ТЕХНІЧНІ НАУКИ

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ANALYSIS OF THE EFFECT OF ECCENTRICITY ON THE MAGNITUDE OF THE DESTRUCTIVE FORCE OF MASONRY

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In the laboratory of the OSACEA the full-scale tests to study the effect of different types of damage to the bearing capacity were conducted. 15 samples were modeled and tested, with three types of damages, which changed at three levels. Selected types of damage that affect bearing capacity most. In the COMPEX software complex, the three-factor ES model was modeled. Based on the three-factor model ES received three two-factor form with different eccentricities x_3 = 1, 0 and 1.
Keywords: load carrying capacity, methods for assessing residual bearing capacity, damaged stone structures, experimental-statistical model, computational experiment .

Formulation of the problem. The number of physically obsolete buildings and structures with operational damage and defects is constantly increasing. In addition, when reconstructing with the change in the designation and conditions of operation of buildings and structures, the load often exceeds those taken at designing. The problem of estimating the residual bearing capacity and reliability of elements of stone structures arose long and intensively in connection with aging (physical and moral wear) of buildings and structures. Attention has recently been focused on the revaluation of fixed assets, which should conduct a technical inspection of buildings, structures and equipment in order to determine their actual technical condition.

Analysis of recent researches and publications. The current DBN V.2.6-162: 2010 [1] requires the calculation of damaged stone elements, taking into account the non-linearity of deformation. This method is the most accurate, since it corresponds to the actual physical model of the masonry work as a non-uniform material. Most of the work on the study of noncentrally compressed elements is devoted to the consideration of such issues as determining the load bearing capacity and strength of the elements, the influence of various factors such as the type of bandage joints, corrosion, the shape of the cross section, the flexibility of elements, reinforcement, different modes of load on the characteristics of the strength of masonry structures. In works by Klymenko I.V. [2; 3] it is emphasized, that currently work on identifying and forecasting technical condition of structures and buildings carried out intuitively and requires more detailed study.

Selection of previously unsettled parts of the general problem. Over time, bearing capacity, reliability and residual life of stone structures are reduced due to accumulation of damage, or the appearance of one or more defects. For example, due to fires, the appearance and development of cracks, the destruction of masonry, etc. To prevent the destruction of structures and accidents, it is necessary to have information on the impact of various types of damage on the residual bearing capacity.

The purpose of the article. On the basis of the field experiment and numerical analysis to investigate the residual load bearing capacity on the basis of comparison of the obtained data, both theoretical and practical research, to establish the most influential on various types of damage to the bearing capacity of structures damaged during the operation process. Assessment of the bearing capacity of damaged structures on the basis of analysis of their stress-strain state.

Presentation of the main material. Before conducting simulations in the program complex COMPEX in the laboratory of OSACEA, in-person experiments [4] on the examination of the bearing capacity of damaged stone pillars were conducted. To determine the bearing capacity of stone pillars with different types of damage an experiment was conducted on a 15-point three-factor symmetric plan (Table 1). As significant input factors, the following are defined:

– angle of inclination of the front of the damage $X_1(\theta)$ = 22.5±22.5 degrees;
– depth of damage $X_2(a)$ = 80±80 mm;
– relative eccentricity $X_3(e_0/h)$ = 0.125±0.125.

The transition to the dimensionless normalized variables 1 hi +1 is performed according to the following formula: $x_i = (X_i - X_{0i}) / \Delta X_i$.

Testing of samples of brick pillars with simulated different damage showed (Fig. 1) that the damaging load varies in a fairly wide range R_u = 1.33/76.7 kN. Also, the dependence of various damages in samples on the size and location of the application of destructive force was revealed.

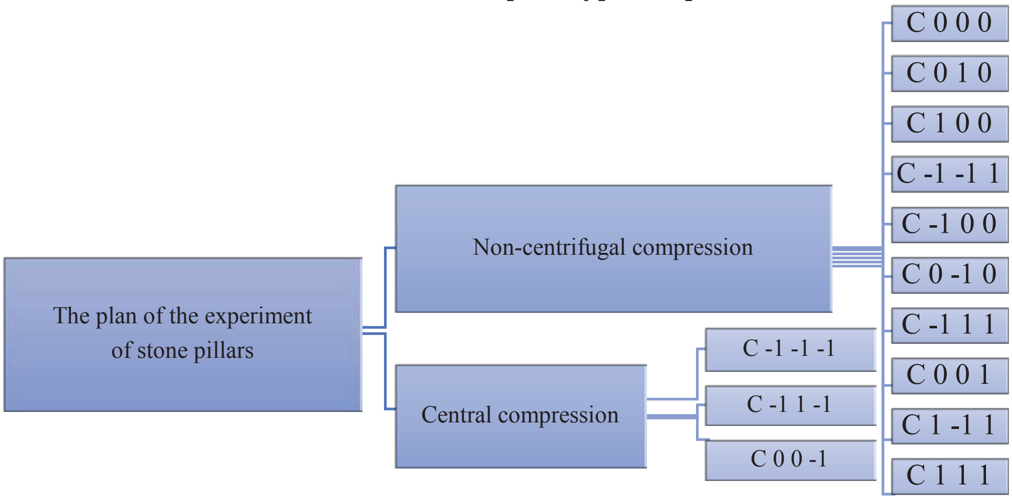
For the analysis of the influence of each of the factors, experimental-statistical model (ES model) [5] was constructed based on the experimental data obtained, which is adequate for the experiment with the statistic error $s_e[\ln\{R_u\}]$ = 0.45, with 7 statistically significant coefficients.

