Faculty of Engineering

Department Of Textile Engineering

PROJECT (THESIS) REPORT ON

Comparative study of Woven fabric properties with different of Weft Yarns under Identical Warp and Machine Conditions

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Submitted By

MD. NIMUR ALAM	**ID: 213-23-1027**
SAMIUL HASAN SOWROV	**ID: 213-23-1028**
FAISAL AHMED	**ID: 213-23-1050**

Supervised By

Md. Farhad Hossain (Lecturer)
Department of Textile Engineering

This Report presented in partial fulfillment of the Requirement for the Degree of

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Advanced in Fabric Manufacturing Technology

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Declaration:

We hereby declare that, this thesis paper has been done under the supervision of **Md. Farhad Hossain**, Lecturer, Department of Textile Engineering, Faculty of Engineering, Daffodil International University. We further declare that no portion of this thesis or any other portion of this paper has ever been submitted elsewhere for the purpose of receiving a degree or diploma.

Department of Textile Engineering

Daffodil International University

MD. NIMUR ALAM	**ID: 213-23-1027**
SAMIUL HASAN SOWROV	**ID: 213-23-1028**
FAISAL AHMED	**ID: 213-23-1050**

Supervisor
Md. Farhad Hossain
Lecturer
Department of Textile Engineering
Faculty of Engineering
Daffodil International University

LETTER OF APPROVAL

The Project titles “Comparative study of Woven fabric properties with different of Weft Yarns under Identical Warp and Machine Conditions” has been submitted to the Board of Examiners of the Faculty of Engineering by the following students on June 2025 in partial completion of the prerequisites for the degree of Bachelor of Textile Engineering and has been approved as satisfactory.

MD. NIMUR ALAM	**ID: 213-23-1027**
SAMIUL HASAN SOWROV	**ID: 213-23-1028**
FAISAL AHMED	**ID: 213-23-1050**

Supervisor

Md. Farhad Hossain
Lecturer
Department of Textile Engineering
Faculty of Engineering
Daffodil International University

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Dedication

We would like to begin by appreciating God in this Industrial Training report.

This project and special research work is fully dedicated to our dear parents.

Our strength in this academic journey is because of the unconditional love, endless support and constant prayers that we have had.

And to these readers we pay our homage and the thanks as well to this work we make. To Md. Farhad Hossain, Lecturer, our noble supervisor, with gratitude whose kinds developed guidance, constant encouragement to us and which has offered us with thoughts of ideas of carrying out this research with so much zeal and energy.

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Statement of Contributions

This research was done under the guidance of **Md. Farhad Hossain**, Lecturer, who helped in such a way with his help to consider this work as successful.

We have prepared the fabric samples, tested the fabric in laboratory (EPI, PPI, GSM, Tensile strength, tearing strength, and Single yarn strength tests), collected, analyzed and interpreted the data in an attempt to assess the possible impact of various weft yarns on the fabric characteristics.

We would like to express our gratitude to the technical assistance of **Md. Selim** and **Md. Alamin Hossain** whose help in undertaking the test in the lab enabled us to achieve reliable and correct results.

Thorough research was done cooperatively by the thesis team which was done under desirable supervision and lab assistance.

Abstract:

The aim of the current thesis “Comparative Study of Woven Fabric Properties with Different Weft Yarns under Identical Warp and Machine Conditions” is to assess the effect of the transitions of woven fabric to the weft yarns on overall woven fabric characters when the warp yarns and machine settings are held constant. The main aim of the study will be to elicit information on an optimized way of fabric performance by choosing an effective selection of the weft yarns in the textile production process.

In the study, various fabrics were formed with various fabric weft yarns and with the same warp yarn and weaving conditions. Consecutive laboratory tests were done to measure crucial fabric criterion, such as Ends Per Inch (EPI), Picks Per Inch (PPI), Fabric GSM (grams per square meter), Tensile Strength, Tearing Strength, and Single Yarn Strength.

Its results show that there are discernible changes on the nature of the fabrics based on the weft yarn. Such differences are evaluated critically in order to come into terms with how the properties of the weft yarn affect the structure and the mechanical performance of the end-woven fabric.

Table of Contents

List of Figure

List of Table

Chapter 1: Introduction

1.1 Background of the Study:

The manufacturing process of the woven fabrics involves interlacing two sets of the warp and weft yarns at the right angle to one another. The quality and nature of the yarns employed is also one of the numerous factors affecting the end products of the denim fabric. Warp yarns tend to be kept constant to maintain stability of the weaving process and minimize yarn breakage during the manufacturing process however weft yarns can be altered providing a greater deal of flexibility and being changed to bring changes to the aesthetic, functional and mechanical qualities of the finished cloth.

It is important to be aware of the qualities of the weft yarns even more so, when the other variables, including the warp yarn specification, machine settings, and the weave design, are kept constant. This will enable one to evaluate much easier the role played by the various weft yarns of different counts in affecting the behavior of the fabric particularly in terms of the tensile, torn strength, fabric weight (GSM) and EPI and PPI.

1.2 Problem Statement:

There is a lack of systematic research comparing woven fabric properties produced with different weft yarns of different counts while keeping the warp yarn and machine conditions constant. Without such controlled comparisons, it is challenging to identify how changes in weft yarn type such as fiber composition (cotton), yarn count, or structure directly influence key fabric characteristics like strength, durability, EPI & PPI, and fabric weight (GSM).

This research addresses this gap by conducting a comparative study under identical warp and loom conditions, using various weft yarns of various counts. The goal is to provide a clear understanding of how different weft yarns of different counts affect the physical and mechanical properties of woven fabrics, thereby supporting more informed decision-making in fabric design and production. [1]

1.3 Objectives of the Study:

The primary objectives of this study are as follows:

- To explicate and contrast the physical and mechanical characteristics of the woven fabric that has been created with various weft yarns of various counts, having equal warp and loom (Rapier) conditions.
- To determine the influence of fiber composition in weft yarn on the properties of the fabric including tensile strength, tear strength, GSM (grams per square meter) and EPI & PPI, and abrasion resistance.
- The need to know the most practical type of weft yarn to be used to manufacture fabrics with the desired performance properties depending on the end usage needs.
- To add useful information to the textile industry in decision-making on weft yarn selection focusing on being cost effective and performance-oriented.
- To give a scientific relationship between structure properties of a woven fabric with different weft yarns to warrant a better control in quality and product development in the textile engineering.

By achieving these objectives, the study aims to bridge the knowledge gap in woven/denim fabric design and support data-driven improvements in textile production.

1.4 Scope of the Study:

The scope of this study is defined by the following key aspects:

- **Weft Yarn Variations:** The study includes different types of weft yarns of different counts, such as 100% cotton. Variations in yarn count and structure are also considered to observe their impact on fabric properties.
- **Controlled Conditions:** The warp yarn type, count, density, and loom settings (such as speed, tension, and reed/pick settings) are kept constant throughout the experiment to isolate the effects of the weft yarn.
- **Fabric Properties Analyzed:** The woven fabrics are tested for several key physical and mechanical properties including tensile strength, tear strength, GSM (fabric weight), EPI & PPI, and abrasion resistance.
- **Standard Testing Methods:** All fabric samples are evaluated using recognized testing standards (such as ASTM or ISO methods) to ensure reliability, repeatability, and industry relevance.

- **Limitations:** The study does not consider the effects of post-weaving processes such as dyeing, finishing, or chemical treatments. It also excludes the influence of fabric structure changes (plain, twill), focusing only on a single weave pattern for consistency.

Through this defined scope, the study aims to provide valuable insights into how weft yarn selection can be optimized to enhance fabric performance in a wide range of applications, particularly where specific fabric properties are critical to end-use performance.

1.5 Significance of the Study:

This study holds significant value for the textile industry in several ways:

- **Enhanced Understanding of Yarn-Fabric Relationship:**
  The research provides clear insights into how different weft yarns of different counts affect key fabric properties, helping bridge the knowledge gap between yarn selection and fabric performance. [2]
- **Support for Data-Driven Decision Making:**
  By presenting quantified data under controlled conditions, the study helps manufacturers make informed decisions in selecting weft yarns for specific product goals. [3]
- **Optimization of Fabric Design and Quality:**
  The results would help to streamline the parameters of construction of fabric to attain desired mechanical and physical properties with no trial-and-error situations.
- **Cost and Resource Efficiency:**
  Knowledge on the particular effect of weft yarns would enable efficient use of resources and maximize benefits since waste is minimized and thus the cost of production and so on.
- **Contribution to Academic and Industrial Research:**
  The research contributes to the current body of the textile information, and it can be used as a valuable source in the further study on woven/denim fabric engineering, material science and textile technology.

In summary, this study not only enhances technical understanding but also supports the practical application of material selection principles in the development of superior woven/denim fabrics.

1.6 Limitations of the Study:

- ❖ **Limited Types of Yarn**: Only selected few types of materials of weft yarn (cotton) are used in the experiment. Existence of other types of the fibers like viscose fiber, linen fiber or specialty yarns is not entailed and applicability of the results may be negatively affected. [4]
- ❖ **Fixed Fabric Structure**: In Experiment We have only a single enumeration of weaves (e.g. plain or twill). The theme is not discussed about what influence is plied on the weft yarns on various fabrics.
- ❖ **Single Warp Yarn Specification**: Type of warp yarn to be used, the count and structure was kept constant and therefore the study has not allowed an interaction of different warp-weft combination.
- ❖ **Loom and Machine Constraints**: The same weaving machine works all the fabric states under the same loom conditions. This cuts off all the variations brought about by the type of machine or the velocity of the machine but it may not be a reflection of the differences in the industry observed in the mass production.
- ❖ **Restricted Mechanical and Comfort Attributes**: The research is largely limited to a physical and mechanical characteristic (i.e. strength, GSM, air permeability). The others performance characteristics does not include the feel of biting the hands, drapability, moisture handling and thermal comfort.
- ❖ **Laboratory-Scale Production**: The fabric production procedure is executed in the small-scale and the tight setting of the laboratory that does not give the whole image of the industrial production dynamic and issues. [4]

Despite all these, the fact that it is somehow constrained in coming out with conclusions related to the performance of the weft yarns on the performance of the fabric coupled with the fact that it was performed with a small backdrop or sample and a fabric yet involved with a less complicated weave as well as the society in which they were generated or produced form some basis on what a subsequent study with a bigger scope and an even more complex form of weave and community that involves generating them can be carried out on.

