MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

O. M. BEKETOV NATIONAL UNIVERSITY
of URBAN ECONOMY in KHARKIV

Methodological recommendations
for independent and practical work
on an academic discipline

«INNOVATIVE STRUCTURES, MATERIALS AND ENGINEERING SYSTEMS»

(for students second (master's) level of higher education all forms of education
speciality 191 – Architecture and town planning,
of educational program "Architecture of buildings and structures")

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O. M. Beketov NUUE
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CONTENT

INTRODUCTION

Discipline «Innovative designs, materials and engineering systems» is an academic discipline of the normative block in the preparation of masters in the specialty 191 – Architecture and town planning, of educational program "Architecture of buildings and structures".

Intended for full-time students, the methodological recommendations are compiled on the basis of and in accordance with the approved O. M. Beketov NUUE by the working program of the academic discipline "Innovative structures, materials and engineering systems".

Teaching the course "Innovative structures, materials and engineering systems" at the final stage of the study of masters of architecture is aimed at preparing for comprehensive diploma design, familiarization with the latest achievements, replenishment and expansion of knowledge obtained in previous years of study on structures, materials, engineering equipment and technologies for the construction of modern buildings.

Master's degree in architecture training has aimed at training specialists of a wide profile who are able to solve urban planning and spatial planning problems of building design with deepening knowledge in the field of building structure design. Therefore, the purpose of studying the course is to constantly deepen knowledge of progressive structures of residential and public buildings using new materials, energy-efficient solutions and technologies, as well as modern building equipment for the use of this knowledge in architectural design.

A feature of teaching of this course is the independent performance of practical and theoretical tasks, where students solve various problems on the choice of the structural scheme of buildings, technologies and materials, energy-efficient solutions and on this basis, practical work is performed, which in turn lays the theoretical and practical basis for the preparation of the master's thesis. Therefore, when performing practical work in the discipline "Innovative structures, materials and engineering

systems", a method of complex design is laid, which involves the implementation of the knowledge and skills that the applicant has mastered in previous years.

As a result of completing the course, applicants should develop skills in "constructive thinking" and methods of independent building design, taking into account knowledge of new building materials and structures, energy-efficient solutions and technologies. Special attention is paid to the development of students' creative initiative and increasing the role of their independent work. Thus, studying the discipline "Innovative structures, materials and engineering systems" unites and systematizes the student's theoretical knowledge, develops skills for independent creative work.

The most important requirement for the training of highly qualified specialists at the present stage is the development of the ability and skills of applicants to independently acquire knowledge and skills necessary to solve the issues of using innovative materials and structures when creating architectural accounting of modern buildings and structures, as well as to implement innovative systems in architectural projects when operating modern buildings and structures. Therefore, the working curriculum of the course provides not only for the transfer of certain scientific information by the teacher, but also for the organization of independent cognitive activity of applicants by working with literature and regulatory documentation.

Applicants should organize their work in the indicated areas in accordance with the recommendations below, using methodological publications, educational, regulatory and reference sources indicated in the list.

Regulatory documents, textbooks, study guides, reference literature and methodological recommendations necessary for independent study of the theoretical part of the course and acquisition of the necessary practical skills are contained on the distance education website of the O. M. Beketov NUUE at the URL:https://dl.kname.edu.ua.

1 STUDYING THE THEORETICAL PART OF THE COURSE

It is recommended to study the theoretical part of the course using normative and educational literature [1−9]. The list of program questions below contains a brief summary of each question and detailed references to literary sources available to students in paper or electronic form.

When studying program questions from the specified sources, it is advisable to make a brief summary according to the given question annotation. This will help to systematize knowledge on each question and speed up preparation for the exam. Answers to questions should be accompanied by explanations, which should be found in the recommended textbooks [1; 2; 5−8] and in design standards [3; 4].

