2021. 17(5). 455–465

СТРОИТЕЛЬНАЯ МЕХАНИКА ИНЖЕНЕРНЫХ КОНСТРУКЦИЙ И СООРУЖЕНИЙ

STRUCTURAL MECHANICS OF ENGINEERING CONSTRUCTIONS AND BUILDINGS

ISSN 1815-5235 (Print), 2587-8700 (Online)

HTTP://JOURNALS.RUDN.RU/STRUCTURAL-MECHANICS

DOI 10.22363/1815-5235-2021-17-5-455-465
UDC 624.012

RESEARCH ARTICLE / НАУЧНАЯ СТАТЬЯ

Published in order of discussion.
Editorial Board

The theory of calculation of reinforced concrete structures and the principles of the Eurocode

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Article history
Received: July 12, 2021
Revised: October 4, 2021
Accepted: October 13, 2021

Abstract. The theory of calculating reinforced concrete is analyzed. As we known reinforced concrete with enormous volumes of application and huge financial costs, due to the great complexity of its nonlinear properties, has a surprisingly unscientific theory of calculation, consisting of two parts: short-term and long-term loading. The work of a number of round tables was devoted to the problem of errors in the theory of calculating reinforced concrete. The round tables held at the Peoples' Friendship University of Russia (RUDN University) on the initiative and under the guidance of famous scientists: V.M. Bondarenko, S.N. Krivoshapko, V.V. Galishnikova (the last one took place in 2020) with a large number of participants of authoritative scientists from Russia and other countries. It is shown that the theory of calculation of reinforced concrete structures, which are widely used (with long-term loading all over the world), includes five inconsistent (among them erroneous) theories, the essence of which and one postulate are set further. Using the rules of mathematics, the principles of mechanics and the results of solid experiments, it was revealed that the analyzed theory contains a set of theories rejecting each other for various purposes, including erroneous ones.

Keywords: theory of concrete creep, superposition principle, instant elastic deformations, long-term resistance, reinforced concrete, modern building codes, Eurocode principles

For citation
Sanzharovskiy R.S., Sieber F., Ter-Emmanuilyan T.N. The theory of calculation of reinforced concrete structures and the principles of the Eurocode. *Structural Mechanics of Engineering Constructions and Buildings.* 2021; 17(5):455–465. http://doi.org/10.22363/1815-5235-2021-17-5-455-465

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Публикуется в порядке обсуждения.
Редакция

Теория расчета железобетонных конструкций и принципы Еврокода

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История статьи
Поступила в редакцию: 12 июля 2021 г.
Доработана: 4 октября 2021 г.
Принята к публикации: 13 октября 2021 г.

Для цитирования
Санжаровский Р.С., Зибер Ф., Тер-Эммануильян Т.Н. Теория расчета железобетонных конструкций и принципы Еврокода // Строительная механика инженерных конструкций и сооружений. 2021. Т. 17. № 5. С. 455–465. http://doi.org/10.22363/1815-5235-2021-17-5-455-465

Аннотация. Анализируется теория расчета железобетона, который, при громадных объемах применения и огромных финансовых затратах, имеет из-за большой сложности его нелинейных свойств удивительно ненаучную теорию расчета, состоящую из двух частей: кратковременного и длительного загружения. Проблеме заблуждений теории расчета железобетона посвящена работа ряда круглых столов, проведенных в Российском университете дружбы народов по инициативе и под руководством известных ученых: В.М. Бондаренко, С.Н. Кривошапко, В.В. Галишниковой (последний состоялся в 2020 г.), с большим числом участников, авторитетных ученых России и других стран. Показано, что теория расчета железобетонных конструкций, имеющих массовое применение (при длительном загружении во всем мире), включает в себя пять не соответствующих друг другу (среди них ошибочных) теорий, суть которых и один постулат изложены в работе. Используя правила математики, принципы механики и результаты солидных экспериментов выявлено, что анализируемая теория содержит набор отвергающих друг друга положений различного назначения, в том числе ошибочных.

Ключевые слова: теория ползучести бетона, принцип наложения, мгновенные упругие деформации, длительное сопротивление железобетона, современные строительные нормы, принципы Еврокода

Introduction

Numerous works of Russian and foreign scientists [1–8] are devoted to the problem of constructing a theory of reinforced concrete. Reinforced concrete, with enormous volumes of application and huge financial costs, due to the great complexity of its nonlinear properties, has a surprisingly unscientific theory of calculation, consisting of two parts: short-term and long-term loading. In the scientific and educational literature, the theoretical essence of the foundations that make up the calculations of reinforced concrete structures of mass use has not been studied and described.