Chapter 2: Literature Review

2.1 Overview of Weaving Technology:

The most commonly used and oldest technology of fabric formation in the textile industry is the process called weaving that is grounded on the principle of interlacement of two mutually exclusive groups of yarns warp (longitudinal) and weft (transverse). The qualities of these yarns, the structure of weave and the dimensional conditions of the weaving machine affect greatly the performance, texture, and functionality of woven fabrics.

2.1.1 Fundamentals of Weaving Technology:

The most common and widely employed fabric construction technique is weaving which engages the interweaving of two different sets of yarns, the warp threads and the weft threads in a 90-degree angle. Warp yarns go along the length of the material whereas the weft yarn is perpendicular across the cloth. Weaving process is done using these looms since they give the required shedding, picking, and beating-up operations. [5]

2.1.2 Influence of Weft Yarns on Fabric Properties:

The kind of weft yarn also contributes penultimately to dictate the physical and mechanical characteristics of woven fabrics. Fabric behavior may be appreciably different though the numbers of warp yarns and machine settings are the same and during occasions when the weft yarn composition, counts, twist and structures vary. One can then take woven fabrics and examine them where all fabric parameters but one such as the weft yarn warp construction and loom conditions are equal to isolate and test the contribution of the weft yarn to fabric performance to tell the fabric manufacturer which combination of yarns to use to achieve the desired results in their end use applications. [6]

2.1.3 Standardization in Weaving and Fabric Testing:

To evaluate woven fabric performance, several standardized testing methods are established globally. These include:

- **ISO 3303-1** : Method for tensile strength
- **ISO 13937-1** : Method for tear strength
- **ISO-3801** : Method for fabric weight (GSM)
- **Method for EPI & PPI**
- **ISO 13937-1** : Method for single yarn strength

2.1.4 Research Gaps and Need for Comparative Studies:

It is clear that numerous studies have been done on the role played by type and structure of yarns but there has been less done on a direct comparative study of the varying weft yarns in woven fabric with the same warp and same machine settings. This provides a research gap in comprehending the role played by isolated weft variances on fabric properties in the absence of other variables. It is advisable to meet this gap to have better material choices and process refinements in both manufacturing of apparel and technical textiles.

2.2 Basic Principles of Weaving:

Weaving A common method of fabric construction is through weaving whereby two sets of continuous yarns warp and weft are interlaced at right angles to each other. Warp yarns go along the length of the fabric whereas the weft yarns are inserted across the length. It is in this interlacement that the fabric structure of woven fabric is set and it is this key element that helps govern the mechanical, functional as well as aesthetic features of this fabric structure.

2.2.1 Components and Mechanism of Weaving

Three major motions control the weaving process which include: shedding, picking, and beating-up. In shedding thread is raised to produce a shed; the weft yarn is inserted through this shed in picking; and the inserted weft yarn is compressed into the fabric structure in beating-up. Additional movements such as warp let-off and cloth take-up make up processes and guarantee the sustained process running and fabric tension stability. High speed, precise weft insertion has been made possible by modern weaving machines (as the rapier, air-jet, or projectile looms), in which one will be able to experiment with a range of different yarns, with a constant warp tension maintained.

2.2.2 Influence of Yarn Direction on Fabric Behavior

Although yarns are used in warp and weft structures, the former tends to provide more uniformity of the structure because it is not only stronger but also tightly twisted because it is always exposed to tension in the weaving process. Conversely, yarns are inserted on the weft side at high rates and in different angles which tends to provide surface variability in terms of texture, elasticity and porosity. When examining how the properties of the fabrics vary with weft yarns held constant conditions except, the warp-weft interaction is established that should be understood. Weft material, weft count, weft twist directly influences tensile strength, air permeability, thickness and drape, despite the warp and machine set being constant.

2.2.3 Relevance of Weaving Parameters in Comparative Studies

When conducting controlled fabric engineering, machine settings are very important to standardize where loom speed, weft insertion rate, pick density and tension are of paramount importance. With these parameters fixed other effects of particular yarn features like the type of fiber or yarn structure can be isolated on the fabric performance. This has been the methodology that happens to be in unison with the implementation of conventional textile testing procedures stated by the ISO, including:

- **Tensile strength Testing (ISO 3303-1)**
- **Tear strength Testing (ISO 13937-1)**
- **Fabric weight Testing (ISO-3801)**
- **EPI & PPI**
- **Single yarn strength Testing (ISO 3303-1)**

These standardized tests are critical to ensuring valid, reproducible comparisons in woven fabric analysis.

2.3 Types of Looms and Their Mechanism

Textile production Weaving is a central procedure and the nature of the loom chosen does largely affect the efficiency, quality and structure of the resultant fabric. Loom is a machine that enables an interlacing of the warp and weft yarns, and the mechanism of its functioning is the key element that defines the physical properties of the fabric. The loom with the mechanism of its weaving has a direct influence on the uniformity of weft insertion, the tensioning of the weft and the structure of the fabric, especially in the case where utilizing different weft yarns is subjects to the same warp and machine setting.

2.3.1 Classification of Looms

There are two broad categories of looms; conventional (shuttle) looms and modern shuttle less looms.

- **Shuttle Looms**: Theses are usually the traditional looms that compose a shuttle to pass the weft yarn over the shed. Shuttle looms are not as fast and efficient as they are simple and versatile in nature. They create vigorous selvedges as well as increase tension on weft yarn and possible yarn breakage.
- **Shuttle less Looms**: These are rapier, air- jet, water- jet and projectile looms. Such looms apply alternative weft insertion mechanisms to improve their speed rate, less waste of yarns, and allow diverse weft yarns with little tension change. They are very productive and suitable to be employed in industrial weaving, as they are very automated.

2.3.2 Mechanisms of Weaving in Modern Looms

In every less loom the weft yarn is threaded into the shed park with diverse mechanism:

- ❖ **Rapier Loom:** it uses either stiff or flexible rapiers to weft yarn. It can be adjusted to any kind of yarn which is coarse/delicate, and it provides flexibility in width of the fabrics and the variety of the weft.
- ❖ **Air-Jet Loom:** This one uses a fast-moving stream of air which blasts the weft on the warp array. It is the most economical on light and medium weight synthetic yarn but inefficient with heavy or streaky yarn due to the fact that it cannot be easily controlled or at times energy consuming.
- ❖ **Projectile Loom:** This is a tiny projectile and it carries and transports their weft yarn across the shed. It feeds weaving at high rate, using thick or broad materials, and it is not usable on soft or elastic fiber. Water-Jet Loom: It is an equivalent to the air-jet only it uses water. It is ideal in the hydrophobic synthetic yarn (as polyester) and it does not apply well in natural fiber and weft yarn that are sensitive to dryness/ dampness.

2.3.3 Importance in Comparative Studies

When trying to compare the characteristics of fabrics, in order to isolate the effects of the weft yarns it is crucial to use the similar type of loom and to keep the same machine settings. The difference in insertions mechanisms, tensions usage and beat up force amongst looms can make huge difference in fabric properties like strength, GSM and the texture. Thus, this research work uses only one kind of shuttle less loom to preface the validity of comparison analysis based on fixed machine parameters.

Due to the familiarity with the mechanics of various loom types, the researchers and manufacturers will be able to find better harmony between the choice of a machine and flexibility of material, particularly in cases when they aim at investigating how various weft yarns may influence the performance of fabrics.

2.4 Common Weave Structures

The weave construction of cloth the arrangement of the fibers constituting the warp and weft in a piece of material is called the weave construction. Out of the many factors that determine the performance of a woven fabric, the weave type has been shown to be very critical in the determination of the strength property; flexible property; drape property; appearance property; porosity property; and dimensional stability property. Although the current research is based on the investigations of the comparative behavior of fabrics with the different weft yarns, woven on the same warp and machine, it is essential to comprehend the role of the underlying weave structure of the fabric behavior.

2.4.1 Plain Weave

The most even and basic structure is plain weave where the weft thread passes over 1 warp thread and under the next, then over then under, etc. The fabrics of plain weave are usually very stable in their dimensions, have a good firm texture, and are not snagged easily because of high frequency of interlacing. They might however be less droppable and less breathable than other, more open structures. Plain weave serves as a standard structure in comparative experiments, and is more predictable with varied yarns, because of its uniformity of fabric response to yarn variation.

2.4.2 Comparative Implications

In this research, uniformity of weave structure will be used in order to make closer comparisons of the effects of different weft yarns in the properties of fabrics. In the past, the Weft fiber type, yarn count or yarn twist fibers proved to have a lot of influence on properties which include tensile strength, tear strength etc. even when the weave pattern is still. In this way, the behavior and nature of the common weave's structures are imperative in the analysis and isolation of the effect of variation of the weft yarn. The same information is also used to make more informed decisions in terms of product development whereby a particular end-use performance requirement will help determine the weave and yarn combination.

2.5 Characteristics of Woven Fabrics

Weave structure A characteristic of a fabric, weave structure is the precise arrangement in which yarns of the warp and the weft pass or interconnect. Among other factors that induce performance in woven fabrics, the weave design is the key contributor to properties like tensile strength, flexibility, drape, appearance, and porosity of the material alongside with dimensional stability. Although, as noted, this research paper is intended to examine the relative performance of fabrics produced with alternative weft yarns produced in the same warp and machine setup, it is important to be able to ascertain how the inherent weave structure influences behavior of the fabric.

2.5.1 Plain Weave

The simplest and most even structure is the plain weave in which each weft warp alternates over and under the next warp. Plain weave fabric fabrics are usually of high dimensional stability, of some firm tube, and snag-resistant because of their high frequency of interlacement. They might however be less drapable and breathable than are more open structures. Because plain weave is regular and predictable in a way as to how the fabric is to behave in various yarn conditions, it finds its frequent application as a basic structure in comparative studies.