$$\mathbf{ln\{R_u\}} = 4.075 + 0.497x_1 - 0.721x_1^2 + 0.634x_1x_2 \pm 0x_1x_3 - 1.008x_2 \pm 0x_2^2 \pm 0x_2x_3 - 0.239x_3 - 0.374x_3^2 \quad (1)$$

The ES model describes the complete field of destructive force with extreme parameters:

Table 1

Nomenclature of prototype samples



the maximum **Ru**.max = 168,7 tf at the factor levels $_1= -0.095$, $x_2= -1$, $x_3= -0.320$; minimum **Ru**.min = 1,8 tf at − $x_1= -1$, $x_2=x_3= +1$.

In view of the fact that the first two factors (x_1 and x_2) reflect the existing damage in the operating columns, further analysis should be carried out when the eccentricity changes (x_3). Three three-factor types (2) with different eccentricities $x_3 = -1$, 0 and +1 have been obtained on the basis of the three-factor ES model.

$$Y = b_0 + b_i \cdot x_i + b_{ii} \cdot x_i^2 + b_{ij} \cdot x_{ij} \quad (2)$$

The fig. 2 shows diagrams constructed on the model (2), in the form of a two-factor field moving along the eccentricity scale X_3. The assessment

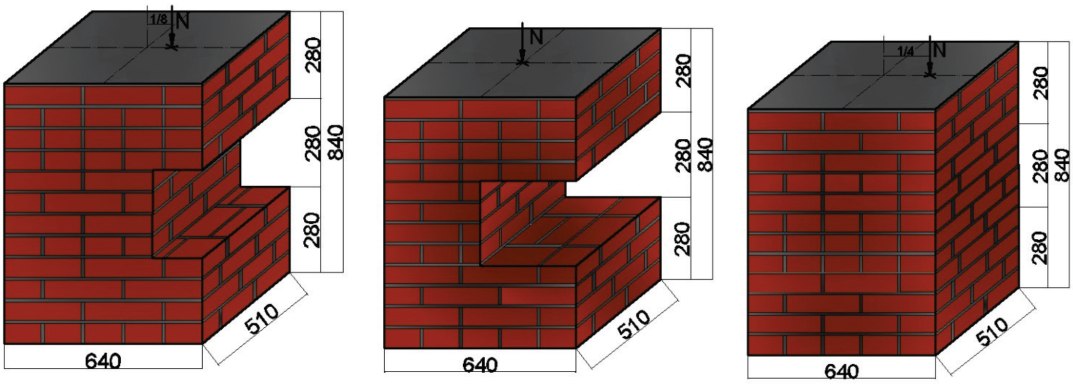
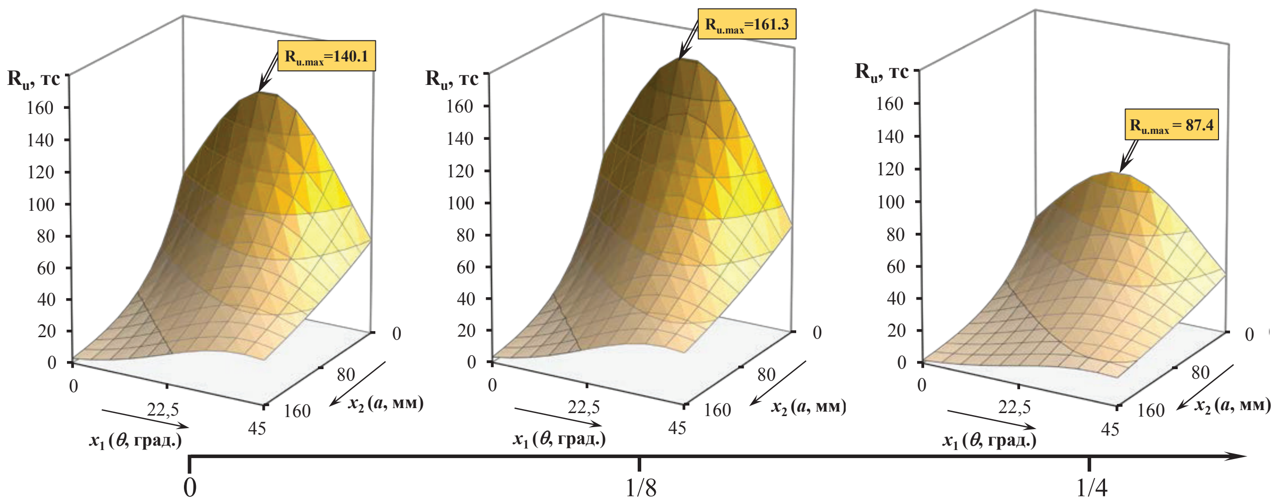


Fig. 1. Diagram of simulation of damaged sample-pillar



The relative eccentricity X_3 (e_0/h)

Fig. 2. Influence of the angle of inclination of the front (X_1) and depth (X_2) on the bearing capacity of the stone pillars (R_u, tf), depending on the eccentricity

of the degree and direction of the impact of this factor is better to use by generalizing indicators. The change in the properties of composites within a field is estimated by its absolute $\Delta\{R_u\} = R_{u.max} - R_{u.min}$ and the relative increment $\delta\{R_u\} = R_{u.max}/R_{u.min}$.