Let's give an example of describing one of the main models of the theory of calculation, in sequence from the moment of creation to the present day (we will consider its essence later):

● reported about the "formation of the so-called plastic hinge," it is also stated that "the hypothesis of flat sections is inapplicable;"

● describes "a new principle of considering a section in a state of destruction... Prerequisites have been created for the development of a general theory of calculation in limiting states, which is a radical change in the design principles on a new scientific basis;"

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● "The criterion for the exhaustion of the strength of normal sections is the achievement of their limit values by deformations of compressed concrete or tensile reinforcement in the section of an element;"

● "There is no plastic hinge;"

● "It is allowed to make calculations based on ultimate efforts."

The theory of long-term resistance does not correspond to the properties of reinforced concrete, contains a set of errors (including rather crude ones), does not notice them, and declares itself:

● "New advanced... International harmonized format;"

● "The completed mathematical theory of concrete creep, which has received universal recognition;"

● "The problem of the stability of reinforced concrete rods has been solved taking into account... long-term processes; ...the task is as close as possible to the actual conditions of their work;"

● The theory is based on "a theorem on the general form of a linear functional in a suitable functional space determined by the requirements imposed on the loading history;"

● "In the process of correcting and updating Euronorms," this theory should be "included in the main text of the standards as a guideline for assessing the effect of concrete work over time in all types of structures."

The work of a number of round tables held at the Peoples' Friendship University of Russia (RUDN University) on the initiative and under the guidance of famous scientists: V.M. Bondarenko, S.N. Krivoshapko, V.V. Galishnikova was devoted to the problem of errors in the theory of calculating reinforced concrete (the last one took place in 2020), with a large number of participants, authoritative scientists from Russia and other countries. V.M. Bondarenko actively participated (after the approval of the Eurocode) in discussions about the discrepancy between the analyzed theory and the Eurocode [1]. He proposed to discuss the complex problem "Eurocode – nonlinear theory – standards" in the form of scientific round tables. The leadership of RUDN University supported this proposal, and the first round table on this issue was held in 2016; V.M. Bondarenko took an active part in it and made a scientific report.

The main questions and opinions of the participants, of all the round tables that took place were caused by the problem named above: in the scientific literature, in textbooks, there is no description of the properties of theories mixed in the calculations of reinforced concrete structures, there is no assessment of their compliance with the properties of the reinforced concrete material and the Eurocode.

The stated analysis of the theory of calculation of reinforced concrete is based on the following circumstances:

– the unscientific use of the theory of creep of reinforced concrete in the design of unique buildings and structures was noted in 2014 by Gordon Clark, president of fib and director of RAMBOLL (Great Britain) [9];

– the current state of the international theory of creep is presented in detail in the publication [10] by M. Chiorino, 2014;

– mathematical errors of the concrete creep law were revealed by us for the first time in 2015–2016 in [11; 12];

– a detailed analysis of these errors is given in [13; 14];

– the foundations of the theory of a plastic hinge in reinforced concrete are presented in [15].

The features of the analyzed theory

The analysis shows that the theory of calculation of reinforced concrete structures, which are widely used (with long-term loading all over the world), includes five that do not correspond to each other (among them are erroneous) theories, the essence of which and one postulate is set out below.

In the theory under consideration, the following are mixed (instead of fulfilling the requirements of the Eurocode):

(s. 1) – theory of a structure that has no length and has a plastic hinge;

(s. 2) – the theory of an elastic-creeping column with initial deflection, which has unlimited stresses and deformations, as well as infinite deflections;

(s. 3) – the theory of an infinitely elastic column from the "deformation theory," erroneously extended to the area of severe plastic deformations, also with infinite deflections;

(s. 4) – warped Euler problem with critical force depending on eccentricity;

(s. 5) – is a deeply erroneous theory of linear concrete creep.

(s. 6) – the "new" theory is substantiated by an erroneous postulate about the sudden "formation of a plastic hinge."

The study shows that this scientific theory and each theory individually does not correspond – neither to the properties of reinforced concrete, nor to the Eurocode.

The theory of the construction without length and the emergence of a plastic hinge

Here it is necessary to first construct an appropriate theory of elastoplastic stability (and there is no other way):

a) record the σ–ε diagrams for concrete and reinforcement. Reject Eurocode and assume that these diagrams have unlimited yield pads ($\varepsilon_т \to \infty$);

b) use (and not reject) the hypothesis of flat sections, and find the values of the main vector and the main moment of the diagram of normal stresses;

c) write down the equations of equilibrium of a compressed column, taking into account the presence of deflection;

d) consider the geometric aspect of the problem, and associate the edge deformations of the section with the deflection;

e) formulate the condition and derive the critical state equation;

f) conduct numerical studies and build critical dependence curves.