2.5.2 Comparative Implications

Within the framework of the present study, a single-patterned weave can be chosen, so that the impact of weft yarn on the characteristics of fabrics can be compared in a concentrated manner. Other studies have indicated that though a weave pattern is fixed, modification in yarn type, yarn count or yarn twist might have a considerable impact e.g. on properties like tensile strength, tear strength etc.

2.6 Importance of Yarn Properties in Weaving

The qualities of the woven fabrics largely depend on the quality of the yarns which are utilized in making them and the performance qualities of the woven fabrics as well. Both warp and weft yarns play a role in the structure of the fabric, however the difference in the personality of the weft yarn is commonly associated with significant change in the fabric behavior, which occurs frequently when the condition of warp and machine stays unchanged.

- ❖ **Yarn Properties and Their Role in Fabric Formation**

The most important yarn parameters namely fiber composition, yarn count (linear density), the level of twist, hairiness, and yarn structure of spun/filament contribute to the critical role performed by a yarn in how it will behave during weaving, and the resultant end-use performance of the fabric. The strength, stretch and flexibility of the yarn and its tendency to friction has on the efficiency of weft-insertion efficiency and fabric uniformity. As an example, cotton yarns are soft, absorb moisture and breathe, which is why they take on great responsibility in apparel manufacturing. Conversely, man-made fibers like polyester do not have moisture regain, they are stronger, and their dimensions retain better shape, thus indicative of better industrial and technical fabrics.

- ❖ **Number and Amount of Twist of Yarn**

Yarn count is very crucial when determining the weight, cover factor and air permeability of resulting fabric. The more breathable fabrics are more often developed with the usage of thinner yarn but stronger and higher GSM is also rather done with usage of coarser yarn. The twist also defines the characteristics of the fabrics like roughness, strength and abrasion high twist of the alpaca makes yarn compact and strong and low twist makes lighter and fluffy cloth. The twist direction (S or Z) has also the ability to govern the hand and beauty of the end product of the fabric which continue as the end product fabrics.

- ❖ **Spun vs. Filament Yarn Design**

The actual way in which the yarn is put together i.e. spun (a yarn made of short staple fiber) versus filament (a yarn made of continuous fiber) actually does play an enormous part in the performance of the weaving as well as the concern of the aesthetics of the appearance of the fabric. Spun yarns are inclined to produce fabrics that are textured, more absorbent and have soft handles, but filaments lack such features and as such fabrics produced in filament yarns are smooth and lustrous and more wear resistant and are less hairy.

- ❖ **Weaving and Weaving Effective Proprieties of Yarn**

Besides the fabric performance, the yarn performance has a direct result on the efficiency of the weaving process. There are failures in insertion of the weft, high breakages and interruptions in the machine caused by severe hairiness and low strength and yarn structure irregularity. The smoothness of the yarn and strength would assist in minimizing the quantity of friction, improved shed formation, in addition to giving even beat-up in processing the yarn during weaving process.

2.6.1 Warp Yarn Requirements

Warp yarns comprise part of the basic unit which forms woven fabric. They are the threads, which run lengthwise of the fabric and are constantly under strain and a mechanical force in the process of being woven. As opposed to the weft yarns which can be inserted occasionally, the warp yarns are also tied on the loom throughout the weaving process. Consequently, they have to support stringent mechanical and structural specifications so as to guarantee material integrity of fabric as well as efficiency of machines.

- **Structural and Mechanical Requirements of Warp Yarns**

The warp yarns should be of high tensile strength, should have uniform linear density, low hairiness, sufficient elongation and should be abrasion resistant. Such qualities are fundamental since the warp yarns need to withstand repetitive stress when they are used during processes like shedding, picking and beating-up. The breakage of yarns, downtimes and fabric irregularities due to faults in the quality of warp yarns are frequent occurrences if there is any fluctuation in the quality of yarn or some weakness in it.

- **Warp Yarn Preparation: Importance of Sizing and Winding**

The warp preparation stage is a vital stage before weaving and the preparation includes activities such as winding, warping and sizing. Sizing, especially improves the value of abrasion resistance and strength of yarns adding a coating, generally of synthetic polymers. Such coating decreases yarn hairiness and defeats friction with the loom components.

2.7 Weft Yarn Requirements and Influence

Weft yarns are very crucial in the determination of the structural, mechanical, and beauty features of woven cloth. Weft yarns have an advantage over warp yarns, in that, they do not need to be as strong as their counterparts need to be during the weaving operation, and hence can yield a wider spectrum of physical qualities. Nevertheless, they do affect the fabric property, i.e., tensile strength, air permeability, drape and softness, and dimensional stability, particularly when the conditions tilt towards regulated warp and machine settings.

2.7.1 Requirements of Weft Yarns in Weaving

To have effective performance in the weaving process, weft yarns should meet a number of requirements, especially in the modern high-speed looms such as the rapier and air-jet looms. The basic ones are:

- **Flexibility and Smooth Surface**: To enable it to move freely in the shed against snagging warp yarns.
- **Sufficient Strength**: The Weft yarns do not have to be so strong as the warp yarns, but should still be able to resist abrasion during insertion.
- **Equal Linear Density**: So that there would be uniform texture and appearance of the fabrics.
- **Minimal Hairiness**: This is of key concern to air-jet looms which otherwise create entangled and loose air flows.
- **Compatibility with Warp Yarns**: Compatibility-in-warp-yarns: twist compatibility, compatibility-in-shrinkage-behavior and compatibility-in- stretchability to produce balanced fabric behavior.

Such necessities affect not only the level of efficiency in production but also the final performance quality of the woven cloth. [7], [8]

2.7.2 Influence of Weft Yarn Type on Fabric Properties

It has been noted in many research articles, that even applying a fixed warp structure and uniform machine streams, and by switching the type of weft yarn alone radically changes fabric response. Natural fiber cotton, e.g. yarns, generate superior moisture absorption, air permeability and comfort. The yarn count, the degree of twist and the type of fiber of the weft yarn has a direct influence on the measurable fabric characteristics like:

- **Tensile strength (ISO 3303-1)**
- **Tear strength (ISO 13937-1)**
- **Fabric weight (ISO-3801)**
- **EPI & PPI**
- **Single yarn strength (ISO 3303-1)**

Using standardized testing methods ensures that the fabric variations observed are truly due to the weft yarn differences, not inconsistencies in warp or loom parameters.

2.7.3 Significance in Controlled Comparative Studies

When evaluating fabric comparisons, as the current one is doing standardizing the warp/weaving environment is imperative in order to properly evaluate the role of the weft yarns. Through this we are able to remove confounding variables and become able to specifically target the effect that material properties like fiber type, yarn count, and the proportion of materials used in a blend have on outcome such as comfort, strength, and the density of the fabric. The method would enhance doing not only quality control and textile design optimization in the textiles manufacturing sector but also help make a more sustainable material choice because of its ability to determine the efficient yarn chosen according to the specific end-use demands.

2.8 Overview of Fibers Used for weft Yarns

Cotton product is one of the most popular natural substances in the world textile industry, which is light, airy and comfortable. It is important in the manufacturing of woven fabrics especially garment and home textiles. Cotton applied as weft yarn gives the piece of clothing many positive features including the ability to absorb moisture, a light fluffy feel, and skin-friendly. When the effect of other weft yarns is studied in the same warp and machine then it is imperative to understand the intrinsic nature of cotton fibers in order to decode behaviors of fabrics.

2.8.1 Structure and Properties of Cotton Fiber

Cotton is a cellulose fiber produced by seed hairs of the cotton plants. It naturally has a zig zag structure and some flatness like a ribbon that makes it spin easily and moderately strong. Fiber length (staple length), fineness, and maturity have strong influence on the quality of yarn and the yarn quality influences the mechanical and aesthetics qualities of a woven material.

The natural structure of cotton is hydrophilic; cotton can absorb water up to 8-10 percent of the weight without becoming wet and therefore cotton can be used in clothing and home fabrics as weft yarns. Its weak nature and capacity to keep the body temperature high contributes to fabric comfort, particularly, being compared to the synthetic fibers.

2.8.2 Suitability of Cotton as Weft Yarn

Cotton yarns (woven as weft) add to the drape as well as hand feel and breathability of fabrics that are woven. They can be used with most weave constructions and can be used with most loom types, but might tend to break in high-speed air-jet looms, because of a relatively low tensile strength in comparison with synthetic filaments.

2.8.3 Yarn Construction and Fabric Behavior

Efficiency with which cotton performs in the role of weft yarn is not only due to innate characteristics of the monofilament but also depend on such yarn building characteristics as level of twists, number of yarns per unit weight, and spinning method (ring, rotor, compact spinning). An example is the increase in the twist level increases the strength yet decreases softness of a fabric and the lighter the yarn count the higher the air permeability of the fabric. Such yarn qualities have to be taken into consideration when a comparison between the influence of cotton and other types of weft yarns is taken in face of equal weaving conditions.

2.9 Review of Previous Studies

A lot has been done by researchers to understand how the qualities of the yarn affect woven fabrics performance. Nevertheless, majority of the research works have been made on generalized correlations of the relationship between fabric construction and mechanical property without ensuring that all process parameters are controlled. Comparatively, research on specific examination of the influence of weft yarn change with unchangeable warp and machine is somehow small, and there is need to increase more controlled comparative study on this topic.

