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INTELECTUAL OUTPUTS AND RESEART RESULTS

SMART (INTELLIGENT) MATERIALS USED IN ARCHITECTURE

Yuriy Fedkovych Chernivtsi National University, Ukraine

Prof. Igor Fodchuk, Prof. Mariana Borcha

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YURIY FEDKOVYCH CHERNIVTSI NATIONAL UNIVERSITY

The University was founded on 1875 by decree of Austro-Hungarian emperor Franz Joseph

The main building of the University – the previous Residence of the Orthodox Metropolitans of Bukovyna and Dalmatia – designed by the prominent Czech architect Josef Hlavka.

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AMAZE team
from YURIY FEDKOVYCH CHERNIVTSI NATIONAL UNIVERSITY

Prof. IHOR FODCHUK

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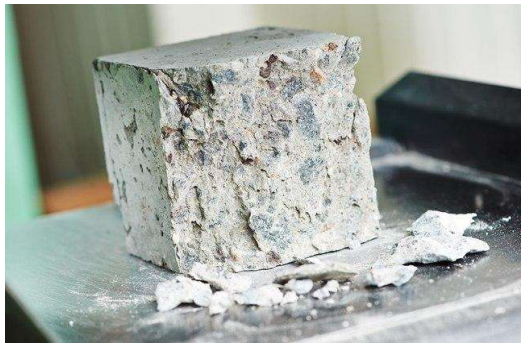
Project objectives
IO1 - AMAZE e-book for developing of complex design industrial
IO2 - AMAZE e-toolkit manual for digital learning in producing complex design industrial parts

module course 2 – Smart (Intelligent) Materials

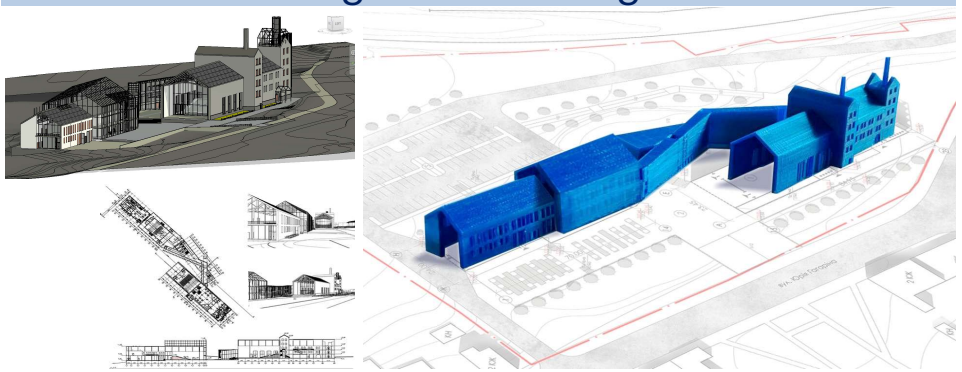
«Ultra-high strength composites»



Principles of structural strength and density, modified composites with a complex of finely dispersed additives of microsilica and metakaolin

module course 3 – CAD/CAM/CAE design

Drawings in the Revit software package using BIM technologies



Our team developed a project for the reconstruction of a brewery in Chernivtsi using Revit software and printed it on a 3D printer.

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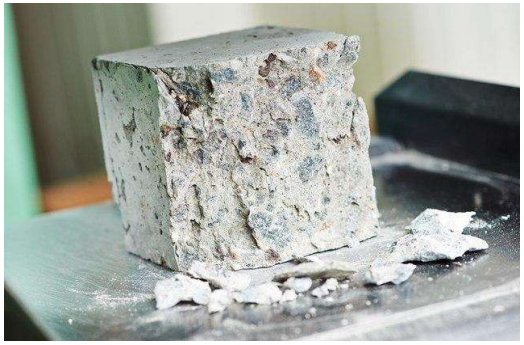
module course 2
Smart (Intelligent) Materials

«Ultra-high strength composites»



Principles of structural strength and density, modified composites with a complex of finely dispersed additives of microsilica and metakaolin

Module course 2
in IO1 - AMAZE e-book
for developing of complex design industrial:

New materials and properties
used in architectural design
«Ultra-high strength composites»

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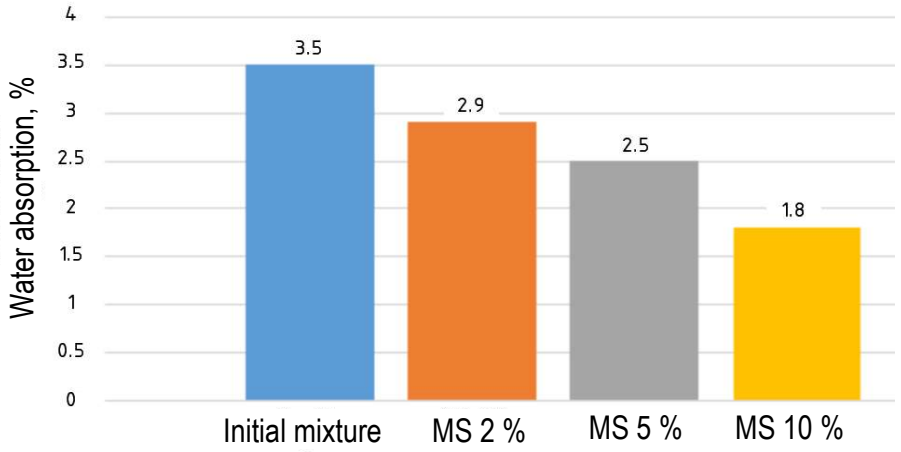
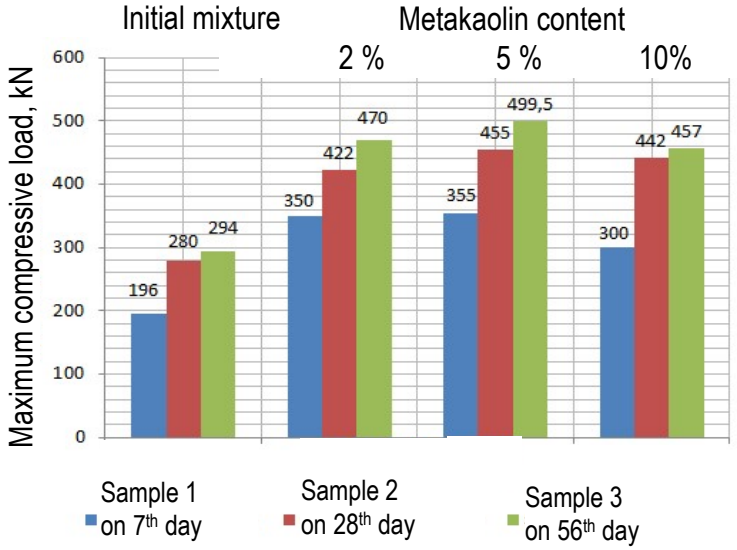
Results of strength testing of concrete mixtures





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Research methods:

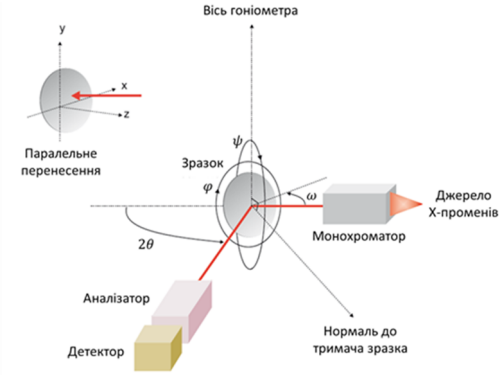
1.Scanning electron microscopy (SEM)

2. Energy dispersive X-ray spectroscopy, Hitach SU-70

3. High-resolution X-ray diffractometry

Zeiss EVO-50 scanning electron microscope with CCD detector

X'Pert PRO MRD diffractometer in a multicrystal diffraction scheme for CuKα1 radiation.