2 LIST OF PROGRAM ISSUES AND RECOMMENDATIONS REGARDING THEIR STUDY

Table 2.1 – Programmatic issues

Content of program questions	Literature
1	2
1 The essence of innovation The essence of innovations in the architectural and construction industry of Ukraine. Innovative approach in the architectural and construction industry of the world. Justification of the introduction of new materials, structures and engineering systems in buildings	[1; 2; 5]
Topic 2 New materials in architecture Innovative waterproofing and thermal insulation materials with dual properties. Special facing and finishing materials based on hydro-gypsum cement, gypsum-sulfur and gypsum-polymer compositions. Bioconcrete for vertical landscaping of facades. High-strength low-emission energy-saving glasses for the architectural and construction industry	[5; 7]
Topic 3 Environmentally positive construction Types of energy-efficient buildings. Energy efficiency. "Green" roofs as an important element of energy efficiency. Environmental efficiency of photocatalytic concrete Smart-coating. Smoke protection systems	[6; 7]

Continuation of table 2.1

1	2
Topic 4 The latest designs for the conversion, modification and renovation of old housing stock A modern view of housing quality. The condition of building structuresold housing stock. The latest designs used for transformation, modification and restoration. Feasibility study of implemented design solutions	[1; 2; 6; 7]
Topic 5 Innovative building structures of the modern structural system "Monofant" Energy approach in design building structures of the modern constructive system "Monofant". Structural features of building structures of the modern constructive system "Monofant" Production technologies for building structures of the modern "Monofant" structural system. Foreign experience in implementing similar design solutions	[5; 7]
Topic 6 Introduction of BIM technology into the architectural and construction industry of Ukraine A new approach to digital information management used in construction and urban planning. Parameterization of architectural solutions in the BIM design environment. Main global approaches to implementing the SMART CITY concept. Prospects for involving the latest information systems in architectural design	[2; 5; 7]
Topic 7 Structural engineering systems of unique buildings in the world Leaning Tower Capital Gate in Abu Dhabi, UAE. Taipei 101 skyscraper in the capital Taipei. Burj Khalifa building, Dubai, UAE	[2; 5]

3 QUESTIONS FOR SELF-CHECK

1. Characteristics of the five stages of development of high-rise buildings with the definition of changes in: structural systems; engineering solutions; spatial planning solutions, height; energy efficiency characteristics.
2. Features of the impact and perception of vertical and horizontal loads in high-rise buildings.
3. Impact of wind loads on high-rise buildings. Means of increasing resistance to wind loads in high-rise buildings (structures, spatial planning solutions, natural analogues), examples of constructive solutions in high-rise buildings.

4. Impact of seismic loads on high-rise buildings. Means of increasing resistance to seismic loads in high-rise buildings (structures, spatial planning solutions, natural analogues), examples of structural solutions in high-rise buildings.

5. Requirements and fire protection system in high-rise buildings.

6. Means of taking into account macroclimatic influences and loads in high-rise buildings (structures, spatial planning solutions, analogues of natural and traditional architecture). Examples of structural and engineering-technological solutions in high-rise buildings.

7. Means of taking into account meso and microclimatic influences and loads in high-rise buildings (structures, spatial planning solutions, analogues of natural and traditional architecture). Examples of engineering, technological and constructive solutions in high-rise buildings.

8. Wind energy-enabled high-rise buildings, characteristics, classification, definition, advantages and disadvantages, design solutions. Examples from the world experience of high-rise construction.

9. Solar energy integration in high-rise buildings: characteristics, classification, definition, advantages and disadvantages, constructive solutions. Examples from the world experience of high-rise construction.

10. Application of others alternative energy systems, environmental friendliness in high-rise buildings: characteristics, classification, definition, advantages and disadvantages, constructive solutions. Examples from the world experience of high-rise construction.

11. Provide a definition of the concept of a structural system. Provide a classification and diagrams of the main and combined structural systems of high-rise buildings.

12. Scope of application of various structural systems and their combinations in high-rise buildings, advantages and disadvantages. Examples from world construction experience.

13. Wall structural system (structural diagrams) in high-rise construction. Advantages and disadvantages. Classification and requirements. Examples from the

world experience of high-rise construction.

14. Provide a definition of a frame structural system. The main structural elements (horizontal and vertical) of a frame system. Features and classification of frame systems in high-rise construction.

15. Frame, provide definition, advantages and disadvantages, classification. Various solutions of frames in high-rise buildings, features of frame load perception. Examples from world experience of high-rise construction using frame frames.

16. Connected frame, provide definition, advantages and disadvantages, classification. Various solutions for the application of connections and stiffness diaphragms in high-rise buildings, types and locations, features of load perception. Examples from world experience of high-rise construction using a connected frame.

17. Characteristics of frames with inclined columns (possible options, principles of operation, features of load perception). Examples of solutions in high-rise buildings.