Analysis of these diagrams allows us to conclude:

– when applying the load in the center of the pillar, the masonry can withstand Ru = 140.1 kN with an angle of inclination of the damage front of 22.5 degrees;

– when displacing the point of application of the load in the direction of the main level, the destructive force is not significantly, but increases by 21.2 tf, while the effect of the impact of various types of damage does not change. It should be noted that in the eccentricity of $X_3 = 1/8$, in the masonry, for the most part, vertical cracks appear;

– with further increase of eccentricity to the maximum level (X3 = 1/4) in the laying of a stone pillar surely there are large voltages, because the boundary destructive power is rapidly decreasing. Compared to the average level of eccentricity, it is 1.84 times.

Conclusion. The analysis of the impact of various types of stone pile damage allowed us to conclude that when increasing eccentricity to the maximum level, the destructive force is rapidly decreasing, and when the load is applied in the center, the masonry can withstand Ru = 140.1 kN with an inclination angle of the damage front of 22.5 degrees.

References:

1. ДСТУ-Н Б В. 1.2-18:2016. Настанова щодо обстеження будівель і споруд для визначення та оцінки їх технічного стану / Мінрегіонбуд України. – К., 2017. – 45 с.
2. Клименко Є.В. Оцінювання технічного стану кам'яних будівель та споруд / Є.В. Клименко, С.А. Шепітько // Строительство, материаловедение, машиностроение: сб. науч. тр. – Днепропетровск: Приднепров. гос. акад. стр-ва и архитектуры, 2003. – Вып. 25. – С. 141–145.
3. Клименко Є.В. Технічні проблеми керування залишковим ресурсом об'єктів культурної спадщини / Є.В. Клименко // Збереження історичної забудови центра Одеси шляхом включення до основного списку всесвітньої спадщини ЮНЕСКО: Матеріали III і IV конференцій. – Одеса: ОДАБА, 2016. – С. 68–74.
4. Гриньова І.І. Методика проведення експериментального дослідження напружено-деформованого стану пошкоджених кам'яних стовпів / І.І. Гриньова // Вісник Одеської державної академії будівництва та архітектури. – Одеса: ОДАБА, 2017. – Вип. 67. – С. 20–26.
5. Klymenko I.V., Dovgan A.D., Grynyova I.I. Experimental-statistical modeling of the work stone pills damaged in the operation process / I.V. Klymenko, A.D. Dovgan, I.I. Grynyova // Bulletin Of The Odessa State Academy Of Civil Engineering And Architecture – Odesa: OSACEA, 2018. – Issue. 70. – P. 60–68.

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АНАЛІЗ ВПЛИВУ ЕКСЦЕНТРИСИТЕТУ НА ВЕЛИЧИНУ РУЙНУЮЧОЇ СИЛИ КАМ'ЯНОЇ КЛАДКИ

Анотація
У лабораторії ОДАБА проведено натурні випробування для вивчення впливу різних видів пошкоджень на несучу здатність. Було змодельовано і випробувано 15 зразків, з 3 видами пошкоджень, які змінюються на 3-ох рівнях. Обрані види пошкоджень, які впливають на несучу здатність найбільше. У програмному комплексі COMPEX була змодельована трьохфакторна ЕС-модель. На основі трьох факторної ЕС-моделі отримано три двофакторного виду з різними ексцентриситетами x_3 = 1, 0 і 1.
Ключові слова: несуча здатність, методи оцінки залишкової несучої здатності, пошкоджені кам'яні конструкції, експериментально-статистична модель, обчислювальний експеримент.

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АНАЛИЗ ВЛИЯНИЯ ЭКСЦЕНТРИСИТЕТА НА ВЕЛИЧИНУ РАЗРУШАЮЩЕЙ СИЛЫ КАМЕННОЙ КЛАДКИ

Аннотация
В лаборатории ОГАСА проведены натурные испытания для изучения влияния разных видов повреждений на несущую способность. Было смоделировано и испытано 15 образцов, с 3 видами повреждений, которые изменяются на 3-ех уровнях. Выбраны виды повреждений, которые влияют на несущую способность больше всего. В программном комплексе COMPEX была смоделирована трехфакторная ЕС-модель. На основе трехфакторной ЕС-модели получено три двухфакторного вида с различными эксцентриситетами x_3= 1, 0 и 1.
Ключевые слова: несущая способность, методы оценки остаточной несущей способности, поврежденные каменные конструкции, экспериментально-статистическая модель, вычислительный эксперимент.