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BIM TECHNOLOGY AND EXPERIENCE OF THEIR INTRODUCTION INTO EDUCATIONAL PROCESS FOR TRAINING BACHELOR STUDENTS OF MAJOR 08.03.01 «CONSTRUCTION»

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The article deals with issues of necessity of training and development of working staff for construction industry of Russian Federation for creation of competitive construction industry, meeting the high quality and efficiency standards, working in basis of modern financial and economic, technical and management mechanisms. One of the ways to solve this task of innovative development is modernization of architectural and building design, in particular implementation of BIM technology enabling making efficient decisions at all stages of building and structures life cycle – from investment concept till operation and even demolition. In relation to this the industry demands highly qualified workers and engineers (bachelor students) being able not only to get new knowledge but to use them for solving practical tasks of modern construction industry and market.

The article present a concept of designing educational programme for training students with major 08.03.01 «Construction» (bachelor degree) focusing on systematized knowledge, skills and tools for training, in particular, through interconnection and continuity during course and diploma papers based on BIM technology.

Key words: quality of education, skill oriented approach, construction industry, information technology, information modelling of buildings, BIM technology

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Relevancy of training bachelor degree constructors basing on construction market demands. One of the largest fields of Russian economy is building and construction industry. It provides significant growth of production capacities and main funds of all national economy. Construction results in buildings and structures of different purpose in various fields of national economy [1].

«Construction industry can become one of the main sources of national economy growth, it is one of the most dynamic and prospective markets having a share of almost 6 % of national GDP. It has all potential for becoming key drivers of Russian economy. That is why we need to its huge and strong potential», – noted Russian president Vladimir Vladimirovich Putin at the meeting of State Council devoted to construction industry development [4].

To enforce the construction industry and national economy we need to make qualitative and quantitative changes promoting more efficient growth of household construction, implementation of large-scale infrastructure projects opening possibilities for development of industrial and economic potential of Russian Federation in general [16].

As a result, the Ministry of Construction, Housing and Utilities of Russian Federation with participation of interested federal executive authorities, national associations in the fields of engineering surveying design and construction, research and academic organizations, worked out the Strategy of innovative development of RF construction industry till 2030 [11, 16].

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The purpose of this strategy is creation of competitive construction industry building safe and comfortable environment for living and working promoting national safety and development of Russian Federation [11].

To achieve this goal and solve other urgent tasks described in the project we need to focus on training and developing the talent pool and human resources for this field.

Currently the human resources issue is very pressing and serious. Now almost every construction company faces lack of qualified workers (hourly and engineers) to any extent. Current Bologna system of higher education provides Bachelor's and Master's degree programs, which are not suitable for demands and requirements of construction industry [11, 16].

Besides this, the urgent problems in the field of construction human resources are: lack of university graduates with relevant practical training; mismatch of quality of training and employers' requirements for this type of specialists; abrupt reduction of vocation engineering and technical institutions; out-of-date training programs and academic staff lacking modern knowledge in the field of new technologies.

The level of professional education and qualification of graduate students (bachelors) are directly connected to the following factors: population of applicants and students; academic staff; content of courses; quality of educational environment and training facilities; quality of educational tools and technology; participation of a specialist in production of goods and services after graduation; quality of his socio-cultural activities in the community; and finally, quality of life of future specialist and his self-fulfillment [2].

It also known that competitiveness of a university is mainly determined by professional and educational level of its graduates and how their professional skills match the requirements of current labor market demands [3, 5-8].

Labor market sets a real value of its «goods» – alumni, which depends on his practical skills and training. The quality of usual goods is how it meets the demands of customers. The quality of professional education is a balance between education process results and training system meeting the several requirements, targets, and standards [2, 3].

As a result, we are facing the most important task of higher education, which is development and implementation of methods and tools for providing practical training of future specialists [3].

Modernization and introduction of innovations into architectural and building design. Among current issues facing construction industry is improvement of architectural and industrial complex with its existing problems influencing the quality of project documentation and its deadlines, particularly the following ones: lack of consistent approaches to organization of planning and surveying activities; insufficient training of workers; absence of reasonable price strategy for planning and surveying activity and customers lower them om purpose; imperfect legislation and design standards database partially because of lack of its unified development strategy; imperfect designing methods and tools including cases of standard designs; imperfect expertise of design documents and results of surveying; lack of good quality Russian design software, etc [11, 16].

