Fig. 5. General view of the foundation block experimental sample reinforced
with the help of a rigid rod - I-beam (welded of U-profiles № 6,5)

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THE PRINCIPLES OF BASES AND FOUNDATIONS CALCULATION CONSIDERING DEFORMATIONS ACCORDING TO THE NATIONAL AND EUROPEAN STANDARDS

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The principles of bases and foundations calculation considering deformations in accordance with the national and European standards are provided. The limit state designs USL and SLS are considered according to the European standards. The similarities and differences of bases and shallow foundations calculation considering deformations in accordance with the national and European standards are identified and generalized.

In May 2015 the Republic of Belarus has officially become a participant of the Bologna Process. The participation in the Bologna process allows the higher education in the Republic of Belarus to be reformed according to the global and European tendencies. Thus, nowadays the harmonization of national and European design standards is of current interest. The Eurocodes introduction in the Republic of Belarus may increase the inflow of foreign investment in construction, therefore one of the main issues nowadays is Eurocodes developing and the ability to use them in practice.

Eurocodes are the normative documents in the construction sector, developed by the European Committee for Standardization and recommended for use in accordance with the national characteristics by the European Union member countries. The National Annexes to the Eurocodes provide the additional requirements for the construction individual parameters, which can be higher, but not lower than the common European ones. Each country defines these requirements independently. In Europe a common approach in geotechnical design hasn't been developed yet.

The National normative documents [1, 2] as well as Eurocode 7 [3] decree the design of various objects according to the two groups of limit states (depending on the bearing capacity and deformation) and have unified terminology and symbols, so there aren't substantial differences between the national Belarussian standards and the European tendencies. However, unlike TCP [1, 2] Eurocode 7 [3] has a more expanded range of the calculation cases.

The national standards of the Republic of Belarus and Eurocode 7 have a number of similar instructions concerning the limit state design. However, despite the current principles and calculations, the results of the design remain different. The direct use of the European standards without taking into account national characteristics of foundations design and calculation is impossible in the Republic of Belarus.

In the articles by G. Scarpelli and R. Frank [4, 5] the examples of shallow foundations calculation for limit states are given. In the article written by Nikitsenko M.I. and Ignatov S.V. [7] the differences in the design of slab foundations according to the standards of the Republic of Belarus and European standards are stated. R. Frank and Andrew J. Bond [8, 9] explain and comment on the articles from Eurocode 7, which include new approaches to the design, besides these authors give examples of bases and foundations calculations for the ultimate limit state according to the European standards. Petrakov A.A., Petrakova N.A., Lobacheva N.G. [6] provide a comparative analysis of the soil settlement according to the standards of Russia and the Ukraine.

Despite the increased interest of the well-known scientists to the chosen issues, "harmonization" of the bases and foundations calculation considering deformations according to the national and European standards is still relevant. These questions remain unsolved, thus their further development is required.

The principles comparison of the bases and foundations calculation considering deformations according to the national and European standards.

To estimate the limit states of the second group it is clearly stated in TCP 45-5.01-67-2007(02250) [1] what kind of calculations need to be done:

– considering deformations of the buildings bases due to the external loads and soil weight;
– considering crack formation and crack opening in the foundations constructions.

Eurocode 7 [3] emphasizes the design criteria one should follow when calculating, and determine a mandatory control procedure using partial factors. The values of partial factors are advisory; they can be changed in the National Annex. The Measures preventing limit states occurrence, as stated in Eurocode 7, mainly include the consideration of stabilized and unstabilized states. Eurocode 7 determines two key conditions, which must be considered: ultimate limit state (ULS) at failure and serviceability limit state (SLS) under working loads, for which settlements must remain within pre-specified tolerable levels. Even national design codes for determining the ULS vary enormously for these simple cases, despite being based on similar mechanisms of failure, as do the designs that are developed from them.

There are three methods of limit states calculation [3, 5, 8, 9].

The methods to analyze working limit states

Method	**Description**	**Constraints**
Direct	Calculations are done separately for each limit state, both ultimate (ULS) and serviceability (SLS)	(ULS) The model provides failure mechanism
		(SLS) Calculations considering deformation (settlement) are used
Indirect	Comparable experience with the results of field & laboratory measurements & observations is used	Only SLS loads are chosen to meet requirements concerning limit states calculations
Directive	Common & conservative calculation rules are applied and construction control is defined	Presumed contact pressure is used (annex G [3])

When calculating slab foundations [1] it is recommended to apply the following foundation calculated schemes:

– linear-deformable half-space with a contingent limitation of compressible thickness depth Hc;
– linear-deformable layer;
– ultimate equilibrium of environment.

TCP 45-5.01-67-2007(02250) clearly defines their application field and the calculation method, corrects calculation formulas, introduces the rules for determining deformation modules.

In order to calculate the limit state one should know that exploitation limit states occurrence is almost impossible [3]. Nevertheless exploitation limit states testing can be performed by two methods:

– by computing calculation values of the impact results S_d (deformation, irregular settlements, vibration, etc.) and by comparing these values with the values of limit states Cd, using mathematical inequality (1);
– by applying a simplified method, based on comparable experience.

Testing of soil foundation on exploitation limit states requires inequality solving:

$$S_d < C_d, \qquad (1)$$

where S_d – the ultimate calculated value of settlement;

C_d – the ultimate value of settlement.

As the ultimate calculated value for the impact effect (settlement) S_d three components of settlement have to be considered:

– S_0 – immediate settlement; To determine the immediate settlement elasticity theory solutions are used, considering the elastic modulus as soil deformation characteristics. Taking the formula from Annex F as an example [3]:

$$S = \frac{p \cdot b \cdot f}{E_m}, \tag{2}$$

where E_m – the calculation value of the elastic modulus;

f – a settlement coefficient;

p – the (average) pressure at the base of the foundation.

