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SOME ISSUES OF CALCULATION IN THE CONNECTION OF THE PREFABRICATED STRUCTURES

Abstracts. *During the development of the buildings design models, very important to take into account the conjugation of prefabricated structures, and to understand whether the continuity of their continuous conjugation will remain under the load. Sometimes errors in modeling can lead to an unreasonable increase in cross sections of structures, their damage, or even an accident during the construction and operation of a building. Below it is drawn attention to the number of tasks in which there are interface problems in the design of buildings and structures from prefabricated structures.*

Keywords: *prefabricated structures, platform joint, reinforced concrete, structural analysis*

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НЕКОТОРЫЕ ВОПРОСЫ РАСЧЕТА ПРИ СОПРЯЖЕНИИ СБОРНЫХ КОНСТРУКЦИЙ

Аннотация. *При построении расчетных моделей зданий с учетом сопряжения сборных конструкций важно понимать, сохранится ли неразрывность их непрерывного сопряжения при приложении нагрузки. Зачастую ошибки в моделировании могут привести к необоснованному завышению сечений конструкций, их повреждению или даже аварии в процессе возведения и эксплуатации здания. Обращается внимание на ряд задач, в которых проблемы сопряжения встречаются при проектировании зданий и сооружений из сборных конструкций.*

Ключевые слова: *сборные конструкции, платформенный стык, железобетон, структурный анализ*

Introduction

For the first time, the author encountered a similar task, studying [1] the water tower (figure 1) formed by a spatial farm with four pillars and a reservoir with a liquid (total weight P) supported by a support ring (R) as an example. The most important issue of calculation in that case was the choice of the calculation scheme. Each tower support pillar that receives a quarter of the weight of a tank of liquid must be individually designed. How to calculate and design the support ring (R)? If the weight of the tank with the liquid is evenly distributed around the ring, and balanced with four reactions of the supports, then designing and calculating the ring on the forces shown in figure 1 (b), we get an incorrect result, since the ring (R), interacting with the frames of the tank (T), will transfer the load associated with the large vertical rigidity of the tank, which means that the forces in the support ring (R) is determined not only by the weight of the reservoir with liquid, but also by the presence of connections between them.

Similar problems arise in the design and construction of prefabricated, in particular panel, structures.

1 The connection of a floor slab supported on internal load-bearing structures on three sides with a hanging panel of the outer wall

The connection of a floor slab supported on internal load-bearing structures on three sides with a hanging panel of the outer wall (see figure 2) is carried out through a mortar joint 20 mm thick. Due to the low tensile strength of the solution, one-sided bonds are formed at the contact, and the rigidity of the outer wall panel in its plane is several orders of magnitude higher than the rigidity of the floor slab. Therefore, effective areas of support for the outer wall panel will be small areas near the support and a gap is formed on the rest of the plate of the support plane, what the calculations indicate, taking into account the real diagram of the work of the mortar weld with low resistance to tensile. Hence, one requires additional reinforcement of floor slabs.

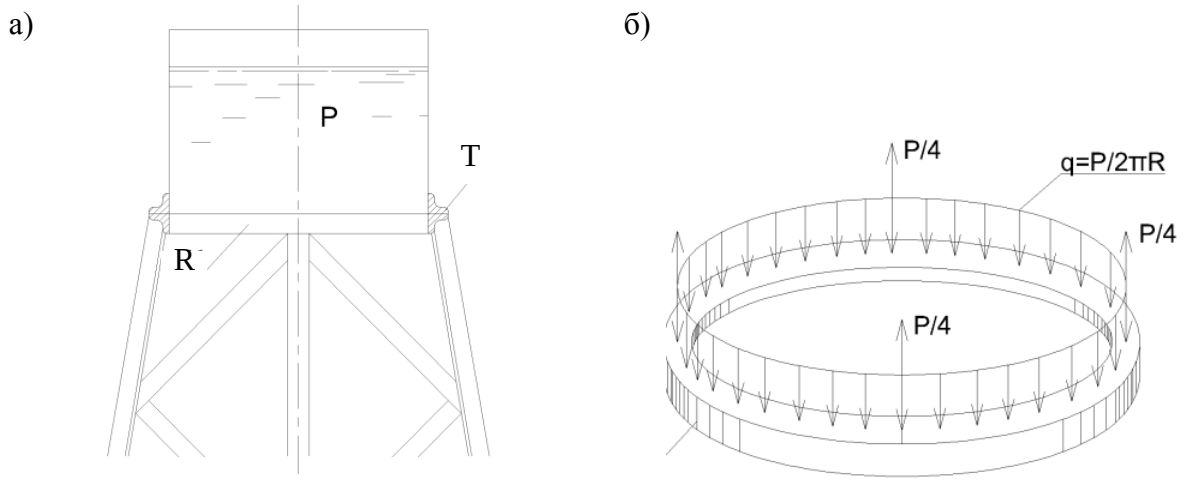

Figure 1 - Liquid tank tower and support ring (a) to transfer the load (b)

