



MATERNITY WEAR DESIGN: ANTHROPOMETRIC ANALYSIS AND EASE CALCULATION USING EMPIRE LINE

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ABSTRACT:

Maternity wear design necessitates a multidisciplinary approach that integrates anthropometry, ergonomics, textile science, and apparel construction principles. The dynamic morphological changes during pregnancy demand garments that provide adaptability without compromising comfort or aesthetics. This study presents a theoretical and applied framework for designing maternity garments using anthropometric analysis and controlled ease distribution. Emphasis is placed on the empire line as a structural design element and the systematic allocation of 6 cm ease between the empire line and natural waist, divided into six equal segments of 1 cm. The research demonstrates that proportional ease distribution enhances biomechanical comfort, supports abdominal expansion, and maintains garment stability across different stages of pregnancy.

Keywords: Maternity Wear, Anthropometry, Ergonomic Design, Empire Line, Ease Distribution, Garment Engineering

INTRODUCTION:

Pregnancy induces complex physiological transformations characterized by progressive weight gain, postural changes, and localized body expansion. These changes significantly alter body proportions, rendering conventional sizing systems ineffective (Chattaraman et al., 2012). Traditional garments, which rely on static measurements, fail to accommodate the dynamic nature of pregnancy.

From a theoretical perspective, maternity wear must be understood as a responsive system rather than a fixed structure. Concepts such as ergonomic adaptability, dynamic fit, and ease engineering become central to garment development (Ashdown, 2007). The integration of anthropometric data into

design ensures that garments align with real human body variations rather than idealized proportions.

The empire line emerges as a critical design intervention. Positioned above the natural waistline, it redistributes garment volume and reduces pressure on the abdomen (Fan, Yu, & Hunter, 2004). This study explores how controlled ease allocation within this region contributes to functional and aesthetic performance.

ANTHROPOMETRIC ANALYSIS:

1. Theoretical Framework:

Anthropometry, the scientific study of human body measurements, serves as the foundation for ergonomic garment design (Pheasant & Haslegrave, 2016). In maternity wear, dynamic anthropometry is particularly relevant, as body dimensions change over time rather than remaining constant.

The study adopts a longitudinal understanding of body changes across trimesters:

- First trimester: Minimal visible change
- Second trimester: Noticeable abdominal and bust growth
- Third trimester: Maximum expansion and posture shift

2. Key Measurements Included:

- Bust circumference
- Waist circumference
- Hip circumference
- Shoulder width
- Sleeve length
- Waist-to-hip length
- Overall garment length

These measurements capture both horizontal girths and vertical dimensions essential for pattern construction (Aldrich, 2015).

3. Observations and Theoretical Implications:

The data revealed consistent growth patterns:

- Abdominal region: Maximum expansion
- Bust region: Moderate increase
- Hip region: Slight to moderate increase

- Upper body: Minimal variation

These findings support the concept of localized ease distribution, where garment expansion is concentrated in high-growth areas (Bye & McKinney, 2010).

DESIGN APPROACH: EMPIRE LINE APPLICATION:

1. Structural Significance:

The empire line functions as a load-distribution seam separating the stable upper torso from the expanding abdomen (Aldrich, 2015).

2. Functional Advantages:

- Reduces pressure on the abdomen
- Improves airflow and comfort
- Allows vertical expansion
- Maintains visual proportion

3. Theoretical Perspective:

The empire line acts as a pivot for volume redistribution, aligning with principles of ergonomic garment engineering (Fan et al., 2004).

EASE CALCULATION METHOD:

1. Concept of Ease:

Ease is the difference between body and garment measurements and is critical for both comfort and movement (Ashdown, 2007). In maternity wear, it also functions as a predictive allowance for body growth.

2. Mathematical Representation of Ease Distribution:

$$E \text{ segment} = E \text{ total} / n$$

$$= 6 \text{ cm} / 6 = 1 \text{ cm}$$

Where:

- E segment = ease per segment
- E total = total ease (6 cm)
- n = number of segments (6)

3. Segmentation Strategy:

Dividing ease into equal segments ensures balanced distribution and structural stability (Joseph-Armstrong, 2014).

4. Distribution Across Pattern Areas:

- Centre front panel
- Side front panel
- Side seams
- Side back panel
- Centre back panel

5. Theoretical Justification:

This method aligns with biomechanical movement patterns and fabric stress distribution principles (Pheasant & Haslegrave, 2016).

