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MODERN METHODS OF CONSTRUCTIVE MODELING OF WOMEN'S GARMENTS WITH COMPLEX SHAPES

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Abstract: This article analyzes modern methods of constructive modeling of women's garments with complex shapes, their theoretical foundations, and possibilities for practical application. In the contemporary fashion industry, enhancing the artistic and aesthetic expressiveness of garments, creating complex three-dimensional forms, and improving structural solutions are increasingly important. The study examines the specific features of using structural and decorative lines, draping, asymmetry, geometric shaping, and transformable structures in designing women's garments with complex silhouettes. It also addresses the relationship between traditional constructive modeling methods, computer-aided design, and three-dimensional virtual modeling technologies. The physical and mechanical properties of materials, structural balance, ergonomic requirements, and compositional integrity are analyzed theoretically. Promising directions for integrating digital technologies into constructive modeling and opportunities to improve design quality are discussed.

Keywords: garment construction, constructive modeling, complex-shaped garments, women's clothing, draping, asymmetry, silhouette, geometric shaping.

The development of the contemporary fashion industry requires the use of new artistic ideas, innovative technologies, and improved structural solutions in garment design. Today, fashion design is not limited to creating functional products that cover the human body; rather, it is a complex creative and technical activity combining aesthetic thinking, technological capabilities, and individual style. In designing women's garments with complex shapes, translating an artistic concept into a precise structural form, developing a three-dimensional spatial configuration, and preserving the ergonomic properties of clothing are major scientific and practical challenges. (Figure 1) The structural organization of a garment is among the main factors determining its external shape, silhouette, proportions, and fit on the human body. Traditional patternmaking creates garment forms by modifying basic patterns, transferring darts, dividing structural pieces, introducing additional volume, and performing other modeling operations. However, standard structural approaches may not always be sufficient for designing complex geometric forms, asymmetric elements, multilayer drapery, and unconventional volumetric solutions. Such cases require combined constructive modeling methods.

A distinctive feature of complex-shaped garments is the close relationship between aesthetic expressiveness and structural organization. Every volumetric element, curved line, fold, or asymmetric detail visible in the garment is formed through a particular structural solution. Therefore, alongside compositional principles, the design process must account for geometric modeling, anthropometric measurements, textile materials, and garment manufacturing requirements.

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The physical and mechanical properties of fabrics are particularly important in garment construction. Material thickness, density, extensibility, flexibility, and drape directly influence the final garment shape. For example, rigid materials with good shape retention are more suitable for creating clearly defined geometric volumes, whereas soft and flexible fabrics facilitate complex drapery, loose folds, and dynamic silhouettes. Thus, material selection is a key condition for implementing an artistic concept in a complex-shaped garment. Recent advances in digital design technologies have introduced new opportunities for garment construction. Computer-aided design systems, three-dimensional virtual modeling software, and digital prototyping tools make it possible to develop complex structural forms, assess their fit on the body, and preview their appearance in different materials. CLO 3D and Browzwear, for instance, use virtual mannequins to visually analyze garment volume, fabric folds, the placement of structural lines, and certain fit indicators.

Nevertheless, digital modeling should not be considered a complete replacement for traditional patternmaking but rather a complementary means of improving it. Structural thinking, artistic and compositional analysis, understanding material properties, and practical draping skills remain essential when creating complex-shaped garments. The effectiveness of digital technologies depends on software capabilities, the accuracy of virtual fabric parameters, and the correctness of structural solutions. The main aim of this study is to analyze theoretically modern methods of constructive modeling of women's garments with complex shapes, identify their shape-forming potential, and substantiate promising ways of integrating traditional and digital design approaches. Constructive modeling of women's garments with complex shapes is a scientific and practical field integrating fashion design, geometric shaping, textile material science, and digital design technologies. The accuracy of garment construction, fit to the human body, and aesthetic expressiveness are central concerns in this field.

Winifred Aldrich's Metric Pattern Cutting for Women's Wear describes practical principles for developing basic women's garment blocks, forming structural lines, and manipulating patterns [1]. This approach provides a theoretical basis for understanding the importance of an accurate starting construction and anthropometric measurements in the design of complex-shaped garments. Helen Joseph-Armstrong's Patternmaking for Fashion Design systematically presents methods of dart transfer, division into structural components, formation of folds, and modeling of different silhouettes [2]. These methods make it possible to translate volumetric elements of an artistic sketch into structural garment pieces.

Tomoko Nakamichi's Pattern Magic proposes unconventional geometric and volumetric forms that extend the possibilities of traditional pattern manipulation [3]. This approach encourages an understanding of garment construction not merely as a collection of flat pieces fitted to the body, but also as an independent three-dimensional spatial composition. Modern digital technologies expand the opportunities for virtual prototyping in garment construction. Three-dimensional modeling software makes it possible to place two-dimensional patterns on a virtual mannequin, observe fabric drape, assess the positions of structural lines, and refine models at an early design stage. At the same time, virtual simulation results depend on the physical and mechanical parameters of the fabric and the anthropometric accuracy of the digital mannequin. For this reason, virtual fitting should be combined with physical mock-up testing when necessary to assess the final construction of complex-shaped

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garments. The literature review indicates that integrating classical pattern manipulation, draping, and digital technologies constitutes an important methodological direction in designing women's garments with complex shapes.

