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Study on the Characteristics of Pressure by Knitted Fabrics for Foundation

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여성 파운데이션용 편포의 압력특성에 관한 연구

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본 문 요 약

여성 파운데이션용 편포의 압력특성에 관한 문제를 공학적 관점에서 검토해보기 위하여 거들용 편포와, 또한 비교를 위하여 드로우어즈용 편포를 시료로하여 완전강체 및 완전탄성체, 그리고 강체와 탄성체를 동시에 가지는 수압체를 모델로 제작하고, 시료를 고리형태로 만들어 피복시킨후 그 압력을 12시간 동안 연속측정하였다. 이때 시료의 신장정도, 수압체의 탄성체 구성비 등을 여러가지로 달리하여 그에 따른 압력의 변화를 봄과 동시에 시간경과의 효과도 검토하여본 바 다음과 같은 결과를 얻었다.

1. 강체를 수압체로한 경우는 시료의 신장률 증가에 따라 압력이 거의 직선적으로 증가하였고, 그 정도는 거들의 재료가 드로우어즈의 재료에 비하여 훨신 크게 나타났다.

2. 수압체의 탄성체구성비가 증가할수록 신장률 증가에 따른 시료의 실질신장률의 증가 경향이 둔화되어, 40% 신장률의 경우는 그 이전보다 오히려 감소하는 경향을 나타내었다.

3. 수압체에 탄성체가 포함된 경우는 매우 적은 압력을 나타내었으며, 시료 신장률의 증가에 따른 변화도 매우 적게 나타남으로써 시료 신장률이 클수록 강체수압체에 대한 압력과의 차이가 더욱 커지게됨을 알 수 있었다. 그러나 드로우어즈 재료의 경우는 탄성체가 받는 부담은 크지 않은 것으로 나타났다.

4. 압력의 경시변화는 초기의 압력분포 안정화 과정을 제외하고는 12시간 까지 어떤 경우에도 크게 나타나지 않았다.

I. INTRODUCTION

The clothings have two kinds of objects. One is a biological object to protect human body against any external obstacles, and the other is a social object such as for etiquette, representation of individuality, or ornament. The kinds of clothings have become diverse to fulfill these objects, especially those of underclothings have been recently increased markedly.

The underclothings have two sides of importance such as clothing-engineering (figure revision) and hygiene (warmth, absorption of perspiration, etc.). The sort of underclothing which has main purpose for figure revision is called as 'foundation' and comprehends many kinds such as brassiere, girdle, corset, bodysuit, gater belt, waist nipper, etc.

The foundations are generally made with elastic fabrics, especially knitted fabrics involving spandex filaments which have very high elasticity recently, so the foundations have some problems in the side of hygiene due to the high clothing pressure.

Many studies for the clothing pressure have been carried out, but most of them with a few exceptions about the measuring method of the clothing pressure[1~3] are about the effects of clothing pressure on the human system[4~18]. Considering them as a whole, it is evident that the clothing pressure is a tax on human system though that does not cause any illness directly. Therefore it is necessary to find out the method to reduce the tax while keeping the primary functions of the foundations by scientific researches for their materials, shapes, wearing conditions, etc.

Most of the researches reported up to the present have been carried out with examinations under wearing condition in the position of consumer science, but it is demanded for researches to offer the foundation producers the useful data.

In this study as a part of them, it was attempted to investigate in a engineering ground the effects of various conditions refered to some kinds of knitted fabrics being used as foundation materials on clothing pressure. The variations of pressure by knitted fabrics, composed of synthetic fibers and used as girdle materials, for rigid body with changes of elongation, wearing time were determined firstly; and those for specific bodies composed of rigid and elastic solids[1], which was designed in consideration of human body, with change of the elastic solid ratios were also determined. Hence the problem from which the establishment of specific condition was impossible in the case of examination under the worn condition could be conquered.

Besides, in order to compose with them the same examination was carried out for the cotton knitted fabric being used as drawers materials.

II. EXPERIMENTAL

Samples

The samples in this experiment were knitted fabrics which are used as materials of girdle or drawers,

Table 1. Characteristics of samples

Item / Sample	fiber	fabric structure	fabric count (wales x courses/in)	thickness (mm)	use
A	nylon polyurethane	tricot (polyurethane weft insertion)	51 x 47	0.45	girdle
B	nylon polyurethane	tricot (polyurethane welf insertion)	42 x 48	0.53	girdle (interlining)
C	cotton polyurethane	1x1 rib (polyurethane weft insertlon)	32 x 27	0.63	drawers

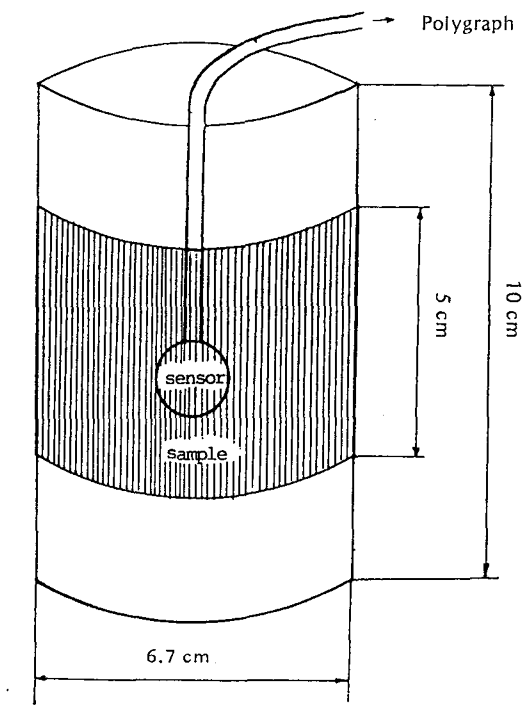

Fig. 1. Shape of body and sample on measuring.

and their characteristics were indicated in Table 1.

