A Study of Awa Shijira Fabric Crepe using Comparison with Plain Fabric

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Abstract : Awa shijira fabric was compared with plain fabric to emphasize its characteristics due to crepe. Results show : 1) Awa shijira fabric did not easily tear in a natural line of fabric in testing of warp tearing strength, but plain fabric tore in testing of warp tearing strength. 2) Thread intersection was less by rib weave in Awa shijira fabric, so warp breaking strength, warp extension percentage, and surface abrasion resistance of Awa shijira fabric was clearly less than those of plain fabric. 3) Compressibility ratio of Awa shijira fabric was more than that of plain fabric. 4) Thickness of Awa shijira fabric was more than that of plain fabric under lighter load and all fabric thickness was similar under heavier load. 5) Awa shijira fabric had bulkiness because of crepe produced by rib weave, so water absorption and drying property of Awa shijira fabric was more than that of plain fabric.

(Received 24 November, 2006 ; Accepted 14 March, 2007)

1. Introduction

Figure 1 shows Awa shijira, a traditional Japanese cotton fabric made in Tokushima, Japan that combines rib weave and plain weave (Fig. 2) [1, 2]. Awa shijira fabric is pleasant to touch, light and comfortable [2, 3]. This fabric feels cool like ramie because it does not cling to sweaty skin [3] and so, Awa shijira fabric is suitable to wear in humid summers in Japan [1, 3].

In the Meiji period (1868-1912), Awa shijira fabric was created and made only by Ms. Hana Kaifu and Mr. Jubei Abe in Awa-han (present Tokushima prefecture) [4]. There was a manufacturing peak near the beginning of 20th century because Awa shijira fabric was used for summer outfits [4, 5]. Later, manufacturing of Awa shijira fabric and other traditional Japanese fabrics declined.

Fig. 1 Awa shijira fabric.

Production of Awa shijira fabric continues in several factories in Tokushima [1, 4, 5]. Because of its appealing crepe, products using Awa shijira fabric are popular souvenirs from Tokushima and the fabric is used for outfits and patchwork quilts [5, 6].

This study focuses on the unique crepe of Awa shijira fabric to try to understand better why this fabric is so attractive. Awa shijira fabric is compared with simpler plain fabric in terms of width, thickness, density, weight, strength, compressive property, shrinkage percentage, water absorption, and drying property.

2. Experiments

2.1 Materials

Samples of Awa shijira fabric and plain fabric (Fig. 3) were supplied by the manufacturer, Nagao-orifu Company. To complete the crepe, in additional processing at the factory, samples were immersed in

Fig. 2 Weave.

Awa shijira fabric Plain fabric
↔: Crepe produced by rib weave

Fig. 3 Samples of Awa shijira fabric and plain fabric.

Table 1 Details of samples (JIS L 1096).

	Awa shijira fabric	Plain fabric
Weight (g/m ²)	108.1	107.8
Thickness (mm)	0.35	0.37
Density warp (1/cm)	30.2	29.2
Density filling (1/cm)	20.3	20.9
Width (cm)	38.3	39.8
Fiber material	Cotton	Cotton
Yarn	Single yarn	Single yarn

Table 2 Testing method.

	Testing method
Weight	JIS L 1096 (1999) 8.4.2
Thickness	JIS L 1096 (1999) 8.5.1
Density	JIS L 1096 (1999) 8.6.1
Width	JIS L 1096 (1999) 8.2.1
Breaking strength	JIS L 1096 (1999) 8.12.1 (A)
Extension percentage	JIS L 1096 (1999) 8.12.1 (A)
Tearing strength	JIS L 1096 (1999) 8.15.5 (D)
Surface abrasion resistance	JIS L 1096 (1999) 8.17.1 (A-1)
Compressibility ratio	JIS L 1096 (1999) 8.18
Compressive elasticity modulus	JIS L 1096 (1999) 8.18
Shrinkage percentage	JIS L 1042 (1992) 6.1
Water absorption rate	JIS L 1907 (1994) 5.1.2

warm water (about 70°C) and dried using a dryer. Details of samples (Table 1) were measured using Japanese industrial standard testing methods. Awa shijira fabric and plain fabric had similar width, thickness, density, and weight.

