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INTEGRATION OF PARAMETRICISM AND BIM: OPPORTUNITIES AND LIMITATIONS OF DIGITAL DESIGN OF COMPLEX FORMS IN HIGH-RISE RESIDENTIAL CONSTRUCTION

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Abstract

This article investigates the issues of applying parametricism, one of the most advanced trends in modern architecture, to the design process of high-rise residential buildings and structures. The scientific and practical differences between parametric design (conceptual-geometric shaping) and parametric modeling (working with material, time, and economic dimensions within the BIM environment) are substantiated based on clear criteria. By comparatively analyzing international and local experiences, the advantages and existing limitations of integration with BIM (Building Information Modeling) technologies in digital modeling of complex organic forms are revealed. Furthermore, within the scope of the study, the project portfolios of leading companies in the global construction market (Zaha Hadid Architects, Gensler, Arup, etc.) were analyzed, and the share of parametric tools in their operations was examined. Using the Uzbekistan construction and design market, specifically the "New Tashkent" project, as an example, the level of implementation of BIM and parametric design elements, along with the current state of the national regulatory framework, was analyzed using statistical data.

Keywords: Parametricism, parametric design, parametric modeling, BIM integration, high-rise residential buildings, complex geometry, digital twin (Digital Twin), interoperability, Zaha Hadid Architects.

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Introduction

The purpose of the research is to comparatively analyze international and local experiences in applying parametricism, an advanced trend in modern architecture, to the design process of high-rise residential buildings. It aims to reveal the conceptual-geometric and engineering-economic opportunities of integrating parametric design and Building Information Modeling (BIM) technologies, and to formulate proposals and recommendations for the national construction market by systematizing the technical, regulatory, and cultural constraints that arise in this synthesis.

According to the research hypothesis formulated to achieve this goal, under the conditions of strict economic budget constraints, short construction timelines, and high levels of element repetition—which are characteristic of high-rise residential construction—the successful implementation of complex, curvilinear, and organic forms of parametricism cannot be limited solely to the conceptual-geometric (script and node logic) stage. Instead, it must be seamlessly integrated with the parametric modeling (BIM) environment, which aggregates real construction data such as material, time, cost, and tolerances, using open data formats (IFC) and hybrid visual programming bridges (Rhino.Inside.Revit), and directly linked to automated manufacturing (CAM) systems.

This approach increases the flexibility of the parametric model, enabling algorithmic optimization of variants and the formation of complete digital twins (Digital Twin), thereby minimizing project risks.

The scientific novelty of the research lies in the fact that, for the first time, the theory and practice of parametricism were systematically studied not only in the context of large public buildings or avant-garde architectural examples, but specifically through the high-rise residential segment, which has much stricter economic and technical criteria. Additionally, based on criteria in global digital architecture workflows (generative-procedural, morphological-visual, and systemic-logical) and the experience of the world's leading design companies (Zaha Hadid Architects, Gensler, Arup, etc.), the efficiency of parametric modeling was evaluated from the perspective of the normalization phase.

Most importantly, under the conditions of accelerating urbanization processes in the republic and the strategy to progressively increase the share of energy-efficient high-rise buildings in accordance with the Presidential Decree of February 2026, the digital capacity of the national construction and design market

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was revealed using statistical and analytical data (using the "New Tashkent" project and leading local contracting companies as examples). This highlighted the dependence of the existing 54,349 active construction enterprises on traditional CAD systems and the current state of the regulatory (ShNQ) framework, justifying the scientific and practical necessity of developing special algorithmic models that balance form freedom (parametricism) with cost control (BIM).

In modern architecture and construction, the style of parametricism—distinguished by its complex, curvilinear, and organic forms—is mainly associated with public buildings, museums, stadiums, and avant-garde architectural landmarks. However, in recent years, the application of this style to high-rise residential construction has also been increasing. Especially in luxury residential complexes, riverside "tower" projects, and exclusive quarters, parametricism elements (wavy facades, variable balcony systems, organic-shaped entrance groups) are becoming more common.