– S_1 – settlement caused by consolidation. This settlement for water saturated soft soil is crucial. It is usually calculated using the assumption of a one-dimensional compression. Soil deformation characteristics can be determined with the help of the empirical relationships of Terzaghi's one-dimensional consolidation theory [9], taking into account the average degree of consolidation Um depending on the corresponding time factor Tv.

– S_2 – settlement caused by creep.

When testing soil foundations on exploitation limit states partial factors are normally set equal to 1.

The national standards provide limitation of the absolute foundation settlement:

$$S < S_u, \tag{3}$$

where S – calculated total (final) settlement;

S_u – the ultimate value of the absolute foundations settlement, for example, given in Annex Б СНБ 5.01.01.

The methods for settlement calculation given in TCP 45-5.01-67-2007(02250) [1] can be used only in the case of the linear soil deformation without the possibility of lateral expansion.

Conclusions

1. When calculating the settlement of the foundation using Eurocode 7 the greater emphasis is put on the settlement caused by consolidation, as it is considered the main value of the three components in the total settlement formula.

2. Eurocode 7 isn't mandatory, it's recommended, so the immediate settlement of the foundation can be determined not only with the formula in Annex F [3], but also with the Menard formula or the Pauli and Davis formula (for sand), etc.

3. Eurocode 7 introduces the approach to the calculation of bases and foundations deformations "using comparable experience ....". In the national standards this approach is absent.

4. The maximum ultimate settlement of the frame buildings and structures foundations is 7.5 cm (sand) and 13,5sm (clay) according to Eurocode 7. In accordance with the national standards the maximum ultimate settlement of the frame buildings and structures foundations is 8 cm (for the reinforced concrete frame) and 12 cm (for the steel framework) and does not depend on the soil type under the foundation.

5. The comparison of the principles of bases and foundations calculation considering deformations in accordance with the national and European standards has revealed that there are differences in the approaches of problem solving and practical bases calculations. These questions remain unsolved and their further development is required.

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PROTECTION FROM CONSTRUCTION BIODETERIORATIONS

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The problem of protecting structures from biological damage is indicated in the article. It was noted that the most aggressive towards concrete is thiobacteria. It is shown that the most common means of protection is biocides. The problem of durable, affordable and ecologically safe biocide protection is urgent.

In the field of construction and maintenance of civil and industrial buildings the problem of biocorrosion is becoming increasingly urgent. Biocorrosion is the destruction of structural materials under the action of microorganisms and their metabolic products [1]. More than 40-50% of the total damages recorded in the world are connected with the activity of microorganisms [2]. The results of a sample survey of various buildings [3] showed that buildings may be affected by bacteria, elementary and other microscopic fungi, algae, lichens and even higher plants. Microscopic fungi considerably worsen service characteristics of materials, causing not only partially damage to the building, but also their complete destruction. The protection against corrosion of building materials based on minerals - concrete, brick and plaster is not given enough attention, despite the fact that the biodegradation of design and decorative materials of civil and industrial buildings and structures in modern conditions is becoming more common. Thus the protection of building structures from biological damage is of practical interest.

The scientific literature on the corrosion of building materials [1-4] shows that microorganisms trigger processes of biodeterioration through their waste products (acids, alkalis, enzymes and other aggressive substances), which interact with the substances belonging to the building materials, destroying the binder solution, brick, rock (stone building), concrete, metal and other building elements. The list of exuded acids is rather extensive: from heavy mineral (sulfuric and nitric) to polyatomic organic (humic acid, pyruvic acid). Structurally simpler organic acids are isolated: acetic, lactic, propionic, tartaric, oxalic, fumaric, malic, citric, and etc. Active acid formation is indicated by the pH on the surface of the building material when investigated.

It was found [1] that the most aggressive towards concrete are nitrifying and thionic bacteria which during the life emit such strong acids as nitric and sulfuric. Under their exposure the protective film of calcium carbonate formed on the surface during the hardening of concrete is destroyed. It is the film that prevents the leaching of calcium hydroxide.

According to the results of the studies performed by G.Y. Drozd [5], the resistance of the concrete is increased with the decrease in permeability (pore size). The penetration of bacteria, whose size is mainly composed of 0.5 - 20 microns, in pore diameter of less than 30 microns is difficult. The thiobacteria size is about 1 micron. Further away from the surface of the concrete the number of aerobic bacteria is decreased more than the number of anaerobic ones.

To eliminate or ensure the destruction of biological pests in infested buildings and structures there are different disinfection technologies. To depress livelihood of thiobacteria it is possible through the usage of biocide additives. The tests carried out in the paper [5] has shown that certain additives - biocides slow down to some extent the destruction of the concrete. However, it was concluded that the tested biocide concrete is not enough resistant to highly aggressive gaseous medium reservoir.

In CRCRI laboratory tests of concrete treated with Penetron were performed [6]. The components of Penetron infiltrate into the concrete and cause in the pores and capillaries the growth of crystals, creating so-called "crystallization obstruction", reducing the permeability of concrete. The concrete treated with Penetron in the initial period had increased the resistance to sulfuric acid solutions. After 6 months of testing concrete samples had minor damages in the reservoir. After 12 months of testing the destruction of protective layers gets started. And bare concrete was extensively breaking down. It is concluded that the Penetron coating applied to the surface of the concrete, only temporarily slows down the process of destruction of concrete in a gaseous environment highly aggressive sewer. The author of the work [6] suggested that in the sewers with slightly and moderately aggressive gas media the material can be useful.