4. Determination of water resistance by the wet spot method in accordance with EN 12390-8

7

5. Determination of compressive strength on a hydraulic press in accordance with EN 12390-4

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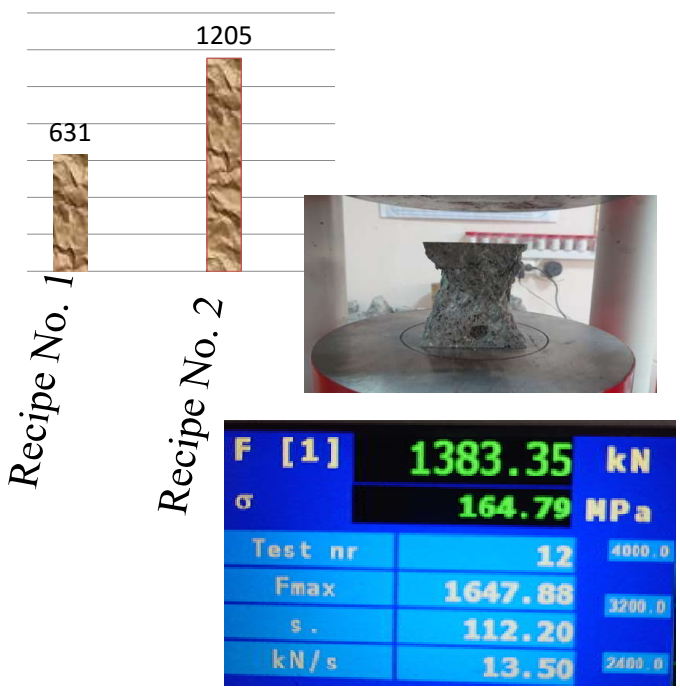
Development of cement composite formulation

	Recipe No. 1 kg/m3	Recipe No. 2 kg/m3
Cement PC-I 500 (EN 197-1:2011)	600	600
Quartz powder 50 microns.	-	30
Quartz sand, fraction 0.4-0.63 mm	584	520
Crushed stone diorite fraction 2/5 mm	315	315
Crushed stone diorite fraction 5/10 mm	315	315
Crushed stone diorite fraction 10/20 mm	660	660
Microsilica 0.1-0.3 microns.	-	60
Metakaolin 1-40 microns	-	30
Distilled water	160	**160**
Fiber	1%	1%
Plasticizer	5%	5%

Compressive strength in kN



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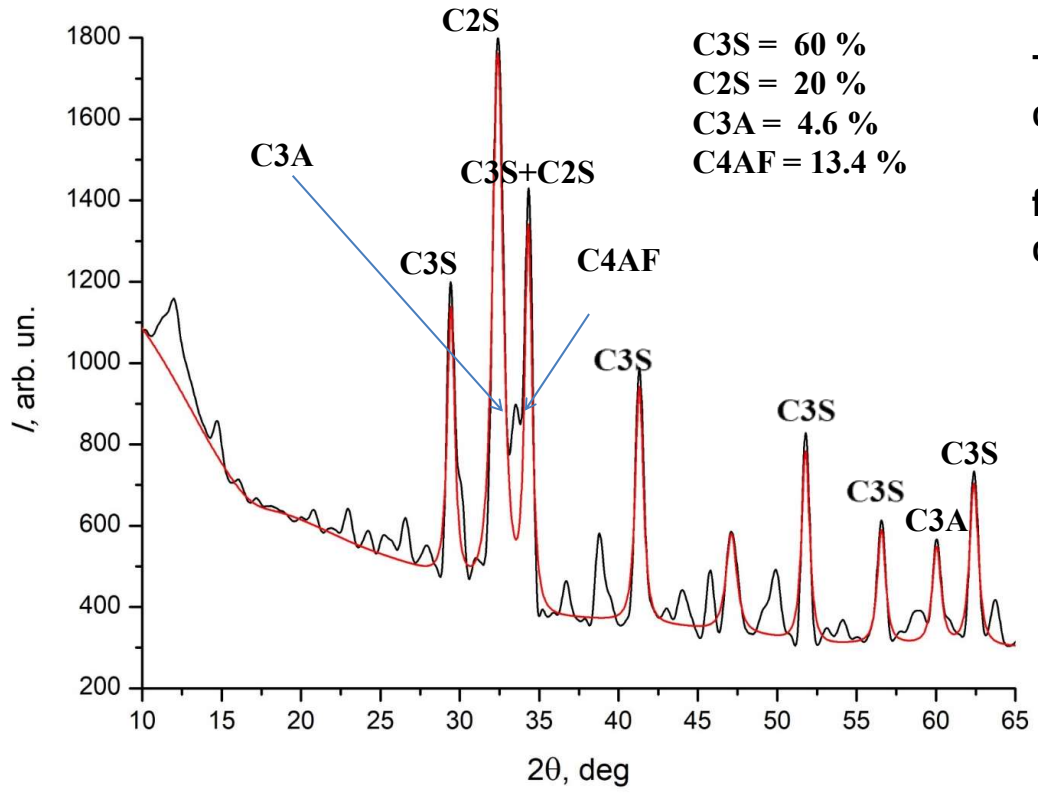

The phase composition of cement containing various clinker minerals

from analysis of experimental X-ray diffractograms (by the Rietveld method)

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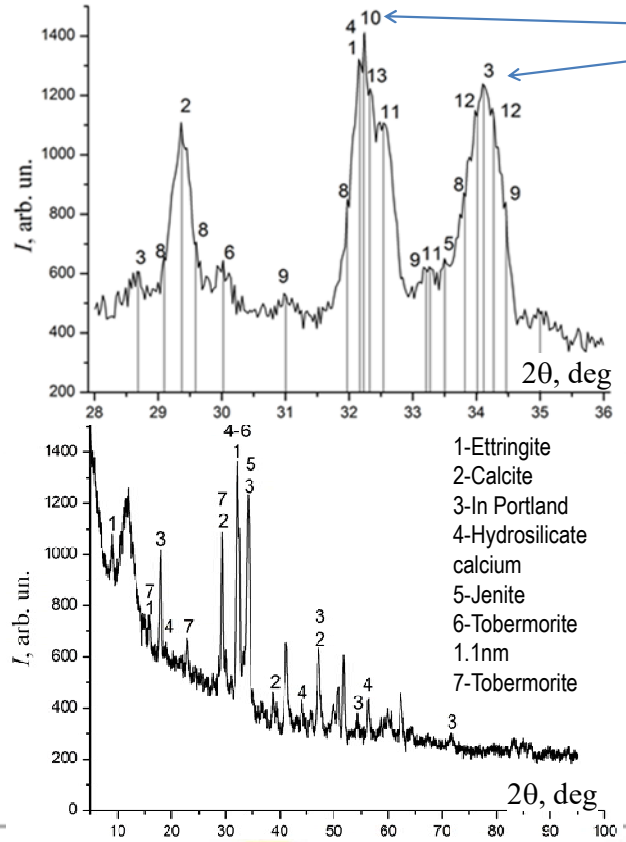

