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TÍTULO: Cuestiones problemáticas de la enseñanza del tema "Sistemas de envolvente de construcción sostenible" en universidades.

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RESUMEN: El artículo es un estudio de proyectos recientes de varios sistemas estructurales. Este tema se está estudiando en todas las universidades técnicas. El artículo considera problemas que impiden el proceso de aprendizaje. Los accidentes de sistemas estructurales se asocian principalmente con la pérdida de estabilidad de toda la estructura; particularmente, el alto riesgo de accidente, porque la pérdida de estabilidad puede ocurrir repentinamente. En general, la carga en varios diseños puede ser cero. Los sistemas de estructuras con pérdida de estabilidad en su plano pueden ser: estática, causada por la bifurcación de la línea elástica, y la curvatura de la sección cargada después de la carga, excediendo el valor crítico. El problema más importante al usar un sistema de envolvente de edificio es la estabilidad.

PALABRAS CLAVES: Aprendizaje, estudiante, sistemas sostenibles, diseños.

TITLE: Problematic issues of teaching the topic "Sustainable building envelope systems" in universities.

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ABSTRACT: The article is a study of recent projects from various structural systems. This topic is being studied in all technical universities. The article considers problematic issues that impede the learning process. Accidents of structural systems are mainly associated with the loss of stability of the entire structure; particularly, high risk of accident due to loss of stability, because the loss of stability can occur suddenly. In general, the load in various designs may be zero. Therefore, systems of structures with loss of stability in their plane have two bends: static, caused by bifurcation of the elastic line, and bending of the loaded section after loading, exceeding the critical value. The most important issue in using a building envelope system is stability.

KEY WORDS: Learning, student, sustainable systems, designs.

INTRODUCTION.

The transformational processes taking place in the Russian economy and on the labor market constantly require the training of highly qualified personnel. Therefore, the need for vocational education teachers who are able to provide training in professional creativity and skill is very high and stable (Mottaeva, 2015). The profession of builder has always been and will be the most demanded on Earth, since it creates a full-fledged environment for human life and activity. Every year this profession is being improved, and with it, residential, cultural, industrial and other architectural and urban complexes are being updated in our cities and villages. Therefore, in the direction of "Construction" the most prestigious profile is "Industrial and civil construction".

The Industrial and Civil Engineering profile is designed for those who would like not only to look into the future of urban development, but to realize their ideas in architectural and construction projects. The faculties are given the acquisition of skills in the automated design of building structures, buildings and structures.

After receiving a bachelor's diploma, graduates themselves will shape the look of our cities and towns, from the design stage to the direct construction and reconstruction of buildings and structures.

The objects of professional activity of bachelors are:

- Industrial and civil buildings.
- Hydrotechnical and environmental facilities.
- Building materials, products and structures.
- Heat and gas supply, ventilation, water supply and sanitation systems of industrial and civil buildings.
- Environmental facilities.
- Real estate objects
- Land.
- Urban areas.

In the process of studying at the Faculty of Construction and Architecture, students receive deep theoretical knowledge and professional skills in all disciplines of the profile.

System sustainability - the ability of the system to maintain the current state when exposed to external influences. First of all, it is the ability of structures to withstand external forces seeking to transfer it from the original state of static and dynamic equilibrium.

The stability of structures or systems of structures is assessed by determining the extent of their damage. Determining the degree of damage and the category of technical condition of building structures or buildings and structures in general, based on a comparison of the actual values of the evaluation criteria with the values of the same criteria established by the project or regulatory document. These systems belong to the building metal structures of prefabricated elements, most often made of aluminum elements, and can be used in the construction of a wide nomenclature - stained glass windows, shop windows, partitions, wall panels, windows, etc. and extended configuration - arches, trapezium, parallelepiped, pyramid, prism, dome, etc.

The current stage of economic and social development in Russia is characterized by the expansion of construction production and the conduct of large-scale construction in large cities, primarily in Moscow and St. Petersburg, accompanied by a constant increase in the complexity of constructed objects and the environment in which the constructions were built. This inevitably gives rise to new challenges, related to ensuring safe life in a megacity, which is determined; firstly, by the reliability of the buildings under construction, and, secondly, by the impact of the construction in existing infrastructure (Kovalenko, 2019; Gazizov et al., 2018; Pecorella et al.,2018; Ardda et al., 2018).

