Crease Recovery Property of Compressive Clothing for Disaster Prevention under Environmental Temperature

Hideaki Katogi * and Ayano Dempoya

Department of Human Environmental Sciences, Jissen Women's University, Hino, Japan
Email: katogi-hideaki@jissen.ac.jp (H.K.); dempoya-ayano@jissen.ac.jp (A.D.)
*Corresponding author

Abstract—**Recently, the emergency survival kit is very important for life when earthquake occurred. The comfortability of fabric for clothing is affected by surface characteristics of constituent material. After earthquake, the clothing as survival kit need to prepare the compact size for disaster prevention. In this study, evaluation of crease recovery property of compressive clothing for disaster prevention was investigated. Material was fabric for clothing after compression. The state of environment in storage room was measured by using the thermohygrometer. The time interval of measurement was one hour. The test period was about 350 h (Jul. 2024). The test place was storage room in Hino, Japan. The surface of compressive fabric was observed before and after heat treatment. Temperature conditions of heat treatment were 110 °C, 150 °C and 190 °C. The crease recovery test of compressive fabric was conducted under some environmental temperatures. The weight was 500 g. The apparatus for crease recovery test under environmental temperature was made by our laboratory. The environmental temperatures were room temperature, 42 °C and 62 °C. Following results were obtained. The maximum temperature in storage room was about 40 °C. The average value of relative humidity in storage room was about 63 %RH. The shrinkage on surface of compressive fabric was found before and after heat treatment. The crease on surface of compressive fabric was found after all heat treatments. The crease recovery ratio of compressive fabric at wale direction was higher than that of compressive fabric at course direction under all conditions. The crease recovery ratio of compressive fabric at 42 °C was lower than that of compressive fabric at 62 °C. Therefore, their results implied that crease recovery property of compressive fabric was affected by flexural stress relaxation and residual strain in structure under environmental temperature.**

Keywords—**compressive clothing, storage room, crease recovery, environmental temperature, structure, surface**

I. INTRODUCTION

The disaster prevention is important for life. Recently, great east japan earthquake occurred about large area in Japan. Then many loads and building were broken by earthquake. So, disaster victims stayed in haven such as school, gym and so on. Many emergency food and blanket have been prepared for disaster prevention of many countries. But disaster victims need to use the clothing as emergency survival kit for life after earthquake. Mechanical properties of fabric have been investigated for new clothing of sustainable development goals [1–41].

Öner *et al.* [42] reported on air permeability and moisture management property on cotton fabrics with single jersey. The overall moisture management capacity of cotton fabric with single jersey was 0.26. And the air permeability of cotton fabrics with single jersey was about 355 $l/m^2/s$. Onofrei *et al.* [43] reported about water vapor permeability of viscose/cotton fabric. The water vapor permeability of viscose/cotton fabric has good performance for comfort. Rahman Bhuiyan *et al.* [44] reported about crease recovery angle of chitosan treated cotton fabric at warp and weft directions. The crease recovery property of cotton fabric depends on molecular weight of chitosan at fiber surface treatment.

In 1976, temperature on roof of house was 68 °C during summer [45]. Recently, environmental temperature in the world increase with an increase of year. Relative humidity in facilities for elderly was 20–40% during winter (Nov. 2014–Jan. 2015) [46]. Many people must be stayed under some temperatures and humidity environments after earthquake. Nemoto *et al.* [47] reported on preparedness for winter disaster in Hokkaido area based on 2024 Noto peninsula earthquake. The body temperature regulation of disaster victims must be controlled by using heater for life support. But the lifeline in disaster area will be damaged by earthquake.

The thermal property of fabric for clothing is very important for body temperature regulation of life support. Souissi *et al.* [48] reported about thermal comfort property of cotton/biocomponent polyester fabric. The thermal comfort property of cotton/biocomponent polyester fabric have good performance. Rijavec *et al.* [49] reported on thermogravimetric analysis of modacrylic fiber in modacrylic/cotton fabric for underwear. The decrease of weight of modacrylic fiber occurred above 220 °C. Bedek *et al.* [50] reported on

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evaluation of thermal property on cotton knitted fabric with interlock. The thermal conductivity of the cotton knitted fabric with interlock was about 82 WmK^{-1}.