Obtaining such curves is necessary for subsequent use in norms and standards, it is due to design tasks: an ordinary designer will not be able to carry out the scientific research specified in paragraphs a–f.

The behavior of these curves depends on the type of the design diagram of the column [16]. Let's consider two important cases: a column with initial deflection, longitudinal-transverse bending.

The design diagram of a column with initial deflection forms the basis of the theories (s. 2) and (s. 3), considered later (Figure 1) within the framework of the linear theory. Here, for clarity of perception, the curves of critical dependences of elastoplastic columns with initial deflection are shown in Figure 1.

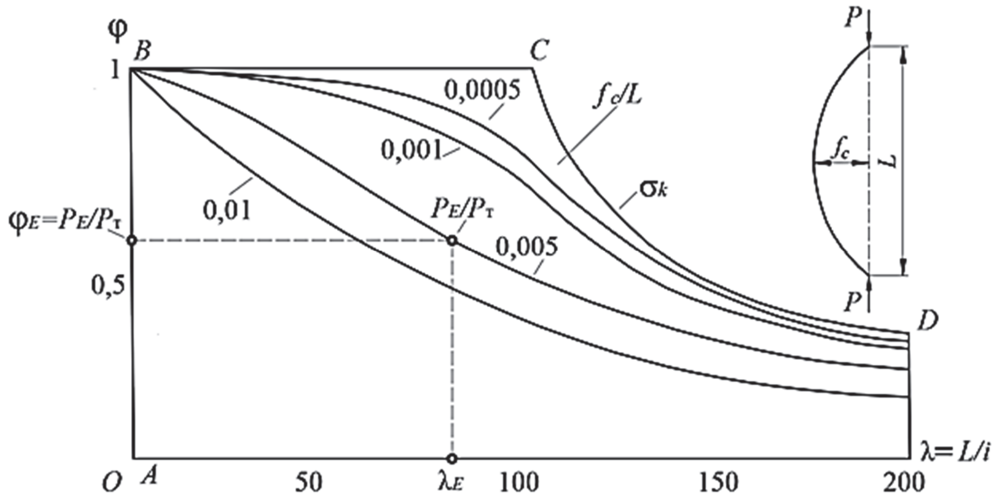

Figure 1. Critical dependencies “force – flexibility – initial deflection” for an elastoplastic column

In the case of the second design scheme – longitudinal-transverse bending, the curves of the critical dependences in the elastoplastic stage have a form similar to Figure 1. Let's pay attention to the absence in the given two cases (different design schemes) of the plastic hinge according to the theory (s. 1)[1] [17; 18], Figure 2. In Figure 1, point B, which characterizes the fully compressed section ($x = h$, Figure 2), can be referred to the plastic hinge. In other words, the theory (s. 1) is “fundamentally unsuitable” in the considered calculation schemes according to the terminology of the developers of the analyzed theory.

About the plastic hinge. To obtain a theory (s. 1), it is necessary to add two actions to the above procedure, a–f:

g) select a special design scheme of the column, Figure 2.

h) carry out a mathematical passage to the limit.

The plastic hinge is the limiting point ($l \to 0$) of the critical states curve ($\frac{dl}{df} = 0$, l is the length, f is the deflection) in terms of stability for columns made of concrete and steel with an unlimited yield area; in it, edge deformations reach infinite values; at the limiting point, the zones of plastic tension and compression (satis-

[1] SP 63.13330.2012. *Concrete and reinforced concrete structures. Basic provisions.* Updated edition of SNiP 52-01-2003. Moscow; 2012. (In Russ.)

fying the hypothesis of flat sections before the beginning of the passage to the limit) converge. And this local point, in a very private design scheme, with unrealistic properties of compressed structures, is taken as the basis for the general theory of calculation of reinforced concrete.