Desuporu D 550 and filter paper (Type 2) were supplied by Ipposha Oil Industries Co., Ltd. and Toyo Roshi Kaisha, Ltd., respectively.

2.2 Testing methods

Table 2 shows Japanese industrial standard testing methods used in this study.

2.3 Scanning electron micrography

Scanning electron micrographs of samples were taken using an S-4300 field emission scanning electron microscopy (Hitachi, Ltd., Japan).

2.4 Thickness, load

Relationship between thickness and load was examined using a compressive elasticity tester (Matsuseiki Co., LTD., Japan). Thickness of three layers of cloth samples was measured after compression for one minute and single layer thickness was calculated by dividing measurements by three.

2.5 Water absorption rate, drying rate

To measure water absorption rate, samples were immersed in 2 g/L Desuporu D 550 liquor with 30 : 1 liquor ratio (95 °C) for 20 minutes, washed three times using distilled water (20 °C) and once using hot distilled water (80 °C), and dried at room temperature as a pretreatment. The distance between the liquor level and the limit of liquor infiltration was measured after 10 minutes to evaluate the water absorption rate. The averages of 5 measurements of warp direction and the averages of 5 measurements of weft direction were calculated.

Water absorption rate and drying rate were evaluated at room temperature (20 °C, humidity ; 65%). Moisture percentage was calculated :

$$\text{Moisture percentage (\%)} = 100 (B-A) / A \quad (1)$$

Measurements were repeated three times in order to calculate average values. Samples were cut into pieces (8cm × 8cm) and weight A was measured. Pieces were arranged on 4 layers of filter paper and 0.5cc distilled water was dropped using a dropper. After one minute, weight B was measured. Weight B was re-measured at one minute intervals for 71 minutes.

3. Results and Discussion

3.1 Scanning electron micrography

Crepe is usually produced by hard twist yarn [4]. Three warp yarns in rib weave produced the crepe characteristic of Awa shijira fabric ; plain weave had no crepe (Fig. 4). Yarn twist in Awa shijira fabric and plain fabric was similar.

3.2 Breaking strength, extension percentage, tearing strength, abrasion resistance

Practical use for fabric is determined by characteristics such as breaking strength, extension percentage, tearing strength, and abrasion resistance (Fig.5). Tearing strength and abrasion resistance relate to fabric endurance [7].

Awa shijira fabric had 13.6% less warp breaking strength than plain fabric and 13.4% less weft breaking

Awa shijira fabric

Plain fabric

Fig. 4 Micrographs of Awa shijira fabric (crepe) and plain fabric (no crepe).

strength than plain fabric. Thread intersection in rib weave of Awa shijira fabric was less than that in plain fabric, so Awa shijira fabric had less resistance against breaking and less strength than plain fabric. In both fabrics, warp was stronger than weft because warp density was higher than weft density.

Awa shijira fabric had 33.3% less warp extension than plain fabric because warp thread in rib weave of Awa shijira fabric was heavier and consisted of three threads. Awa shijira fabric had 40.6% more weft extension than plain fabric because of less intersection resistance of weft threads.

Warp tearing strength of Awa shijira fabric could not be measured easily because the fabric could not be torn. Weft tearing strength could be measured because a single thread could tear easily along a natural line of fabric. Warp and weft tearing strength of plain fabric could be measured. Awa shijira fabric had 38.5% more weft tearing strength than plain fabric because three threads provided more resistance against tearing.