2.9.1 Influence of Weft Yarn Type on Fabric Properties

Carried out an experiment to test the physical properties (strength, tearing and abrasion resistance) of weft yarn type (cotton), on its influence on physical characteristics. They noticed that the use of polyester weft yarns made the fabric increase in tensile strength and dimensional stability, whereas cotton increased in softness and air permeability. The study however failed to keep the warp parameters or machine settings constant between samples opening the possibility of other variables getting in the way of the research variables. [9]

In the same way, examined the role of fiber type on mechanical characteristics of woven fabrics and found that synthetic yarn added to increased breaking strength as well as resistance to wear. In the experiment listed by the authors, effects of weft yarn were stronger on the elongation characteristics than warp yarns. But differences in density of fabric and finishes were not balanced, which reduces to their accuracy of conclusions. [10]

2.9.2 Studies with Controlled Weaving Parameters

A more controlled version examined fabrics generated using various weft yarns and using a constant weft yarn count and type of yarn used as warp. In their study, it became evident that even in the case of fixed warp condition, the type of weft yarns played an instrumental role in determining the properties like fabric GSM, air permeability, and tensile behavior etc. However, the analysis focused on mere two types of weft yarns and the scope of comparison was narrowed.

2.9.3 Identification of Research Gap

An acute assessment of the above works reveals that there is a great deal of recognition with regards to the effects of weft yarn on fabric characteristics but there are few studies that rigorously account on the warp and machine settings when the different weft yarns are used. Most of the exiting experiments differ in one or more uncontrollable factors, like pick density, loom type, or warp yarn characteristics and this factor can severely bias the results.

Hence this thesis will focus on addressing this gap by conceptualizing an experiment whereby warp yarn count, structure, loom type, weaving parameters and environmental conditions will be kept constant so as to have a clear direct comparison of the influence of different weft yarns on the properties of woven fabrics. The research is an improvement of the earlier research with the added advantage of controlled and focused research to facilitate proper attribution of the weft yarns alone even as the differences in fabric is noted.

Chapter 3: Methodology

3.1 Materials:

3.1.1 Yarns:

- **Warp Yarn:** Material-Cotton (1 Warp yarn was used for all 4 fabrics)
- **Weft Yarn:** Material-Cotton (4 different counts of Cotton weft yarn will be used separately to produce 4 fabrics.)

3.2 Machine and Weaving Parameters:

3.2.1 Parameters and Details:

Parameter	Details
Weaving Machine	**Loom:** Rapier Loom
	Brand: Tsudakoma
	Reed Count: 66
Weaving Process Parameters	**Loom Speed:** 180 ppm
	Weave Design: 2/2

Figure 1: Rapier Loom Machine

3.2.2 Main Parts:

a. Warp Beam
b. Heald/Harness Frame
c. Heald Wires
d. Reed (66 Reed Count)

e. Rapier Mechanism
f. Shedding Mechanism
g. Picking Mechanism
h. Beat-up Mechanism
i. Take-up Mechanism
j. Let-off Mechanism
k. Frame/ Loom Structure
l. Control Panel

3.2.3 Weaving Process:

In this process, pre-beamed cotton warp yarn is mounted on the loom. The rapier loom inserts the weft yarn (of different counts) across the warp threads with high accuracy and speed. The reed with 66 dents per inch keeps the warp threads aligned and helps beat the weft into place. The fabric is woven in a 2/2 weave design at a loom speed of 180 picks per minute, ensuring uniform fabric structure and quality.

3.3 Production of Fabric Samples:

- **Warp Preparation :** Pre-beamed warp used
- **Weaving of Samples :** Number of Samples: 4

3.4 Test Methods and Testing Machines:

3.4.1 Determination of EPI:

EPI (Ends Per Inch) refers to the number of warp yarns present in one inch of woven fabric, measured along the fabric's width (warp direction).

Machine name: Thread Counting Glass

To determine EPI:

a. A counting glass or pick glass (magnifying glass with marked scale) is placed over the fabric.
b. A known length (usually 1 inch) is selected in the warp direction.
c. The number of warp threads crossing within that length is counted carefully.
d. Multiple readings are taken at different places on the fabric and the average is calculated for accuracy.

Figure 2: Counting Glass

3.4.2 Determination of PPI:

PPI (Picks Per Inch) refers to the number of weft yarns inserted per inch of woven fabric, measured along the fabric's length (weft direction).

Machine Name: Thread Counting Glass

To determine PPI:

a. A pick glass is placed over the fabric in the weft direction.
b. A known length (usually 1 inch) is selected along the weft direction.
c. The number of weft threads (picks) within that length is counted precisely.
d. Multiple readings are taken from different areas and an average is taken to ensure consistency.

3.4.3 Determination of Fabric Weight (GSM):

The mass per unit area (GSM) of a fabric can be determined accurately by following standardized methods.

Machine Name: GSM Cutter

Standard: ISO 3801

This International Standard specifies methods for determining the mass per unit length and mass per unit area of fabrics.

Standard Atmosphere for Conditioning and Testing:
The atmosphere for conditioning and testing textiles is defined according to ISO 139, which specifies a relative humidity of 65 ± 2% and a temperature of 20 ± 2°C.

To Determine GSM:
A fabric specimen is first conditioned in the standard testing environment. Using a GSM Cutter, a precise circular specimen is cut. The specimen is then weighed using a digital balance.
Formula: gram * 885dia con.

Figure 3: GSM Cutter

Figure 4: Weight Balance Machine

3.4.4 Determination of Tensile Strength Test:

Machine name: James Heal (Universal Strength Tester)

Standards: ISO 3303-1

Figure 5: James Heal (Universal Strength Tester)

Method of Determine Tensile Strength:
The sample of fabric material is cut off in the required size, as defined at the standard. The sample is then clamped between the upper jaws and the lower jaws of the Universal Strength Tester. Until breaking the sample a constant rate of extension is maintained. A measure of the greatest force directed to rupture the sample is registered as tensile power. Several samples of the test are taken and then the mean of the value is taken to get accuracy.

3.4.5 Determination of Tear Strength Test:

Machine name: Elmendorf Tear Tester
Standards: ISO 13937-1

Figure 6: Elmendorf Tear Tester

Method of Determine Tear Strength:
The sample of a fabric is cut into the necessary size and a small pre-thickening is performed to begin the tear. The specimen is then clamped on the Elmendorf Tear Tester. The pendulum is unleashed and used to rip through the fabric on the cut fiber. The force of tearing can be showed directly on the strain gauge on the test scale, or on the digital display of the test instrument. To determine the results properly the same test is again done in warp and weft directions and the average tear strength is determined.

3.4.6 Determination of Single Yarn Strength Test:

Machine name: James Heal (Universal Strength Tester)

Standards: ISO 3303-1

Method of Determine Single Yarn Strength:

A single yarn specimen is prepared with a specified length according to the standard. The yarn is mounted carefully between the upper and lower jaws of the Universal Strength Tester, ensuring it is straight and free from slack. A constant rate of extension is applied until the yarn breaks. The maximum force required to break the yarn is recorded as the single yarn strength. Multiple yarn specimens are tested, and the average value is calculated to ensure reliable results.

Chapter 4: Result and Discussion

4.1 Test Results

The test results are shown here following the completion of testing (EPI & PPI, GSM, Single Yarn Strength, Tensile Strength & Tearing Strength) & Yarn Quality in accordance with the previously discussed standards.

4.1.1 EPI & PPI

Table 1: EPI & PPI Test Result

SL No	EPI	PPI
1	61	26
2	61	31
3	61	34
4	61	25

4.1.2 GSM

Table 2: GSM Test Result

SL No	Fabric Type	Weight	GSM
1	Denim	0.22	195
2	Denim	0.20	177
3	Denim	0.18	159
4	Denim	0.16	141

4.1.3 Single Yarn Strength

SL No: 1

Table 3: Single Yarn Strength Test Result SL No. 1

Specimen	Max Force(N)	Max Tenacity	Extension%
1	11.38	-	6.871
2	12.39	-	7.618
3	11.10	-	7.166
Mean	11.59	-	7.608

SL No: 2

Table 4: Single Yarn Strength Test Result SL No. 2

Specimen	Max Force(N)	Max Tenacity	Extension%
1	7.514	-	4.966
2	8.195	-	5.079
3	8.189	-	5.575
Mean	7.966	-	5.207

SL No: 3

Table 5: Single Yarn Strength Test Result SL No.3

Specimen	Max Force(N)	Max Tenacity	Extension%
1	7.089	-	6.269
2	6.919	-	5.775
3	6.635	-	6.174
Mean	6.881	-	6.072

SL NO: 4

Table 6: Single Yarn Strength Test Result SL No.4

Specimen	Max Force(N)	Max Tenacity	Extension%
1	10.74	-	14.17
2	10.36	-	13.78
3	10.05	-	12.76
Mean	10.38	-	13.57

4.1.4 Tensile Strength

SL No: 1

Warp Result:

Table 7: Tensile Strength Test SL No.1 Warp Result

Specimen	Maximum Force(N)	Elongation at Max Force (%)
1	482.19	15.99
2	481.39	16.66
3	451.64	16.37
Mean	471.74	16.34

Weft Result:

Table 8: Tensile Strength Test SL No.1 Weft Result

Specimen	Maximum Force(N)	Elongation at Max Force (%)
1	342.47	17.58
2	376.74	17.24
3	415.37	17.57
Mean	378.19	17.46

SL No: 2

Warp Result:

Table 9: Tensile Strength Test SL No.2 Warp Result

Specimen	Maximum Force(N)	Elongation at Max Force (%)
1	428.75	12.03
2	425.85	11.57
3	424.39	12.16

Mean	426.33	11.92

Weft Result:

Table 10: Tensile Strength Test SL No.2 Weft Result

Specimen	Maximum Force(N)	Elongation at Max Force (%)
1	317.70	17.87
2	328.36	18.04
3	326.02	17.53
Mean	324.03	17.81

SL No: 3

Warp Result:

Table 11: Tensile Strength Test SL No.3 Warp Result

Specimen	Maximum Force(N)	Elongation at Max Force (%)
1	439.71	9.827
2	441.79	9.950
3	407.63	9.034
Mean	429.71	9.604

Weft Result:

Table 12: Tensile Strength Test SL No.3 Weft Result

Specimen	Maximum Force(N)	Elongation at Max Force (%)
1	243.53	17.49
2	213.84	18.33
3	184.88	17.70
Mean	214.08	17.84

SL No: 4

Warp Result:

Table 13: Tensile Strength Test SL No.4 Warp Result

Specimen	Maximum Force(N)	Elongation at Max Force (%)
1	344.63	7.741
2	395.53	8.116
3	395.62	6.993
Mean	378.51	7.617

Weft Result:

Table 14: Tensile Strength Test SL No.4 Weft Result

Specimen	Maximum Force(N)	Elongation at Max Force (%)
1	301.59	27.24
2	307.90	26.70
3	297.13	26.95
Mean	302.21	26.96

4.1.5 Tearing Strength

Table 15: Tearing Strength Test Result

SL No	Fabric Type	Warp	Weft
1	Denim	40	36
2	Denim	59	44
3	Denim	50	30
4	Denim	57	64<

4.2 Discussion Based on Test Results

4.2.1 EPI & PPI

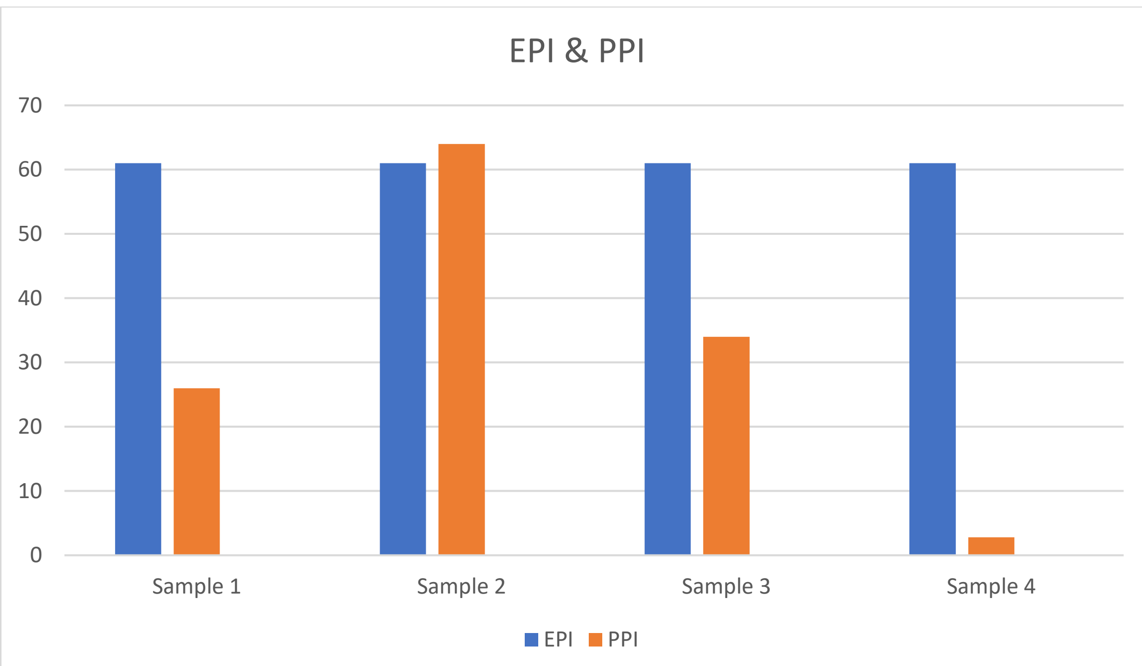

Figure 7: EPI & PPI Graph Discussion

Discussion: According to data we can see the EPI & PPI for the $sample we got. We found that every sample has the same EPI which is 61 but we can see the difference in PPI. In sample 1 we found the PPI is 26, in sample 2 PPI is 61, in sample 3 PPI is 34 and the sample 4 has PPI 25.

4.2.2 GSM

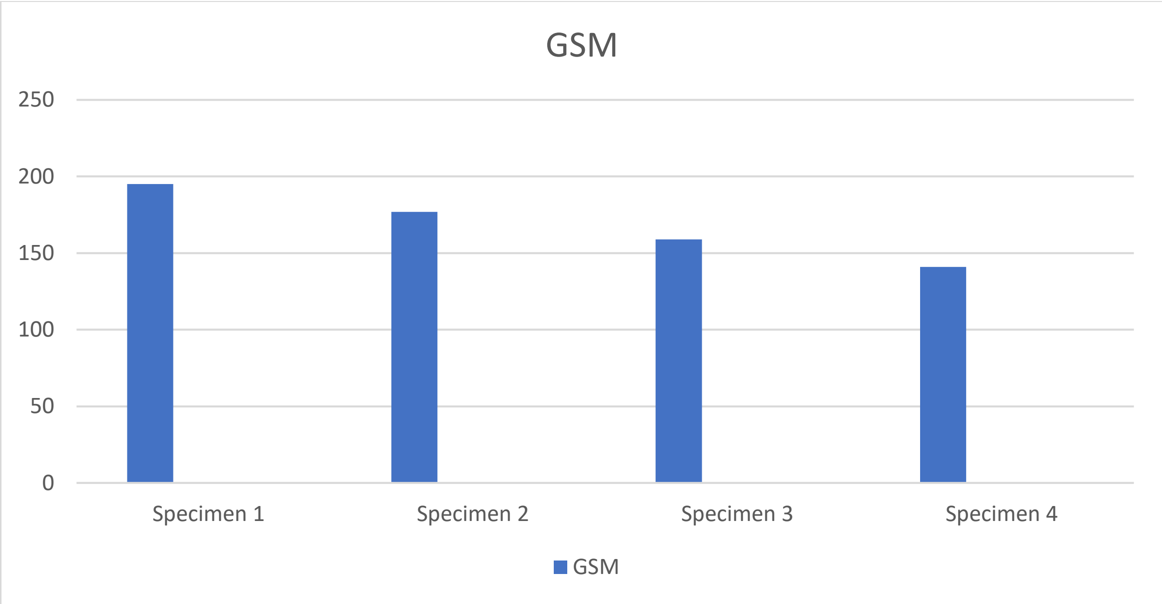

Figure 8: GSM Graph Discussion

Discussion on GSM: According to the table there are 4 specimens of different types of fabric. The first specimen weight 0.22 and its GSM is 195. The second specimen weight 0.20 and 177 GSM. The third one has 159 GSM with 0.18 weight and the last one has 141 GSM with 0.16 weight. We found it by multiplying the weight with the constant rate 885.

4.2.3 Single Yarn Strength

SL No: 1

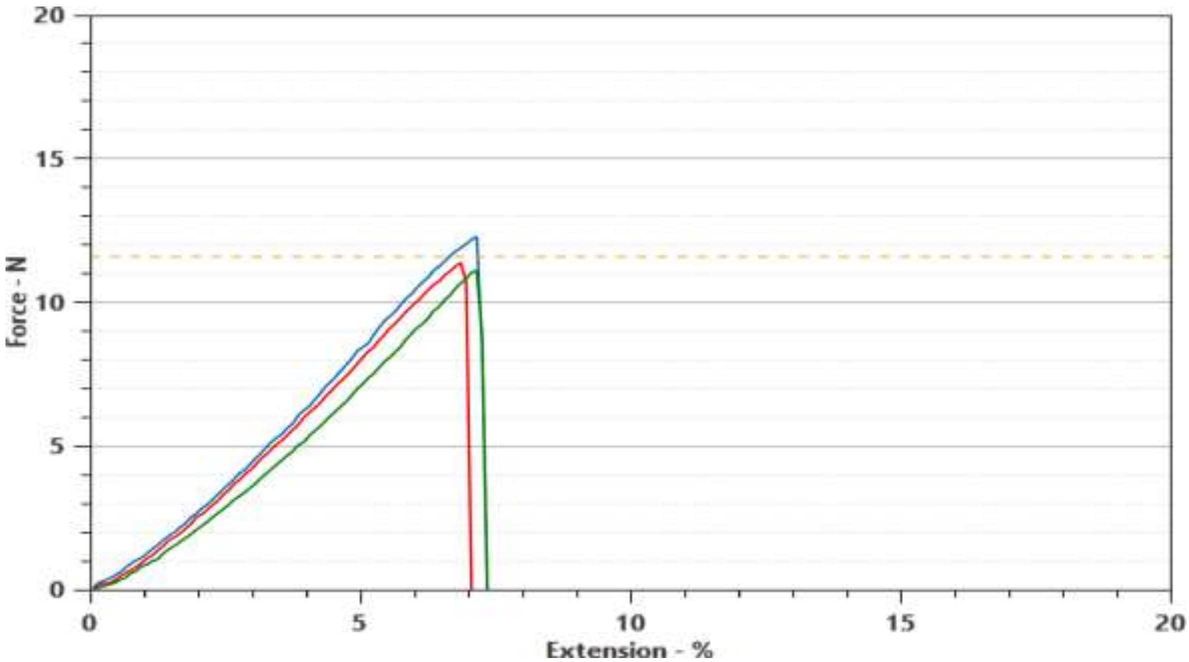

Figure 9:Single Yarn Strength Test SL No.1 Graph Discussion

Discussion SL No 1: According to the graph we can see the result of single yarn strength by showing the force and extension. The first specimen max force is 11.38, the second one is 12.29 and third one force is 11.10 and the extension are 6.871,7.168 and 7.166. We got the mean force 11.59 and the extension is 7.068.