Current trends in construction, namely, an increase in the number of floors of buildings, compaction of urban buildings, constrained construction sites, development of underground space, and saturation of utilities invariably lead to the emergence and subsequent increase in the negative anthropogenic impact of construction in constructed facilities located in surrounding areas.

In this regard, of particular importance is the problem of monitoring the technical condition of buildings and structures in order to prevent the occurrence of emergency situations and the validity of the choice of a complex of engineering measures to prevent it. It is obvious that the control of the technical condition of the supporting structures should be systematic in nature and allow for the assessment of the changes taking place on the basis of quantitative criteria, i.e. be based on procedures for identifying compliance of actual strength, stiffness and stability of structural elements with regulatory requirements.

Currently in Moscow, work is underway to survey the technical condition of individual objects for sustainability. However, a large number of buildings and structures are not covered at all by any control, although the vital activity of the city dynamically leads both to the deterioration of soil properties and to negative effects of a power and non-power character on the ground structures of buildings and structures. All this in the conditions of the exhaustion of the regulatory life of a large number of objects is not permissible and requires systematic observations. After all, the terms of operation of many buildings in Russia have long exceeded all permissible norms, there is an accumulation of physical deterioration, which is extremely dangerous for people's livelihoods. Such buildings need constant monitoring of their technical condition.

DEVELOPMENT.

Methodology.

This study uses the methods of observation, description and interpretation.

Basic terms for enclosing structures:

1. The wall of the building - the main building envelope. Along with the enclosing functions, the walls at the same time in varying degrees, perform supporting functions (serve as supports for the perception of vertical and horizontal loads).

The main requirements for walls: strength, heat resistance, sound insulation ability, fire resistance, durability, architectural expressiveness and economy.

There are external and internal walls. By the nature of the static work, the outer walls are divided into load-bearing ones, which, apart from their own weight, perceive and transfer to the foundation loads from ceilings, coatings, wind pressure, etc.; self-supporting, bearing on the foundation, carrying the load only from its own weight (within all floors of the building) and to ensure stability, the buildings associated with the frame: non-bearing (including attached), perceiving its own weight only within one floor and transmitting it to frame or other supporting structures of the building. Internal walls can be carrier (capital) or non-bearing (partitions, intended only for the separation of premises, they are installed directly on the floor). In the inner walls, channels and niches for ventilation, gas ducts, water and sewage pipes, etc. are often arranged. The bearing walls together with the floors form a stable spatial system of the bearing frame of the building. In frame buildings, self-supporting walls often perform the functions of the so-called diaphragm stiffness (Khan et al.,2018; Jingting Xue et al.,2018).

According to the method of construction of the wall is divided into prefabricated, assembled from prefabricated elements of factory production; monolithic - usually concrete, erected in mobile or sliding formwork, hand-laid - from small-piece materials on solutions. Depending on the size of prefabricated elements, the degree of their factory readiness and the adopted cutting system, there are large-block and large-panel prefabricated walls. By constructive solution, the walls are single-layered and multi-layered (Zhang etal., 2018; Mao et al., 2018; Khalaf et al., 2018).

Materials for the construction of the wall are selected depending on the climatic conditions, purpose and capital of the building, its height, from the technical and economic feasibility. In high-rise building construction with bearing walls, brick, ceramic stones, large blocks of light and cellular concrete, reinforced concrete panels and other large-sized products are used. Non-supporting walls, the weight of which should be minimal, are made of multi-layer reinforced concrete panels with effective insulation, especially lightweight concrete panels, asbestos-cement panels. In low-rise construction, wood, silicate and raw bricks, cinder, ceramic and natural stones are used.

Walls largely determine the constructive solution and the overall architectural appearance of the building. The name of the wall material often characterizes the architectural and constructive type of house: large-panel, large-block, brick, wooden chopped, frame-shield, etc.

2. The framework (French -carcasse, from Italian -carcassa) in the technique is the skeleton of any product, structural element, the whole building or structure, consisting of individual rods fastened together.

The frame is made of wood, metal, reinforced concrete and other materials. It determines the strength, stability, durability, shape of the product or structure. Strength and stability are provided by rigid bonding of the rods in the nodes of the pairing or swivel and special elements of rigidity, which give the product or construction of a geometrically unchanging shape. Increasing the rigidity of the frame is often achieved by the inclusion in the work of the shell, plating or walls of the product or structure. The frame of the building consists mainly of columns (pillars) and crossbars supported on them, girders, beams, trusses on which the elements of the floor and the flooring are laid. According to the types of buildings in which they are used, the frames are single and multi-tiered; single, dual and multi-span; with the location in terms of the main supporting structures in the transverse, longitudinal or in both directions. There are complete and incomplete building frameworks: the full frame perceives all vertical loads of the building, while the frame elements are located throughout the building plan; incomplete frame is placed only inside the building, where the outer walls are bearing and participate together with the frame in the overall work of the building (Ali at al., 2017; Penz et al, 2018).