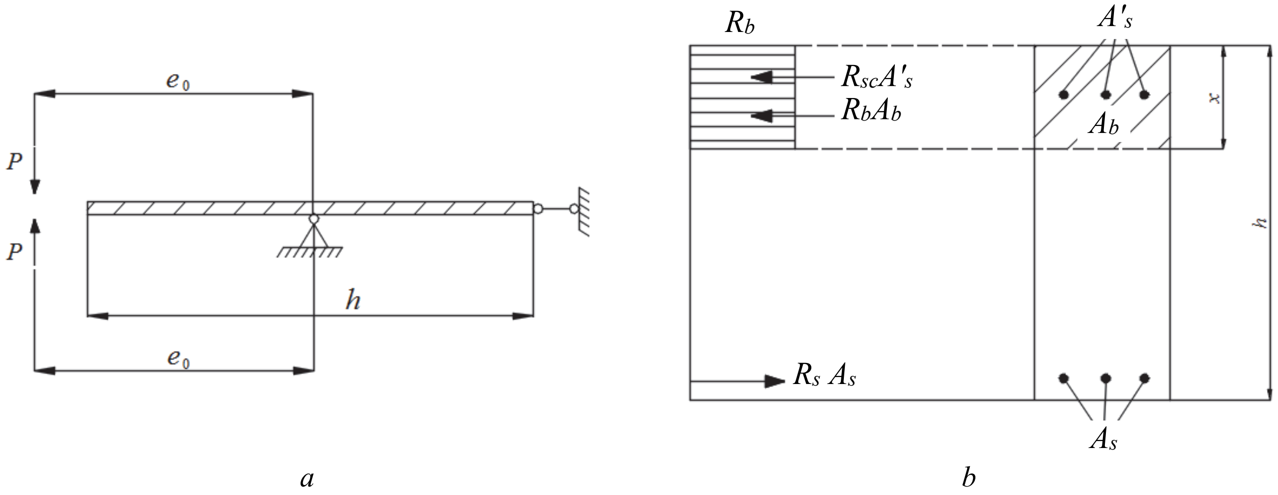

Figure 2. Column without length, for which a plastic hinge is possible:
a – design scheme; *b* – cross-section, "ultimate forces" and stress diagram of concrete

About the unreality of properties (the column has no length; the section of the column has the property of an absolutely rigid body). When passing to the limit, the elastic zone of the section of the column tends to zero, the plasticity covers the entire height of the compressed zone, and a degenerate model of the column is obtained in the form of one degenerate section, in which the force distribution system has one degree of freedom, with a generalized coordinate x, Figure 2.

Thus, the theory (s. 1) has nothing to do with the calculation of real compressed structures, including reinforced concrete ones.

The foregoing also shows that under the Eurocode conditions, when the diagrams σ–ε of concrete and reinforcement are limited by ultimate deformation (ε_{b2}, ε_{s2}), theory (s. 1) does not exist at all[2].

Finally, consider the theory (s. 1) for the case of small eccentricities, described in the literature on reinforced concrete in a very confusing way. Here the compressed zone with the x coordinate captures a part of the section of the lower reinforcement A_s, Figure 2, *b*. In this reinforcement A_s, a local plastic hinge is formed, with a local main vector of forces and a main moment. Expressions for describing the values of the local principal vector and the principal moment of forces are very cumbersome due to the circular cross-section of the reinforcement. This cumbersomeness is overcome by two simplifications:

– the value of the local principal moment of forces in the reinforcement is considered negligible, see (8.10) in SP 63.13330.2012;

– the formula for the local principal vector is simplified by replacing the circular section with an equivalent section with constant width, see, for example, (8.13) in SP 63.13330.2012.

External attractiveness and apparent simplicity made the main features of the theory invisible (to this day) (s. 1): *[3],

– the column has no length;

– the column section has the properties of an absolutely rigid body;

– endowing concrete and reinforcement with an endless flow area;

– the impossibility of obtaining (clause 1) in any other way, except for the mathematical passage to the limit;

– gives fundamentally incorrect results in structural calculations: qualitative and quantitative. The performed analysis shows that the theory (s. 1) is unsuitable for calculations of compressed reinforced concrete structures.

[2] EN 1992-2 2004. *Eurocode 2: Design of constructions*.

[3] A list of errors is indicated.

The theory of an elastic-creeping column with initial deflection and the theory of an infinitely elastic column from the "deformation theory"

In the theories (s. 2) and (s. 3), reinforced concrete is endowed with new fantastic features that reject the theory (item 1): **,

– there are no cracks in the sections;

– concrete works well in tension and compression;

– concrete and reinforcement are infinitely elastic materials;

– concrete has infinite linear creep deformations under tension and compression (see also (s. 5));

– stresses (in compression and tension) can many times exceed the ultimate strength of concrete and reinforcement;

– theories are based on the hypothesis of "insignificant deflections" (in the terminology of S.P. Timoshenko), and in the calculation results the deflection infinitely "increases:"

$$f(p) \to \infty;$$

$$f(t) \to \infty, \dot{f}(t) = \text{const},$$

in general mechanics indicate that with such a contradiction – "the method is unsuitable." For example, it leads to the creation of a (non-existent) critical force in flexural compression. In the analyzed theory, it is called "conditional critical force." In problems of the considered format, as shown by Lagrange and Zhichkovsky (see Figure 4), this linearization hypothesis leads to incorrect results. In the educational literature, the features listed under the ** sign are not noticed: there is only a formal indication "to multiply by the coefficient η."

The calculation scheme for these theories is shown in Figure 3.