Natural fiber has good fatigue and creep properties [51, 52] as structure material of architecture. Also, the natural fiber has good thermal, moisture and water absorption properties for comfort of clothing. Mechanical properties of natural fabric for clothing were affected by environmental factors. So, there are many papers about effect of weatherability on mechanical properties of clothing for comfort. The shrinkage of cotton fabric will be occurred after outdoor exposure environment.

Katogi *et al.* [53] reported about abrasion property of cotton fabric under outdoor exposure environment. The structure of cotton fabric for clothing was changed by short-term outdoor exposure environment. The thickness of cotton knitted fabric increased with an increase of test time. And the abrasion property of cotton knitted fabric was improved by outdoor exposure environment.

There are also some papers about environment simulation in museum storage room [54] and large room [55]. However, there are not a few reports about preparation and mechanical properties of emergency clothing for disaster prevention. And, the comfortability of disaster victim is affected by roughness on surface of fabric for thermal and mechanical properties of clothing. The compact size of clothing as survival kit can be advantageous for disaster prevention.

In this study, the crease recovery property of compressive clothing under environmental temperature was investigated for disaster prevention. Fastly, the temperature and humidity in storage room were measured by using the thermohygrometer. Secondly, the crease recovery property of compressive fabric was evaluated by apparatus for environmental temperature.

II. Environmental Measurement

Temperature and humidity in storage room were measured by using the thermohygrometer. The time interval of measurement was one hour. The test period was about 350 h. (Jul. 2024). The test place was storage room in Hino, Japan.

Figs. 1 and 2 show environmental temperature and humidity measurements in storage room. The maximum environmental temperature in storage room was about 40 °C. The minimum environmental temperature in storage room was about 26 °C. And the average value of environmental temperature was about 31 °C. The maximum value of relative humidity in storage room was about 78 %RH. The minimum value of relative humidity in storage room was about 46 %RH. And, the average value of relative humidity in storage room was about 63 %RH. Generally, July in Japan is high temperature and humidity environments. The state of the environment in storage room was affected by climate of Tokyo area (Jul. 2024).

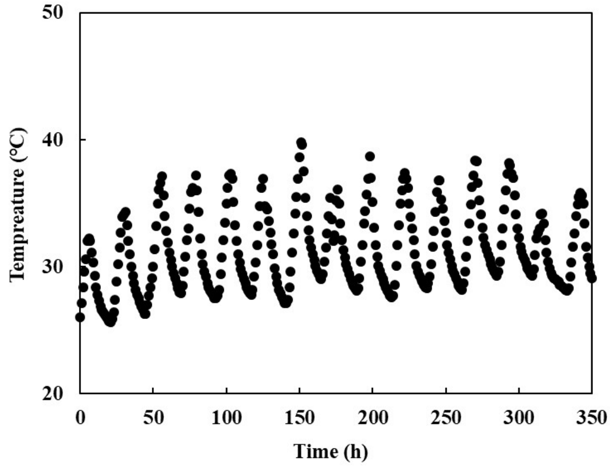


Fig. 1. Temperature measurement in storage room (Hino, Japan).

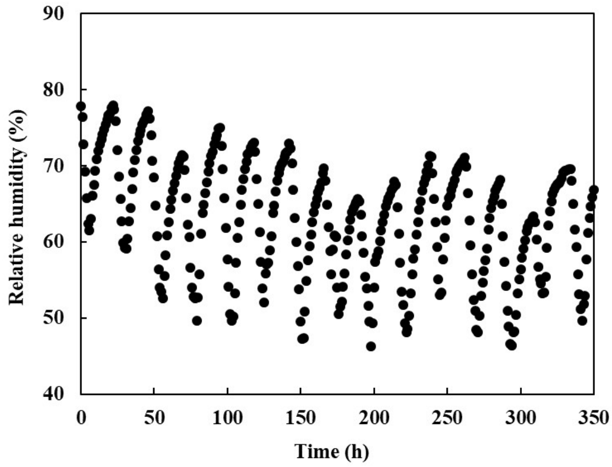


Fig. 2. Relative humidity measurement in storage room (Hino, Japan).

III. Material

The specimen was the cotton knitted fabric of compressive clothing (SWC Tokyo Katsushika Welfare Factory). Fig. 3 shows compressive clothing for disaster prevention.