18. Horizontal rigid lattice belts and grillages – definition and functional purpose, types and location in high-rise buildings. Structural solutions.

19. Provide a definition of a structural system with a rigid core. Main structural elements (horizontal and vertical) of a rigid core system, characteristics of the system's operation, classification.

20. “Clean” systems with a stiffening core, design options, advantages and disadvantages. Examples of solutions in high-rise construction.

21. Truss-suspended structural system, design options, advantages and disadvantages. Examples of solutions in high-rise construction.

22. “Combined” systems with a stiffening core, design options, advantages and disadvantages. Examples of solutions in high-rise construction.

23. “Bridge” systems with a stiffening core, design options, advantages and disadvantages.

24. Provide a definition of a shell structural system. Main structural elements (horizontal and vertical) of the system, performance characteristics (advantages and disadvantages), classification. Examples of solutions in high-rise construction.

25. Characteristics of the main structural elements of high-rise buildings Provide definitions of horizontal and vertical load-bearing structures. Explain the principles of load perception and distribution in a high-rise building.

26. Provide a definition, classification and characteristics of floors of high-rise buildings. Provide examples of constructive solutions.

27. Provide a definition, classification, and characterization walls of high-rise buildings. Give examples of constructive solutions.

28. Provide a definition, classification and characteristics of facade systems of high-rise buildings. Provide examples of constructive solutions.

29. Provide a definition, classification and characteristics of the foundations of high-rise buildings. Give examples of design solutions. Factors of influence when choosing and calculating the foundations of high-rise buildings. “Wall in the soil” - functional purpose and design solutions.

4 RECOMMENDATIONS FOR PRACTICAL CLASSES

4.1 Purpose and practical work tasks

Tasks for practical work is:

– show a high level of special training of the applicant, his/her ability and skill to apply theoretical and practical skills in solving specific problems project tasks;

– analysis of scientific and methodological literature on a given topic with generalizations, comparisons and conclusions, while candidate must demonstrate the ability to formulate and prove their position.

So, during practical classes, the applicant acquires a complex of functional, ergonomic, and constructive knowledge.

During practical classes, applicants perform three practical tasks.

4.2 Practical work number 1

Practical work "Development of a structural system for a high-rise building according to a given architectural and planning solution" are performed by applicants as part of the study of the first module on the basis of theoretical knowledge obtained from lectures. The range of topics for practical work is of a conceptual design nature. Particular attention should be paid when performing the work to the areas of solving ecological, ergonomic, functional and energy-efficient design solutions using modern structures, materials and technologies.

Composition of the work:

1. Clause "Variant design". Develop three options for different structural solutions for high-rise buildings, based on the given scheme of the planning solution, the building height is 60 floors. Each option in the closure must be presented at least in a section and plan, with an indication of dimensions, heights, and cut line marks.

2. Development of the final version of the structural solution of a high-rise building according to a given planning scheme.

It is necessary to develop: facades (quantity as needed); plans (show plans, where there is a change in configuration, dimensions, constructive solution); sections (longitudinal, transverse); volumetric solution of the building (axonometry, perspective or other); constructive units and details with reference to the main drawings; energy efficiency and environmental friendliness solutions. Graphic design should reflect the constructive idea, the concept of energy efficiency, etc. All drawings are made with scale markings. When designing the graphic part, it is important to ensure the requirements for the design of drawings and images: put the required number of dimensions on projections and images; mark coordinate axes; sign all images; mark scale; make footnotes indicating the composition of constructive elements, etc. Images must be clear, with legible inscriptions and signatures. Graphic presentation can be arbitrary, using color, different presentation of material (computer, manual graphics or a combination thereof).

4.3 Practical work number 2

Practical work "Analysis of the implementation of modern design solutions in high-rise construction using the example of modern design and construction experience" are performed by applicants as part of studying the second module based on the theoretical knowledge obtained from lecture classes.