Peaks of intensity of of CHS, HAlC compounds

№	Chemical formula	*d*/*n*	Name of the compound
1	$Al_2Ca_6H_{66}O_{49.68}S_3$	0.974, 0.563, 0.388,	Ettringitis
2	$CaCO_3$	0.278, 0.303, 0.191	Calcite
3	$Ca(OH)_2$	0.491, 0.262, 0.192	Portlandite
4	$Ca_3H_2O_{7.5}Si_{1.5}$	0.278, 0.335, 0.181	Hydrosilicate calcium
5	$Ca_9H_{22}O_{32}Si_6$	1.049, 0.262, 0.278	Janite
6	$Ca_2H_3O_{11}Si_3$	0.308, 0.297, 0.351	Tobermoryt 1.1-nm
7	$Ca_{2.5}H_{11}O_{12.5}Si_3$	0.552, 0.310, 0.301	Tobermorite 1.4 nm
8	$Ca_5H_{10}O_{22}Si_6$	0.307, 0.301, 0.279	Wedge tobermorite
9	$Ca_2H_2O_5Si$	0.287, 0.269, 0.260	HSC
10	$Ca_5H_2O_{10}Si_2$	0.303, 0.277, 0.256	GSK
11	$Al_2CaH_{10}O_{21}Si_6$	0.305, 0.275, 0.268	CHS
12	$Al_2CaH_8O_{10}Si_{12}$	0.263, 0.262	CHAS
13	$Al_{3,5}Ca_3H_{9,7}O_{12}$	0.276, 0.309	CHA

X-ray diffractometry of cement containing ultradisperse modifiers

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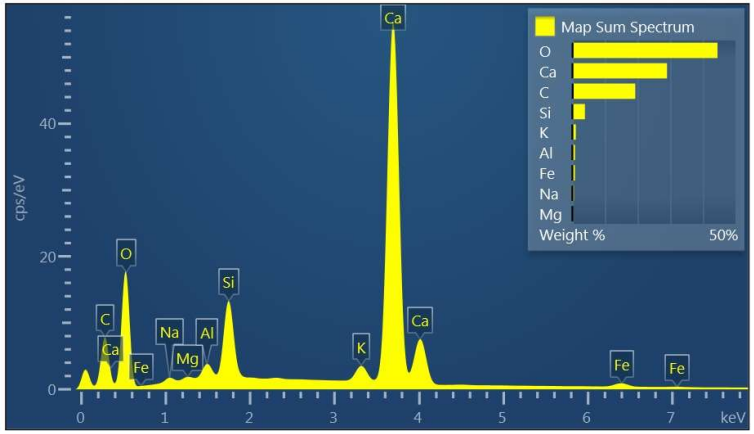
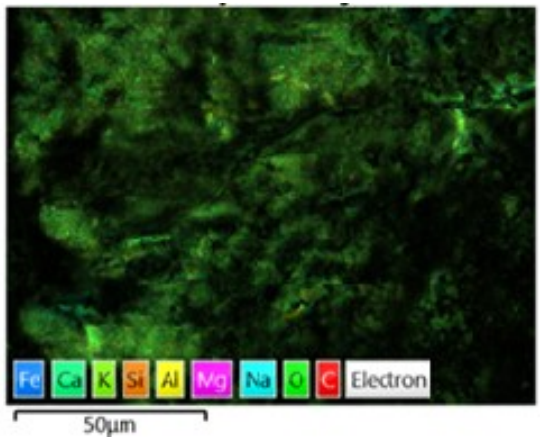


Element	Apparent Concentration	Wt%	Standard Label
C	108.28	**19.27**	C
O	285.15	**44.50**	SiO2
Na	5.13	0.45	Albite
Mg	2.27	0.21	MgO
Al	10.60	0.82	Al2O3
Si	55.79	3.86	SiO2
K	19.90	1.07	KBr
Ca	495.17	**29.03**	Wollastonite
Fe	10.54	0.79	Fe

Elemental composition of concrete samples of the initial mixture according to the results of EDX analysis, and the results of energy dispersive X-wave analysis, respectively, on maps



[11] The list of elements in the table and their percentage content indicate the presence of the vast majority of calcite CaCO3 in concrete matrix No. 1. In the presence of moisture, as a result of the reaction of calcium oxide with atmospheric carbon dioxide, a layered structure with low adhesion and cohesion is usually formed. According to the EDX analysis, the fracture of concrete composite No. 1 mainly occurs in areas with high concentrations of calcite.

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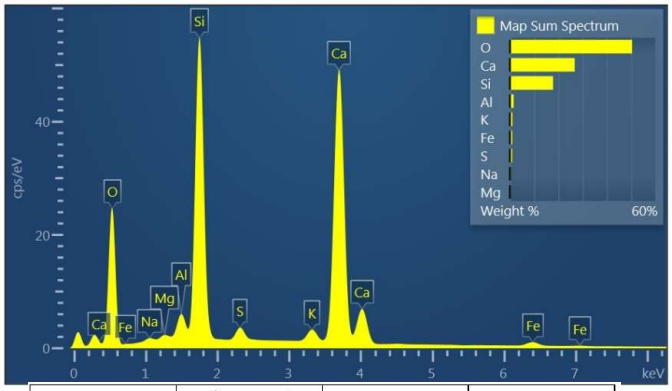
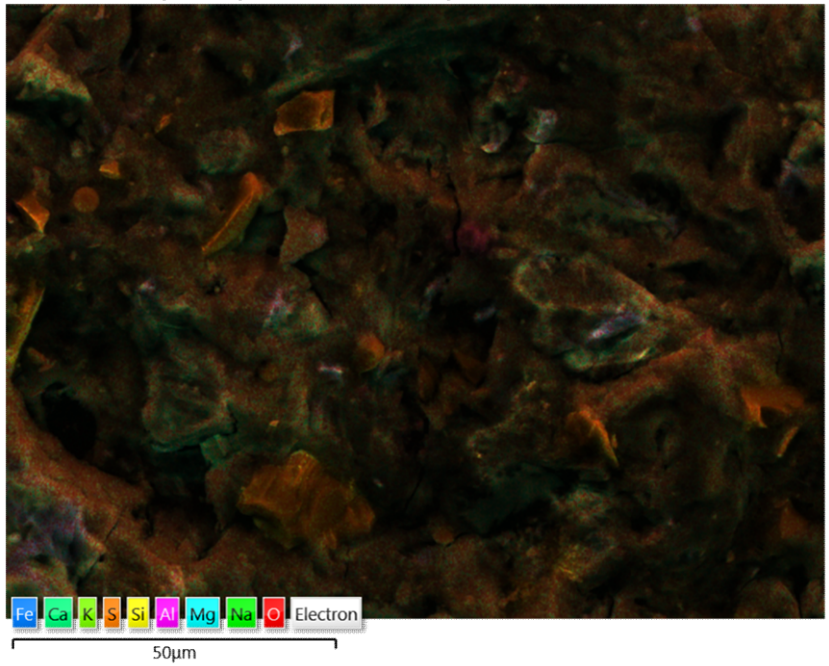
Elemental composition of concrete samples with the mixture modified by a complex based on microsilica and metakaolin EDX analysis and the results of energy dispersive X-ray analysis, respectively