We need to improve architecture and construction design including one of the most important and principal innovations, which has been actively used in modern design and construction – this is building information modeling technology (BIM).

«Usage of BIM technology enables finding efficient solutions at all stages of construction lifecycle – from pure idea to operation or even demolition. This is very important even for budget objects because it allow efficient use of budget funds and it is relevant to construction and operation processes in general», – noted minister of Ministry of Construction of RF Mikhail Men [15].

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Currently the Ministry of Construction, Housing and Utilities of Russian Federation started to implement the plan of staged introduction of BIM technology in civil and industrial construction, which was approved by the decree of the Ministry N 926/pr a.t. December, 29, 2014 and developed in cooperation with Federal Agency of Technical Regulating and Metrology, Expert Council of Russian Federation government and other institutions of economy modernization and innovation [15].

Implementation of this BIM technology introduction plan will enable improvement of competitiveness of Russian construction industry on a global market and quality of surveying activities, building design and construction, reduce working costs at design and expertise stages, and lower emergency risks.

BIM technology. It would be wrong to think that BIM technology is a tool for construction of 3D model, visualization of future object and creation of its project documentation. BIM is not only a three-dimension picture of an object but processes and methods of complex information processing, concerning this object, which can be used at all stages of its life cycle and building process: design, construction, operation, reconstruction and demolition. BIM model has information on intellectual objects of its components and parametric links between them. All of this helps to make management decisions at any stage and new data can be added at any moment and through the whole life cycle of this object. The information model is a database of purchasing system, calendar planning, management of other subprojects and systems of this object. The key feature of this technology is a possibility to select a level of BIM model detail at any stage of object life cycle (Fig.1) [7, 8, 12].

This technology enables optimization of construction process, which is very expensive as we all know. Using this information model of a building we can get a very accurate calculation of this project, which helps to monitor all the construction expenses.