Composition of practical work:

1. Name of the architectural structure.
2. Functional purpose of the building.
3. General characteristics of the architectural– planning decision.
4. Basic initial data: height, number of floors, dimensions in axes.
5. Location of the building: country, settlement, characteristics of the surrounding development, climatic conditions (temperature, wind regime, seismic activity and other).
6. Structural system of the building.
7. The general concept of ensuring the requirements of rigidity, strength, durability, and fire safety of the building.
8. Characteristics of the main structural load-bearing elements of the building: vertical (walls, columns, stiffeners, stiffener cores, shells) and horizontal (floors, coatings), solutions foundations.
9. Features of the design solution of external enclosing structures (translucent facade structures, double facade systems, etc.).
10. Energy efficiency, use of alternative sources energy in the building, environmental friendliness, etc.
11. Construction technology, stages, construction features.
12. Conclusions, list of information sources.

Graphic material must be designed in accordance with from the requirements for the design of drawings, with dimension lines, height marks, composition of floors, coatings, etc. It is mandatory to have plans, sections, facades, structural details and assemblies.

4.4 Practical work number 3

As part of studying the third content module, applicants, based on the theoretical knowledge obtained from lectures, perform practical work, the topic of which is chosen by the applicant independently or on the recommendation of the teacher in accordance with the course topic, taking into account the topic of the thesis.

The purpose of the work is the formation of skills in creating a design solution for a building as a synthesis of spatial and volumetric elements that have functional significance in the system of load-bearing and enclosing structures, building elements. At the same time, it is important for the applicant to master the skill of designing a completed, functional building object, which involves understanding the accepted norms and rules of design, modern constructive and engineering solutions, characteristics and capabilities of the building materials used, taking into account the natural and climatic conditions of the environment.

Practical work consists of an explanatory note (theoretical study) executed on standard A4 sheets, with a volume of 7 to 10 pages, and a graphic part executed on A3 sheets, combined into an album.

Composition of practical work:

1. Theoretical study of analogues, research from the topic. Theoretical analysis should be performed independently. There may be an option to “update” or supplement primary sources. Theoretical research should end with analytically substantiated conclusions, proposals from the research conducted, which will serve as the basis for further project development. It is mandatory to create list of sources of information and refer to it in the text and figures.

2. Development of a solution option for the project proposal, based on the selection of the best option. The project proposal must be presented both graphically and analytically and be formed taking into account the conclusions of theoretical research, with reference to the area and taking into account natural and climatic conditions.

The graphic material should reveal the chosen topic of the practical work. When designing the graphic part, it is important is to ensure the requirements for the design of drawings and images: to put the required number of dimensions on projections and images; to mark coordinate axes; to sign all images; to execute drawings to scale; to make footnotes indicating the composition of structural elements, etc. Images must be clear, with legible inscriptions and signatures.

REFERENCES

1. Білявський Г. О. Основи екології: теорія та практикум : навч. посіб. / Г. О. Білявський/ – Київ : Лібра, 2002. – 352 с.

2. Вотінов М. А. Інноваційні прийоми формування інтерактивних будівель і споруд у міському середовищі : монографія / М. А. Вотінов, О. В. Смірнова ; Харків. нац. ун-т міськ. госп-ва ім. О. М. Бекетова. – Харків : ХНУМГ ім. О. М. Бекетова, 2019. – 112 с.

3. Гетун Г. В. Багатоповерхові каркасно-монолітні житлові будинки : навч. посіб. / Г. В. Гетун, Б. Г. Криштоп. – Київ : Кондор, 2005 – 232 с.

4. Ковальський Л. М. Архітектурне проєктування висотних будинків : навч. посіб. / Л. М. Ковальський, Г. В. Кузьміна, Г. Л. Ковальська. − Київ : КНУБА, 2010. – 123 с.

5. Криштоп Б. Г. Конструкції великопрогонових покриттів для зальних приміщень громадських будівель : навч. посіб. / Б. Г. Криштоп. – Київ : КНУБА, 2008. – 106 с.

6. Світлопрозорі огородження будинків : навч.посіб. для студ. вищ. навч. закл. / [О. Л. Підгорний, І. М. Щепетова, О. В. Сергейчук та ін.] ; за заг. ред. О. Л. Підгорного ; Київ. нац. ун-т буд-ва і архіт. – Київ : Вид. Домашевська О. А., 2005. – 281 с.

7. Цифровий репозиторій Харківського національного університету міського господарства імені О. М. Бекетова [Електрон. ресурс] : сайт. − Електрон. дані, − Оновлюється постійно, − Режим доступу: https://eprints.kname.edu.ua, вільний (дата звернення: 25.05.2024). – Назва з екрана.

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