}}$ .

Deformations  $\epsilon_{c(2)} = \epsilon_{cu,3} (1 - e_0 / r)$ . The greatest stress in concrete is in the more compressed zone  $\sigma_{c(1)} = \epsilon_{cu,3} E_{cd} = f_{cd}$ . The least stress in concrete in the less compressed zone:  $\sigma_{c(2)} = \epsilon_{c(2)} E_{cd} = f_{cd} \frac{x-h}{x-x'}$ .

Deformations in the reinforcement of the more compressed zone (Fig. 1) from the proportion  $\frac{\epsilon_{cu,3}}{x} = \frac{\epsilon_{s(1)}}{x-a'}$ , where  $\epsilon_{s(1)} = \frac{\epsilon_{cu,3}(x-a')}{x}$ . Stress in this reinforcement  $\sigma_{s(1)} = \epsilon_{s(1)} E_s$ . Deformations in the reinforcement of the less

compressed zone (Fig. 1) with a ratio of:  $\frac{\varepsilon_{cu,3}}{x} = \frac{\varepsilon_{s(2)}}{x-d}$  where

$$\varepsilon_{s(2)} = \frac{\varepsilon_{cu,3}(x-d)}{x}. \text{ Stress in this reinforcement } \sigma_{s(2)} = \varepsilon_{s(2)}E_s.$$

When all internal forces are projected onto the axis of the element, the load-bearing capacity can be determined from the equilibrium condition (Fig. 1):

$$N = \sigma_{s(1)}A'_s + f_{cd}b \left[ x' + 0,5(h-x') \left( 1 + \frac{x-h}{x-x'} \right) \right] + \sigma_{s(2)}A_s.$$

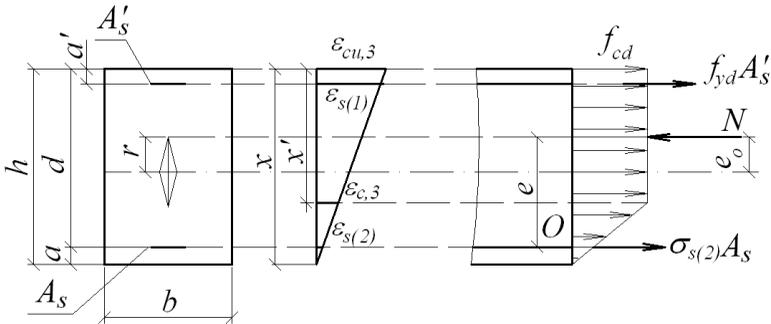


Fig. 2. The first form of equilibrium of a compressed element, a special case under the condition  $e_0 = r$

Under the condition  $e_0 = r$  the deformation in the reinforcement of the more compressed zone (Fig. 2) is proportional to  $\frac{\varepsilon_{cu,3}}{h} = \frac{\varepsilon_{s(1)}}{h-a'}$ , where

$$\varepsilon_{s(1)} = \frac{\varepsilon_{cu,3}(h-a')}{h}. \text{ Stress in this reinforcement } \sigma_{s(1)} = \varepsilon_{s(1)}E_s = f_{yd}.$$

Deformations in the reinforcement of the less compressed zone (Fig. 2) with a ratio of  $\frac{\varepsilon_{cu,3}}{h} = \frac{\varepsilon_{s(2)}}{a}$ , where  $\varepsilon_{s(2)} = \frac{\varepsilon_{cu,3}a}{h}$ . Stress in this reinforcement  $\sigma_{s(2)} = \varepsilon_{s(2)}E_s$ .

Given the strength relative to the axis passing through the centre of gravity of the stretched reinforcement, the holding capacity will be:

$$N = \left[ f_{yd}A'_s(d-a') + f_{cd}b \frac{h+x'}{2} \left( d - \frac{h+x'}{4} \right) \right] / e.$$

Provided that  $\epsilon_{c,3} < \epsilon_{c,2} < \epsilon_{cu,3}$  (Fig. 3), the bearing capacity of the compressed element is determined by the strength condition relative to the axis passing through the centre of gravity of the tensioned reinforcement:

$$N = [f_{yd}A'_s(d - a') + f_{cd}bh(0,5h - a)] / e.$$

When all internal forces are projected onto the axis of the element, the compressive force can also be determined from the equilibrium condition (Fig. 3):