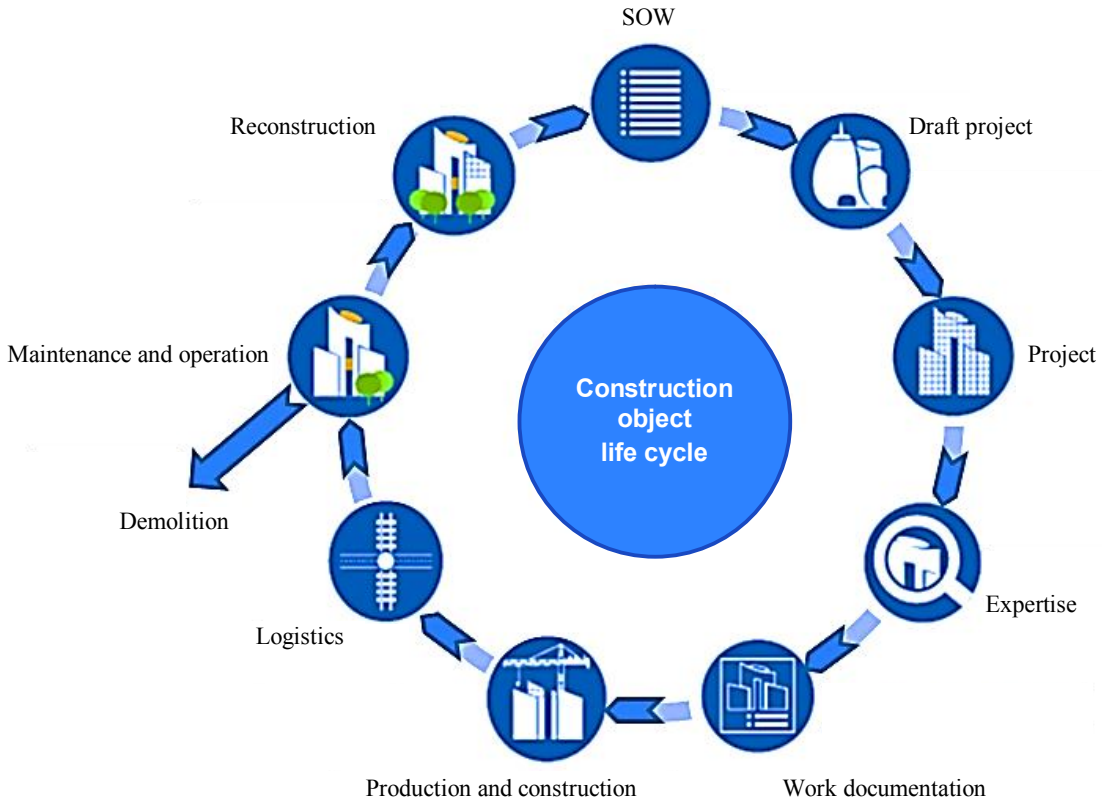


Fig.1. Construction object life cycle in BIM technology

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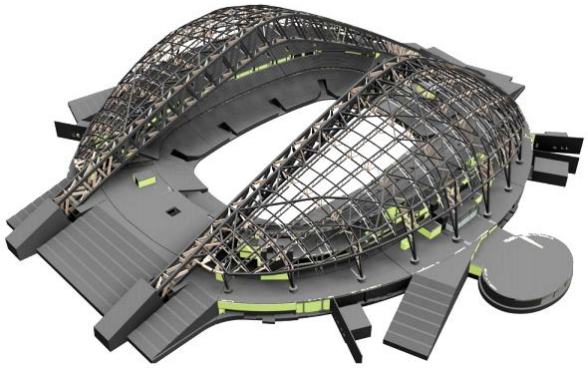


Fig.2. «FISHT» stadium model (Sochi)

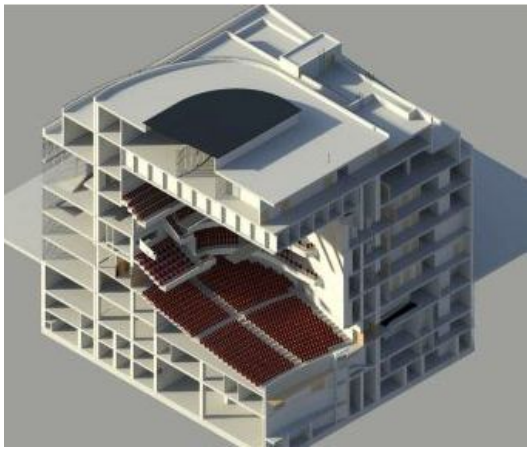


Fig.3. Model of the second stage of Mariinsky Theater (Saint-Petersbrug)

For example, if there is construction of adjacent buildings and cranes have the same working schedule, they can hit their booms. This scenario cannot be taken into account when buildings belong to different contractors. Presence of visual schedule will help to find optimal load of any machine and if it is even for all machinery. You can calculate expenses on every stage and when a building is already built and it needs maintenance, the software provides information on bearing constructions and facilities [9, 14].

Currently Russia has been using this technology for construction of Olympic objects in Sochi like «Fisht» arena (Fig.2), Bolshoy and Iceberg Ice Domes, closed Skating rink «Adler-arena», infrastructural objects of Olympic village, football stadium «FIFA-2018», high rise building of ITC «Moscow city», second stage of Mariinsky theater in Saint-Petersburg (Fig.3) and many others.

BIM technology solves the following main tasks: creation of concept model of future object; multi-variant design; TEO; placement of object into existing construction process; presentation of a project to interested parties; high-quality design according to set deadlines; creation of information model; joint work of distant subgroups – participants of development and implementation of the project; coordination of all divisions; presentation of all required working documents; absence of double data; cooperation of designers with builders; preparation of construction organization and management processes; dates – 4D calendar and network schedule of works; cost – 5D large-sized calculation of construction costs; calculation of material requirements; organization and management of construction process; construction supervision; tracking of construction dynamics; comparison of plans and acts; deviations control; quick search of any object information; accurate information; connection to facility systems [17, 18].