IV. Specimens and Methods

A. Surface Observation

Surface observation of compressive fabric was conducted before and after heat treatment. The specimen size of compressive fabric was 40 mm long and 40 mm wide. The heat treatment was conducted by using clothes iron. Temperature conditions of heat treatment were about 110 °C, 150 °C and 190 °C. The test time of heat treatment was 30 s.

B. Crease Recovery Testing Method

Crease recovery test of compressive fabric was conducted based on Japanese Industrial Standard (JIS) L 1059. The specimen size was 40 mm long and 10 mm wide. The environment temperatures were room temperature, 42 °C and 62 °C. The apparatus for crease recovery test under environmental temperature was made by our laboratory. The loading time for crease recovery test at room temperature was about 5 min. The loading time for crease recovery test at 42 °C and 62 °C was about 45 min. The weight was 500 g. Fig. 4 shows schematic drawing of apparatus for crease recovery test.

Fig. 3. Compressive clothing for disaster prevention.

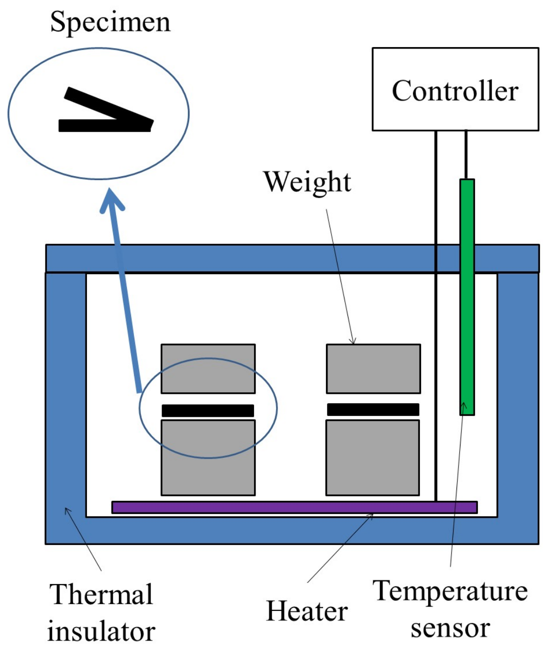


Fig. 4. Schematic drawing of crease recovery test during environmental temperature.

The crease recovery ratio of compressive fabric was calculated by using Eq. (1).

$$c\ [\%] = \frac{a}{180} \times 100 \quad (1)$$

where c is the crease recovery ratio of compressive fabric and a is the angle of compressive fabric after loading.

V. Results and Discussion

A. Surface Observation

Figs. 5 and 6 show surfaces of compressive fabrics before and after heat treatment. The crease on surface of compressive fabric was found before heat treatment. But the crease on surface of compressive fabric did not change before and after heat treatment. And the shrinkage of compressive fabric was after heat treatment. The large crease on surfaces of compressive fabrics was also found after all heat treatments. Burnt surfaces of compressive fabrics were not found after all heat treatments. Generally, cotton fiber as constituent material has hydroxyl group. The main constituent material of cotton fiber is cellulose. But the crease recovery on surfaces of compressive fabrics was not found after all heat treatments. Their results implied that residual strain in cotton knitted fabric occurred by compressive press.