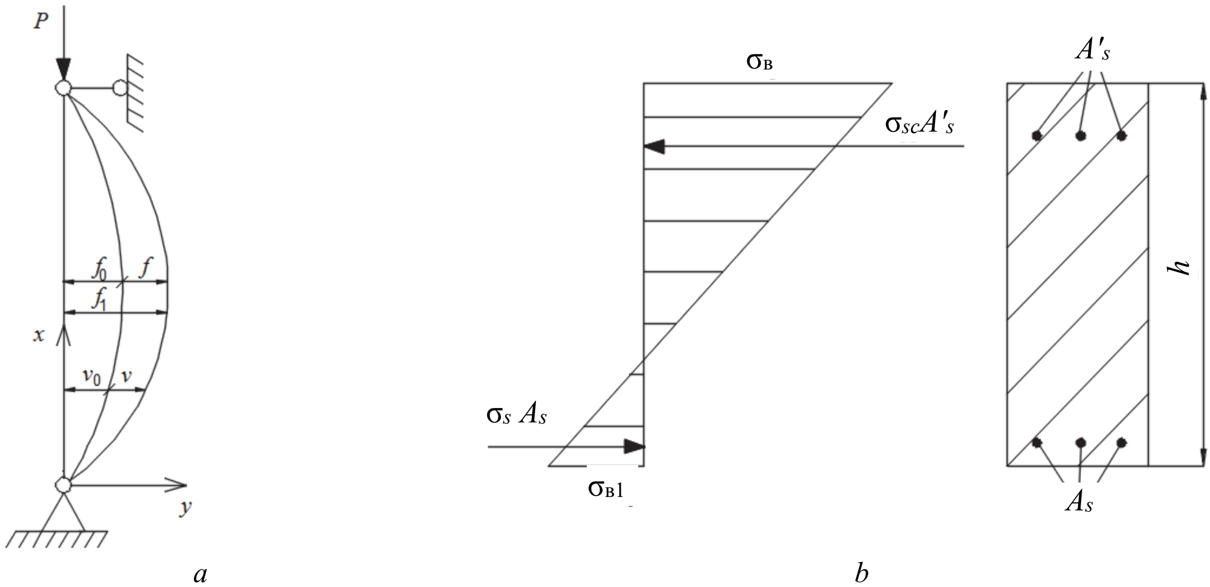

Figure 3. Elastic or viscoelastic column with initial deflection:
a – design scheme; *b* – cross section, unlimited stresses in concrete and reinforcement – no cracks

In theory (s. 2), "the relationship between stresses and strains is established by a formula based on a linear relationship between stresses and strains and on the principle of superposition."

$$\varepsilon^*(t) = \frac{\sigma^*(t)}{E(t)} - \int_{\tau_1}^{t} \sigma^*(\tau) \frac{\partial \delta(t,\tau)}{\partial \tau} d\tau, \tag{1}$$

where $\delta(t,\tau) = \dfrac{1}{E(\tau)} + C(t,\tau)$; $C(t, \tau)$ is the creep measure.

Here, and in what follows, the generally accepted designations of the constructed theory with the theory (s. 2) states: "It is known that in the case when the material of the rod has creep and aging (1), the problem of the stability of an elastic rod, which has an initial deflection ($y_0 = f_0$) and compressed by a constant force *P*, is reduced to solving the equation"

$$\frac{d^2 y^*(x,t)}{dx^2} + \frac{P}{I}\left[\frac{y^*(x,t)}{E(t)} - \int_{\tau_1}^{t} y^*(x,\tau)\frac{\partial\delta(t,\tau)}{\partial\tau}d\tau\right] = \frac{d^2 y_0}{dx^2}.$$

The problem of determining the deflection *f*(*t*) is reduced to solving the "Volterra integral equation of the 2nd kind"

$$f(t) - \frac{E(t)}{1-\xi(t)}\int_{\tau_1}^{t} f(\tau)\frac{\partial\delta(t,\tau)}{\partial\tau}d\tau = f_1(t),$$

where $\xi(t) = \frac{P_э(t)}{P}$; $P_э(t) = \frac{\pi^2 IE(t)}{l^2}$; $f_1(t) = \frac{f_0}{1 - \frac{P}{P_э(t)}}$.

The critical state of the stability of a reinforced concrete column during concrete creep is determined by a criterion that is untenable according to the Eurocode and surprising for the theory of reinforced concrete: the deflection of the middle section of the column increases to infinity (with a constant rate of its growth). The structure of the formula for additional infinite deflection caused by concrete creep becomes identical to the structure of infinitely elastic deflection according to the theory (s. 3) (see, for example, formula (8.13) in SP 63.13330.2012). Only the value of the critical force changes: instead of the short-term critical force of Euler, the concept of a long-term critical force is used, equal to the Euler force, divided by a coefficient that depends on the creep characteristics of concrete.