$$N = f_{yd}A'_s + f_{cd}bh + f_{yd}A_s.$$

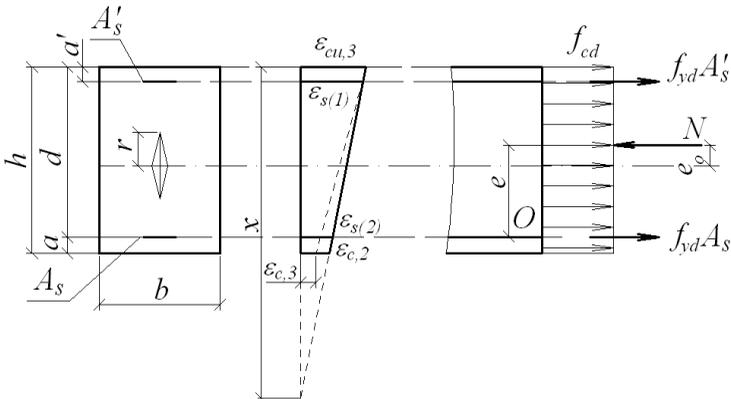


Fig. 3. The first form of equilibrium of a compressed element, a special case when  $\epsilon_{c,3} < \epsilon_{c,2} < \epsilon_{cu,3}$

If an eccentrically compressed reinforced concrete element operates with significant eccentricities, then a second form of equilibrium is observed, and the stresses in the compressed concrete can be distributed according to a bilinear diagram (Fig. 4) or a rectangular diagram (Fig. 5).

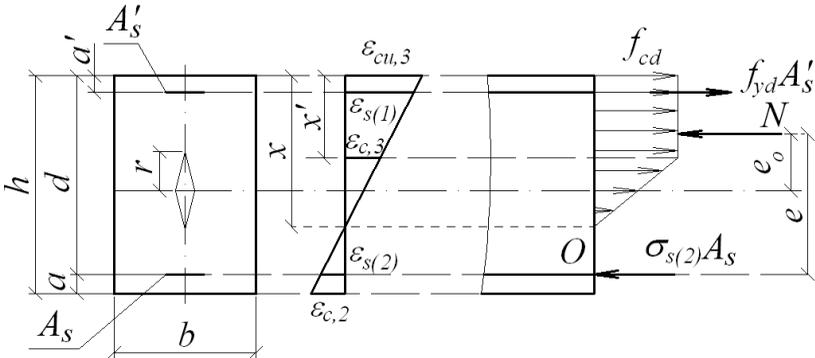


Fig. 4. The second form of equilibrium of a compressed element with stress distribution in concrete according to a two-line diagram

At the limit state (Fig. 4), the height of the compressed part of the cross-section is  $x = x_R = \xi_R d$ . According to the deformation model  $\frac{\varepsilon_{cu,3}}{x} = \frac{\varepsilon_{c,3}}{x - x'}$ , where  $x' = x \frac{\varepsilon_{cu,3} - \varepsilon_{c,3}}{\varepsilon_{cu,3}} = x_R \frac{\varepsilon_{cu,3} - \varepsilon_{c,3}}{\varepsilon_{cu,3}}$ . The stresses in the reinforcement of the compressed zone reach their limit value  $\sigma_{s(1)} = \varepsilon_{s(1)} E_s = f_{yd}$ .

From the condition of strength relative to the axis passing through the centre of gravity of the stretched reinforcement, the holding capacity:

$$N = \left[ f_{yd} A'_s (d - a') + f_{cd} b \frac{x_R + x'}{2} \left( d - \frac{x_R + x'}{4} \right) \right] / e.$$

If the stress diagram in concrete is considered rectangular (Fig. 5), then based on the condition of cross-sectional strength relative to the axis passing through the centre of gravity of the tensioned reinforcement, the holding capacity will be:

$$N = \left[ f_{yd} A'_s (d - a') + f_{cd} b \lambda x_R (d - 0,5 \lambda x_R) \right] / e.$$

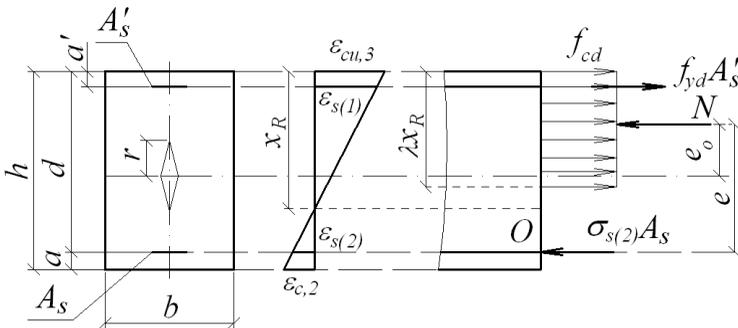


Fig. 5. The second form of equilibrium of a compressed element with stress distribution in concrete according to a rectangular diagram

## Results and discussion

The scientific research construction laboratory of LNTU, which operates within the Department of Building and Civil Engineering, provides qualified services for the inspection of building structures and structures. The laboratory specialists measure structures, examine them using non-destructive testing methods, determine the strength of concrete, the presence of reinforcement, its diameter, strength, and the protective layer of concrete. Fig. 6 shows photographs

of some inspections of reinforced concrete columns.