The main advantages of BIM technology Autodesk are immediate implementation of project planning and dimensional-design solution with a 3D-model; convenient visual assessment of suggested project solutions; possibility to examine several variants and select the most optimal one basing on project data and estimated construction costs; acceleration of design process due to usage of pre-project data at the next stages without any data loss; project errors correction because of assembly of the object in one shared space; absence of project data loss during communication between departments and platforms; reduction of time needed for consideration of bottle neck issues and decision making; search of project errors and their correction before construction; issuing of up-to-date project documentation; data exchange between subcontractors; optimization of service roads for construction machinery; overlapping of calendar schedules from planning modules and model; search and solution of space and time collisions; access to object info enabling fast decision making for all project participants (designers, managers,

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constructors, subcontractors; tracking of equipment commissioning; provision of safety measures implementation; reduction of errors and time of construction process; increase of speed and quality of maintenance [9, 14, 17, 18].

The most advanced Russian companies start using BIM technology and see its advantages. Those who didn't switch to this technology have realized the inevitable changes in the architecture and design field and try to find optimal solution for introducing information modelling [7, 8, 12]. That is why the problem of training the highly-qualified staff working with BIM technology is of great importance.

A concept of BIM technology introduction into academic process. Since 2012 Saint-Petersburg Mining University has been training bachelor degree students in the field 08.03.01 «Construction» and this year we had first graduates. The key department of Constructing Mining Enterprises and Underground Structures has to solve many tasks related to bachelor degree students training who are in great demand in construction industry.

One of the possible methodological solutions for training Bachelors in major 08.03.01 «Construction» is development of basic academic programme (BAP) not only according to federal educational standard but to requirements of construction market to future construction specialists and engineers. In the authors' opinion, we need to introduce interdisciplinary integration of course and diploma papers with BIM technology.

Among the most important requirements to bachelor students training of construction major we can single out the following ones: interdisciplinary knowledge and ability to use them to justify design solutions; ability to think consistently and independently; to find out and solve production tasks using skills acquired during academic training; drive for results in professional sphere [10].

BAP has to be developed in such a way that a student will get knowledge and skills in the order, which matches the life cycle of construction object and has the following nominal stages: pre-project (pre-design, feasibility study), project (rough design, engineering design), working design and documentation, construction, management and operation, repair or/and reconstruction (see fig.1).

When getting knowledge of fundamental (mathematics, physics, chemistry), basic engineering (engineering graphics, theoretical and construction mechanics, material resistance, geodesy) and professional (special) courses (basics of architecture and building structures, architecture of civil and industrial buildings and structures, foundations and basements, ferroconcrete frames and stone structures, metallic structures, plastic and wooden structures, etc.), doing course papers applying basic skills of construction information modelling software in such courses as «Computer graphics in design», «Information technology in construction» students are involved in professional design activities (Fig.4).

Working on concept model of civicl or industrial building using Autodesk Revit Architecture package, a student can later continue his course paper project in this software and use it to develop architecture-constriction drawings.

Study of key construction structures provides general theoretical knowledge that can be used in course papers for working with modellling, documentation and installation process software and master calculation packages like Autodesk Robot Structural Analysis Professional and SOFiSTiK, enabling design and construction on a modern level and promoting finding optimal construction solutions.

Autodesk Revit MEP used for desiging of engineering networks can be mastered durign such courses as «Engineering equipment of heating and air conditioning systems», «Sanitary installation », «Design and operation of internal water supply and drainage systems».