SL No: 2

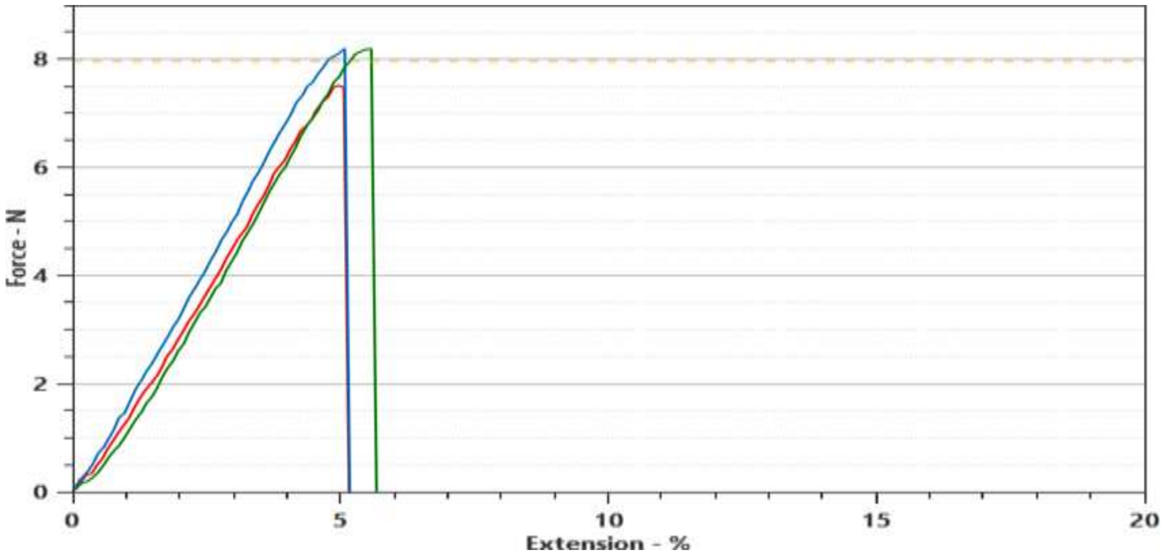

Figure 10: Single Yarn Strength Test SL No.2 Graph Discussion

Discussion SL No 2: According to the graph we can see the result of single yarn strength by showing the force and extension. The first specimen max force is 7.514, the second one is 8.195 and third one force is 8.189 and the extension are 4.966, 5.079 and 5.575. We got the mean force 7.966 and the extension is 5.207.

SL No: 3

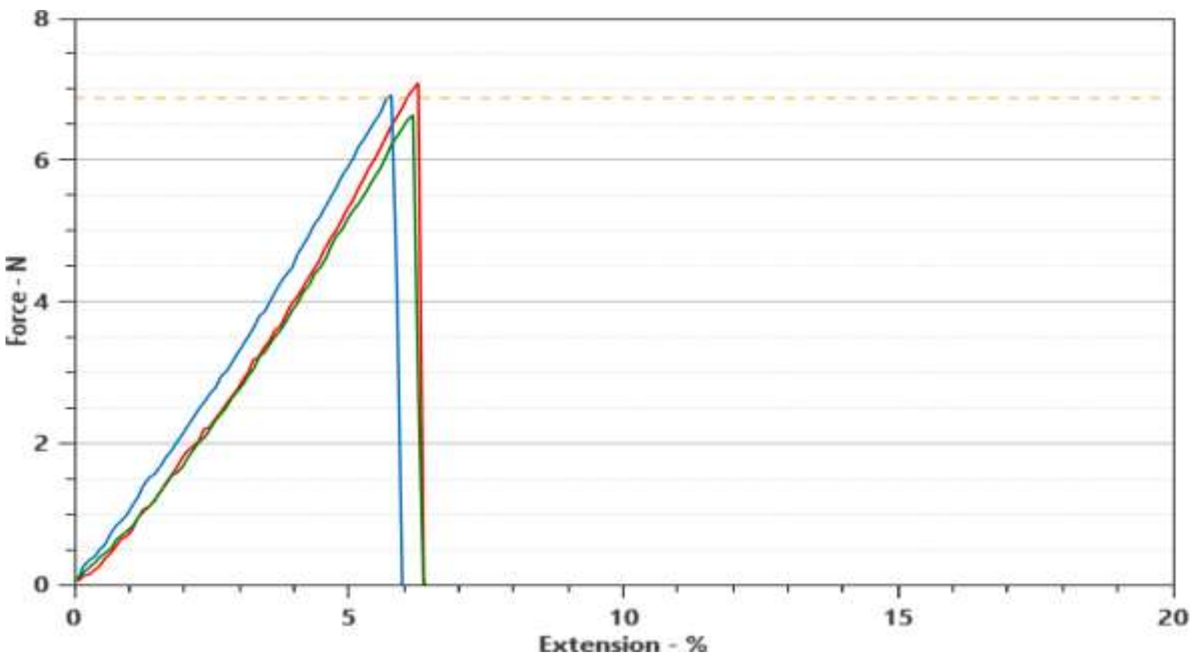

Figure 11: Single Yarn Strength Test SL No.3 Graph Discussion

Discussion SL No 3: According to the graph we can see the result of single yarn strength by showing the force and extension. The first specimen max force is 7.089, the second one is 6.919 and third one force is 6.635 and the extension are 6.269, 5.775 and 6.174. We got the mean force 6.881 and the extension is 6.072.

SL No 4:

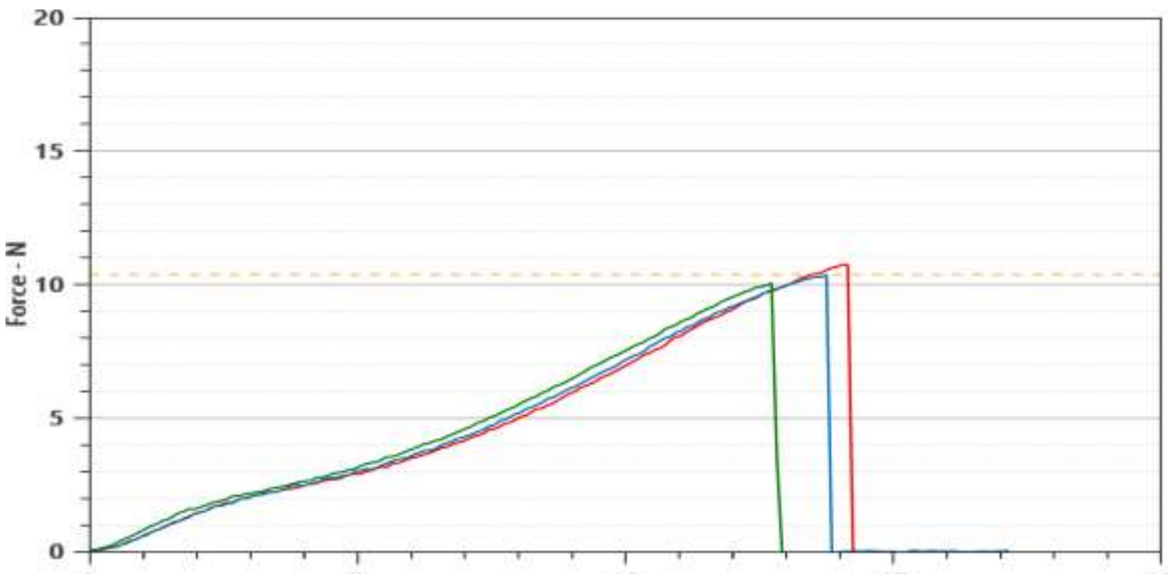

Figure 12: Single Yarn Strength Test SL No.4 Graph Discussion

Discussion SL No 4: According to the graph we can see the result of single yarn strength by showing the force and extension. The first specimen max force is 10.74, the second one is 10.36 and third one force is 10.05 and the extension are 14.17, 13.78 and 12.76. We got the mean force 10.38 and the extension is 13.57.

4.2.4 Tensile Strength

SL No: 1

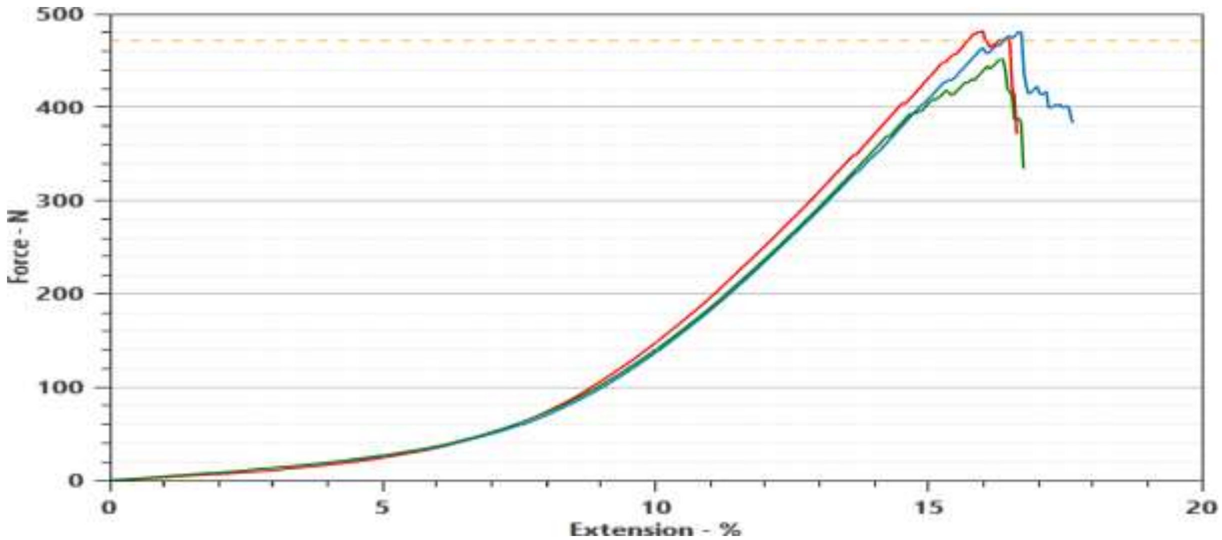

Figure 13: Tensile Strength Test SL No.1 Warp Graph Discussion

Warp Graph:

Weft Graph:

Discussion: Based on graph we can see the result of Tensile Strength of warp and weft for sample