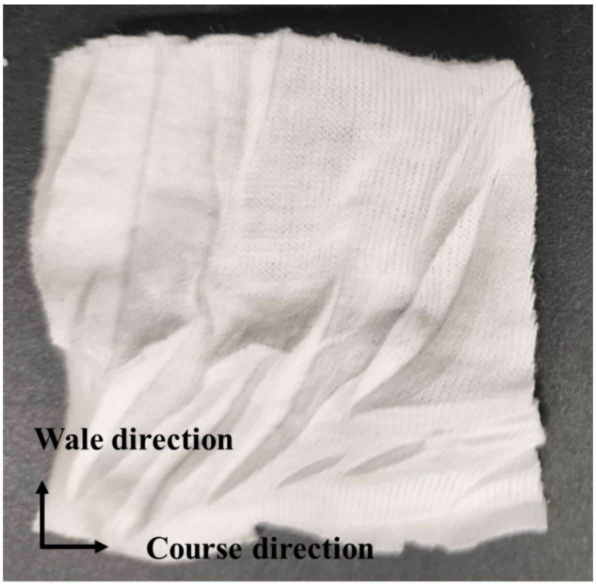
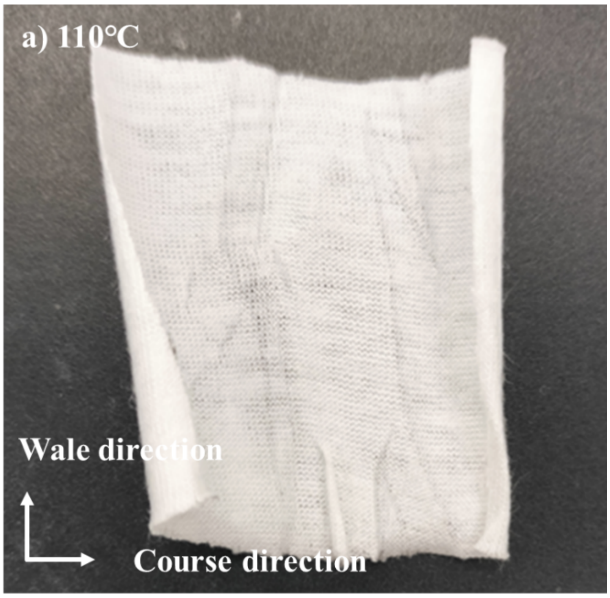
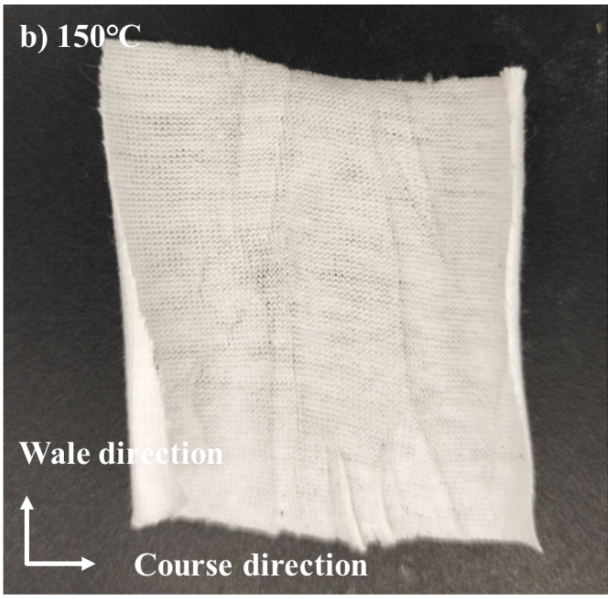


Fig. 5. Surface observation of compressive fabrics before heat treatment.

B. Crease Recovery Property

Figs. 7 and 8 show crease recovery properties of compressive fabric at environmental temperatures. Crease angle ratios of compressive fabrics at wale and course directions were about 41% and 30%, respectively. The crease angle ratio of compressive fabric at wale and course directions increased with an increase of heat temperature when heat temperature was over 42 °C. When environmental temperature was 62 °C, crease angle ratios of compressive fabrics at wale and course directions were about 25° and 20°. In case of all temperatures, crease angle ratios of compressive fabrics at course direction were lower than those of compressive fabrics at wale direction. Author [53] reported about structure of cotton knitted fabric under outdoor exposure environment. The structure of cotton knitted fabric was affected by environmental factors. The flexural stiffness and residual strain of cotton yarns in structure of compressive fabric were probably affected by loading under environmental temperature. Therefore, the crease recovery property of compressive fabric was mainly affected by flexural stress relaxation and residual strain in the structure under environmental temperature (see Fig. 9).





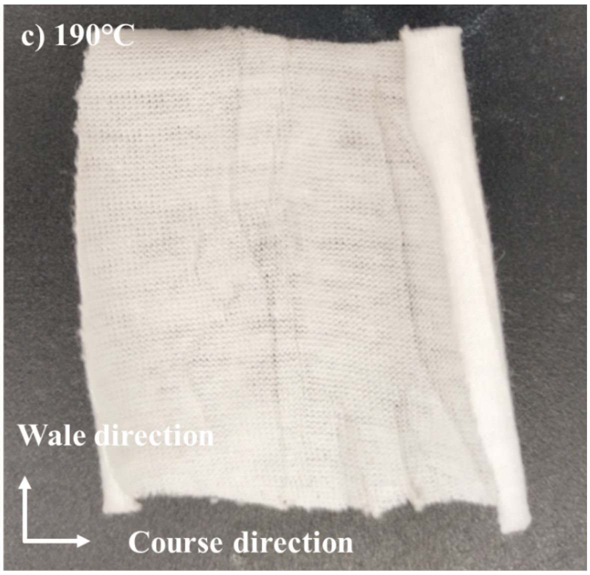


Fig. 6. Surface observation of compressive fabrics after heat treatment: a) 110 °C; b) 150 °C; c) 190 °C.