Designing and building such complex shapes using traditional drafting methods is nearly impossible. At this juncture, parametric design tools and BIM (Building Information Modeling) technologies operate in an interconnected manner. Parametricism and BIM are complementary technologies—parametricism generates complex shape geometry, while BIM enriches this shape with construction process data (material, time, cost). In the context of high-rise residential buildings, this integration carries special significance. This is because residential construction is characterized by stricter economic constraints (cost estimates, price per 1 m² of an apartment), repetitive elements (same type of windows, balconies, radiators), and short construction timelines compared to public buildings. Therefore, applying parametric design and BIM to residential projects in the parametricism style has its own specific challenges and advantages.

However, the meeting of these two worlds brings not only advantages but also serious problems. The main difficulties include the "language" problem between software platforms (for example, the integration issue between Grasshopper and Revit), technical limitations in "teaching" complex geometry to BIM, the shortage of institutional and personnel readiness for digital transformation in the construction industry, and high costs in manufacturing unique elements. At the same time, this synthesis offers invaluable advantages such as automatic flexibility, the ability to optimize thousands of variants, the creation of a complete digital twin (Digital Twin), and clash detection before construction begins. Below, these problems and advantages are analyzed in detail within the context of high-rise residential construction.

Literature Review

Parametricism is a modern avant-garde architectural style that utilizes parametric design tools. This concept is an ideology and aesthetic program focused on "what to create". The term was officially introduced into architecture in 2008 by Patrik Schumacher, the head of Zaha Hadid Architects, through the "Parametricism Manifesto" presented at the Venice Biennale [1].

Although the terms parametric design and parametric modeling are often used interchangeably, there is a clear scientific and practical distinction between them. Parametric design primarily refers to a conceptual and geometric process. It is a methodology for creating design shapes, geometry, and algorithmic structures based on parameters and the mathematical relationships between them [2]. Parametric design is mostly applied in architecture and art, and its main output is a dynamic geometric model that adapts to variable parameters. At this stage, questions regarding "how the project looks" and "how it changes" are resolved.

Parametric modeling (or parametric engineering/design development) is a broader, engineering-and manufacturing-oriented concept. It takes the geometric model created during parametric design and prepares it for the real construction or manufacturing process. Parametric modeling encompasses not only geometry but also material selection, tolerances, technological constraints, assembly sequences, costs, and manufacturing parameters [3]. At this stage, answers are sought for questions such as "how to build", "how to manufacture", and "how much it costs".

To implement the style of parametricism, as well as parametric design and modeling, certain tools are required. For instance, hand-drawing techniques might suffice for a sketch of a building in the parametricism style, but this technique is insufficient for its practical implementation. For this reason, computer software tools are widely used today.

Parametric design tools refer to software and methods that allow representing, managing, and automatically generating new variants of parameters and their relationships during the design process. The core principle of parametric design is that design elements are formed based on algorithmic processes rather than being modeled directly by hand—meaning parameters and rules establish the relationship between design intent and design response [4].

Parametric modeling is divided into two main types: first, propagation-based systems, where algorithms generate final shapes that are not predetermined based on initial parametric inputs; second, constraint systems, where final constraints are set and algorithms are used to find fundamental aspects (such as structures or material usage) that satisfy these constraints [5]. We attempt to systematize the main computer tools used in practice through the following table (Table 1).

Table 1. Classification of Software Tools Used in Digital Architecture

Direction	Applied Software
Parametricism (Style of complex, curvilinear, organic forms)	Rhinoceros 3D + Grasshopper, CATIA, Blender + Geometry Nodes, Autodesk Maya, 3ds Max (with Modifier Stack), Generative Components (Bentley)
Parametric Design (Methodology of creating shapes based on parameters and algorithms)	Rhinoceros 3D + Grasshopper, Dynamo (for Revit), Blender + Geometry Nodes, CATIA, SolidWorks, Fusion 360, Siemens NX, Autodesk Inventor, FreeCAD, OpenSCAD
Parametric Modeling / Detailing (Implementing the project based on BIM, i.e., geometry + time + cost + material + manufacturing)	Autodesk Revit + Dynamo, Graphisoft Archicad + PARAM-O, Tekla Structures, Allplan (PythonParts), Bentley AECOsim Building Designer, Navisworks (for checking and management), Trimble Connect, BricsCAD BIM

In a study conducted by Alafandy and Al-Kazzaz (2018), the lack of clear specifications for building a parametric model was identified as a problem. They characterize parametric modeling as a "flexible level that allows continuous evaluation, revision, and updating of design" [6]. According to the research results, parametric modeling mainly begins during the design development phase and continues into the detailing and manufacturing stages.