Element	Apparent Concentration	Wt%	Standard Label
O	**393.92**	**50.40**	**SiO2**
Na	3.87	0.34	Albite
Mg	3.43	0.31	MgO
Al	19.98	1.52	Al2O3
Si	**257.48**	**17.81**	**SiO2**
S	12.53	0.90	FeS2
K	17.78	1.03	KBr
Ca	**439.97**	**26.75**	**Wollastonite**
Fe	12.70	0.94	Fe



The phase structure of the cement composite of formulation No. 2 is characterized by a large number of phases and their heterogeneity.The phase composition is dominated by compounds of low and high basicity HSCs, as well as unreacted microsilica particles. Probably, the significantly higher compressive strength of formulation No. 2 is associated with a more developed specific surface area of pozzolanic particles, which are able to react faster with Ca(OH)2, forming a dense microstructure.

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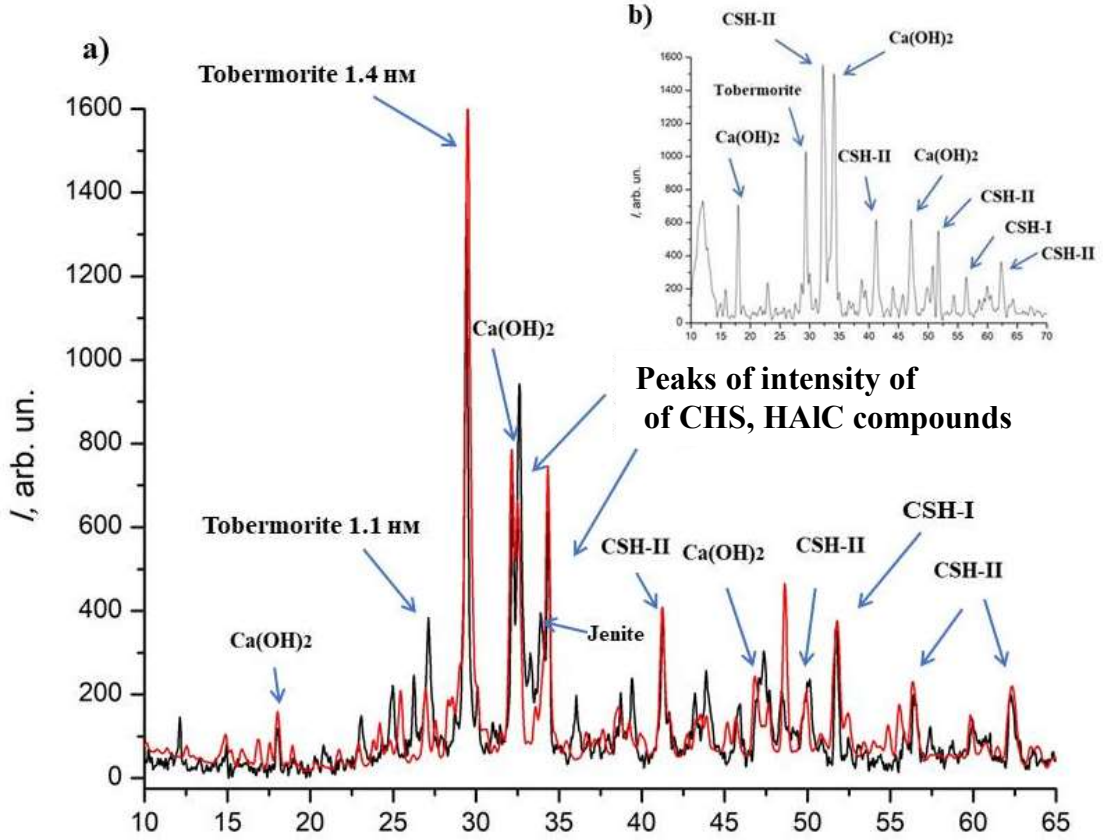

a) - experimental (dark line) and calculated (red) diffractograms for more than a year of hydration of the compounds of the modified composite;

b) - on the 28th day of hydration of the composite.

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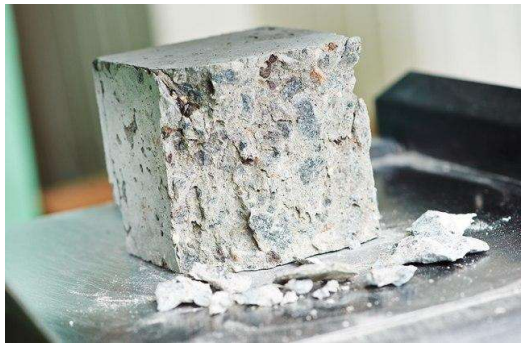
Module course 2 in IO2 - AMAZE e-toolkit manual for digital learning in producing complex design industrial parts. Ultra-high strength composites

module course 2
Smart (Intelligent) Materials

«Ultra-high strength composites»



Principles of structural strength and density, modified composites with a complex of finely dispersed additives of microsilica and metakaolin