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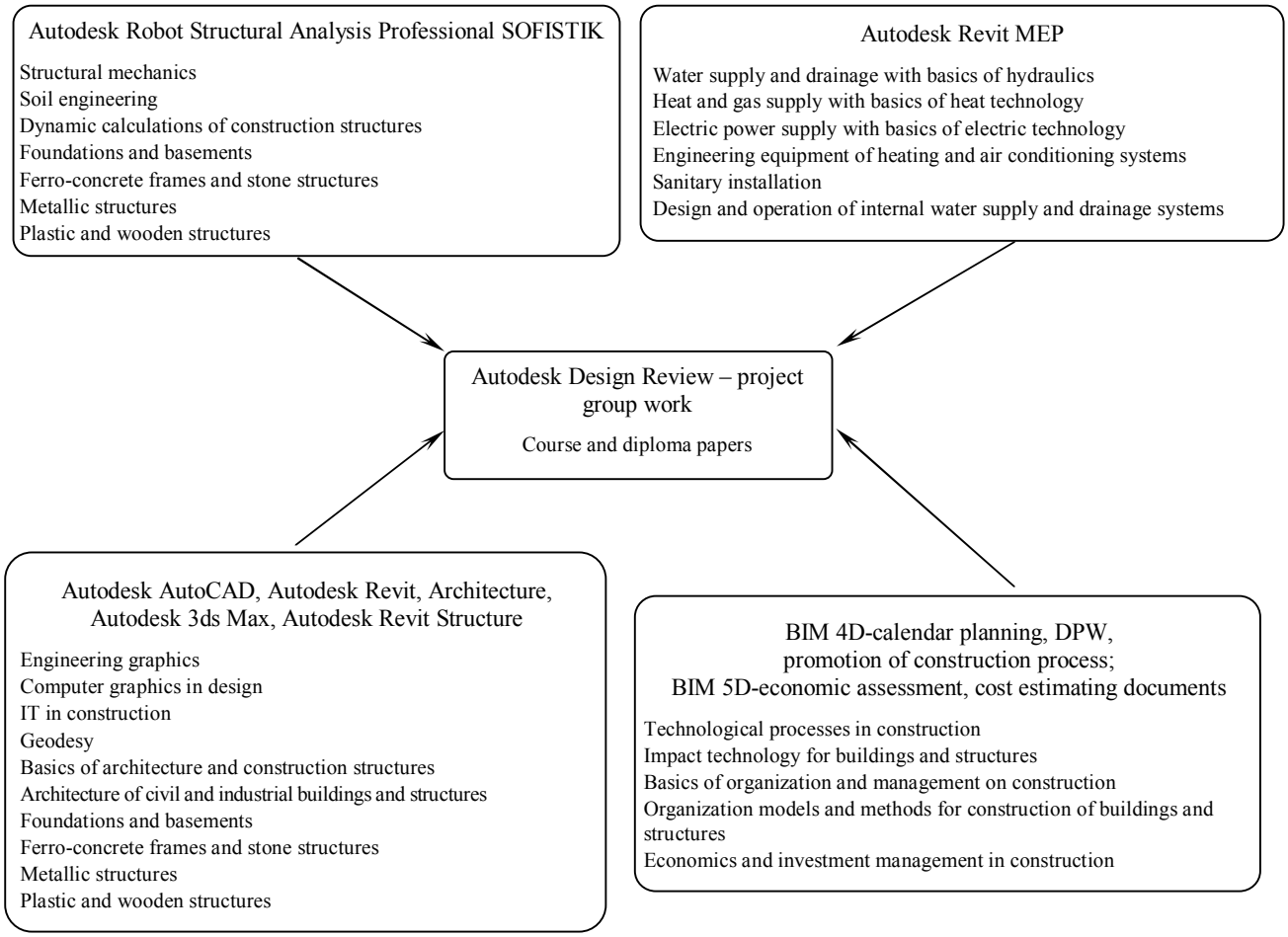


Fig.4. A concept of BIM technology introduction into academic process

When working on interdisciplinary course paper including dimensional and planning tasks in BIM technology software a student can get deep and reinforce theoretical knowledge in general professional courses but will have motivation to get professional skills in working with modern software and have better understanding of multi-staged design and interconnection of all intellectual and technical elements of a building (structures and materials, networks, machinery and mechanisms, etc), and will have teamworking skills. This approach can be applied to diploma papers as well.

The experience of introducing BIM technology in Saint-Petersburg Mining University. In Saint-Petersburg Mining University within the framework of courses «Engineering graphics», «Computer graphics in design» students of major 08.03.01 «Construction» (specialization in «Industrial and civil construction»), gain basic knowledge and skills in Autodesk AutoCAD for doing two-dimension architecture-building drawings according to existing standards.

Further in the course of «Architecture of civil and industrial buildings and structures» and «IT in construction» students get a chance to improve their skills in Autodesk Revit Architecture, using its functionality to the maximum level and designing a structure from a concept till working documents for architecture-building part of the project. Auto design systems of BIM technology enables visualizing any elements and systems of a building in 3D format, calculating different types of their arrangement, aligning them with existing standards, analyzing operational characteristics of future building simplifying the selection of optimal variant (Fig.5-7).