According to the method of ensuring the overall rigidity and stability of the building, the frames are divided into frame frames in which the junctions of the elements of columns and girders are constructed rigid in the form of frames, capable of perceiving bending moments and lateral forces from wind loads and their own weights, and connected with hinged or partially clamped nodes where wind loads are perceived by rigid horizontal and vertical diaphragms. The frame is used instead of the supporting walls or in combination with them when it is necessary to open a large internal space or to transform it multiple times with the help of mobile (moving) structures and partitions.

3. Overlappings - horizontal bearing and enclosing structures. They perceive vertical and horizontal force effects and transmit them to the bearing walls or frame. Overlappings provide heat and sound insulation of the premises.

Overlaps must have sufficient strength and rigidity to withstand both the load from its own weight, and useful (static and dynamic), as well as have a standard amount of deflection. The material and pattern of the floor, laid on the ceiling, as well as the finishing of the lower part of the ceiling - the ceiling play a certain role in the decoration of the interior.

Interfloor overlappings are internal fences, and their main function is sound insulation. Attic overlaps, over the driveways and undergrounds are external fences, and their main function is to insulate the fenced premises.

Discussion and results.

The system of building fencing includes a number of fencing structures, each of which contains frame of box or solid section struts and profile girders, racks made monolithic or composite with a step along the generatrix, girders made monolithic or composite with a mustache, struts and girders are joined butt-congruently - ush-girder-rack mounts, struts and gables are fitted with C -shaped fastening elements for filling elements of precast struts of girders into a monolith and auxiliary elements; the rack is equipped with a U-shaped element on the inner surface; the C-shaped fasteners for the elastic seal of the lock and the gaskets of the uprights and the bolts are mutually perpendicular, and the thickness of the junction of the vertical elastic strip is equal to the sum of the thickness of the junction of the elastic strip and the width of the C-shaped fastener of the bar, and the racks are; for example, of the three prefabricated elements, the outermost which are provided with internal C-shaped fasteners, and the middle one - of heat-insulating material with protrusions corresponding to C-shaped fasteners.

A disadvantage of the known device, preventing the obtaining of the desired technical result is the complexity of the node connection, including due to the cutting of the ledge on the end of the bolt, the attachment of the bolt bar to the hollow C-shaped bar, which is a console; development of the structure limits the possibility of increasing (increasing or strengthening) the rack and in the presence of a cold bridge, the need for inserts for fastening the filling, incl. folds and transoms.

The task is to eliminate these drawbacks and to obtain the following technical result: simplifying the system of enclosing structures and improving its strength characteristics by placing in the head parts of the racks and crossbars a set of C-shaped fasteners for locks, gaskets and various opening-closing devices; changing the nodal connection - eliminating the complicated configuration of the cutter end of the bolt at any angles of connection of the bolt and the stand (using a direct cut of the end face of the bolt), the possibility of developing and strengthening the bearing capacity of the structure as a whole due to strengthening (increasing) the stand and the bolt and ties without additional elements, ensuring heat technical characteristics, the possibility of local dismantling of individual elements of the building envelope during operation (without dismantling the frame as a whole) for a wide range and expanded oh configuration, and hence reduction of labor costs in the manufacture, installation and operation, decrease of metal.

The required technical result is achieved by the fact that, in the known system of building fencing structures, the struts and girders are made monolithic or composite, the frame struts are made with ledges arranged along the forming fence, the bolts of the transom are placed congruently to the ledge of the struts, the struts and girders are “butt-joined consoles”, the connection elements contain an elastic seal, a lock with C-shaped fasteners on the side surfaces of bolts and struts, a U-shaped fastener on the inner side with respect to the attachment point of the stand-bolt surfaces of the struts, the C-shaped fasteners for the elastic seal, the lock and the gaskets of the struts and the bolt are mutually perpendicular, and the thickness of the junction of the vertical elastic strip is equal to the sum of the thickness of the junction of the elastic strip and the width of the C-shaped fastener of the bar bolt, racks and girders are made; for example, of three prefabricated elements, the outermost of which are provided with internal C-shaped fasteners, and the middle one of heat-insulating material.