Laboratory work #1
Production and storage of cement prisms

Laboratory work #2
Bending and compressive strength testing of cement prisms

Laboratory work #3
Preparation of a concrete sample

Laboratory work #4.
Class of concrete according to strength

Laboratory work #5
X-ray studies of cement

Laboratory work #6
Scanning electron microscopy of concrete

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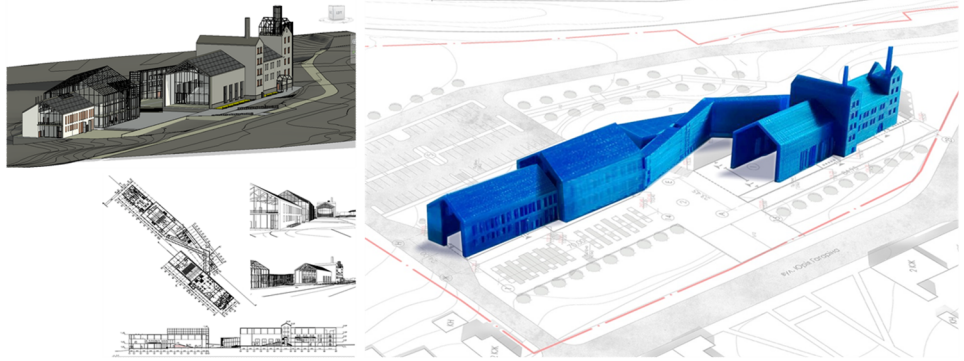
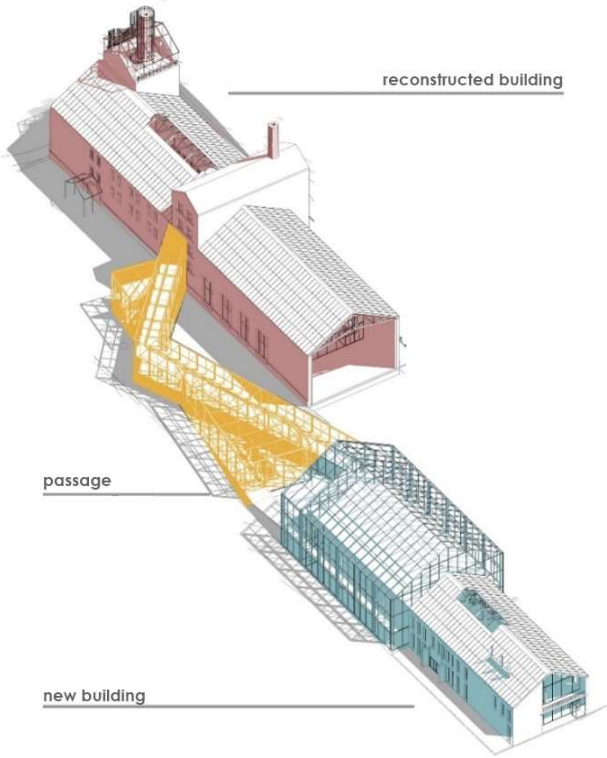
module course 3 – CAD/CAM/CAE design

Drawings in the Revit software package using BIM technologies



Our team developed a project for the reconstruction of a brewery in Chernivtsi using Revit software and printed it on a 3D printer.

These guidelines are aimed at learning Autodesk Revit at the level that allows to build a 3D model of a building and create basic architectural and construction drawings – plans, facades, sections.



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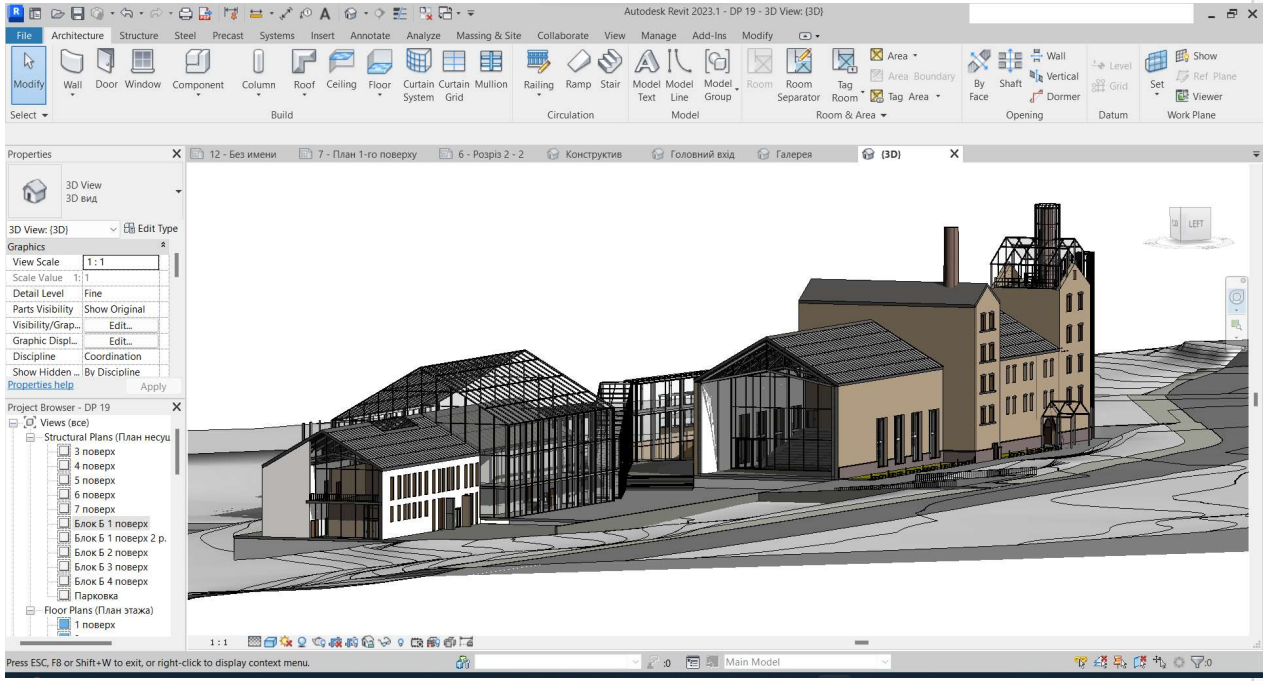
These guidelines can be used as supplementary documentation for practical training on following topics:

1. Description of the programme. Installation, interface, methods of work.
2. Setting up plan levels. Creating a grid of axes.
3. Description of walls, their characteristics.
4. Description of windows and doors, their properties. Create and configure types/styles.
5. Description of stairs and handrails, their properties. Custom shapes.
6. Description of floors and roofs. Building and editing.
7. Create a facade and section, flat and three-dimensional. Setting up the perspective view of the camera.
8. Visualisation – styles, materials and light sources.
9. Create and design Sheets. Transfer of Views (plans, facades, sections, 3D views) to sheets.
10. Create and configure text types and sizes.