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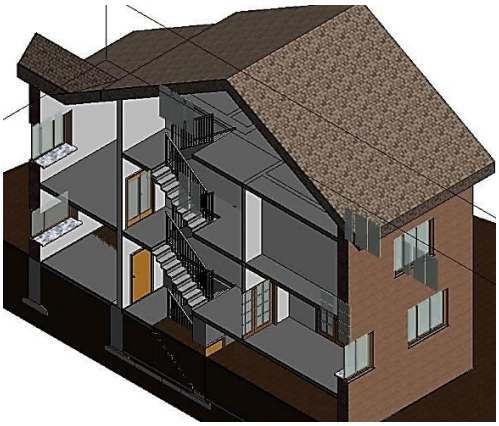


Fig.5. Creation of building model



Fig.6. Visualization of an object

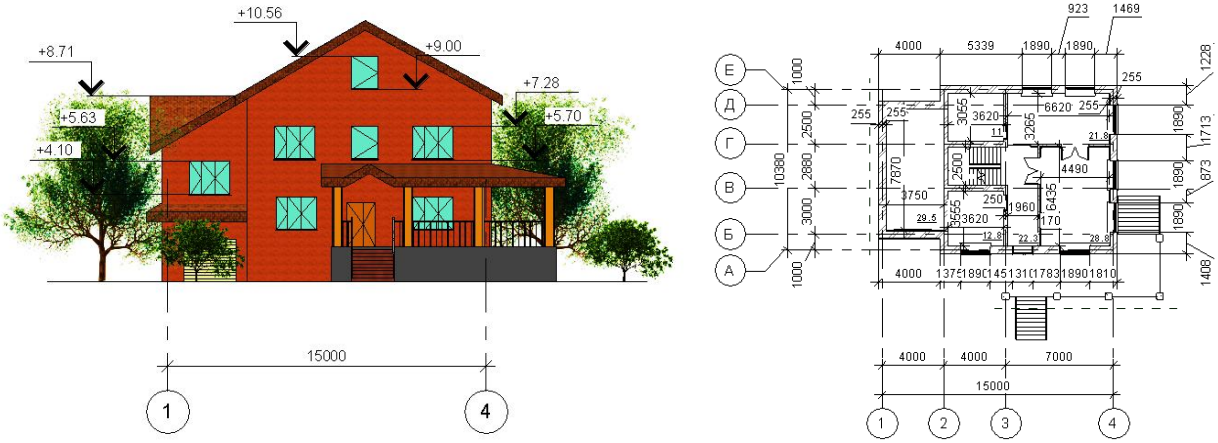


Fig.7. Creation of working documentation

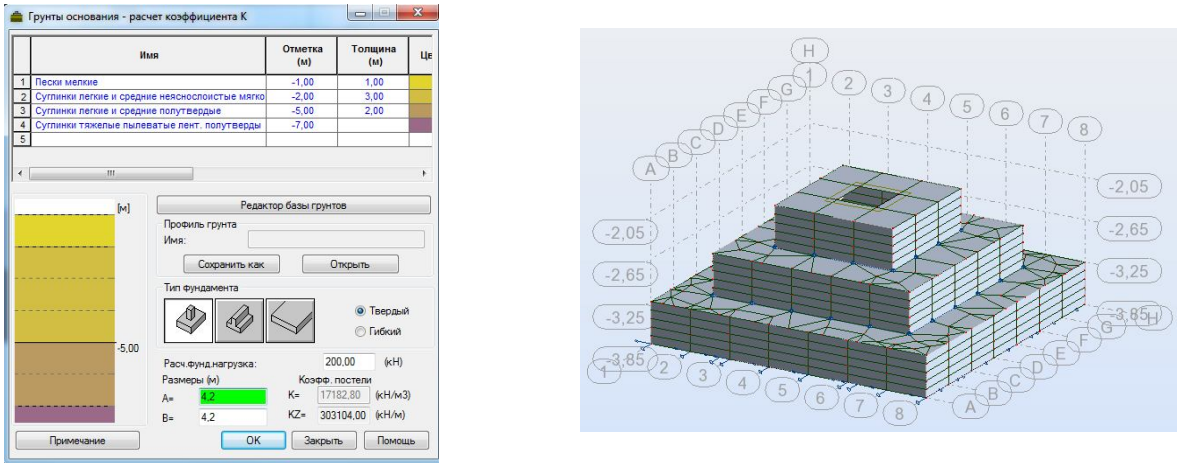


Fig.8. Design and construction of foundation