PATTERN DEVELOPMENT:**1. Methodological Approach:**

Pattern development follows a transformational process based on flat pattern techniques (Joseph-Armstrong, 2014).

2. Steps in Pattern Adjustment:

1. Draft basic bodice block
2. Shift waistline to empire line
3. Mark natural waist
4. Add 6 cm ease
5. Divide into six segments
6. Apply slash-and-spread technique

3. Fabric Considerations:

Fabric properties significantly influence ease performance:

- Woven fabrics require precise ease
- Knits allow flexibility
- Drapability affects distribution (Fan et al., 2004)

4. Outcome:

The developed pattern demonstrates a structured yet flexible approach to maternity garment construction by integrating anthropometric insights with controlled ease allocation. The introduction of segmented ease between the empire line and natural waist creates a progressive expansion mechanism, allowing the garment to respond to gradual abdominal growth without requiring structural modification.

From a material behavior perspective, the pattern supports uniform stress distribution across seams and panels. Instead of concentrating strain at a single point—such as the center front—the division of ease into six equal segments ensures that tension is diffused throughout the garment. This reduces the risk of seam slippage, fabric distortion, and premature wear.

Additionally, the pattern enhances fabric drape dynamics. By allowing incremental volume addition, the garment falls naturally along the body's contours, avoiding excessive gathers or bulk formation. This results in a smoother silhouette and improved visual continuity between the upper bodice and lower garment section.

The outcome also reflects principles of predictive design, where future body changes are anticipated during the initial pattern-making stage. This reduces the need for multiple garment sizes across pregnancy stages, contributing to both economic efficiency and user convenience.

Results and Discussion:

1. Comfort Enhancement:

The even distribution of ease plays a critical role in improving physiological comfort. During pregnancy, the abdominal region becomes highly sensitive to pressure due to internal expansion and increased blood circulation. Concentrated tightness in this area can lead to discomfort, restricted breathing, and reduced mobility.

By allocating ease uniformly, the garment minimizes localized compression and supports pressure equilibrium across the body surface. This aligns with ergonomic principles that emphasize reducing mechanical stress on sensitive regions. Furthermore, the empire line positioning eliminates direct constriction at the natural waist, enhancing respiratory ease and allowing unrestricted abdominal movement.

Thermal comfort is also indirectly improved, as looser garment structures promote better air circulation, reducing heat retention—an important factor during pregnancy when body temperature regulation may fluctuate.6.2 Fit Adaptability

The garment adapts across trimesters, supporting dynamic fit theory (Ashdown, 2007).

2. Fit Adaptability:

The concept of dynamic fit is central to maternity wear design. Unlike conventional garments, which are designed for static body dimensions, maternity garments must accommodate continuous morphological changes.

The segmented ease system supports temporal adaptability, meaning the garment remains functional across different stages of pregnancy. In early stages, the additional ease remains visually subtle, maintaining a standard silhouette. As the body expands, the same ease gradually becomes functional, accommodating increased volume without distortion.

This adaptability reduces the need for frequent garment replacement, making the design both cost-effective and sustainable. It also aligns with user-centered design principles, where garments are expected to evolve with the wearer's changing needs.

3. Aesthetic Stability:

Maintaining visual appeal is a significant challenge in maternity wear, as increased volume can often lead to shapeless or oversized silhouettes. The structured distribution of ease ensures that the garment retains a balanced and proportionate form.

The empire line contributes to aesthetic stability by visually elongating the body and drawing attention upward, away from the expanding abdomen. Meanwhile, the symmetrical placement of ease across panels prevents uneven fullness, ensuring that the garment appears intentionally designed rather than oversized.

This reflects the principle of controlled volume design, where additional fabric is integrated in a way that enhances rather than disrupts the overall silhouette. The result is a garment that combines functionality with contemporary fashion aesthetics.

4. Mobility:

Mobility is a key functional requirement, particularly as pregnancy progresses and body movement becomes more restricted. The distributed ease allows the garment to accommodate a wider range of motion, including sitting, bending, walking, and transitional movements.

From a biomechanical perspective, the garment reduces resistance against body movement by providing sufficient allowance at critical points such as the

abdomen and side seams. This minimizes fabric strain during motion and enhances overall comfort.

The design also supports postural adjustments, which are common during pregnancy due to changes in the center of gravity. By allowing flexibility in the midsection, the garment adapts to these shifts without pulling or riding up.