The integration of parametric design with BIM (Building Information Modeling) technologies is one of the important research directions in the field of architecture and construction. Research shows that the parametric model is dynamic in nature, enabling the creation of a range of alternatives by changing variables. However, the flexibility of a parametric model depends on and is limited by its internally defined parameters [7].

Globa and Ulchickiy (2013) attempted to develop criteria for measuring the effectiveness of parametric modeling. Their study emphasizes the necessity of comprehensive and well-founded metrics for evaluating parametric CAD and design creativity [8].

In a recent study by Abdullah (2024), parametricism is analyzed from a semiotic perspective. The study identifies three interactive dimensions of parametricism: "building-user", "building-context", and "building-architect" [9]. Analysis conducted on the Heydar Aliyev Center shows that parametricism covers not only organizational levels but also phenomenological articulation and semiotic signification. According to the study's conclusion, parametricism communicates with its context not as an "object" but as a "field".

Krispel, Gramazio, and Kohler (2017) analyzed the application of parametric design using three practical projects—The Future of Us Pavilion, Louvre Abu Dhabi, and Morpheus Hotel. The study showed that the power of parametric design lies not in generating numerous design variants, but in executing highly precise, differentiated, rule-based designs. In this sense, parametric design has transitioned to the phase of "normalization" (entering everyday practice) in modern architectural practice [10].

Extensive research has been conducted abroad on the application of BIM technology to high-rise building design. The "BIM Handbook" written by Eastman, Teicholz, Sacks, and Liston (2018) forms the primary theoretical basis of the field. This source highlights the importance of ensuring interoperability to increase the effectiveness of applying BIM technology [11].

A study by Ma et al. (2024) shows that the parametric modeling capabilities of BIM technology play a critical role in optimizing structural schemes and facilitating interdisciplinary collaboration. As a result of this study, it was concluded that integrating BIM and cloud computing systems is laying the groundwork for forming next-generation design environments [12].

In a study by Shahsavari, Hart, and Yan (Texas A&M University, 2021), the possibilities of assessing risks during the building life cycle using BIM-based parametric methods were explored. The study showed that, compared to deterministic methods, probabilistic parametric models allow for a much more accurate evaluation of project variants from a risk perspective [13].

A major literature review published in the journal ScienceDirect (2025) fully reviewed current challenges in integrating parametric design, generative design, and BIM in the construction sector. According to the main conclusion, the lack of interoperability between platforms, standardization issues, and the low level of

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applying GD-BIM combinations in real projects are the three main obstacles in the industry [14].

In the architectural-construction practice and scientific schools of Uzbekistan, the issues of introducing digital technologies and information modeling (BIM) systems have begun to be analyzed rapidly at regulatory and conceptual levels in recent years. The legal and regulatory foundation for transitioning to digital construction in our country is directly linked to the Decree of the President of the Republic of Uzbekistan of February 2026, "On measures to accelerate housing provision and effectively organize the construction of multi-apartment buildings," and the systematic plans of the Ministry of Construction and Housing and Communal Economy of the Republic of Uzbekistan to gradually introduce BIM technologies into the field. These strategic decisions serve as the legal basis for transferring national design practice from traditional CAD systems to digital information modeling environments and platforms that progressively increase the share of energy-efficient high-rise buildings.

However, because the current state of the national regulatory framework (ShNQ) in force in the republic is mainly based on traditional two-dimensional drawings and strictly standardized systems of elements, serious regulatory limitations arise in legalizing and passing state expertise for the complex, curvilinear geometries of parametricism. This exact problem was also highlighted in the work "BIM: Third Generation Technologies" by Boronov N.S., which compared the experiences of Russia and Kazakhstan to scientifically demonstrate the weakness of the current regulatory framework in introducing BIM technologies in our country [15].

In the context of practical architecture, the technical directions of the Directorate for Building the "New Tashkent" project serve as the initial experimental arena in this regard [16].

Implementing elements of digital technologies is required within the first phase area of this project. The Alisher Navoiy International Scientific Research Center project, designed by the world-famous company Zaha Hadid Architects and being built within this area, brought complex parametric design solutions and top-tier criteria of digital integration into our national architecture. Additionally, the use of parametric forms in the Culture Center project in the Yashnabod district of Tashkent indicates the entry of this style into local design practice [17].