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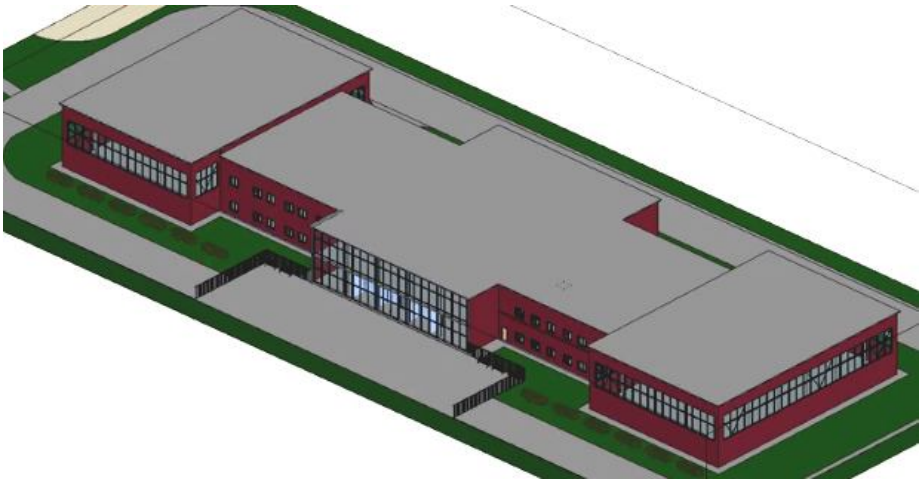


Fig.9. Model of children sport school reconstruction (Pushkin) – Diploma paper of K.S.Papushina

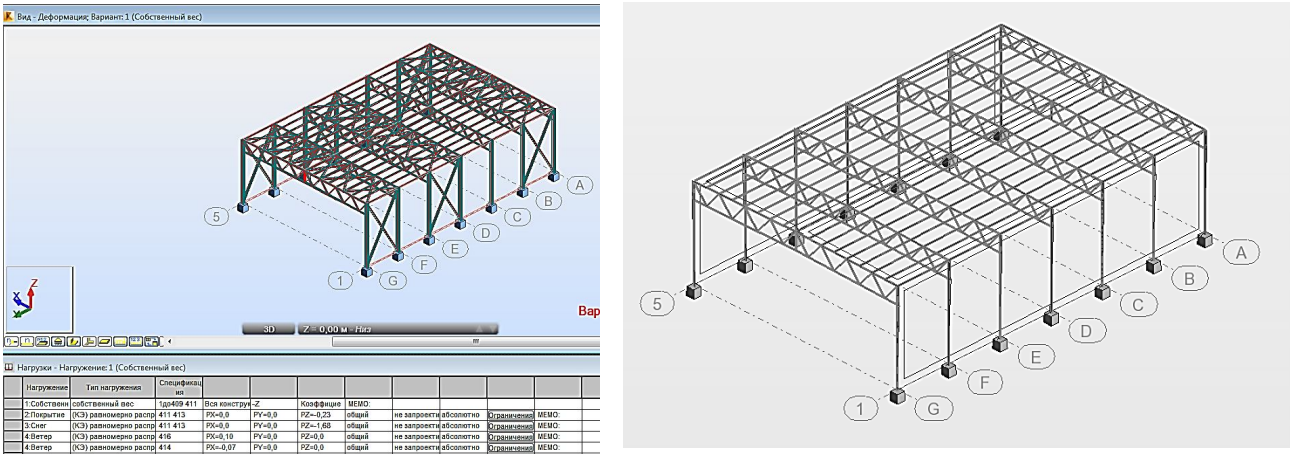


Fig.10. Creation of analytical model of metal frame of added sport halls
and results of «dangerous bars» parameters optiization (Autodesk Robot Professional) –
Diploma paper of K.S.Papushina

