Trends in the development of composite reinforced concrete structures of pedestrian aboveground overpasses

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Abstract. Pedestrian bridges are an important part of the urban infrastructure that ensures the safety and comfort of pedestrians. They have a number of distinctive features compared to road bridges. Also, the pedestrian load itself has a significant dynamic component, which can lead to the occurrence of resonant phenomena. Composite reinforced concrete bridges are widely used among the road bridges. This is due to the possibility of including the roadway structure in the act, which increases the load-bearing capacity and reliability of the structure. The same advantages are typical for pedestrian aboveground overpasses. However, pedestrian bridges have a number of features that affect the operation of the composite reinforced concrete structure. It is well-known that the difference between bending structures in civil construction and bending structures in bridge and road construction is the ratio of the rigidness of the concrete and steel parts. The load on pedestrian aboveground overpasses is similar to the temporary load in civil buildings, adjusted for a large dynamic component. But at the same time, the spans of pedestrian aboveground overpasses are similar to the spans of road bridges. In this article, the prospects for the development of composite reinforced concrete structures of pedestrian overpasses are reviewed.
Keywords. Pedestrian overpasses, Development prospects, Trends in the development, Composite reinforced concrete structures.

1 Introduction

Pedestrian bridges are an important part of the urban infrastructure that ensures the safety and comfort of pedestrians. They have a number of distinctive features compared to road bridges. For example, the structure of a pedestrian overpass takes up a relatively small pedestrian load, with significant spans, which leads to high slenderness ratio. Also, the pedestrian load itself has a significant dynamic component, which can lead to the occurrence of resonant phenomena [1-6]. Accordingly, pedestrian overpasses should provide dynamic pedestrian comfort [7-12].

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Pedestrian bridges should also be constructed in such way to allow vehicles to pass under them if they are located above the roadway.

Composite reinforced concrete bridges are widely used among the road bridges. This is due to the possibility of including the roadway structure in the act, which increases the load-bearing capacity and reliability of the structure. The same advantages are typical for pedestrian aboveground overpasses.

However, pedestrian bridges have a number of features that affect the operation of the composite reinforced concrete structure. It is well-known that the difference between bending structures in civil construction and bending structures in bridge and road construction is the ratio of the rigidness of the concrete and steel parts. The load on pedestrian aboveground overpasses is similar to the temporary load in civil buildings, adjusted for a large dynamic component. But at the same time, the spans of pedestrian aboveground overpasses are similar to the spans of road bridges. As the result, it can be assumed that the optimal ratio of concrete and steel parts in pedestrian overpasses will differ from the ratio in composite reinforced concrete structures of civil and bridge construction. In this article, the prospects for the development of composite reinforced concrete structures of pedestrian overpasses are reviewed.

2 Materials and methods

The prospects for the development of composite reinforced concrete structures of pedestrian overpasses are similar to the prospects for the development of composite reinforced concrete structures in general, taking into account some distinctive features. In this article, the following development prospects will be considered:

1. Development of shear connectors;
2. Development of industrial composite reinforced concrete structures;
3. Application of new materials;
4. Development of multi-profile composite reinforced concrete columns.

2.1 Development of shear connectors

The connectors are divided into rigid, flexible and combined. In addition to traditional connectors, such as cylindrical flexible connectors, dowel strips connectors have become widespread [13-18].

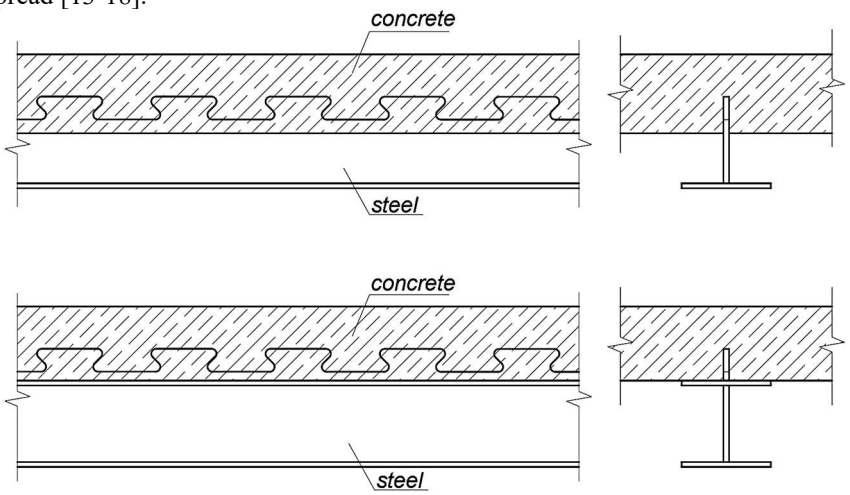

Fig. 1. Dowel strips connectors.