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Recent studies conducted by Tashkent Architecture and Civil Engineering University and local scientific schools also examine the impact of parametric design principles on shaping architectural environment objects, as well as balancing form freedom with economic efficiency in designing high-rise buildings [18-26]. As noted in the scientific works of local researchers, under conditions where a large portion of all active construction enterprises in the country (54,349) still rely on traditional CAD technologies and software tools [27], and strict economic budget constraints exist, transitioning parametric models from simple visualization stages to engineering-economic constraint systems and developing special algorithmic models adapted to the characteristics of the national construction market is an urgent scientific and practical necessity.

Methodology

This study is built upon a mixed-methods methodology, harmonizing qualitative and quantitative analysis methods.

Research Design and Approach: Comparative analysis and document analysis methods were used in the study. Comparative analysis served to identify differences between leading global companies and the local market of Uzbekistan, while document analysis served to systematically study scientific literature, corporate reports, and regulatory documents.

Sample Selection Criteria: Companies for global study were selected based on the following criteria:

1. Recognition in global construction and design rankings (ENR Top 500, Clutch.co, GoodFirms);
2. Availability of open data regarding the use of BIM and/or parametric technologies;
3. Diversity of activity directions—firms from various categories were chosen to cover architecture, engineering, contracting, and specialized BIM services.

Quantitatively comparable data was found for 11 of them; for the remaining companies, since only data allowing qualitative descriptions was available, they were not included in the comparative table.

Data Sources: The research was formed based on the following databases and sources:

Scientific article databases: Articles published between 2010–2025 were searched using keywords such as "parametric design", "BIM integration", and "computational architecture" on Scopus, Web of Science, ScienceDirect, and Google Scholar platforms;

Corporate and industry sources: Official annual reports (Annual Reports), official websites, press releases, and B2B platforms (Clutch.co, Good Firms, Procore, LinkedIn) data of the companies;

National statistical data: Official publications of the Statistics Agent under the President of the Republic of Uzbekistan, data from the Ministry of Construction and Housing and Communal Economy, and the "Shaffof Qurilish" (Transparent Construction) national information system.

Data Analysis Methods: Collected data was analyzed in three stages: first stage—systematization, bringing data from all sources into a single table format; second stage—quantitative comparison, calculating the number of projects, share of technologies, and market indicators; third stage—qualitative interpretation, interpreting digital indicators along with literature reviews and expert evaluation criteria.

Limitations

The main limitation of the study is that most large companies do not publish the number of parametric projects as a separate indicator in their financial reports. Moreover, the definition of a "project" varies from firm to firm: some companies count each building or structure as a separate project, while others record multiple objects within a large program as a single project. This situation causes a certain degree of uncertainty in quantitative comparisons and requires cautious interpretation of results.

There are a number of criteria to determine if parametric design was applied in projects. First, the presence of non-repetitive elements—if there are many non-identical components on a building facade or structure, where each element is adjusted individually, this indicates that parametric design was used [28]. Second, complex, organic, or fractal geometries—parametric design is usually used to create complex geometries that are difficult to create using traditional methods. Third, adaptability to environmental parameters—a building's envelope or shading elements that change based on external factors such as solar radiation, temperature, and wind are signs of parametric design [29]. Fourth, multiple variants of the same basic shape—if variants of the same basic shape in different sizes, proportions, and configurations exist within the project framework. Fifth, automation of documentation for manufacturing and assembly—in projects produced with parametric design, manufacturing drawings and assembly instructions for each component are generated automatically [30].

Scientific criteria have been developed to identify and evaluate parametric design. In an article published in the journal "Design Studies" by Krispel, Gramazio, and Kohler (2017) [31], digital workflows in modern architectural practice were analyzed, proposing criteria such as whether the project consists of non-repetitive elements, whether the parametric model covers the generation, documentation, manufacturing, and assembly processes of the project, and whether the project has details unachievable with traditional BIM. Furthermore, decomposition (fragmentation—how the complex model is divided into parts), algorithms (what computational strategies are applied), and data structures were shown as important factors for the practical viability of parametric models.

Criteria for identifying parametricism are generally divided into three types based on the detection method:

1. Generative-procedural criteria — checks whether the project was generated through a system of algorithms, parameters, and interconnected rules (script, node logic, entire form adapts if a parameter changes);
2. Morphological-visual criteria — analyzes features detectable from appearance even without digital files (continuous flowing geometry, graded variation, inter-element continuity, sense of "field logic");
3. Systemic-logical criteria — evaluates whether a unified parametric logic exists between plan, section, facade, structure, and environment, meaning whether parts of the building work as a single connected system.

