the construction industry responds to by developing innovative housing concepts. Construction and innovation are deeply interconnected and important to the modern world.

A key factor contributing to the development of the construction industry is technological innovation. One of the bright directions is the introduction of digital technologies and information systems. The use of the BIM (Building Information Modeling) system allows you to create three-dimensional models of buildings and objects, providing more accurate planning and project management. This allows you to reduce construction time and costs, as well as improve interaction between project participants [1].

Another innovation that is actively being implemented in construction is 3D printing. With the help of 3D printers, you can create building elements and details with complex geometry, which allows you to speed up the construction process and reduce its cost. Also, 3D printing allows you to use environmentally friendly materials and reduce construction waste [2].

A promising area of innovation in construction is the use of "smart" materials and systems. For example, self-cleaning surfaces, self-installing materials or solar panels integrated into building structures. These technologies make it possible to create more efficient and environmentally sustainable buildings [3].

It is also necessary to note the importance of innovations in the field of construction management. The use of the project management system, data analytics and artificial intelligence allows to optimize the planning, control and coordination of construction works. This reduces risks and increases the efficiency of projects [4].

Construction and innovation are inextricably linked. Innovations bring significant changes to construction processes, increasing efficiency, sustainability and quality. The introduction of digital technologies, 3D printing, the use of "smart" materials and systems, as well as innovations in construction management open new perspectives for the industry. In addition the development of innovations has a significant potential to improve the quality of life of people, provide them with comfort and strengthen the sustainability of buildings.

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USING ARTIFICIAL INTELLIGENCE TOOLS IN CALCULATIONS AND DESIGN OF METAL STRUCTURES

At present, the use of artificial intelligence can bring the solution to problems of calculation and design of metal structures to a new level. There are many uncertainties in such tasks which are associated with creating descriptions of the existing object and the design of a new one. There is a need to agree on conflicting criteria for ensuring strength and reliability, cost-effectiveness, safety, installation speed and other factors, as well as the probabilistic nature of loads, material characteristics and geometric characteristics of cross-sections. The limit state method used to solve this problem has its limitations, related to the analysis of the limit states. The use of artificial intelligence can optimize the processes of data analysis, modeling, forecasting, and automation in tasks of calculating and designing metal structures [1-3].

Chat GPT can explain the fundamental concepts and principles of detailed modeling of structures, as well as clarify when and why detailed modeling may be beneficial or undesirable.

Python with machine learning and data analysis libraries (such as TensorFlow, scikit-learn, pandas) can simplify the design and calculation of structures. It can provide guidance, suggesting calculating force of "50 kN" for connection elements without detailed calculation. For instance, it is necessary to analyze the stress distribution in a beam structure. Starting with a simple model that considers only the main components of the beam (such as the beam itself and the supports) it may provide sufficient accuracy for initial calculations.

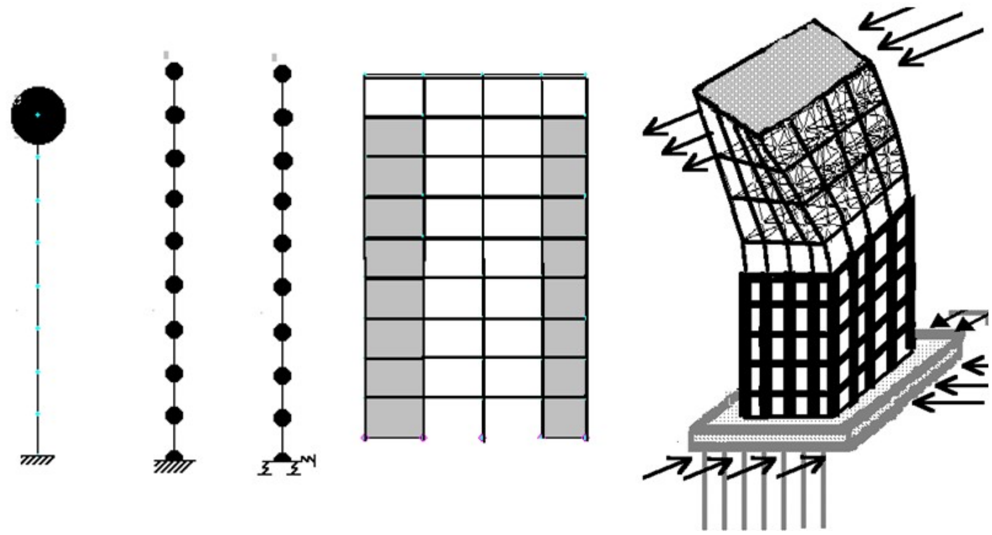

Fig. 1.Options for modeling multi-story frame buildings

This approach is applied in student education to eliminate unexpected errors. As calculations using construction mechanics methods are not performed, standard diagrams and formulas are used.