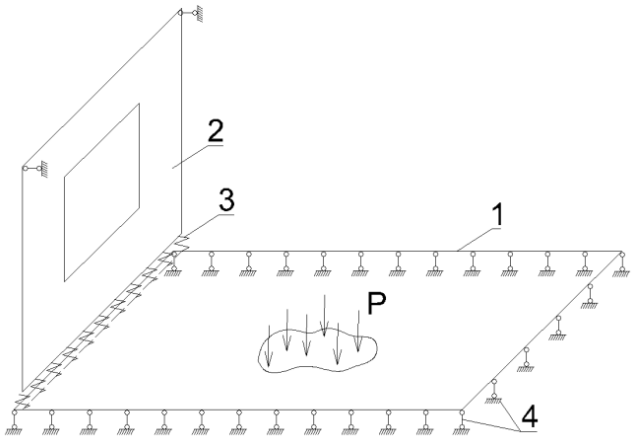

Figure 2 - The connection of the floor slab with a hanging outer wall panel

Its work in the process of installation becomes a multistage, which should be taken into account in the design and calculations. At the first stage, reinforcement is assigned according to the results of calculation for the own weight of the floor slab from the condition of its support on three

sides. In the second stage, after the installation of the exterior wall panel, the introduction of links and all loads (permanent and useful), the floor slab should be considered sup-ported on four sides due to the "suspension" of the exterior wall panel, and the own weight of the floor plate should be considered only partially due to with creep concrete.

2 Conjugation of bearing internal wall panels with floor slabs.

In a panel building, the pairing of supporting internal wall panels with floor slabs forms a node, called a platform's joint, which is filled with either a cement-sand mortar 15-30 mm thick or 5-10 mm cement paste. The contact zone (joint) has similar physical and mechanical characteristics, as in Example 1, while the low tensile strength of the solution forms one-sided connections between the wall panels and the floor slabs.

Numerical calculation of the platform's joint by the finite element method, made in [3], showed that the strength of the joint depends not only on the amount of vertical forces in the supporting wall panel (as is customary in the calculations and design standards), but also on the horizontal forces in the floor plate disk. The values of the ratio of vertical and horizontal efforts depend on the location of the joint in the building and its architectural planning solution.

3 The connection of the bearing elements of the building with the sharp changes in its structural and planning decisions in height

When two floors are connected: the lower one, made in the form of a frame, monolith or panels with large openings, and the upper supporting panels with small openings, a complex stress-strain state occurs in the joint area, characterized by the appearance of tensile stresses, an increase in the tensile strength of the mortar, the crack in the seam will be formed across the plane of the construction support. Therefore, a computational model with connection elements describing the work of a contact joint as in examples 1 and 2 is considered. The principle of operation of these finite elements (compounds) is that when the specified limit forces (compression and / or tension) the final element of the contact connection ceases to perceive the additional load and is disconnected from further work.

At the same time, the final elements, in which the limiting efforts were achieved, continue to deform like elements from an elastoplastic material until the maximum deformations are reached.

Reinforced concrete models of structures were carried out on a large scale and experimental studies were carried out with them. Calculations based on these studies were also performed. The test fragment, built on a 1: 2 scale, consisted of a lower floor wall with a large opening (1), an overlap (2), a wall panel of the upper floor (3), mating with the structures through the mortar seam (4) (figure 3).

Comparison of the results of numerical simulation with the results of field tests showed their con-vergence [5-7]. From the computational analysis performed by the method of limiting equilibrium in the kinematic formulation, it is clear that all the mechanisms formed as a result of plastic defor-mations in the lintels and the seam were calculated with an accuracy of several parameters obtained during the tests, which allowed us to estimate the "contribution" of each structural element in overall strength and optimize load-bearing structures.

The lack of a unified approach in real structures and calculations leads to damage and defects in structures. The inadmissibility of such an approach became clear after conducting the above analysis of the calculations and the above experimental studies.

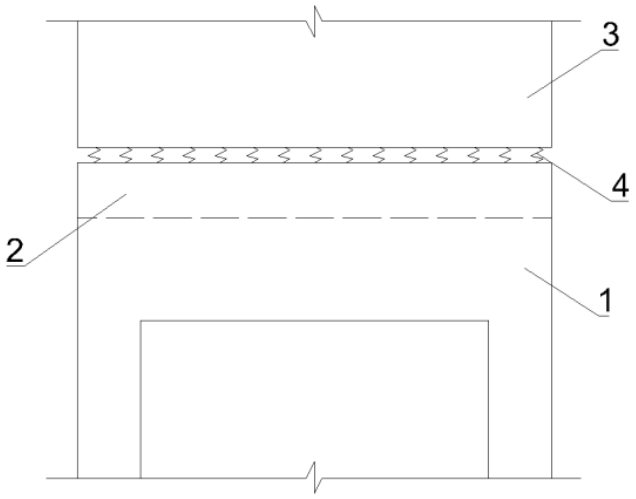

Figure 3 - Scheme of the walls of the lower and upper floors connection

In [8], there is a requirement to take into account the actual work of the joints of buildings when designing such systems.

4 Connections in panel buildings bearing prefabricated structures (walls) from the base plate

It should be noted that the solution of this problem is similar to the solution of the problem in Example 3.

Today, the described approach has been implemented in the LIRA-SAPR 2019 software package.

Conclusions

Possible problems that arise during the design and construction of prefabricated panel buildings are considered. It is noted that due to the low tensile strength of the mortar along the contact strip of the wall panel and the floor slab supported on three sides, one-way bonds are formed, while the stiffness of the outer wall panel in its plane is several orders of magnitude higher than the stiffness of the floor slab.

The values of the ratios of vertical and horizontal forces depend on the location of the joint in the building and its architectural and planning decisions.

The lack of a unified approach in real design and calculations leads to structural damage and structural defects.

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