This classification was conceptually systematized based on the views of Patrik Schumacher, who developed the theory of parametricism, and the experience of analyzing projects from the Zaha Hadid school in practice.

Analysis

In this study, an attempt was made to determine the extent to which parametricism, parametric design, and BIM technologies were used in completed and conceptual projects of companies operating globally and in Uzbekistan, along with the share of these approaches in residential buildings. The results of the conducted research were formed based on open data.

The list of construction and design companies utilizing advanced BIM technologies globally was formed based on global market analyses, industry awards and rankings, regional analyses, and open project portfolios. In the subsequent stage, the total number of completed projects for each company was determined according to analyses of companies' official annual reports, websites, press releases, independent B2B platforms (Clutch.co, GoodFirms), project portfolio data, public interviews, and mentions in industry publications.

Observed Problems and Limitations:

Large companies publishing indicators like revenue, number of employees, or number of active projects in their annual reports rather than the total number of projects;

Medium and small firms publishing financial indicators or certain project samples, but not providing overall quantitative statistics;

The definition of a project not being uniform: one firm counting each building or infrastructure object as a separate project, while another announcing multiple objects within a large program as a single project.

As a result, exact or relative numbers were found for 11 companies. Among companies with a known exact number of projects, the highest indicators are:

AECOM – 150+ aviation projects (AECOM, 2022. Aviation portfolio overview);

Gensler – 10,000+ total projects (Gensler, 2024. Facts & figures);

WSP Global – 200,000+ simultaneous active projects (WSP Global Inc. (2025). Annual report and sustainability report 2025);

VIATechnik – 2,000+ global projects (VIATechnik, 2025. Company website portfolio);

Tejjy Inc. – 2,500+ total projects (Tejjy Inc., 2025. Project experience page);

BIM Services LLC – 1,000+ global projects (Clutch.co. (2025). BIM Services LLC company profile);

Advenser – 1,500+ structural BIM projects (Advenser, 2025. Structural BIM projects);

Hitech CADD Services – 5,000+ total projects (Hitech CADD Services. (2025). Company profile);

OMI Architects – around 4,000 housing projects (OMI Architects. (2025). LinkedIn company page);

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Excelize – 250+ successfully completed projects (Excelize, 2025. Company website portfolio);
Arup – projects in more than 160 countries (exact number not specified) (Arup annual report 2024).

Table 2. Application of BIM and Parametric Technologies in Global Construction and Design Companies

Company	Total Number of Projects	Quantity of Projects in Parametricism Style	Notes	Source
Zaha Hadid Architects	950+	~950 (nearly all)	As the founder of parametricism, the vast majority of the company's projects are created in this style.	Grokipedia, 2026; ZHA World, 2026
Arup	Projects in over 160 countries	Parametric modeling: 13 (large infrastructure projects in the last 6 years) + used in many other projects	Parametric design is used as an engineering tool, but the quantity is low.	LinkedIn, 2025; Trimble, 2025
Gensler	10,000+	Exact parametric projects: 3 (Lijia Smart Hall, Zhangjiang Twin Towers, Perch Play Fortlandia) + used in Shanghai Tower and others	The number of parametric projects is limited.	Baidu, 2017; Gensler, 2023; Parametric Architecture, 2023
WSP	200,000+	Unknown	Produces and applies parametric tools.	WSP, 2025
AECOM	Unknown	Unknown. Parametric modeling: 9 Serpentine Pavilion projects and others	Created parametric tools, quantity not disclosed.	AECOM, 2022; New Civil Engineer, 2022
VIATechnik	2,000+	Unknown	Parametric modeling is a core service.	VIATechnik, 2025; Procore, 2022
BIM Services LLC	1,000+	Unknown	Creates parametric families, project quantity not disclosed.	Clutch.co, 2025
Advenser	Total: 10,000+	Unknown	Provides parametric modeling services.	Linknovate, 2026; Advenser, 2023
Hitech CADD Services	Total: 5,000+	Unknown	Provides parametric modeling services.	Hitech CADD, 2026
OMI Architects	4,000+	0	Does not apply parametric design.	LinkedIn, 2025
Excelize	250+	Unknown	Application of parametric design is unknown.	Excelize, 2025