Fig. 6. Instrumental examination of columns

Based on the results of instrumental studies, the load-bearing capacity of columns is calculated and conclusions are drawn (confirmation of the declared quality of the structure, the possibility of further operation or reuse of dismantled elements, etc.).

The load-bearing capacity of existing reinforced concrete columns with a square cross-section, which are designed to operate with random eccentricities, is calculated using the following algorithm:

<i>Initial data:</i> dimensions of the structure $b, h, l$ , mm, (based on measurement results); concrete strength $f_{cd}$ (determined using a Schmidt hammer, BETON PRO CONDTRONL device or other) and concrete class $C$ ; protective layer of concrete, mm; diameter, number of working reinforcement bars and their strength $f_{yd}$ set using the POISK-M device); reinforcement area $A_s, A'_s$ mm <sup>2</sup> , (according to the assortment); concrete deformation $\varepsilon_{c,3}, \varepsilon_{cu,3}$ (from normative literature, depending on the concrete class $C$ )	
1	Calculate the actual value $a, a'$ taking into account the diameter of the longitudinal reinforcement and the protective layer of concrete
2	Determine the working height of the cross-section $d = h - a$
3	Determine the random eccentricity $e_i \geq \max \{ h/30; l/600; 10\text{MM} \}$
4	Determine the distance from the central axis of the cross-section to the core point $r = W_{red} / A_{red} = h / 6$
5	Determine concrete deformations $\varepsilon_{c,2} = \varepsilon_{cu,3} (1 - e_0 / r)$
6	Determine the nominal height of the compressed zone of concrete $x = h \frac{\varepsilon_{cu,3}}{\varepsilon_{cu,3} - \varepsilon_{c,2}}$
7	Check if the condition is met $\varepsilon_{c,3} < \varepsilon_{c,2} < \varepsilon_{cu,3}$ (Fig. 3)
8	Calculate the eccentricity of the compressive force $N$ relative to the axis passing through the centre of gravity of the reinforcement $S$ : $e = (0,5h - a) + e_i$
9	Determine the moment that perceives the cross-section of the column relative to the axis passing through the centre of gravity of the reinforcement $S$ $M_O = Ne = f_{yd} A'_s (d - a') + f_{cd} b h (0,5h - a)$
10	Calculate the value of the compressive force $N = M_O / e$

11	Determine the moment that perceives the cross-section of the column relative to the axis passing through the centre of gravity of the reinforcement $s'$ $M_{o1} = N(d - e) = f_{yd} A_s (d - a) + f_{cd} b h (0,5h - a')$
12	Calculate the value of the compressive force $N = M_{o1} / (d - e)$
13	From the two values of $N$ obtained in points 10 and 12, select the smaller one. This value corresponds to the load-bearing capacity of the column

## Conclusions

The load-bearing capacity of the reinforced concrete column on the first floor of a public building scheduled for reconstruction with the addition of a third floor was determined using the above algorithm. The column cross-section dimensions are 300×300 mm, height 3.0 m, concrete strength 13.71 MPa, as determined by the BETON PRO CONDTRON device, which corresponds to concrete class C16/20 with a design strength value of  $f_{cd} = 11.5$  MPa. According to DBN, the deformation of C16/20 concrete is  $\varepsilon_{c,3} = 0.00058$ ;  $\varepsilon_{cu,3} = 0.00323$ . Reinforcement of cross-section 4Ø14A400C, protective layer 25 mm, detected by POISK-M device. Calculated strength of reinforcement 365 MPa. Cross-sectional area  $A_s = A'_s = 307,7$  mm<sup>2</sup>, determined by the assortment. Based on the known reinforcement  $a = a' = 25 + 14/2 = 32$  mm is established. Working height  $d = 300 - 32 = 268$  mm;  $e_i = 10$  mm;  $r = 50$  mm;  $\varepsilon_{c,2} = 0,00258$ ;  $x = 1490,8$  mm; condition  $\varepsilon_{c,3} < \varepsilon_{c,2} < \varepsilon_{cu,3}$  is satisfied;  $e = 128$  mm;  $M_o = 148,6$  kNm;  $N = 1161,2$  kN;  $M_{o1} = 148,6$  kNm;  $N = 1061,7$  kN. Therefore, the bearing capacity of the inspected column is 1061.7 kN. This value is compared with the calculated compressive load according to the reconstruction project, and a conclusion is made about the adequacy of the bearing capacity or the need to reinforce the column.

## Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study, as well as the results reported in this paper.

## Funding

The study was conducted without financial support.

## Data availability

All data is available in digital or graphic form in the main text of the article.

## Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies in the creation of the current work.