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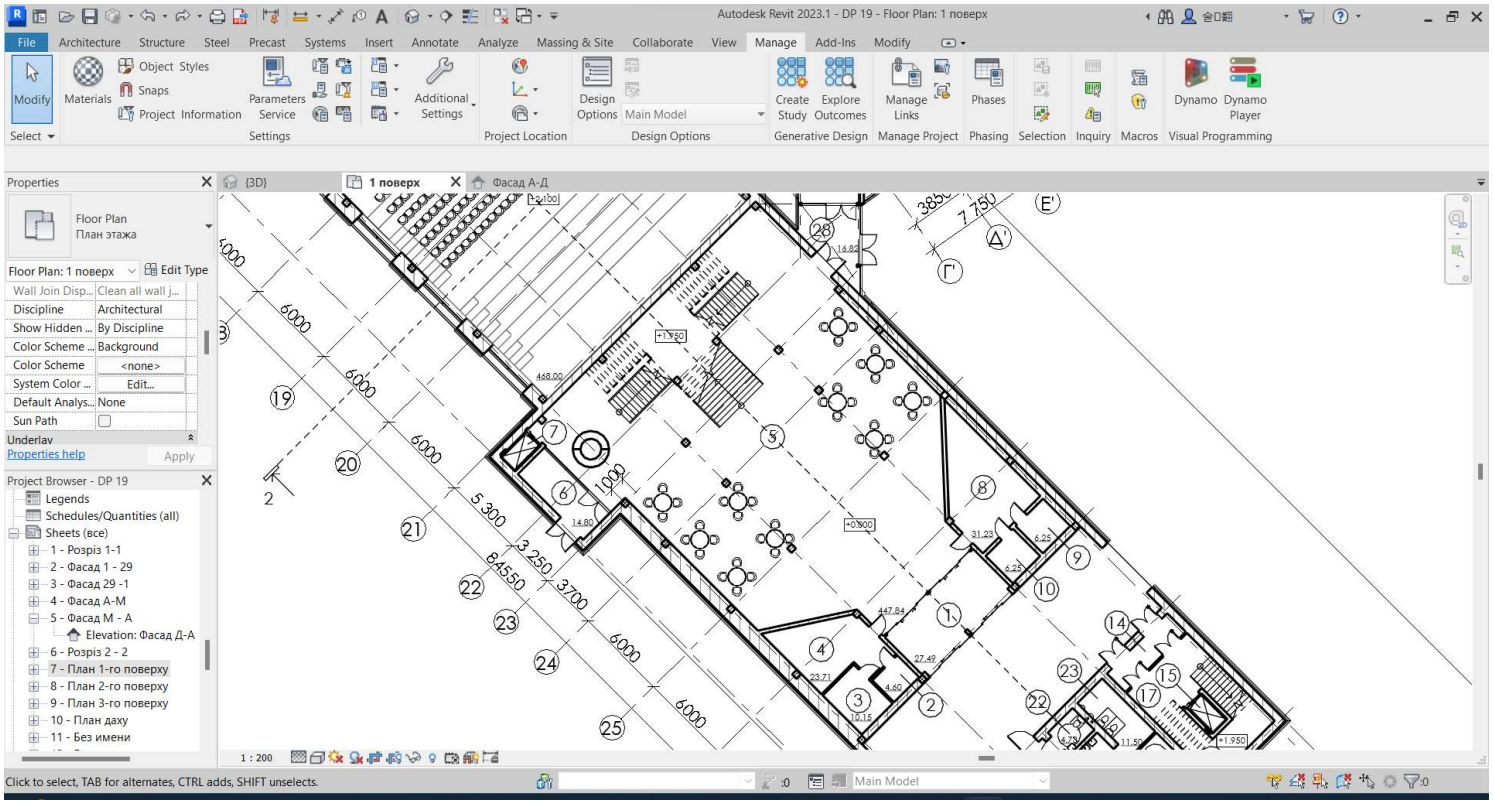

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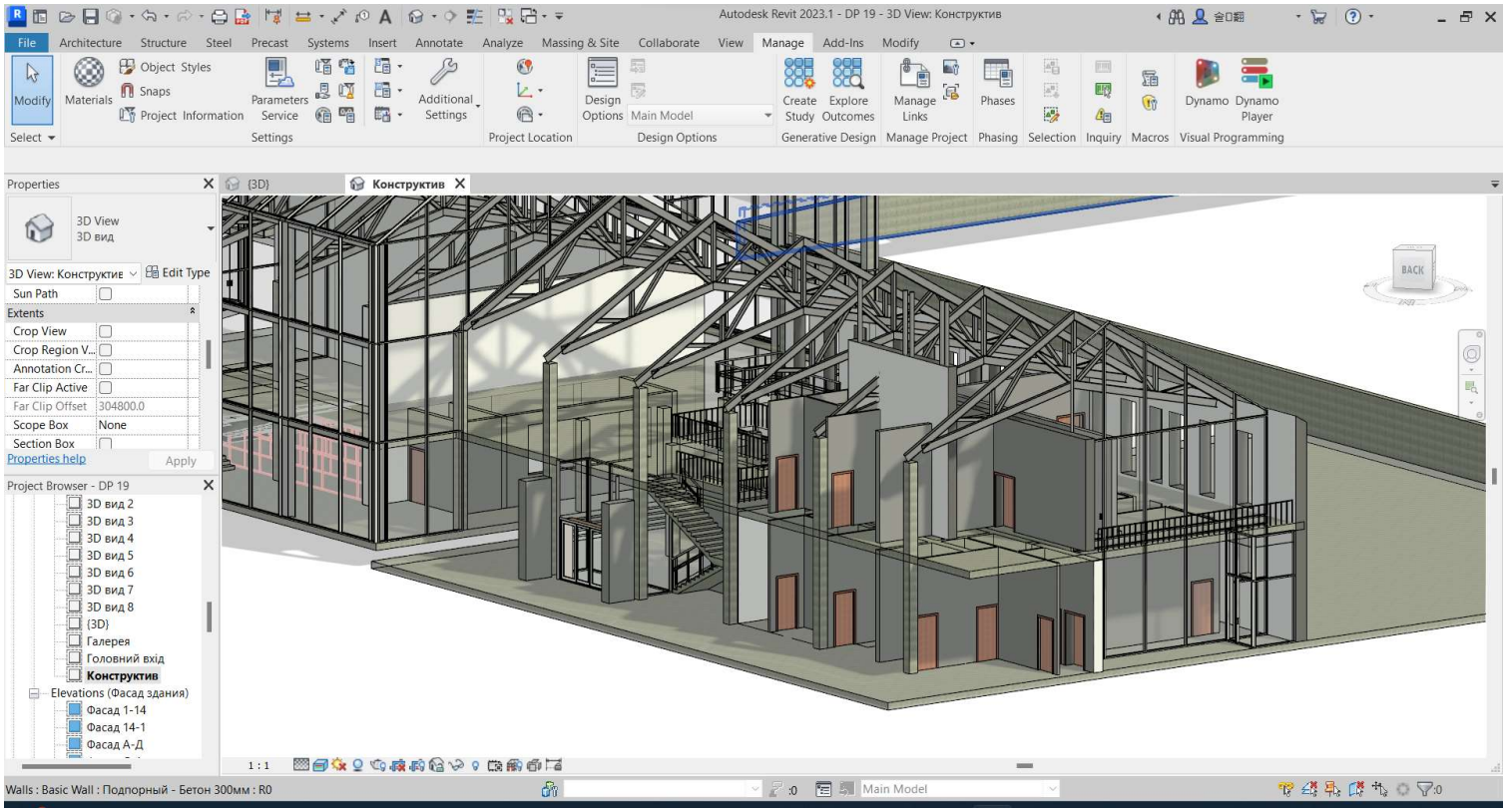

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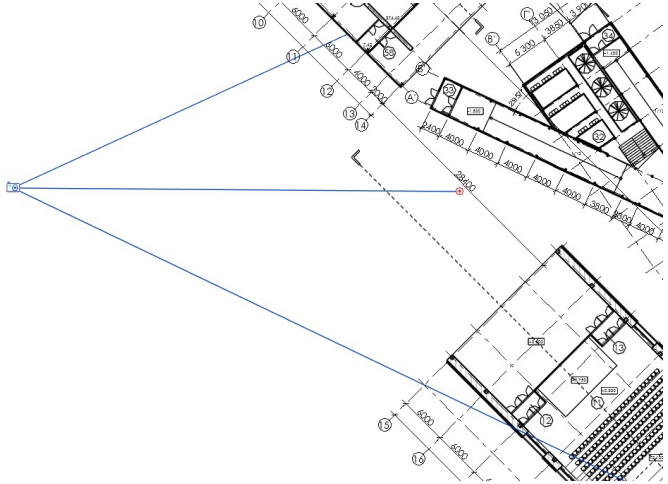