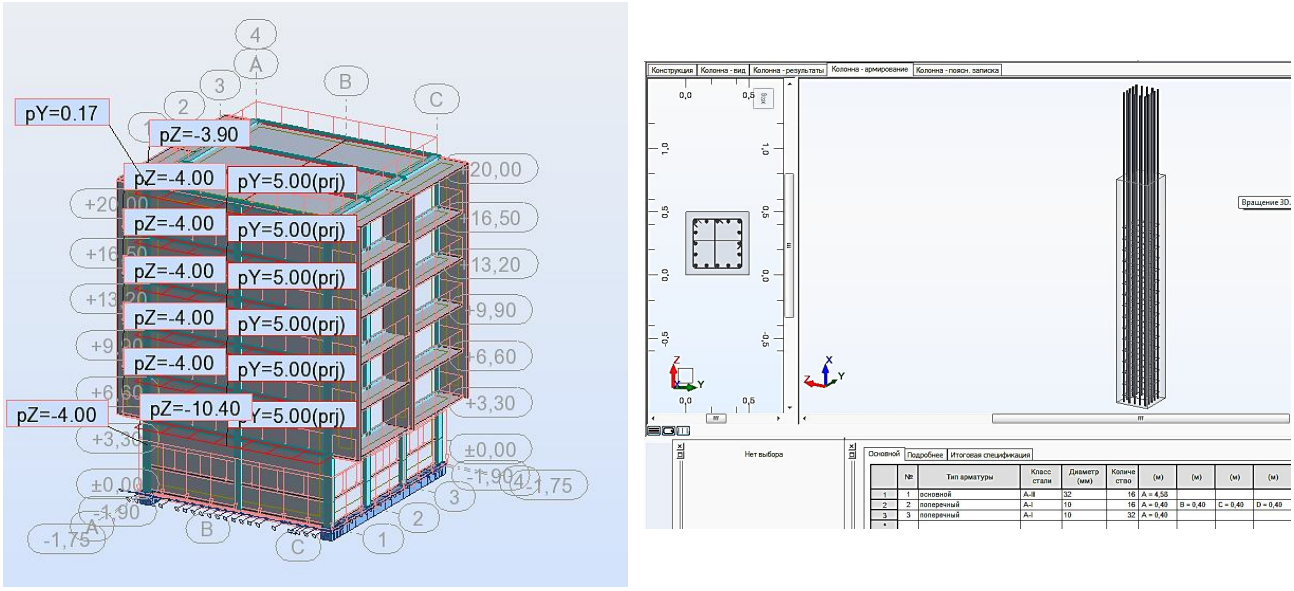


Fig.11. Analytical model of multi-sotrey apartment building (Gelendzhik) and suggestion for armoring of monolith ferro-concrete column on the basis of this model (Autodesk Robot Professional) – Diploma paper of A.S.Maiderosova

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Since Autodesk Revit enables working with an object at all stages of its life cycle, when studying the following special professional courses such as «Ferro-concrete and stone structures», «Metallic structures», «Sanitary equipment» and etc., we can recommend to use the packages like Autodesk Revit Structure, Autodesk Revit MEP, Autodesk Robot Structural Analysis Professional and SOFiSTiK, which are avaliable at the graduate deparment.

In 2016 the graduates of major 08.03.01 «Construction» presented the State Attestation Commission members their good skills in BIM technology usage for solving the goals of their diploma papers. The final papers involved all stages from concept of a construction object to design of structures using Autodesk Revit Architecture и Autodesk Robot Structural Analysis Professional (Fig.8-11).

Conclusions

1. To create competitive construction industry forming safe and comfortable living and working environment promoting national safety and spatial development of Russian Federation we need to solve an urgent task of professional staff training and development.

2. To provide construction industry of Russian Federation with highly demanded well-qualified engineers we need to modernize the content and tools of higher education, which should be oriented at integration of courses and provision of results at any stage of educational process, particularly when training bachelor students of major 08.03.01 «Construction» we suggest to introduce practically oriented inter-connected course and diploma papers using BIM technology.

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