## References

1. Baloch W.L., Siad H., Lachemi M., Sahmaran M. 12 - Modern assessment techniques to evaluate concrete repairs. *Eco-Efficient Repair and Rehabilitation of*

*Concrete Infrastr. (Second Edition)*, 2024, 327-348. <https://doi.org/10.1016/B978-0-443-13470-8.00010-1>

2. Bao X., Li B. Residual strength of blast damaged reinforced concrete columns. *Int. Journ. of Impact Eng.*, 2010, 37(3), 295-308. <https://doi.org/10.1016/j.ijimpeng.2009.04.003>

3. Habib, A., Yildirim, U., Eren, O. Column repair and strengthening using RC jacketing: a brief state-of-the-art review. *Innov. Infrastruct. Solut.*, 2020, 5, 75. <https://doi.org/10.1007/s41062-020-00329-4>

4. Ye-Eun Kim et al. Proposing Improvements for Blast Resistance Performance of Reinforced Concrete Columns Based on Strength and Ductility Analysis. *Journal of the Korea Concrete Institute*, 2024, 36(4), 337-345. <https://doi.org/10.4334/JKCI.2024.36.4.337>

5. Krainskiy P, Blikharskiy Z, Khmil R. Experimental Investigation of Reinforced Concrete Columns Strengthened By Jacketing. *JMEST*, 2015, 2(7), 1959-1963. <https://www.jmest.org/wp-content/uploads/JMESTN42350952.pdf>

6. Krantovska O., Ksonshkevych L., Synii S. et al. Modeling of the stress-strain state of a continuous reinforced concrete beam in ANSYS mechanical. *AIP Conf. Proc.*, 2023, 2684(1), 030021. <https://doi.org/10.1063/5.0142710>

7. Ksonshkevych L. M., Krantovska O. M., Synii S. V. et al. Ensuring the functioning of engineering, transport networks thanks to the strengthening of damaged reinforced concrete columns of their structures. *Modern technologies and methods of calculations in construction*, 2024, 22. 80-88. [https://doi.org/10.36910/6775-2410-6208-2024-12\(22\)-08](https://doi.org/10.36910/6775-2410-6208-2024-12(22)-08)

8. Mostafa Osman, Ata El-Kareim Shoeib Soliman Behavior of confined column under different techniques. World Academy of Science, Engineering and Technology.2014. <http://doi.org/10.5281/zenodo.1099456>

9. Pan J. L., Gu J., Chen J. H. Theoretical modeling of steel reinforced ECC column under eccentric compressive loading. *Science China Technological Sciences*. 2015. Vol.58 (5): P. 889-898. <doi.org/10.1007/s11431-015-5798-z>

10. Sezen, Halil, Setzler, Eric J. Reinforcement Slip in Reinforced Concrete Columns. *ACI Structural Journal*; Farmington Hills.2008. P. 280-289. <https://search.proquest.com/openview/755b82f7f2cf923a8050f576dcc5efbf/1?pq-origsite=gscholar&cbl=36963>

11. Shi Y., Stewart M. G. Spatial reliability analysis of explosive blast load damage to reinforced concrete columns. *Structural Safety*, 2015, 53, 13-25. <https://doi.org/10.1016/j.strusafe.2014.07.003>

12. Tytarenko R., Khmil R., Selejdk J., Blikharskiy Y. Influence analysis of the most common defects and damages on the durability (residual resource) of RC members: a review. *LNCE*, 2024, 438, 448-455. [https://doi.org/10.1007/978-3-031-44955-0\\_45](https://doi.org/10.1007/978-3-031-44955-0_45)

13. Bondarskiy O. G., Drobyshynets S. Y., Luchynets S. A. Rotko S. V., Uzhehova O. A. Technical inspection of reinforced concrete structures. *Modern technologies and methods of calculations in construction*, 2023, 19, 22-32. [https://doi.org/10.36910/6775-2410-6208-2023-9\(19\)-03](https://doi.org/10.36910/6775-2410-6208-2023-9(19)-03)

14. Drobyshynets S. Y., Uzhehova O. A., Bondarskiy O. G., Uzhehov S. O., Rotko S. V., Denychuk V. E. The results of the inspection of the structures of the extension to the public building in Lutsk. *Modern technologies and methods of*

calculations in construction, 2024, 22, 57-66. [https://doi.org/10.36910/6775-2410-6208-2024-12\(22\)-06](https://doi.org/10.36910/6775-2410-6208-2024-12(22)-06)

15. Klymenko Ye.V., Antoniuk N. R., Maksiuta E. V. Carrying capacity of damaged reinforced concrete two-tube columns. Bulletin of Odessa State Academy of Civil Engineering and Architecture, 2021, no. 85, page 18-27. <http://visnyk-odaba.org.ua/2021-85/85-2.pdf>

16. Klymenko Y., Kos Z., Grynova I., Crnoja A. Damaged reinforced concrete columns of various flexibility: research and calculation. Monograph // Varaždin, Croatia, 2020. 179 p.