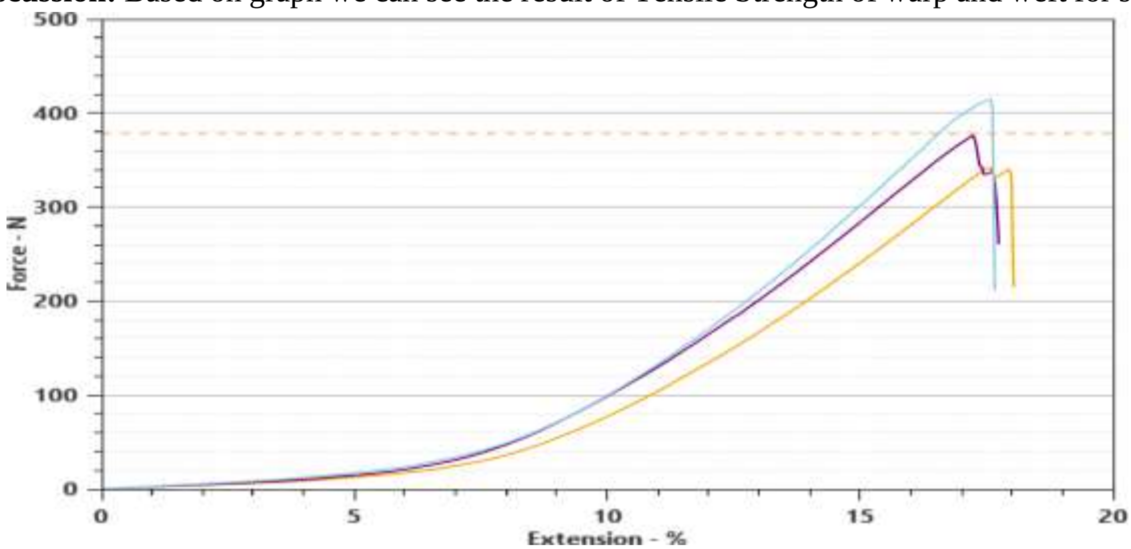

Figure 14: Tensile Strength Test SL No.1 Weft Graph Discussion

1. There are 3 specimens for warp and weft. Their results are for warp force are 482.19, 481.39,

451.74 and elongation are 15.99, 16.66, 16.37. We get the mean force 471.74 and elongation16.34. For the weft we found force are 342.47, 376.74, 415.37 and the elongations are 17.58, 17.24, 17.57. The mean force is 378.19 and elongation is 17.46.

SL No 2

Warp Graph

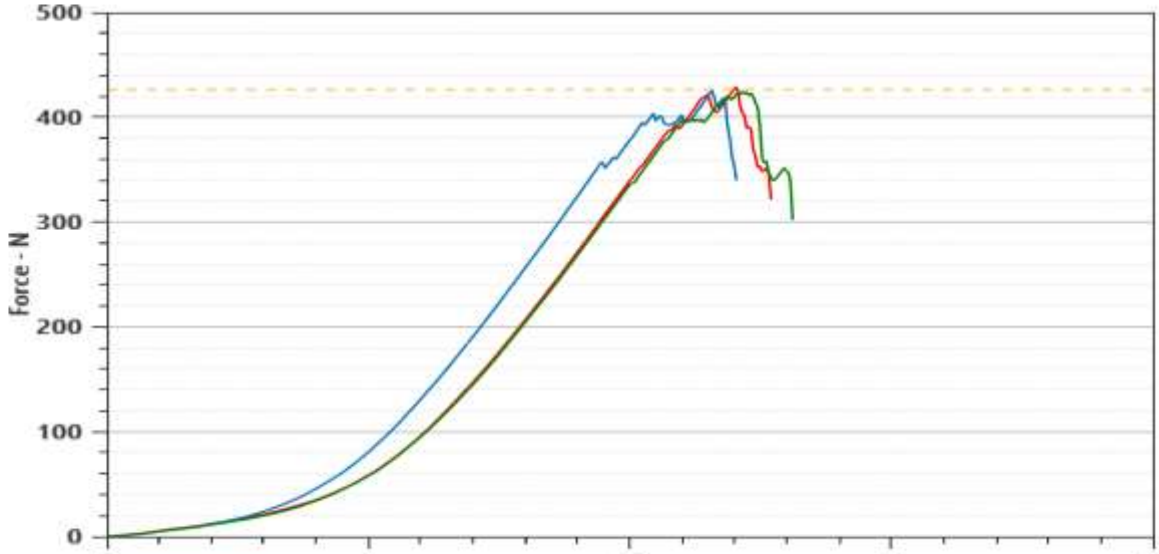

Figure 15: Tensile Strength Test SL No.2 Warp Graph Discussion

Weft Graph

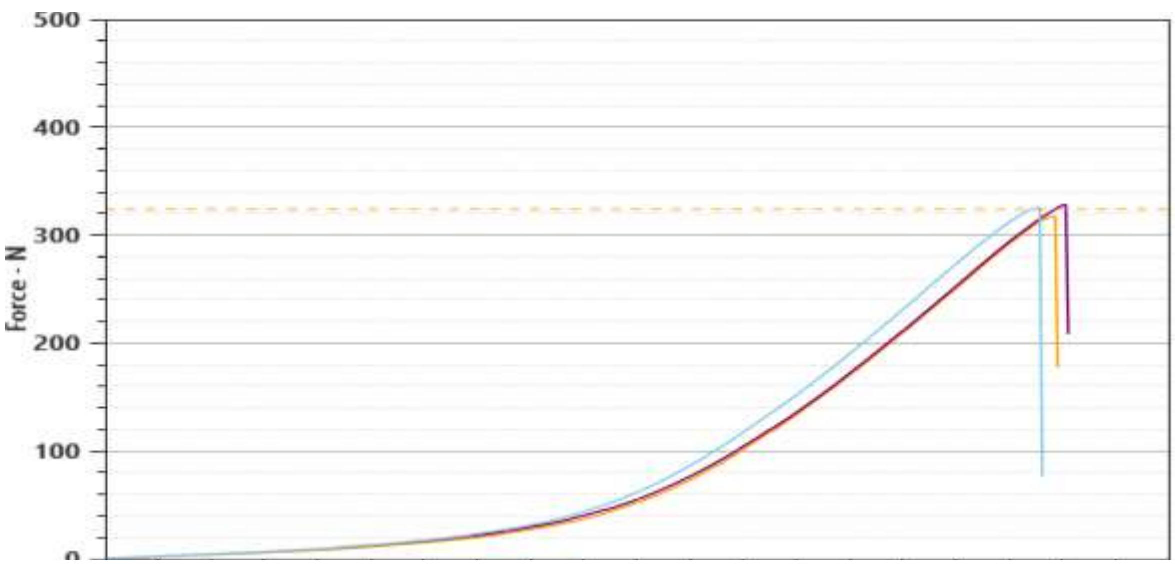

Figure 16: Tensile Strength Test SL No.2 Weft Graph Discussion

Discussion: Based on graph we can see the result of Tensile Strength of warp and weft for sample 1. There are 3 specimens for warp and weft. Their results are for warp force are 428.75, 425.85, 424.39 and elongations are 12.03, 11.57, 12.16. We get the mean force 426.33 and elongation 11.92. For the weft we found force are 317.70, 328.36, 326.02 and the elongations are 17.87, 18.04, 17.53. The mean force is 324.03 and elongation is 17.81.

SL No 3

Warp Graph

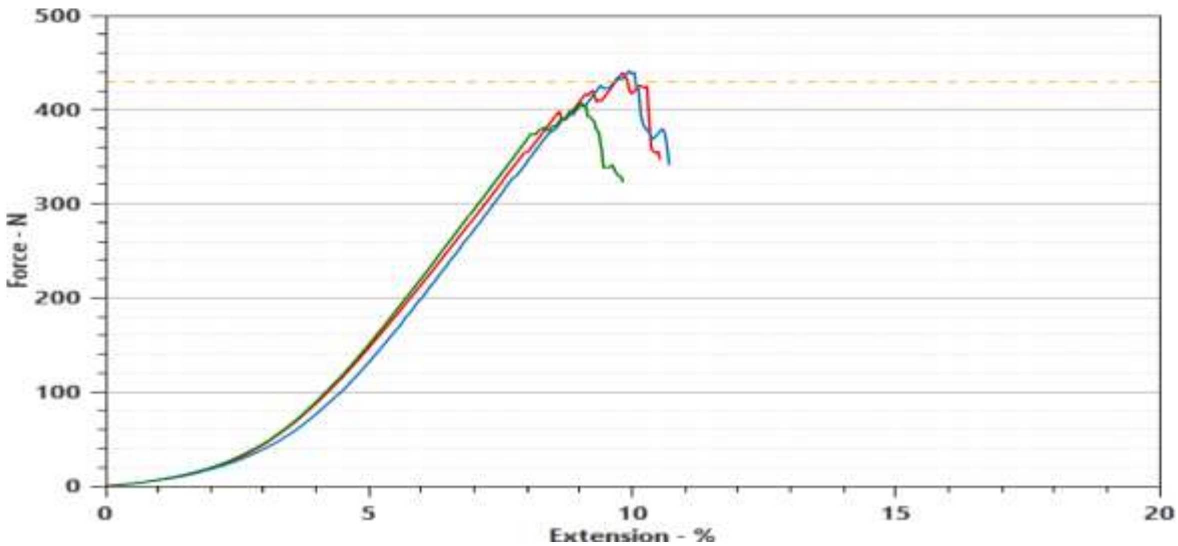

Figure 17: Tensile Strength Test SL No.3 Warp Graph Discussion

Weft Graph

Discussion: Based on graph we can see the result of Tensile Strength of warp and weft for sample

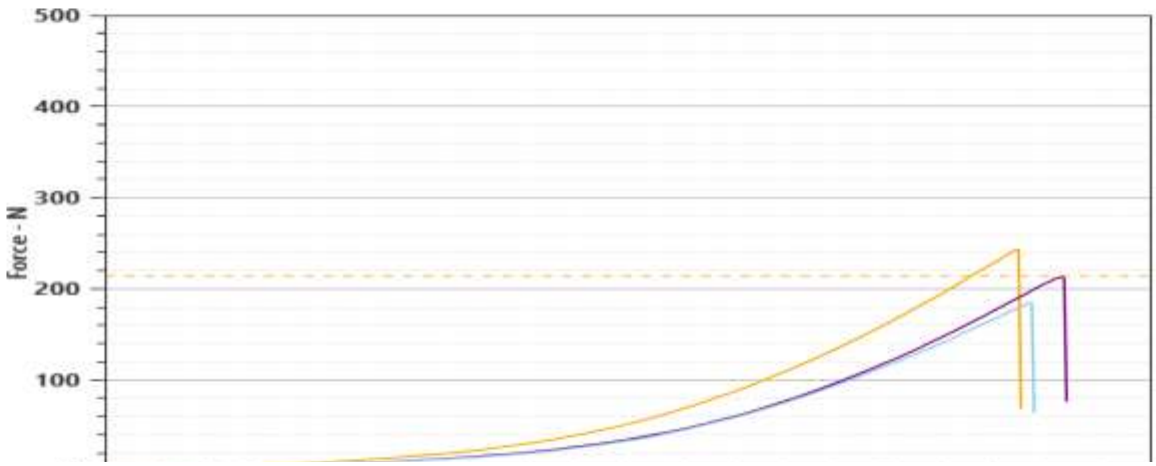

Figure 18: Tensile Strength Test SL No.3 Weft Graph Discussion

1. There are 3 specimens for warp and weft. Their results are for warp force are 439.71, 441.79, 407.63 and elongations are 9.827, 9.950, 9.034. We get the mean force 429.71 and elongation 9.604. For the weft we found force are 243.53, 213.84, 184.88 and the elongations are 17.49, 18.33, 17.70. The mean force is 214.08 and elongation is 17.84.