Because thread intersection in rib weave of Awa

Fig. 5 Breaking strength, extension percentage, tearing strength, and surface abrasion resistance.

shijira fabric was less than that in plain fabric, resistance against rubbing was less. So, Awa shijira fabric had 18.4% less surface abrasion resistance than plain fabric.

3.3 Compressibility ratio, compressive elasticity modulus

Fabric for outfits often requires higher compressibility ratio to flex [8]. Fiber material with poorer compressibility ratio has less change of air content and warmth retaining property and is generally harder [9]. Compressive elasticity modulus refers the rate of return to original thickness after compression and decompression [10]. Higher rate of compressive elasticity modulus means less variation of air content and less variation of warmth retaining property [11].

Figure 6 shows compressibility ratio and compressive elasticity modulus. Compressibility ratio of Awa shijira fabric had more than 3 times higher than in that of plain fabric because of bulkier crepe. Awa shijira fabric had 22.0% less compressive elasticity modulus than plain fabric, showing that the crepe was less elastic.

3.4 Thickness, load

Figure 7 shows that, under weaker load, Awa shijira fabric was thicker than plain fabric because thickness depended mostly on crepe. Under stronger load, thickness of samples was similar. Relationship between thickness and load depended on weave. In 2.1, Awa

Fig. 6 Compressibility ratio and compressive elasticity modulus.

Fig. 8 Shrinkage percentage.

Fig. 7 Thickness and load.

Fig. 9 Water absorption rate.

shijira fabric was thinner than plain fabric under load 240 gf/cm² but in 3.4, Awa shijira fabric was thicker than plain fabric under load 237.5 gf/cm². Load was similar and experimental results were different because of measurement errors. Results of the experiments in 2.1 and 3.4 were not contradictory.

3.5 Shrinkage percentage

Awa shijira fabric had 84.6% more warp shrinkage than plain fabric (Fig. 8). Plain fabric had no weft shrinkage. These differences were produced by less shrinkage resistance because three warp threads intersected with a single weft thread in Awa shijira fabric.

3.6 Water absorption rate, drying rate

Awa shijira fabric had 43.8% higher warp absorption rate and 9.2% lower weft absorption rate than plain fabric (Fig. 9). Because warp thread in rib weave of Awa shijira fabric consisted of three yarns, there was less thread intersection. So Awa shijira fabric had less resistance against water absorption than plain weave.

Water is dropped on Awa shijira fabric. After one minute, moisture percentage of Awa shijira fabric was 58.0% more than that of plain fabric (Fig. 10). After 71 minutes, moisture percentage of Awa shijira fabric was

Fig. 10 Moisture percentage and time.

35.9% less than that of plain fabric (Fig. 10). Awa shijira fabric could absorb more water and dry faster because its crepe was more uneven and bulkier.

4. Conclusions

Japanese consumers require industrial fiber products that are functional, durable, and pleasing to the senses of sight and touch.

Awa shijira fabric does not contain hard twist yarn, so this study suggests that attractive characteristics of Awa shijira fabric depends on crepe produced by rib weave.

Awa shijira fabric may be less durable than plain fabric according to results of experiments on breaking strength and abrasion resistance, but Awa shijira fabric is superior to plain fabric in terms of compression, water absorption, and drying.

Without compression, Awa shijira fabric is bulkier and is more water absorbent than plain fabric because the crepe of Awa shijira fabric produces larger surface area and faster drying.

This study helps support the popular view that Awa shijira fabric is pleasant to touch and particularly suitable for summer outfits in Japan and other areas with similar hot climate. Future study will focus on Awa shijira fabric crepe depending on fiber materials.

Acknowledgement

I acknowledge a donation of cloth samples by a Nagao-orifu Company. Acknowledgement also goes to staff at Tokushima Prefectural Industrial Technology Center, especially Mr. Masanori Nakaoka for a braking strength testing and Ms. Kayo Miyagi for data processing. I also wish to express my sincere thanks to Mr. Don

Sturge, Tokushima University for his advice on English.

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