17. Rotko S. V., Uzhehova O. A., Zadoroznikova I. V., Ryabiy O. I. Analysis of the effectiveness of using high-strength concrete in compressed elements of monolithic frame buildings. *Modern technologies and methods of calculations in construction*, 2024, 22, 191-198. [https://doi.org/10.36910/6775-2410-6208-2024-12\(22\)-19](https://doi.org/10.36910/6775-2410-6208-2024-12(22)-19)

18. Pavlikov A. M., Harkava O. V., Barylyak B. A. Rozrakhunok nesuchoyi zdatnosti zalizobetonnykh kolon bezbalkovykh karkasiv. *Novi tekhnolohiyi v budivnytstvi*, 2020, 23-29. <https://doi.org/10.32782/2664-0406.2020.38.4>

19. Rotko S. V., Uzhehova O. A., Pasichnyk R. V., Hontar V. O. Tekhnichne obstezhennya konstruksiyi tekhpipillya adminbudivli u m. Lutsku. *Suchasni tekhnolohiyi ta metody rozrakhunkiv u budivnytstvi*, 2022, 17, 120-130. [https://doi.org/10.36910/6775-2410-6208-2021-7\(17\)-16](https://doi.org/10.36910/6775-2410-6208-2021-7(17)-16)

20. Uzhehova O. A., Uzhehov S. O., Rotko S. V., Zadorozhnikova I. V. Rozrakhunok stysnutykh elementiv za pershoju formoyu rivnovahy. *Resursoekonomni materialy, konstruksiyi, budivli ta sporudy*, 2016, 32, 274-281. [http://nbuv.gov.ua/UJRN/rmkbs\\_2016\\_32\\_39](http://nbuv.gov.ua/UJRN/rmkbs_2016_32_39)

21. Uzhehova O. A., Uzhehov S. O., Rotko S. V., Samchuk V. P. Rozrakhunok stysnutykh elementiv za druhoju formoyu rivnovahy. *Mistobuduvannya ta terytorial'ne planuvannya*, 2016, 61, 432-437. [http://nbuv.gov.ua/UJRN/MTP\\_2016\\_61\\_55](http://nbuv.gov.ua/UJRN/MTP_2016_61_55)

22. Murashko L. A., Kolyakova V. M., Smorkalov D. V. Rozrakhunok za mitsnistyu pereriziv, normalnykh ta pokhylykh do pozdovzhnoyi osi, zhynalnykh zalizobetonnykh elementiv za DBN V.2.6-98:2009: Navchalnyy posibnyk – K.: KNUBA, 2012. – 62 s.

23. Praktychnyy rozrakhunok elementiv zalizobetonnykh konstruksiyi za DBN V.2.6-98:2009 u porivnyanni z rozrakhunkom za SNyP 2.0301-84\* i EN 1992-1-1 (Eurocode 2) / V. M. Babaev, A. M. Bambura, O. M. Pustovoytov ta in.; za zah. red. V. S. Shmuklera. – Kharkiv: Zoloti storinky, 2015. – 208 s.

24. DBN V.2.6-98:2009 Konstruksiyi budynkiv i sporud. Betonni ta zalizobetonni konstruksiyi. Osnovni polozhennya. Zi Zminoyu № 1. [https://e-construction.gov.ua/files/new\\_doc/3080063210573792873/2023-04-13/adb4cae-8595-4d35-9b22-a858d85864b4.pdf](https://e-construction.gov.ua/files/new_doc/3080063210573792873/2023-04-13/adb4cae-8595-4d35-9b22-a858d85864b4.pdf)

25. DSTU B V.2.6.-156: 2010. Konstruksiyi budynkiv i sporud. Betonni ta zalizobetonni konstruksiyi z vazhkoho betonu. Pravyla proektuvannya. [https://www.ksv.biz.ua/GOST/DSTY/dsty\\_b\\_v.2.6-156-2010.pdf](https://www.ksv.biz.ua/GOST/DSTY/dsty_b_v.2.6-156-2010.pdf)

26. Eurocode-2: Design of concrete structures. – Part 1-1: General rules and rules for building: EN 1992-1-1. – [Final draft, december, 2004]. – Brussels: CEN, – 2004. – 225 p. <https://www.phd.eng.br/wp-content/uploads/2015/12/en.1992.1.1.2004.pdf>

27. DSTU 9273:2024 Nastanova shchodo obstezhennya budivel i sporud dlya vyznachennya ta otsinyuvannya yikhnoho tekhnichnoho stanu. Mekhanichnyy opir ta stiykist.