Special attention should be paid to three circumstances in the theory (s. 2, s. 3): **,

– Euler's hyperbola is interrupted at point C (Figure 1), that is, in the CB section of the plastic region, the concept of Euler's critical force (also a long-term critical force) is a fiction;

– with unlimited elastic properties of compressed-bent columns, the critical Euler force does not exist, Figure 4, which additionally characterizes the inconsistency of the theory (s. 2, s. 3) from the point of view of the Eurocode;

– within the framework of any theory of creep, the theory (item 2) is unsuitable for assessing the long-term resistance of reinforced concrete, since it endows concrete with fantastic properties of infinite deflections, infinite elasticity and the absence of cracks.

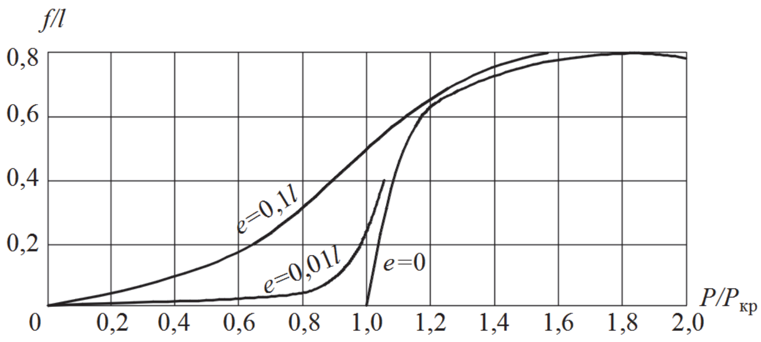

Figure 4. The relationship between the deflection and the longitudinal force for the compressed-curved and centrally compressed (*e* = 0) columns

Each of the theories outlined is true only in its place in the general theory of the calculation of structures. So the theory (s. 1) is just one of four lines – the boundaries of the region in the particular scheme of loading the elastoplastic stability – just one of many schemes in which there are no such boundaries at all (example, Figure 1). Moreover, in this particular scheme, an ideally elastoplastic material is considered, with an infinite yield area, that is, it is outside the rules of Eurocode 2 and is an error for the theory of reinforced concrete [13].

The apparent novelty of an unusable theory (s. 1) and its erroneous attractiveness in the forties of the last century caused decisive actions to be introduced, and for the sake of these actions the essence of the theory of calculating reinforced concrete was sacrificed, as evidenced by the hypothesis put forward by theory (s. 6) about the connection of theories (s. 2, s. 3) and theory (s. 1):

"With eccentric compression... the phenomenon of destruction proceeds almost the same as during bending, and the calculation is based on the same considerations and assumptions.

...In the interests of simplicity of calculation, it is even more desirable than when bending symmetrical sections, to assume... that the section behaves elastically up to the formation of a plastic hinge."

So, consider the sequence of jumps from one theory to another. Suppose initially there is a reinforced concrete column with the given properties of the bearing capacity. We apply the theory to it (s. 1), we get, after the execution of the calculation, a greatly overestimated bearing capacity. For this reason, we pass to the theory (s. 3) or (s. 2), replacing the design model of the theory (s. 1) with the design model of the column with initial deflection. It would be possible to use the theoretical data for the sample in Figure 1, but it doesn't.

The process of loading an infinitely elastic column is considered, at the end of which the cited hypothesis is extracted and the transition from (s. 3) to (s. 1) is made in the form of the following amazing actions:

– the length of the infinitely elastic column disappears abruptly; there remains only one section with a linear stress diagram, without a crack;

– elastic stress diagram, according to Figure 3, instantly turns into a diagram of the stresses of the plastic hinge, according to Figure 2;

– the initial deflection f_0 of the elastic column from (s. 3) instantly becomes the specified eccentricity in the theory (s. 1);

– the arrow of additional deflection of the elastic column f of the theory (s. 3) turns into eccentricity of the theory (s. 1), which is called additional eccentricity and the appearance of which destroys the theoretical essence of the plastic hinge, described above, as the essence of a column that has no length;

– a "new" scientific essence of the general theory appears in the form of a plastic hinge that has no length, but has a deflection $e_0 + f$; the amount becomes the calculated eccentricity $e_0\eta_1$ in theory (s. 1).

Based on the "new" entity, the bearing capacity of the given reinforced concrete column is again calculated: the calculation results again overestimate the bearing capacity of the given column. Even more paradoxical is the combination into one theory of a plastic hinge according to (s. 1) with a time-varying deflection of the theory (s. 2). The "new" scientific essence in this case is an amazing continuous change in the longitudinal force of the column, which occurs over time, as well as a continuous phenomenon of jumps.