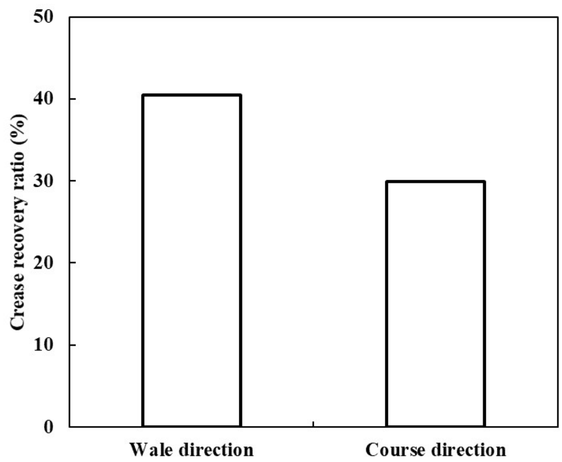


Fig. 7. Crease recovery property of cotton fabric during environmental temperature.

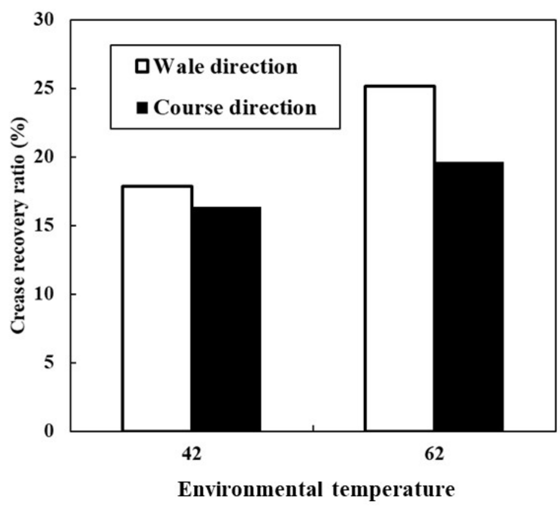


Fig. 8. Effect of environmental temperature on crease recovery property of cotton fabric.

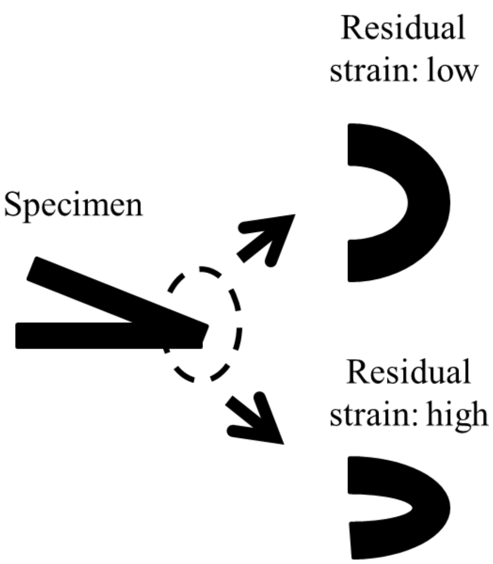


Fig. 9. Schematic drawing of residual strain in structure of compressive fabric after loading at environmental temperature.

VI. CONCLUSION

The crease recovery of cotton fabric during environmental temperature was investigated for clothing of disaster prevent. Following conclusions were obtained.

Crease recovery ratios of compressive fabrics at wale and course directions increased with an increase of environmental temperature when heat temperature was over 42 °C. Crease recovery ratio of compressive fabric at wale direction was higher than that of compressive fabric at course direction under all environmental temperatures. But large crease on surface of compressive fabric at wale direction was found after heat treatment. Their results implied that crease property of compressive fabric was affected by flexural stress relaxation and residual strain in the structure under environmental temperature.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

HK wrote this paper; AD measured the data of environment in storage room; HK contributed to the experimental work of fabric. All authors had approved the final version.

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