Uzbekistan's construction and design market is highly dynamic and multi-faceted, with hundreds of companies operating in it. Several large local companies lead the Uzbekistan construction market in terms of turnover and taxes. These include

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Discover Invest, Agromir Buildings, Mimar Group, Trest-12 JSC, and Enter Engineering. Many large projects, especially in urban planning and infrastructure, are developed and implemented by state-owned institutes. Examples include O‘zshaharsozlik LITI, Toshkentboshplan LITI, Toshuyjoy LITI, and others. There are over 1,160 foreign construction companies in the Uzbekistan market, the majority of which are from the following countries [32]:

China: 495 companies, mainly involved in building large infrastructure and industrial objects;

Turkey: 273 companies, active in residential complexes, business centers, and modern urban planning projects;

Russia: 93 companies;

Kazakhstan: 63 companies;

South Korea: 47 companies.

The application of advanced technologies in construction and design in Uzbekistan was

prepared based on open sources in the following table [33-36].

Table 3. Technological Indicators of the Uzbekistan Construction Market

Indicator	Value	Additional Information
Total number of construction firms (2025)	54,349	This indicator covers all active construction enterprises in the country.
Number of projects using BIM technology	Over 70 (for 2023 alone)	Data is presented based on plans within state programs, not on a statistical basis. In 2023, at least 70 objects included in the state investment program were planned to be designed based on BIM. It is intended to design 5 objects from each region included in the targeted program using digital modeling methods.
Number of projects using parametric design	2 (exemplary)	There is no information in open sources about the widespread use of parametric design. The following examples indicate the beginning of the application of this technology in the country: The Alisher Navoiy International Scientific Research Center in the "New Tashkent" project. The project author is the world-famous "Zaha Hadid Architects" company, whose style is distinguished by "complex parametric design solutions". Parametric forms were used in the Culture Center project in the Yashnabod district of Tashkent.
Number of projects using CAD technology	No exact data available	CAD (for example, AutoCAD) is one of the most widespread and basic tools in construction and design. Almost all modern projects are prepared using this technology.

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Table 4. Object Portfolio and Digital Technology Integration of Leading Construction-Contracting Companies in Uzbekistan

(Compiled based on official corporate reports of companies, open portfolios, and analytical data of the "Shaffof Qurilish" national registry [37]; systematized based on data from Discover Invest, Enter Engineering, Mimar Group, Trest-12, and Agromir Buildings)

Company Name	Company Name	Company Name	Company Name	Company Name
Discover Invest	150+	Premium residential, hotels, international and administrative public buildings	• Tashkent City Congress Hall & Hilton; • Boulevard and Gardens Residence RCC; • Trilliant Business Center (contracting segment); • Al-Khwarizmi School.	The company actively uses BIM (Revit, Navisworks) systems in modeling complex architectural geometries. Analyzed visual collisions (clash detection) in complex structures within the Tashkent City area.
Enter Engineering	100+	Ultra-large industrial, energy, infrastructure, and complex public objects (EPC)	• "Silk Road Samarkand" tourism center; • Humo Arena ice palace; • Center of Islamic Civilization; • Tashkent Metallurgical Plant.	Uses full LOD 400-500 level BIM models and cloud collaboration environments in industrial projects. Has experience conducting parametric and aerodynamic tests for complex curvilinear steel structures (using Humo Arena as an example).
Mimar Group	30+	Modern urban planning, large micro-districts, residential and commercial complexes	• Olmazor Business City; • Tashkent City Mall (contracting partner);	Uses BIM engineering models to prevent the intersection of engineering networks when planning large massifs (for example, Olmazor Business City). The possibility of implementing parametric facades in the residential segment is high.
Trest-12 AJ	50+	State administrative buildings, reconstruction, large culturaleducational and religious buildings	• Senate and Cabinet of Ministers buildings; • Center of Islamic Civilization building; • Tashkent Financial Institute complex.	Due to working on projects within the framework of state orders, it is transitioning to digital modeling standards in accordance with the regulatory requirements of the Cabinet of Ministers on BIM. In the transformation stage from traditional methods to digital control systems.
Agromir Buildings	Around 10 large massifs (Hundreds of buildingblocks)	Mass and business-class high-rise large residential massif construction	• "Qorasuv" massif in Samarkand (100+ high-rise houses); • Mass multiapartment complexes in Tashkent and Samarkand.	Applies a structural modular BIM approach in massive panel construction. Due to the high number of repetitive elements, it has the opportunity to apply parametric design mainly in optimizing panels and frames according to material consumption (algorithmic saving).