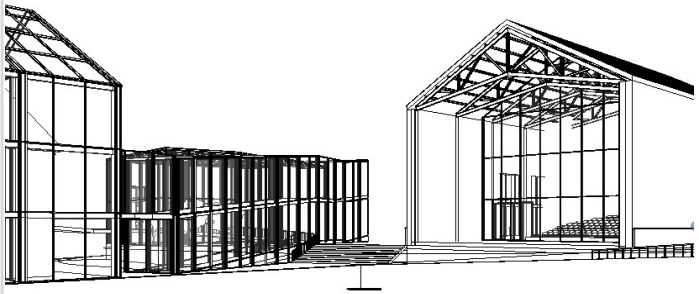

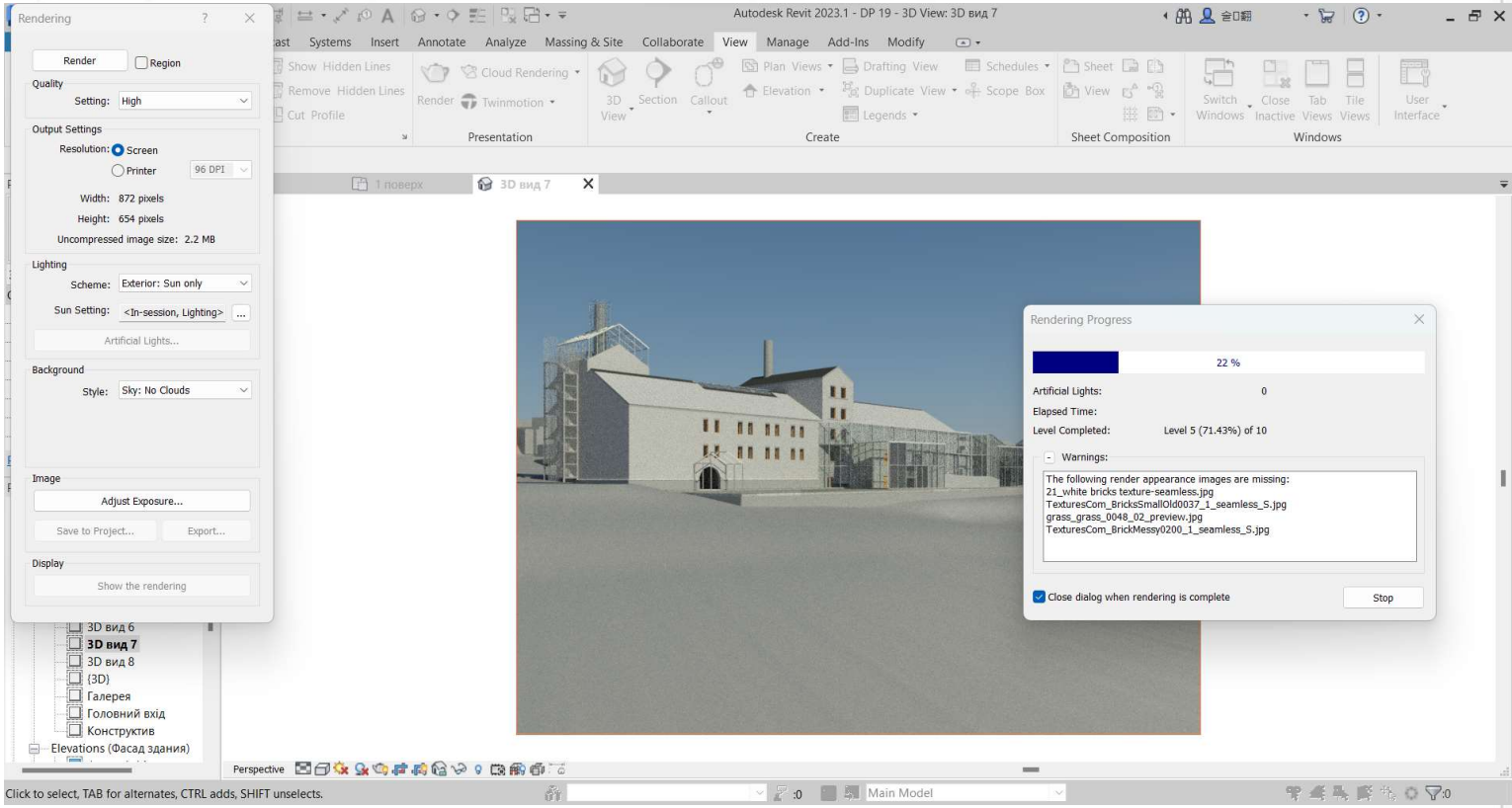

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IO2. Module course 3. Drawings in the Revit software package using BIM technologies

Task: Create an architectural design of a building.

It is possible to use ideas and sketches for designing a building from already finished student works.

1. Creating axes and walls:

Placement of windows, doors, openings in the walls;

Creating and editing rooms, defining areas, creating specifications.

2. Create a constructive scheme of the building:

Creating overlaps;

Placement of columns and beams;

Building a roof.

3. Creating a 3D visualization of the project:

Setting up materials and camera;

Rendering the image.

4. Creation of project documentation:

Generation of floor plans, facades, sections;

Creation of a master plan.

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AMAZE Summer School

Students
from Yuriy Fedkovych
Chernivtsi National University

Specialities:

- ARCHITECTURE AND URBAN PLANNING
- CONSTRUCTION AND CIVIL ENGINEERING
- INFORMATION SYSTEMS AND TECHNOLOGIES

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ARCHITECTURE AND URBAN PLANNING