[https://uscc.ua/uploads/page/images/normativnye%20dokumenty/dstu/dstu\\_9273\\_2024.pdf](https://uscc.ua/uploads/page/images/normativnye%20dokumenty/dstu/dstu_9273_2024.pdf)

28. DBN V.1.2-14:2018 Systema zabezpechennya nadiynosti ta bezpeky budivel'nykh ob'ektiv. Zahalni pryntsypy zabezpechennya nadiynosti ta konstruktyvnoyi bezpeky budivel i sporud. Zi Zminoyu № 1. <https://dreamdim.ua/wp-content/uploads/2018/12/DBN-V1214-2018.pdf>

29. DSTU B V.2.7-220:2009 Budivelni materialy. Betony. Vyznachennya mitsnosti mekhanichnymy metodamy neruynivnoho kontrolyu. [https://dnaop.com/html/59798/doc-%D0%94%D0%A1%D0%A2%D0%A3\\_%D0%91\\_%D0%92.2.7-220\\_2009](https://dnaop.com/html/59798/doc-%D0%94%D0%A1%D0%A2%D0%A3_%D0%91_%D0%92.2.7-220_2009)

30. DSTU B V.2.7-224:2009 Betony. Pravyla kontrolyu mitsnosti. [https://dbn.co.ua/load/normativy/dstu/dstu\\_b\\_v\\_2\\_7\\_224/5-1-0-1867](https://dbn.co.ua/load/normativy/dstu/dstu_b_v_2_7_224/5-1-0-1867)

31. DSTU B V.2.7-226:2009 Budivelni materialy. Betony. Ultrazvukovyy metod vyznachennya mitsnosti. [https://ultracon.com.ua/images/beton.ultrazvukovoy\\_metod\\_opredeleniya\\_prochnosti.pdf](https://ultracon.com.ua/images/beton.ultrazvukovoy_metod_opredeleniya_prochnosti.pdf)

### Література

1. Baloch W.L., Siad H., Lachemi M., Sahmaran M. 12 - Modern assessment techniques to evaluate concrete repairs. *Eco-Efficient Repair and Rehabilitation of Concrete Infrastr. (Second Edition)*, 2024, 327-348. <https://doi.org/10.1016/B978-0-443-13470-8.00010-1>

2. Bao X., Li B. Residual strength of blast damaged reinforced concrete columns. *Int. Journ. of Impact Eng.*, 2010, 37(3), 295-308. <https://doi.org/10.1016/j.ijimpeng.2009.04.003>

3. Habib, A., Yildirim, U., Eren, O. Column repair and strengthening using RC jacketing: a brief state-of-the-art review. *Innov. Infrastruct. Solut.*, 2020, 5, 75. <https://doi.org/10.1007/s41062-020-00329-4>

4. Ye-Eun Kim et al. Proposing Improvements for Blast Resistance Performance of Reinforced Concrete Columns Based on Strength and Ductility Analysis. *Journal of the Korea Concrete Institute*, 2024, 36(4), 337-345. <https://doi.org/10.4334/JKCI.2024.36.4.337>

5. Krainskiy P, Blikharskiy Z, Khmil R. Experimental Investigation of Reinforced Concrete Columns Strengthened By Jacketing. *JMEST*, 2015, 2(7), 1959-1963. <https://www.jmest.org/wp-content/uploads/JMESTN42350952.pdf>

6. Krantovska O., Ksonshkevych L., Synii S. et al. Modeling of the stress-strain state of a continuous reinforced concrete beam in ANSYS mechanical. *AIP Conf. Proc.*, 2023, 2684(1), 030021. <https://doi.org/10.1063/5.0142710>

7. Ksonshkevych L. M., Krantovska O. M., Synii S. V. et al. Ensuring the functioning of engineering, transport networks thanks to the strengthening of damaged reinforced concrete columns of their structures. *Modern technologies and methods of calculations in construction*, 2024, 22. 80-88. [https://doi.org/10.36910/6775-2410-6208-2024-12\(22\)-08](https://doi.org/10.36910/6775-2410-6208-2024-12(22)-08)

8. Mostafa Osman, Ata El-Kareim Shoeib Soliman Behavior of confined column under different techniques. *World Academy of Science, Engineering and Technology*.2014. <http://doi.org/10.5281/zenodo.1099456>

9. Pan J. L., Gu J., Chen J. H. Theoretical modeling of steel reinforced ECC column under eccentric compressive loading. *Science China Technological Sciences*. 2015. Vol.58 (5): P. 889-898. [doi.org/10.1007/s11431-015-5798-z](https://doi.org/10.1007/s11431-015-5798-z)