The rack is attached to general construction structures using any of the known methods; for example, an anchor that is connected at one end to a building structure (for example, by welding), and the other is mounted on a stand through a U-shaped element, such as a side mount or inside a rack, in U-shaped The elements are inserted metal plate fixed below.

The head of the rack and bolt structurally represent part of the profile with the C-shaped elements for filling, auxiliary elements, gaskets, locks. Functionally used for placement in the building envelope.

The tail parts of the rack and the bolt constructively represent part of the profile (on the rack are ledges, on the crossbar are whiskers) with C-shaped elements for gaskets and serve to form the frame of the enclosing structure, since on the ledge (the tail of the rack) fixed mustache (tail portion of the bolt).

The proposed system of enclosing structures allows you to fulfill any requirements of architectural solutions, regardless of the shape, size and configuration of the building (structure) and the type of filling.

In structures of the dome type, the enclosing fence is an arc, and the stand with ledges bends on the rolls of the corresponding part of the arc; while the ledges of the stand are also curved along the same arc, and the mustache of the bolt is pressed from the angle corresponding to the angle of the same arc. The connection of the rack curved in an arc with the bolt made in the same way as the planar main part of the bolt adjoins to the main part of the rack end-to-end butt and the mustache of the bolt "match", "match", i.e. placed congruently ledges racks.

Buildings such as the Rotunda in Nantes, the University of Glasgow, Park-President in Hamburg, etc. using our system is easier and cheaper.

Creating a frame of racks with protrusions along a generatrix, crossbars with a mustache, congruent stands, and fixing racks with a crossbar at the same time “butt-joint congruently ledge”; internal, i.e., fastening in a frame and to general construction structures), makes it possible to modify the building according to the architect’s plan with simpler means.

Fig.1. The ancient Roman aqueduct Pont du Gard.

Arched structures are widely used in construction since antiquity. The Romans were the first to use arches of considerable size, and some of them have survived to this day.

One example of the use of arched structures in Roman architecture is the ancient Roman aqueduct Pont du Gard. It was the most significant arched structure until the Middle Ages (Fig.1).

In modern architecture there is a significant increase in the use of steel arches. They are used in buildings and long-span bridges, combining design and architectural advantages. In 2014, Abu Dhabi completed the assembly of the first steel arch of the roof structure, a span of 120 meters and a weight of 200 tons. The largest, 180 meter arch will weigh 300 tons. In total, there will be 18 arches in the airport terminal.

In 2010, next to the unique Hoover Dam, Mike O'Callaghan's Memorial Bridge, Pat Tillman, was commissioned. The bridge consists of 14 columns and 2 arches in the central part. Each arch contains 53 sequentially otbetonirovannyh fragments, most of them 7.3 meters long (a total of 106 casting and compacting cycles of concrete were performed). Arches were built up from both banks of the river at the same time in the form of converging semi-arches, eventually merging into a single structure. In the process of pouring, compacting and hardening the concrete, the growing semi-arches were supported by inclined cables stretched from temporary pylon towers. In the process of increasing the half-arches, their weight changed, additional supporting cables were constantly installed. In 2013-2014 on the railway tunnel of Cherli (UK), stone arches preventing the walls of the tunnel from collapsing were replaced with steel ones.

In 2014, one more object was added to the collection of unique engineering structures of the city of Novosibirsk - the fifth bridge across the Ob River. The main design feature of the bridge is its unique metal arch. The length of the arched span is 380 meters. The arch is the largest for the CIS countries and the second of a similar construction in the world bridge construction. The arch tightening consists of two steel box-shaped and two main I-shaped steel beams. The lifting arm of the combined arch with a puff was 74 m.

Accidents of arched structures are mostly due to the loss of stability of the whole structure. Steel structures, with respect to H / B ≥6 (where H is the full height, B), check the overall stability of the frame as a whole as a composite rod clamped at the base and free at the top (SP 16.13330.2011).

The danger of an accident from loss of stability is especially great because a loss of stability can occur suddenly. Of all the engineering structures, metal structures are most susceptible to buckling, since they are made of relatively thin and long rods.

In the general case of loading at the arch, there may be areas where there is no load. Therefore, the arches, when it lose stability in the plane, experience two bends: static, caused by bifurcation of the elastic line, and bending of the loaded section after the load exceeds a critical value.