5. Structural Durability and Performance:

An important outcome of segmented ease distribution is improved garment durability. When stress is evenly distributed, the likelihood of seam failure and fabric fatigue decreases significantly. This enhances the garment's lifespan, making it suitable for extended use throughout pregnancy.

The design also ensures construction efficiency, as balanced pattern modifications reduce complexity during stitching and finishing processes.

CONCLUSION:

This study establishes that the integration of anthropometric data with a structured system of ease distribution forms the foundation of effective maternity wear design. By recognizing pregnancy as a phase of continuous and non-uniform body transformation, the research moves beyond conventional static sizing systems and proposes a dynamic, responsive design framework.

The application of the empire line, positioned strategically above the natural waist, serves as a pivotal structural element that redistributes garment volume while minimizing pressure on the abdominal region. When combined with a total ease allowance of 6 cm—systematically divided into six equal segments of 1 cm—this approach ensures balanced expansion, structural integrity, and ergonomic comfort. The segmentation method not only accommodates physical growth but also prevents distortion, thereby maintaining both functional performance and aesthetic stability.

From a theoretical standpoint, the study reinforces key principles of ergonomic design, adaptive fit, and predictive pattern engineering. The findings highlight that effective maternity wear must address three interconnected dimensions:

- Physiological needs (comfort, pressure reduction, mobility)
- Functional adaptability (multi-stage usability across trimesters)
- Aesthetic considerations (maintaining proportion and visual appeal)

Furthermore, the research demonstrates that controlled ease distribution is not merely a technical adjustment but a design strategy that bridges the gap between body variability and garment stability. This contributes to the broader field of apparel design by emphasizing the importance of data-driven and user-centered methodologies.

Implications for Design Practice:

The outcomes of this study provide practical guidelines for designers and manufacturers:

- Adoption of segmented ease systems can improve fit accuracy
- Empire line construction can be standardized for maternity collections
- Pattern-making processes can be optimized for scalability and efficiency

These implications support the development of maternity garments that are not only functional but also commercially viable and sustainable.

Future Developments and Research Directions:

The scope of maternity wear design can be further expanded through the integration of emerging technologies and interdisciplinary approaches:

- **Smart Textiles:** The incorporation of responsive and stretchable materials, such as shape-memory fabrics and adaptive knits, can enhance garment flexibility. These textiles can automatically adjust to body changes, reducing the need for manual ease calculations.
- **3D Body Scanning:** Advanced body scanning technologies can provide accurate, real-time anthropometric data for pregnant women at different stages. This enables the creation of highly precise and customized garment patterns, improving fit and reducing production errors.
- **Personalized Digital Pattern Systems:** The use of computer-aided design (CAD) and algorithm-based pattern generation can facilitate mass customization. Digital platforms can generate individualized patterns based on user measurements, allowing for on-demand production and reduced material waste.
- **Integration of Artificial Intelligence:** AI-driven systems can predict body changes during pregnancy and recommend optimal garment adjustments, making maternity wear more intelligent and user-responsive.

- Sustainability Considerations: Future research can also focus on sustainable maternity wear by developing garments that adapt across multiple stages, thereby reducing consumption and promoting long-term usability.

REFERENCES:

1. Aldrich, W. (2015). *Metric pattern cutting for women's wear* (6th ed.). Wiley-Blackwell.
2. Ashdown, S. P. (2007). *Sizing in clothing: Developing effective sizing systems for ready-to-wear clothing*. Woodhead Publishing.
3. Bye, E., & McKinney, E. (2010). Fit analysis using live and 3D scan models. *International Journal of Clothing Science and Technology*, 22(2/3), 88–100. <https://doi.org/10.1108/09556221011024459>
4. Chattaraman, V., Simmons, K. P., & Ulrich, P. V. (2012). Age, body size, body image, and fit preferences of male consumers. *Clothing and Textiles Research Journal*, 30(4), 291–305. (Used conceptually for body change and fit behavior)
5. Fan, J., Yu, W., & Hunter, L. (2004). *Clothing appearance and fit: Science and technology*. Woodhead Publishing.
6. Joseph-Armstrong, H. (2014). *Patternmaking for fashion design* (5th ed.). Pearson.
7. Pheasant, S., & Haslegrave, C. M. (2016). *Bodyspace: Anthropometry, ergonomics and the design of work* (3rd ed.). CRC Press.