The theory of reinforced concrete in the "new" scientific essence acquires dual properties in many circumstances and parameters, which makes it possible to change the meaning of these parameters, to conduct unscientific discussions.

For example, in the theory of a plastic hinge (s. 1), the section stiffness $D = EI$ is not needed. But to "correct" the analyzed theory of reinforced concrete, the "new" scientific essence allows us to use and distort this concept.

Modified Euler's problem

In the classical Euler problem on the stability of a column, the theory (s. 4), representing the differential equation of bending, has the form

$$D\frac{d^2 v}{dx^2} = -Pv .$$

As already noted, this equation does not exist in the BC segment according to Figure 1 in the plastic region. As well as rigidity in theory (s. 1); there is no Euler force either. The "new" scientific entity not only introduces Euler's force that does not exist here, but also distorts its meaning, inventing Euler's force, which depends on eccentricity e_0:

$$N_{cr} = \frac{\pi^2 D(e_0)}{l^2} .$$

*** – the general theory is “corrected” by this technique: the critical forces of a reinforced concrete column (N_{cr}) under short-term loading, and P_d under long-term loading, which are impossible under eccentric compression (see Figure 4), are declared not only possible, but also “undergo evolutionary development” in the form of an absurd dependence on eccentricity.

Experimental estimates of the results of calculating compressed reinforced concrete structures according to the analyzed theory, given by well-known scientists in publications in recent years, are ± 50%, indicating that unscientificness and non-compliance with the Eurocode, in addition to political aspects, give low economic efficiency of reinforced concrete.

The erroneous theory of linear concrete creep

In the theory (s. 5), which is a world theory, the Volterra integral equations representing the creep of concrete with its unsteady and non-linear properties have fictitious kernels that violate the prescribed mathematical order of their construction: as a result, concrete forms an erroneous set of fictitious forces that incorrectly form creep deformations [11; 13; 14; 19].

We found that all the main provisions of the theory (item 5) grossly violate the rules of higher mathematics, the principles of mechanics. Eurocode requirements and results of solid experiments. Among them: ****,

– the foundation of the theory, its principle of imposition, violates the rules of differentiation of functions. This violation is accompanied by a crafty justification [2] that “the superposition principle is characteristic of Volterra's theory:” as a result, erroneous kernels of integral equations are constructed. There are a number of other ridiculous “mathematical” justifications for this principle;

– “There is no linear creep,” the well-known scientists S.V. Aleksandrovsky testify and P.I. Vasiliev [20], giving experimental data on Figure 5;

– instantaneous concrete deformations, nonlinear according to the Eurocode, are declared elastic, which is justified by non-existent experiments;

– the nonstationarity of instantaneous deformations is incorrectly identified with the Maxwell model, and is described using the superposition principle, introducing an error of up to 300%;

– inadmissible in mechanics, alteration of instantaneous nonlinear concrete properties, creep properties (minute creep, chain models, fast-flowing creep) is carried out; this leads to the emergence of resistance forces proportional to acceleration, creates a violation of the principle of independence of the action of forces (the fourth axiom), distorting the whole theory;

– “algebraization” of the theory of creep rejects the basic equation of Newtonian mechanics, returns to the level of Aristotle's mechanics; this was repeatedly emphasized by N.Kh. Harutyunyan and S.V. Aleksandrovsky.

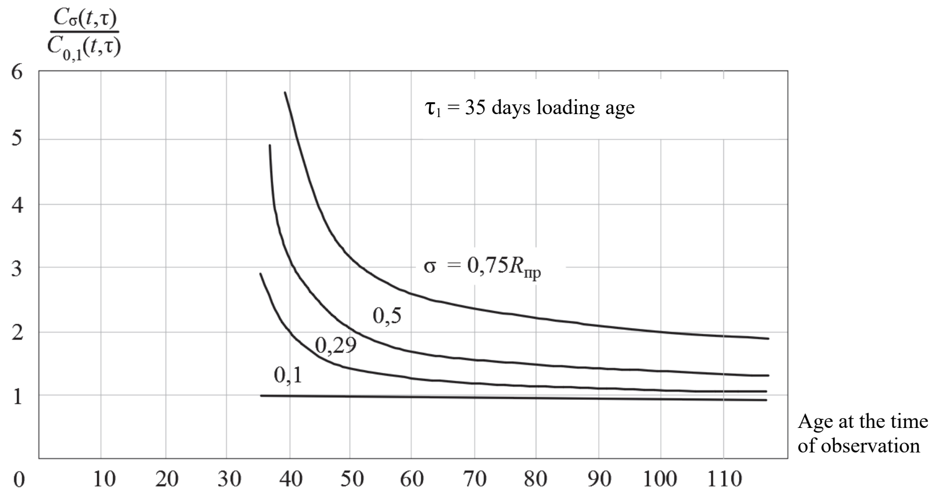

Figure 5. Changes in the specific creep strains ratio at different initial stress levels $C_{\sigma}(t, \tau)$ to specific creep deformations at the initial stress level $C_{0,1}(t, \tau)$