Loss of stability is possible both from the plane and in the plane. Flat structures - trusses, arches, frames better resist bending in the plane of structures than from the plane. Cases of accidents of industrial and civil structures, resulting from the loss of stability of the flat form of bending are little known. The loss of stability of the flat form of bending of structures working for transverse bending has received little attention, since it is believed that, if in some cases it has space, it does not lead to an accident due to the general interconnection of beams with other structures.

In recent years, work has emerged on the development of an algorithm for calculating arches of arbitrary shape and variable stiffness in the elastic stage.

New design solutions have been developed for arches and frames, in which the lateral stability of compressed belts of arches is enhanced. The stability of combined arch systems with V-shaped racks were conducted by D. B. Kiselev, the geometrical parameters of the design scheme were optimized taking into account the stability of the system. The abilities of the arched structures are used in metro construction, road construction. Since a structure such as a culvert has a considerable length in the body of a highway embankment, this task can be considered as flat. As a design scheme, you can take a double-hinged arch.

The work of arched structures under the ground has its own characteristics. The main type of violation of the strength of the soil - the displacement of one part of it in relation to the other, due to a continuous shear, rolling in the cut. When the action of the soil is replaced by normal pressure and limiting friction forces acting along the entire surface of the arch, an increase in the maximum moment by 20% is observed. The reason for this discrepancy in the inaccurate description of the forces of interaction of the soil with the arch. Virtually along the entire axis of the arch, soil slippage occurs - the soil “wrap” around the arch.

Consequently, the modeling of the interaction of the arch with the ground should be carried out according to the scheme of limiting friction throughout the arch. The new incremental method of calculating the ultimate load, with an algorithm that monitors the singular states of the stiffness matrix, increases the reliability of predicting the loss of stability of the structure and makes it possible to identify its cause. The importance of imposing a static load. It is known that an arch, when a suddenly applied load is applied to its arc, can lose stability in a plane, since it has a nonlinear equilibrium trajectory.

In the arch, excessive oscillations occur due to a suddenly applied load. In practice, a certain static load is usually imposed on the arch before a sudden load. Static load, can have a strong influence on the dynamics of the arc of the arch, in part, eliminating the instability of the arch under a sudden application of load. In the general case of loading at the arch there may be areas where there is no load. Therefore, the arches in case of loss of stability in their plane experience two bends: static, caused by the bifurcation of the elastic line, and bending of the loaded section after the load exceeds a critical value. In addition, the bonds at the ends of the arch, limiting its rotation, representing adjacent structural elements (or an elastic base) have a significant effect on the geometric nonlinearity of the arc, and therefore the connections affect the stability of the arch to dynamic loads under a suddenly applied load.

Employees of the Faculty of Civil and Environmental Engineering of the University of New South Wales Yun-Lin Pi and Mark Bradford used the energy method to study the stability of arches in the plane. They experienced arches with a small span, preloaded with a static load, with connections in the supports, limiting their rotation. It was found that the preload-loaded arches can be susceptible to dynamic loads through deformation. It was also found that the deformation of arches under dynamic loading is significantly influenced by the magnitude and differences in the flexibility of the supports limiting the rotation of the arch. For arches that have the same axis of rotation, the supports may have dynamic buckles at the top as well as at the bottom, while at the arches having a single axis of rotation, there is a unique single dynamic buckling from the load.

The effect of the “stretchability” parameter on the boundaries of flat arch loss scenarios depending on the size of the central angle solution (in fact, on the degree of elevation of the arch) was also studied. The role of the “extensibility” of the χ axis of the arch, equal to the ratio of the moment of inertia of the cross section I, to its area A and the square of the arc length is noted.

CONCLUSIONS.

Everything that is built by man is called a structure. Structures in which there are premises designed to perform certain functions by a person are called buildings. Other buildings are called engineering structures.

Buildings and structures play an important role in the life of modern society. It can be argued that the level of civilization, the development of science, culture and production are largely determined by the quantity and quality of the buildings and structures built. The life and life of people are determined by the presence of the necessary buildings and structures, their compliance with their purpose, technical condition. Of particular importance is the further development of theoretical and general technical research, which should be aimed at creating new methods for the optimal design of enterprises, buildings and structures, at developing fundamentally new constructive solutions.

The need for austerity of the area suitable for industrial construction will inevitably lead to the widespread use of multi-story buildings and buildings of high-rise buildings.

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