Large companies in the local market have been gradually applying digital models (BIM) in their large projects (especially in the public and premium segments). However, companies specializing in mass housing, such as Agromir Buildings or Mimar Group, less frequently apply parametric design elements (complex, non-repetitive, curvilinear geometry) in their project portfolios due to strict budget constraints and standardized construction materials. This proves once again the urgency of developing special algorithmic models that ensure a balance between form freedom (parametricism) and costs (BIM) in new-generation residential buildings planned in the capital and large cities.

The share of residential buildings in the total project portfolio of the studied leading construction companies is distributed as follows according to their direction of activity:

Agromir Buildings: 95% (highest share; mainly mass housing and large micro-districts);

Mimar Group: 70% (large high-rise massifs in medium and business class);

Discover Invest: 40% (high-rise residential in premium and business class segments; the remaining 60% consists of administrative and public buildings);

Trest-12 JSC: Less than 10% (mainly state administrative buildings and cultural reconstruction objects);

Enter Engineering: Less than 5% (ultra-large industrial, energy, and infrastructure objects).

Companies with an extremely high share of residential housing in the local market (70–95%) less frequently resort to complex shapes (parametricism) due to strict economic budget constraints. Conversely, the premium-contracting segment (40% share) serves as the main experimental ground for practically applying complex and aesthetic parametric shapes and calculating them on BIM platforms.

Today, the acceleration of urbanization processes and demographic growth in the Republic of Uzbekistan necessitate the structural transformation of the construction industry. Analyzing the volume of total construction work carried out in the republic allows determining the share and dynamics of high-rise residential objects in the sector. According to official data from the Statistics Agency under the President of the Republic of Uzbekistan, the direction of erecting buildings and structures holds a leading place in the structure of total construction work performed in the country, accounting for 70–72% of the total share. Multi-apartment residential construction emerges as the main driver of this segment.

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However, a mismatch remains between the share of high-rise buildings and individual housing (courtyard houses) within the cross-section of net residential areas put into use across the republic (averaging 14–18 million m² per year):

Table 5. Structural Share of Residential Types Put into Use in Uzbekistan (for the years 2025–2026)

Type of Housing / Regional Feature	General Share across the Republic	Share in Large Urbanized Centers (Tashkent City, Samarkand, Andijan)
Individual housing (Built by the population)	75 – 80 %	< 20 %
High-rise (block) residential (Commercial and state programs)	20 %	> 80 %

As seen from the table data, although individual housing construction still holds a high weight (75–80%) on a republic scale, the share of modern high-rise housing records indicators higher than 80% in large megapolises and urbanization centers (for example, in Tashkent city).

According to the technical-statistical condition of the existing multi-apartment housing fund, only 27.1% of the total multi-apartment buildings in the republic (over 46,500) are constituted by modern buildings of 5 stories and higher (Statistics Agency, 2025). The remaining part consists of houses in the old fund that are architecturally in need of modernization [39].

The limited nature of land resources and ecological sustainability requirements demand that the construction sector transition from extensive growth to an intensive form. In accordance with the Decree of the President of the Republic of Uzbekistan of February 2026, "On measures to accelerate housing provision and effectively organize the construction of multi-apartment buildings," a radical turning strategy was defined in the network [40]. According to this document, it is planned to erect high-rise residential buildings with 140.2 thousand apartments in the year 2026 alone, due to complex reconstruction (renovation) of territories and increasing the share of energy-efficient "green" buildings. This guarantees a progressive growth in the share of high-rise buildings in the general construction balance in the coming years.

Recommendations

To successfully implement the integration of the parametricism style and BIM technologies in high-rise residential construction and to increase design efficiency, the following scientific and practical recommendations are proposed:

1.Ensuring Technical and Software Interoperability (Cross-platform Integration)

Transitioning to open data formats (IFC): To reduce inter-software "language" and integration problems (for example, geometric losses between Grasshopper and Revit), it is necessary to utilize international IFC (Industry Foundation Classes) standards more widely.