Anastasia Aurite

3th year of
Bachelor program

Sofia Kolodrivska

3th year of
Bachelor program

CONSTRUCTION AND CIVIL ENGINEERING

Vita Buzyniak

3th year of
Bachelor program

Angelina Auziak

First year of
Master program

INFORMATION SYSTEMS AND TECHNOLOGIES

Natalia Panivnyk

3th year of
Bachelor program

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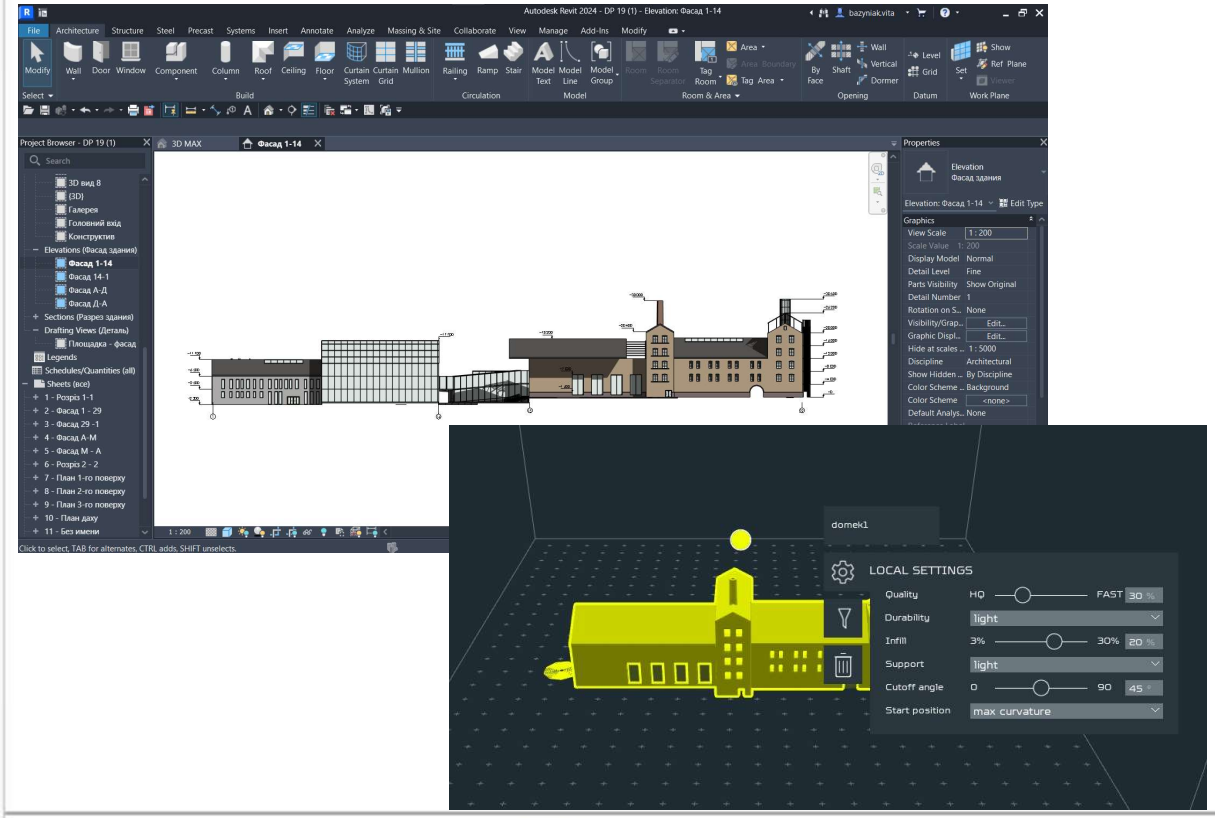
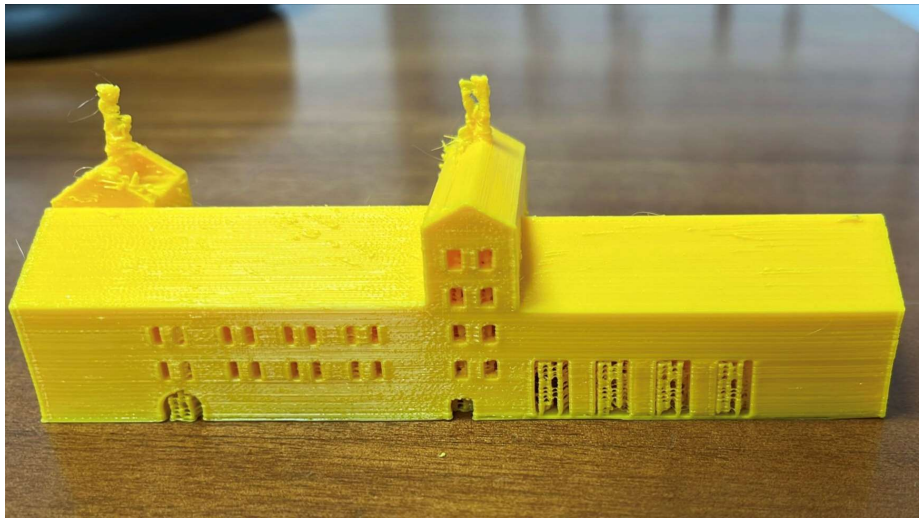
Agreement number 2023-1-RO01-KA220-HED-000155412

European Network for Additive Manufacturing in Industrial Design for Ukrainian Context

Transnational Project Meeting – TPM 3 hosted by EDIBON International S.A. company, Madrid, Spain



AMAZE Summer School



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AMAZE

Research of Ti-6Al-4V Alloy

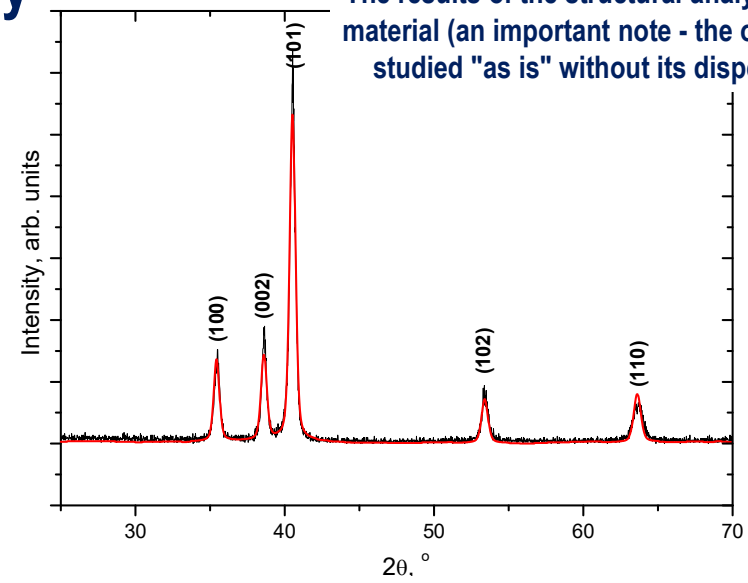
X-ray fluorescence method (an important note - the object was studied "as is" without its dispersion)

Fe	C	Si	V	N	Ti	Al	Zr	O	H	Домішок
< 0.6	< 0.1	< 0.1	3.5 - 5.3	< 0.05	86.45 - 90.9	5.3 - 6.8	< 0.3	< 0.2	< 0.015	0.3

content of industrial alloy Ti-6Al-4V

Element	Content (wt %)	
	Minimum	Maximum
Al	6.12	6.15
V	3.90	4.00
Fe	0.17	0.18
N	0.01	0.01
C	0.03	0.03
O	0.11	0.12
H	0.004	0.005
Y	0.0020	0.0021
Ti	Balance	

The results of the structural analysis of the material (an important note - the object was studied "as is" without its dispersion):



Alloy	*a*/nm	*c*/nm	*c*/*a*
Ti-6Al-4V-0.17O	0.2944	0.4677	1.58865
Ti-6Al-4V-0.20O	0.2945	0.4679	1.58879
Ti-6Al-4V-0.23O	0.2948	0.4685	1.58921