In the design of women's garments with complex shapes, constructive modeling is one of the main means of transforming an artistic idea into a precise three-dimensional spatial form. Unlike conventional silhouettes, these garments frequently incorporate asymmetric details, unusual geometric forms, multilayer structures, voluminous folds, and complex drapery. The positioning of structural lines, the physical and mechanical properties of fabrics, and the anthropometric characteristics of the human body must be coordinated when creating complex shapes. In designing volumetric elements, it is especially important to maintain a balance between visual appearance and functional comfort. Constructive modeling uses techniques such as transferring darts, modifying relief seams, widening or narrowing pattern pieces, and creating additional structural components. These operations allow complex silhouettes to be developed and compositional solutions specified in artistic sketches to be converted into practical patterns. Draping is widely used to create complex-shaped women's garments because it allows volumetric folds to be formed through the natural flexibility and plastic properties of fabric. Drapery can express dynamic rhythm, volumetric contrast, and compositional movement across the garment surface. Asymmetric modeling involves different structural solutions on the right and left sides of a garment. Shoulder lines, hem lengths, relief seams, and decorative elements may be positioned asymmetrically. In contemporary fashion design, asymmetric forms help create distinctive artistic images and strengthen the visual expressiveness of garments. Preliminary draping and mock-up development are important when constructing complex draped and asymmetric garments. They help determine how fabric lies on the body, the direction of folds, and the distribution of volume. The resulting form is subsequently translated into structural patterns. Modern digital technologies provide additional opportunities to improve constructive modeling of women's garments with complex shapes. Software such as CLO 3D and Browzwear nables designers to create virtual garment prototypes, assemble structural pieces in a three-dimensional environment, and simulate the approximate behavior of fabric. An important advantage of virtual modeling is the ability to evaluate structural solutions visually at an early stage. For garments with complex relief seams or asymmetric forms, the placement of structural lines, formation of folds, and fit to the body can be examined digitally.

However, the effectiveness of 3D technologies depends on the accuracy of anthropometric measurements and material parameters entered into the software. An apparently successful virtual prototype does not automatically guarantee that the finished garment will satisfy all ergonomic and technological requirements.

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Figure 1. Geometric folds, volumetric shapes, asymmetric details, and spatial garment construction.

The theoretical analysis indicates the need to consider artistic and compositional approaches, geometric shaping, textile material science, and digital design tools together in the constructive modeling of complex-shaped women's garments. There is no single universal structural method for creating complex shapes. The choice of modeling technique depends on the garment silhouette, volumetric organization, material properties, and functional purpose. On theoretical grounds, combining traditional draping with 3D virtual prototyping is considered promising. However, experimental evidence is required to establish whether this combination offers advantages in terms of time, material consumption, or structural accuracy. The proposed algorithm is intended to integrate traditional constructive modeling methods with digital design tools. Its practical effectiveness must be tested on garment samples of different levels of complexity. The study of modern methods of constructive modeling of women's garments with complex shapes demonstrates the importance of the interrelationship among artistic and aesthetic solutions, structural shaping principles, and innovative technologies in fashion design. Creating complex three-dimensional spatial forms requires coordination of structural lines, geometric elements, draping, asymmetry, and the physical and mechanical properties of materials. The theoretical and comparative analysis supports the following conclusions.

First, traditional patternmaking methods constitute an essential methodological foundation for the constructive modeling of complex-shaped women's garments. Dart transfer, the development of relief seams, the transformation of structural pieces, and volume-forming techniques enable complex forms in artistic sketches to be translated into practical garment constructions.

Second, draping and asymmetric modeling enhance the artistic expressiveness of garments while directly affecting their structural organization. Designing such forms requires attention to material plasticity, fold direction, structural balance, and anthropometric characteristics.

Third, three-dimensional digital modeling technologies expand opportunities for virtual prototyping, visual assessment of structural elements, and early identification of certain design

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deficiencies. However, the accuracy of virtual testing depends on material parameters, digital mannequin characteristics, and simulation conditions.

Fourth, integrating traditional constructive modeling and digital prototyping is a promising direction for designing complex-shaped garments. This approach may help systematize the translation of an artistic concept into a structural solution, the gradual refinement of a design, and the preparation of a final model for production.

Fifth, the effectiveness of structural solutions for complex-shaped garments should be evaluated not only by their visual aesthetics but also by ergonomic comfort, shape stability, material properties, and technological feasibility.

In conclusion, the integrated use of classical patternmaking, draping techniques, and modern 3D technologies represents a theoretically and practically justified approach to the constructive modeling of women's garments with complex shapes. Future research should experimentally test its effectiveness, compare the correspondence between virtual and physical prototypes made from different materials, and improve criteria for evaluating structural solutions.

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