Introducing hybrid visual programming bridges: Utilizing open-source and dynamically linking plugins like Rhino.Inside.Revit to "teach" complex organic shapes to the BIM environment automates model decomposition and data exchange.

2.Improving the Regulatory-Legal and Methodological Base

Developing national BIM standards: Considering that digital modeling is being adopted within the framework of state programs in the Uzbekistan construction sector, it is necessary to create unified national BIM standards and parametric modeling specifications that eliminate the weakness of the regulatory framework.

Introducing economic optimization criteria for residential projects: To transfer parametric design from simple visualization to the engineering-economic stage, it is necessary to apply constraint systems algorithms in practice that automatically calculate material consumption, cost estimates, and the price per 1 m² of apartments.

3.Increasing Education and Personnel Capacity

Modernizing academic programs: In higher education institutions in the direction of architecture and construction (specifically, at Tashkent Architecture and Civil Engineering University), it is necessary to completely transition to a system of teaching visual programming (Dynamo, Grasshopper) and modern BIM platforms in an integrated manner instead of traditional CAD systems.

Forming a culture of collaborative (interdisciplinary) working groups: To break down misunderstandings between architect, constructor, and economist during the design process, and the industry's cultural resistance to traditional processes, it is recommended to create a collaboration environment based on cloud technologies.

4. Developing Local Manufacturing and Digital Twin Technologies

Establishing a link with Automated Manufacturing (CAM): Transferring non-repetitive, complex, and organic elements (balconies, facades) created based on a parametric model directly from the project to factory equipment (CNC machines) drastically reduces project costs.

Introducing parametric risk management in building operations: In the phase of constructing and subsequently operating high-rise residential buildings, it is appropriate to abandon deterministic methods and utilize BIM-based probabilistic parametric models and complete digital twins to assess potential risks.

Financial incentive mechanisms: Introducing a system of state subsidies, tax incentives, or preferential loans for projects applying BIM and parametric technologies, along with special funding for pilot projects.

Conclusions

As a result of investigating the integration of the parametricism style and BIM (Building Information Modeling) technologies in high-rise residential construction, the following scientific and practical conclusions were reached:

Terminology and Functional Differentiation: A clear boundary exists between the concepts of parametric design and parametric modeling. Parametric design is a methodology for creating dynamic geometric models based on parameters and mathematical relationships, applied in the conceptual stage of a project. Parametric modeling is a broader engineering stage that prepares it for the real construction and manufacturing process (material, cost, time, tolerances). Successfully implementing complex organic forms in high-rise residential buildings requires the seamless integration of these two stages.

Global Integration Trends: The level of using advanced BIM and parametric tools globally varies. While leading firms like Zaha Hadid Architects create nearly all of their projects in the parametricism style, most large engineering companies (Gensler, Arup, AECOM) apply parametric modeling locally as an engineering tool to optimize complex structural schemes and assess risks, rather than for the entire building architecture. Some companies specializing purely in housing

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projects, such as OMI Architects, do not apply parametric design at all due to economic constraints.

Technical and Cultural Limitations: The primary obstacles in the digital design process are the lack of mutual interoperability (data exchange) between platforms—such as integration problems between Grasshopper and Revit—and a low level of standardization. Furthermore, strict economic budgets of residential projects and the construction industry's cultural resistance to traditional processes make it difficult to introduce complex, non-repetitive, and expensive elements into practice.

Local Market and Development Prospects: The construction and design market of Uzbekistan is rapidly transitioning into a phase of digital transformation. Although systematic plans are being adopted to apply BIM technologies within the framework of state investment programs, parametric design elements have so far begun to appear only in an exemplary form in large public buildings (for example, the Alisher Navoiy International Scientific Research Center in the "New Tashkent" project or the Culture Center in the Yashnabod district). The virtual non-application of parametricism features in high-rise mass residential construction is caused by the weakness of the local regulatory framework, as well as the fact that the level of introducing BIM and parametric technologies for the majority of the 54,349 construction enterprises in the Republic has not yet been evaluated, with a large part of them still relying on traditional CAD technologies.

In general, the integration of parametricism and BIM is a future technology that allows creating a digital twin (Digital Twin) in high-rise residential construction and identifying project errors before construction. However, its entry into mass practice requires resolving software interoperability problems and perfecting the national regulatory-standardization base.

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