It all depends on understanding the function of specific structural elements in the collaborative operation of the structural system. In any case, there should be an understanding of the design scheme that, to some extent, can forecast the calculation results.

Specialized tools for engineering modeling help in such tasks. Autodesk Revit, Ansys, Tekla Structures use artificial intelligence methods for modeling and analysis of building structures.

The use of a highly detailed model and a powerful computing complex will not always lead to the correct result. Artificial intelligence suggests that it's better to proceed from simple to complex, predicting calculation results and refining them during the detailing of the design in the next stage. Initially, a flat diagram is created, followed by a spatial one, and then accounting for wall filling, and adjacent subsystems of the foundation, structures, and load fields. (Fig. 1)

When using software packages, there is a distinct issue that arises: the details of the breakdown into finite elements and the methods of node modelling. For example, when defining a relative eccentricity for rods with ends fixed from displacement perpendicular to the plane of action of the moment, the maximum moment within the middle third of the length, but not less than half of the greatest moment along the length of the rod, should be taken as the design moment.

To enable stability checks from the plane using the maximum moment in the middle third of the column element and other compression-bending elements, the breakdown should ensure nodes along the middle third's boundaries, and stability checks from the moment's action plane should be conducted on the final element with the maximum moment in the middle third of its length. It's essential to ensure that the moment is at least half the maximum.

Therefore, the finite element breakdown scheme of the lower part of columns will give different outcomes – either meeting or not the requirements of the first group of limit states.

Rigid inserts, solids, or translation merges can be applied. For instance, rigid inserts move the flexible part of the element away from the node, creating an infinitely rigid insert between the flexible part and the node. When modeling sheet hinges, transferring forces in specific directions - only vertical, or only horizontal can be used to 'combine movements'. Different ways of modeling floor structures will result in different outcomes.

It becomes even more complicated when calculations are required for progressive collapse, when optimizing the life cycle processes of manufacturing, installation, operation, and application of effective methods of analysis and forecasting the behavior of structures under the influence of external factors.

Artificial intelligence can be introduced at all the above stages of calculation and design both in teaching students and in creating innovative methods of design, monitoring the state of structures in real time, when modelling dynamic features of structural work.

Artificial intelligence can be integrated as a direction for the development of advanced calculations and models aimed at enhancing the reliability and durability of designed buildings and structures (it should be noted that this need arises not only in the design of new buildings and structures, but also in the inspection, diagnosis, and reconstruction of existing facilities).

Artificial Neural Networks can be employed to refine and test calculation models, optimizing various parameters based on training data and real-world performance.

Comprehensive approach is used in application of spatial models, taking into account modeling of nodes, boundary conditions, stiffening on different subsystems of constructions. Finite Element Analysis software, such as Abaqus or ANSYS, uses AI algorithms for spatial modeling, considering factors like node behavior, boundary conditions, and subsystem interactions.

Modeling of non-linear properties and characteristics (elastic and dissipative), taking into account structural non-linearities (gaps, one-sided connections, working, for example, only for stretching or compression, "included" or "off"). Machine learning algorithms, such as Random Forests or Gradient Boosting Machines, can be applied to model non-linear properties and structural behaviors, adapting to complex relationships between variables and conditions.

Genetic Algorithms can optimize the design process of metal structures by providing solutions that meet specified criteria, such as energy efficiency, safety, and weight reduction, while considering spatial and material constraints.

Artificial intelligence tools are used in individual tasks and calculations when selecting a technology in the manufacture of metal structures, transportation, installation and technological processes of construction production, operation and repair, tests of metal structures, technical diagnostics. As a result, Robotics Process Automation combined with machine learning algorithms can automate various tasks involved in metal structure manufacturing, transportation, installation, and maintenance, improving efficiency and accuracy while reducing costs and human errors.

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