10. Sezen, Halil, Setzler, Eric J. Reinforcement Slip in Reinforced Concrete Columns. *ACI Structural Journal*; Farmington Hills.2008. P. 280-289. <https://search.proquest.com/openview/755b82f7f2cf923a8050f576dcc5efbf/1?pq-origsite=gscholar&cbl=36963>
11. Shi Y., Stewart M. G. Spatial reliability analysis of explosive blast load damage to reinforced concrete columns. *Structural Safety*, 2015, 53, 13-25. <https://doi.org/10.1016/j.strusafe.2014.07.003>
12. Tytarenko R., Khmil R., Selejdak J., Blikharskyi Y. Influence analysis of the most common defects and damages on the durability (residual resource) of RC members: a review. *LNCE*, 2024, 438, 448–455. [https://doi.org/10.1007/978-3-031-44955-0\\_45](https://doi.org/10.1007/978-3-031-44955-0_45)
13. Bondarskyi O. G., Drobyslynets S. Y., Luchynets S. A. Rotko S. V., Uzhehova O. A. Technical inspection of reinforced concrete structures. *Modern technologies and methods of calculations in construction*, 2023, 19, 22-32. [https://doi.org/10.36910/6775-2410-6208-2023-9\(19\)-03](https://doi.org/10.36910/6775-2410-6208-2023-9(19)-03)
14. Drobyslynets S. Y., Uzhehova O. A., Bondarskyi O. G., Uzhehov S. O., Rotko S. V., Denychuk V. E. The results of the inspection of the structures of the extension to the public building in Lutsk. *Modern technologies and methods of calculations in construction*, 2024, 22, 57-66. [https://doi.org/10.36910/6775-2410-6208-2024-12\(22\)-06](https://doi.org/10.36910/6775-2410-6208-2024-12(22)-06)
15. Klymenko Ye.V., Antoniuk N. R., Maksyuta E. V. Carrying capacity of damaged reinforced concrete two-tube columns. *Bulletin of Odessa State Academy of Civil Engineering and Architecture*, 2021, no. 85, page 18-27. <http://visnyk-odaba.org.ua/2021-85/85-2.pdf>
16. Klymenko Y., Kos Z., Grynova I., Crnoja A. Damaged reinforced concrete columns of various flexibility: research and calculation. Monograph // Varaždin, Croatia, 2020. 179 p.
17. Rotko S. V., Uzhehova O. A., Zadoroznikova I. V., Ryabiy O. I. Analysis of the effectiveness of using high-strength concrete in compressed elements of monolithic frame buildings. *Modern technologies and methods of calculations in construction*, 2024, 22, 191-198. [https://doi.org/10.36910/6775-2410-6208-2024-12\(22\)-19](https://doi.org/10.36910/6775-2410-6208-2024-12(22)-19)
18. Павліков А. М., Гарькава О. В., Бариляк Б. А. Розрахунок несучої здатності залізобетонних колон безбалкових каркасів. *Нові технології в будівництві*, 2020, 23-29. <https://doi.org/10.32782/2664-0406.2020.38.4>
19. Ротко С. В., Ужєгова О. А., Пасічник Р. В., Гонтар В. О. (2022). Технічне обстеження конструкцій техпідпілля адмінбудівлі у м. Луцьку. *Сучасні технології та методи розрахунків у будівництві*, 17, 120-130. [https://doi.org/10.36910/6775-2410-6208-2021-7\(17\)-16](https://doi.org/10.36910/6775-2410-6208-2021-7(17)-16)
20. Ужєгова О. А., Ужєгов С. О., Ротко С. В., Задорожнікова І. В. Розрахунок стиснутих елементів за першою формою рівноваги. *Ресурсоекономічні матеріали, конструкції, будівлі та споруди*, 2016, 32, 274-281. [http://nbuv.gov.ua/UJRN/rmkbs\\_2016\\_32\\_39](http://nbuv.gov.ua/UJRN/rmkbs_2016_32_39)
21. Ужєгова О. А., Ужєгов С. О., Ротко С. В., Самчук В. П. Розрахунок стиснутих елементів за другою формою рівноваги. *Містобудування та територіальне планування*, 2016, 61, 432-437. [http://nbuv.gov.ua/UJRN/MTP\\_2016\\_61\\_55](http://nbuv.gov.ua/UJRN/MTP_2016_61_55)
22. Мурашко Л. А., Колякова В. М., Сморкалов Д. В. Розрахунок за міцністю перерізів, нормальних та похилих до поздовжньої осі, згинальних залізобетонних елементів за ДБН В.2.6-98:2009: Навчальний посібник – К.: КНУБА, 2012. – 62 с.
23. Практичний розрахунок елементів залізобетонних конструкцій за ДБН В.2.6-98:2009 у порівнянні з розрахунком за СНиП 2.0301-84\* і EN 1992-1-1 (Eurocode 2) / В. М. Бабєв, А. М. Бамбура, О. М. Пустовитов та ін.; за заг. ред. В. С. Шмуклера. – Харків: Золоті сторінки, 2015. – 208 с.