In the analyzed theory, one can find more absurd situations when the conditional (for reinforced concrete) theory (s. 2) of elastic-viscous stability of a compressed bar, with initial deflection, with infinite stresses, with its value of long-term critical force $P_{Д} = \frac{\pi^2 EI}{l^2(c+1)}$, where $c = \varphi_\infty$, becomes the theory for calculating the limiting state of reinforced concrete shells with cracks during prolonged loading. It is included in the methodological recommendations, it is under the guise of the elastic modulus $E_{Д} = \frac{E}{c+1}$ ($c = \varphi_c = 2$), the limiting characteristic of the creep of ordinary concrete), it is masked by empirical expressions, which is especially clearly seen from the problem of calculating the structures of the Transvaal Park.

Results

In a number of works, also in the norms, the analyzed theory is preceded by an explanation in the form of two Provisions: I – that it is necessary to use a nonlinear deformation model (signboard); II – that it is allowed to calculate on the basis of the analyzed theory (with different names: calculation by limiting forces; calculation by the stage of destruction or by the principle of plastic destruction; method of limiting equilibrium; method of calculated limiting states).

One of the developers of the norms in 2011 warned that an ordinary designer would not be able to use Provision I: "The deformation model of force resistance is mainly implemented through computing systems, so a number of formal procedures arise here, for example, stability, estimation of the solution's accuracy. The lack of tools is also due to the multi-iteration process of the solution, especially as the acting force approaches the bearing capacity... The results depend on the correctness of the choice of the initial (calculated) state diagrams." Russia joined the WTO and is obliged to comply with the requirements of the Eurocode.

Since the Eurocode prohibits changing its Principles and Rules of Application, and an ordinary designer will not be able to apply Regulation I, we come to the misconception that Regulation II corresponds to the Eurocode. In the educational literature in this regard, you can read: "Instead of the hypothesis of flat sections, the principle of plastic destruction is applied;" "The proposal to determine the bearing capacity by the limiting ('plastic') state for tens of years was ahead of the world practice in this matter;" "In the calculation models of the Eurocode, there is also a calculation for the ultimate effort" – which misleads specialists. Comparing the national standard and European standards, A.A. Gvozdev et al. [21] pointed out their significant difference in the principles and methods of calculation and, in particular, concerning the "calculation of normal... sections, taking into account the influence of the flexibility of the columns and the duration of the load."

The unscientific nature of the analyzed theory of reinforced concrete in certain aspects and at different times was pointed out by authoritative scientists: B.G. Skramtaev, V.M. Keldysh, G.V. Nikitin, A.R. Rzhanitsyn, G.A. Geniev, P.F. Drozdov, K.E. Tal and others. The average response to criticism sounded evasive: "The choice of the calculation scheme is determined by considerations of a didactic nature." After the approval of the Eurocode, the unscientific nature and inconsistency with the Eurocode of the analyzed theory became obvious.

The problem of the unscientific nature of the theory of concrete creep is indicated by the negative results of design practice, including the world experience in the design of unique structures with RAMBOLL structures (Great Britain) [2]; fib president Gordon Clark warns: "accurate prediction of the impact of creep... is highly controversial" [9]; we have established the reasons for the unscientific nature of this theory – among them are mathematical errors and violation of the principles of classical mechanics[4] [12–14; 19], we also developed a new nonlinear theory of concrete creep, which has not yet been published, supplementing the general theory [22].

The results of the analysis of the theory of calculation of reinforced concrete [23], as well as the essence of mathematical errors in the theory of concrete creep were reported and discussed at the international symposium in 2018 in Belgium [24], and at the international conference in 2014 in Moscow [2].

[4] ACI 209.3R-XX. *Analysis of creep and shrinkage effects on concrete structures. Final draft* (Chiorino M.A., Chairm. of Edit. Team). ACI Committee 209; 2011.

Conclusion

It is shown that the theory of calculation of reinforced concrete structures, which are widely used (with long-term loading all over the world), includes five inconsistent (among them erroneous) theories, the essence of which and one postulate are set further. Using the rules of mathematics, the principles of mechanics and the results of solid experiments, it was revealed that the analyzed theory contains a set of theories rejecting each other for various purposes, including erroneous ones.

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