Their special feature is the reduced labor intensity on the construction site, as they can be welded on the I-beam shelf at the factory or obtained by cutting the part of the *T*-beam. Such connectors have become widespread in both bridge and civil construction. It can be assumed that in pedestrian overpasses, such connectors will have their own characteristics associated with the presence of a dynamic component of the load.

There is a study [19] in which, in order to improve the technical and economic indicators, demountable bolt connectors were developed that can be reused after disassembling the primary structure. Within the area of pedestrian overpasses, such structures are of interest from the point of view of the possibility of their use for the construction of temporary structures. In this case, additional studies are needed to study the influence of the dynamic component of the pedestrian load on the technical state of the connectors (fig. 1).

2.2 Development of industrial composite reinforced concrete structures

The use of industrial composite reinforced concrete structures has a number of advantages, such as the ability to ensure the best quality of construction, single-stage operation and speed of installation. These structures may be of interest in terms of the possibility of use them in pedestrian overpasses, but it is not known how much the stress and strains in the structure will decrease. There is also insufficient data on the impact of the dynamic component of the load on the state of the connectors (fig.2).

Fig. 2. Production of single-stage operation beams.

2.3 Development of industrial composite reinforced concrete structures

Concrete and steel are traditionally used as materials for the composite cross-section of the bent elements. However, research on the replacement of steel elements with polymer composite ones has been developed [20]. The use of new materials in pedestrian overpasses is connected to a relatively low load from pedestrians, in comparison with road bridges.

The use of composite materials for a road bridge [20] illustrated the need to ensure the elastic horizontal and vertical operation of the connectors. Further research is needed to determine this need for pedestrian bridges (fig. 3).

Fig. 3. Fragment of a road bridge superstructure made of composite polymer material.

2.4 Development of multi-profile composite reinforced concrete columns

The features of the columns of pedestrian overpasses include the possibility of impact from the vehicle. To ensure safety in this case, it is of interest to study the development of composite reinforced concrete columns consisting of several non-directly connected steel elements [21-25]. Studies are required to study the failure of one of the steel elements due to impact and to determine the load-bearing capacity in this case (fig. 4).

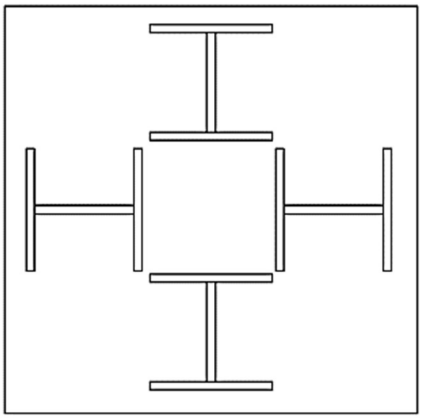

Fig. 4. Diagram of a multi-profile composite reinforced concrete column of 4 I-beams.

3 Results and discussion

According to the results of the work, the following prospects for the development of composite reinforced concrete structures of pedestrian overpasses were identified:

1. The study of shear connectors traditionally occupies an important place in the study of composite reinforced concrete structures, since it is often the shear strength that provides the load-bearing capacity and reliability of the structure as a whole. Studies of the connectors of composite reinforced concrete structures generally correspond to pedestrian overpasses, but studies on adaptation are required, taking into account the distinctive features.

2. Industrial construction has prospects in the construction of pedestrian overpasses, but in order to determine the feasibility, studies are required to determine the benefits.

3. The development of industrial capacities of plants for the production of composite polymer materials has allowed them to be used in a greater number of structures, including pedestrian overpasses. However, further research is needed for wider distribution.

4. Aboveground pedestrian overpasses are usually arranged in places of heavy traffic, which entails the risk of a vehicle hitting the column. One of the solutions can be the use of a multi-profile composite reinforced concrete column, considered in the article.

4 Conclusions

The considered trends and prospects for the development of composite reinforced concrete structures of pedestrian aboveground overpasses correspond to the development of composite reinforced concrete structures in general, but distinctive features, such as the ratio of concrete and steel stiffness, as well as the presence of a dynamic component of the load from pedestrians, lead to the need for additional research. The authors of the article plan to conduct further research taking into account the prospects and trends of development discussed in the article.

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