SL No 4

Warp Graph

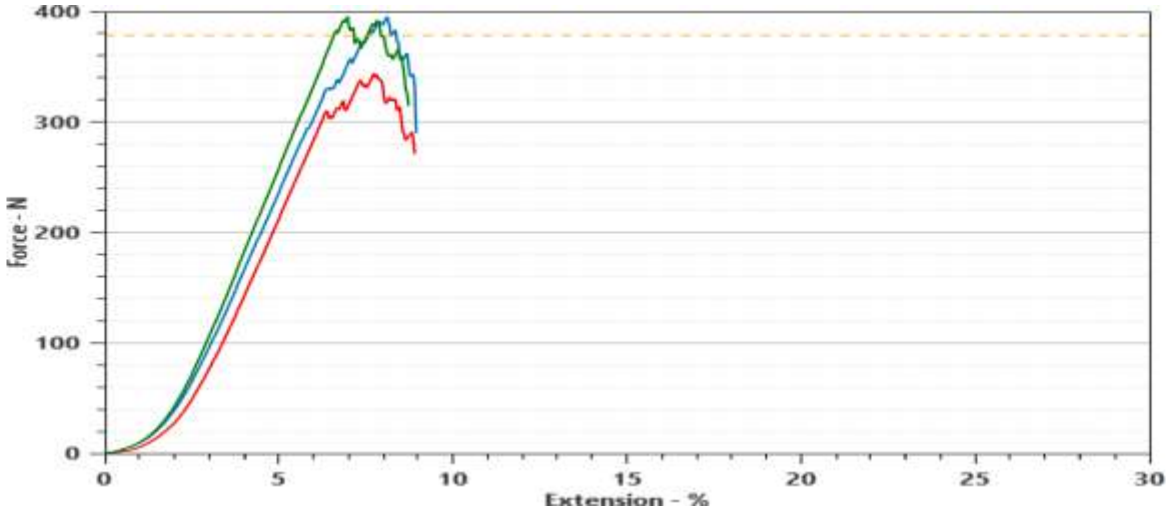

Figure 19: Tensile Strength Test SL No.4 Warp Graph Discussion

Weft Graph

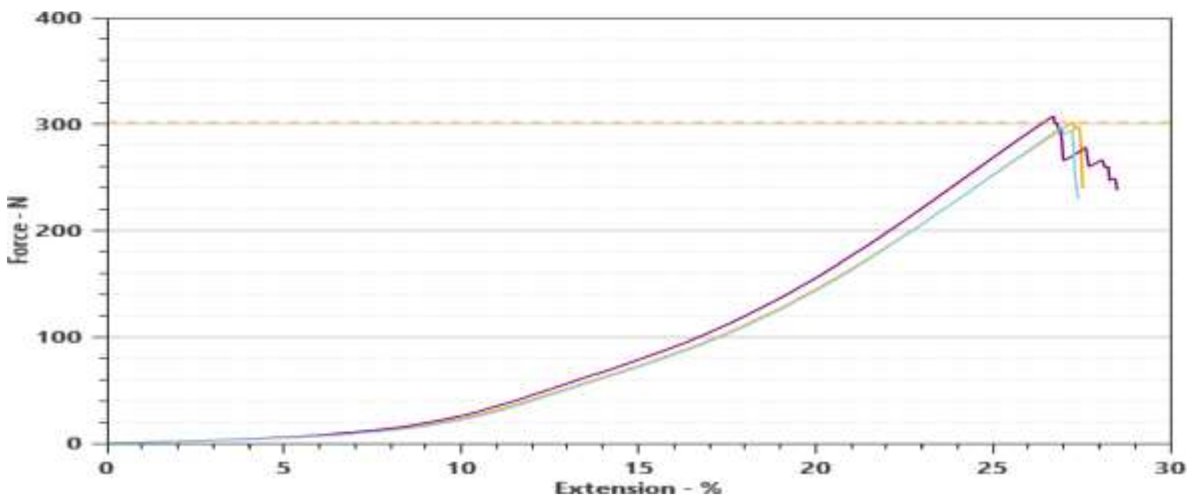

Figure 20:Tensile Strength Test SL No.3 Weft Graph Discussion

Discussion: Based on graph we can see the result of Tensile Strength of warp and weft for sample 1. There are 3 specimens for warp and weft. Their results are for warp force are 344.36, 395.53, 395.62 and elongations are 7.741, 8.116, 6.993. We get the mean force 378.51 and elongation 7.617. For the weft we found force are 301.59, 307.90, 297.13 and the elongations are 27.24, 26.70, 26.95. The mean force is 302.21 and elongation is 26.96.

4.2.5 Tearing Strength

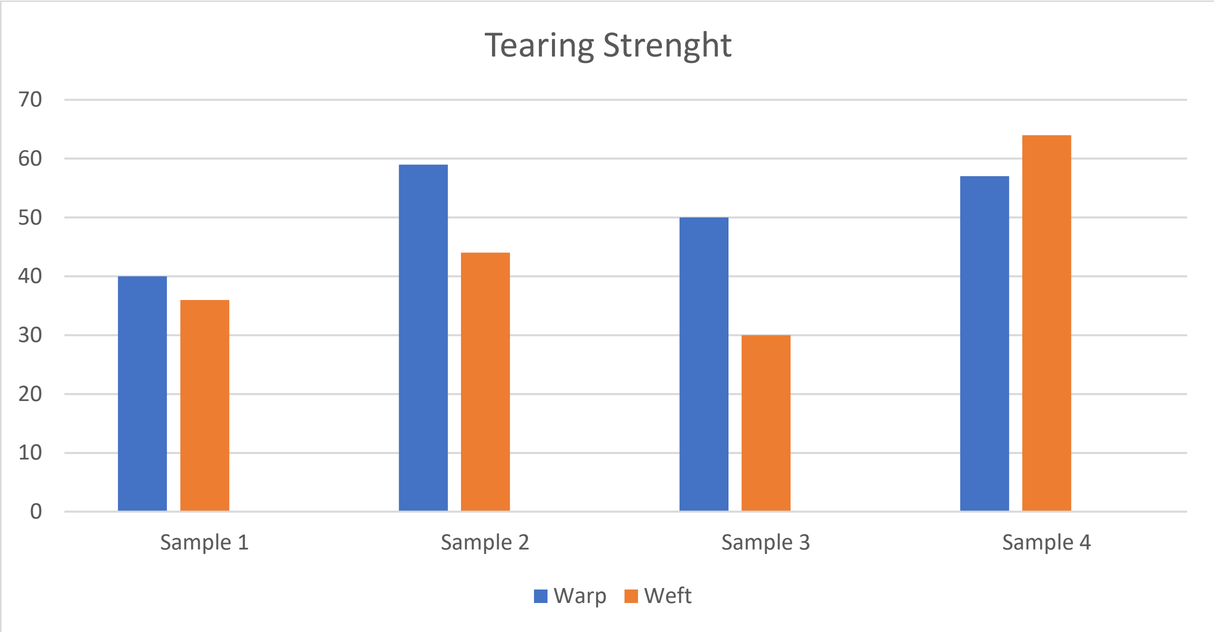

Figure 21: Tearing Strength Test Graph Discussion

Discussion: According to the graph we can see the results of tearing strength for warp and weft. For the sample 1 the tearing strength of warp is 40 and tearing strength of weft is 36. For sample 2 the tearing strength of warp is 59 and tearing strength of weft is 44. In sample 3 we can see the tearing strength of warp is 50 and weft has 30. And the last 4th tearing strength is 57 and weft's tearing strength is greater 64. So, we can get the conclusion that for warp the tearing is of sample 3 is most as it is 50 and for the weft sample 4 has the most tearing strength which is greater than 64.

Chapter 5: Conclusion

5.1 Conclusion:

This study systematically investigated how different weft yarn counts affect the physical and mechanical properties of woven fabrics**,** while keeping warp yarn and loom settings constant. We found that weft yarn count significantly impacts EPI & PPI, GSM, tensile strength, and tearing strength**.** Specifically, we observed varying PPI and GSM directly related to weft yarn changes, along with noticeable differences in both warp and weft tensile and tearing strengths across the samples. By controlling variables, we've provided clear insights into how weft yarn choices influence fabric performance.

5.2 Recommendation:

We recommend textile manufacturers strategically choose weft yarn counts based on desired fabric properties like GSM, tensile strength, and tearing strength. For future research, expanding the study to include diverse weft yarn types (e.g., blends, other fibers) and different weave structures would further enrich the understanding of yarn-fabric relationships. These findings can be directly applied to optimize production and enhance quality control in textile manufacturing.

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