24. ДБН В.2.6-98:2009 Конструкції будинків і споруд. Бетонні та залізобетонні конструкції. Основні положення. Зі Зміною № 1. [https://e-construction.gov.ua/files/new\\_doc/3080063210573792873/2023-04-13/adb4ca1e-8595-4d35-9b22-a858d85864b4.pdf](https://e-construction.gov.ua/files/new_doc/3080063210573792873/2023-04-13/adb4ca1e-8595-4d35-9b22-a858d85864b4.pdf)
25. ДСТУ Б В.2.6.-156: 2010. Конструкції будинків і споруд. Бетонні та залізобетонні конструкції з важкого бетону. Правила проектування. [https://www.ksv.biz.ua/GOST/DSTY/dsty\\_b\\_v.2.6-156-2010.pdf](https://www.ksv.biz.ua/GOST/DSTY/dsty_b_v.2.6-156-2010.pdf)
26. Eurocode-2: Design of concrete structures. – Part 1-1: General rules and rules for building: EN 1992-1-1. – [Final draft, december, 2004]. – Brussels: CEN, – 2004. – 225 p. <https://www.phd.eng.br/wp-content/uploads/2015/12/en.1992.1.1.2004.pdf>
27. ДСТУ 9273:2024 Настанова щодо обстеження будівель і споруд для визначення та оцінювання їхнього технічного стану. Механічний опір та стійкість. [https://uscc.ua/uploads/page/images/normativnye%20dokumenty/dstu/dstu\\_9273\\_2024.pdf](https://uscc.ua/uploads/page/images/normativnye%20dokumenty/dstu/dstu_9273_2024.pdf)
28. ДБН В.1.2-14:2018 Система забезпечення надійності та безпеки будівельних об'єктів. Загальні принципи забезпечення надійності та конструктивної безпеки будівель і споруд. Зі Зміною № 1. <https://dreamdim.ua/wp-content/uploads/2018/12/DBN-V1214-2018.pdf>
29. ДСТУ Б В.2.7-220:2009 Будівельні матеріали. Бетони. Визначення міцності механічними методами неруйнівного контролю. [https://dnaop.com/html/59798/doc-%D0%94%D0%A1%D0%A2%D0%A3%D0%91%D0%92.2.7-220\\_2009](https://dnaop.com/html/59798/doc-%D0%94%D0%A1%D0%A2%D0%A3%D0%91%D0%92.2.7-220_2009)
30. ДСТУ Б В.2.7-224:2009 Бетони. Правила контролю міцності. [https://dbn.co.ua/load/normativy/dstu/dstu\\_b\\_v\\_2\\_7\\_224/5-1-0-1867](https://dbn.co.ua/load/normativy/dstu/dstu_b_v_2_7_224/5-1-0-1867)
31. ДСТУ Б В.2.7-226:2009 Будівельні матеріали. Бетони. Ультразвуковий метод визначення міцності. [https://ultracon.com.ua/images/beton.ultrazvukovoy\\_metod\\_opredeleniya\\_prochnosti.pdf](https://ultracon.com.ua/images/beton.ultrazvukovoy_metod_opredeleniya_prochnosti.pdf)

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## Визначення тримкої здатності залізобетонних колон

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*Анотація.* Залізобетонні конструкції, за умов належної експлуатації, надійні і зберігають свої початкові (проектні) характеристики протягом усього терміну існування будівлі. Навіть після демонтажу їх можна використовувати повторно, встановивши попередньо їх тримку здатність. Визначати тримку здатність існуючих будівельних конструкцій доводиться і при реконструкції будівель та споруд, їх надбудові, зміні конструктивної схеми, збільшенні корисного навантаження внаслідок модернізації технологічних процесів, зміни призначення об'єкту, для контролю якості виконаної будівельної конструкції тощо.

Завданням дослідження є розробка алгоритму розрахунку тримкої здатності залізобетонних колон, що працюють з випадковими ексцентриситетами, в основу якого покладена деформаційна модель.

Залізобетонні колони розглядають як позацентрово стиснуті елементи з випадковими або розрахунковими ексцентриситетами, що працюють за першою або за другою формою рівноваги.

У роботі наведено схеми перерізів, розподіл деформацій, епюри напружень, формули для визначення тримкої здатності залізобетонних колон за різних можливих умов прикладання стискувальної сили і відповідних деформацій у перерізах позацентрово стиснутих елементів. Складено алгоритм для розрахунку тримкої здатності залізобетонних колон, що працюють з випадковими ексцентриситетами. Усі вихідні дані отримують в результаті інструментального обстеження існуючих конструкцій, з використанням нормативної літератури. За складеним алгоритмом встановлено несучу здатність залізобетонної колони першого поверху громадської будівлі, запланованої до реконструкції з добудовою третього поверху. Це значення порівнюють з величиною розрахункового стискуючого навантаження згідно проекту реконструкції і роблять висновок про достатність тримкої здатності або про необхідність підсилення колони.

*Ключові слова:* тримка здатність, неруйнівний контроль, розрахунок, стиск, залізобетонна колона, форма рівноваги