Pressure Determination

The pressure was measured by Polygraph (360 system, San-ei, Japan) for 12 hours continuously. The samples (width of wale direction: 5 cm, length of course direction: required size) were made into ring-shapes, and the cylinderical bodies (diameter: 6.7 cm, height: 10 cm) were covered with each sample ring. And then the sensor of the Polygraph was inserted between the body and sample like Fig. 1.

In all cases, the elongations of samples were changed with 10, 20, 30, and 40%.

By kinds of samples

The pressures for rigid body by A, B, overlapping A and B (A+B), and C samples were determined.

By states of bodies

The pressures by two typical samples (A and C) for rigid and elastic solid bodies, whose ratios of elastic solid were changed with 0.25, 0.50, 0.75, and 1.00, were determined. The polyurethane foam whose compressive resilience was about 90% under load of 100 g/cm^2 was used as the elastic solid. Fig. 2 shows the constituent state of the body[1].

III. RESULTS AND DISCUSSION

Change of Elongation by Kinds of Samples

The degree of pressure may be expressed most distinctly when the body is rigid. Therefore, the changes of pressure with the passage of time by change of elongation were read at intervals 1 hour, and indicated in Table 2.

The changes of pressure with the passage of time were next to nothing except a little change for beginning of 2~3 hours, which may correspond to the period of time occupied on equilibration of pressure distribution. The fact that the pressure was not varied almostly may be resulted from that not only

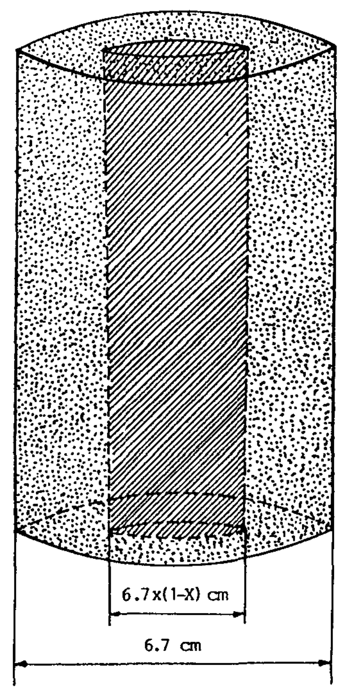

Fig. 2. Model of body composition.
rigid elastic
X : elastic solid ratio

Table 2. Pressures for rigid body by samples with various elongations

(unit : g/cm^2)

Sample	Time (hr) / Elongation (%)	0	1	2	3	4	5	6	7	8	9	10	11	12
A	10	10.20	10.34	10.20	10.20	10.20	10.20	10.20	10.06	10.06	9.93	9.93	9.93	9.93
	20	15.37	15.64	15.64	15.64	15.50	15.50	15.50	15.50	15.37	15.23	15.23	15.23	15.23
	30	22.40	22.03	21.76	21.76	21.62	21.62	21.62	21.49	21.49	21.35	21.22	21.22	21.08
	40	32.64	32.10	31.55	31.28	31.28	31.01	30.87	30.74	31.01	31.01	31.01	31.01	30.60
B	10	6.94	7.07	7.07	7.07	6.94	7.07	7.07	7.07	7.07	7.07	7.21	7.21	7.34
	20	10.61	11.29	11.29	11.15	11.29	11.29	11.29	11.29	11.29	11.29	11.29	11.42	11.42
	30	19.86	19.99	19.86	19.86	19.72	19.86	19.99	19.86	19.99	19.86	19.86	19.86	19.86
	40	25.70	25.16	24.75	24.48	24.48	24.21	24.21	24.07	24.21	24.21	24.34	24.21	24.07
A+B	10	16.86	16.59	16.46	16.32	16.18	16.32	16.32	16.32	16.32	16.18	16.32	16.32	16.32
	20	25.57	25.84	25.57	25.43	25.30	25.16	25.16	25.16	24.89	24.89	24.75	24.89	25.02
	30	38.08	36.99	36.72	36.17	36.04	35.90	36.04	36.04	35.90	35.63	35.63	35.36	35.50
	40	53.72	52.36	51.00	51.00	50.73	50.05	50.05	49.37	50.32	50.32	50.73	50.32	50.05
C	10	0.54	1.36	1.50	1.50	1.50	1.50	150.	1.50	1.50	1.50	1.50	1.50	1.63
	20	0.68	1.63	1.90	1.90	1.90	1.90	190	1.90	1.90	1.90	1.90	1.90	1.90
	30	4.76	5.30	5.44	5.44	5.30	5.44	5.44	5.44	5.44	5.30	5.30	5.30	5.44
	40	6.53	6.53	6.39	6.26	6.26	6.12	6.12	5.98	6.12	6.12	6.12	6.12	5.98

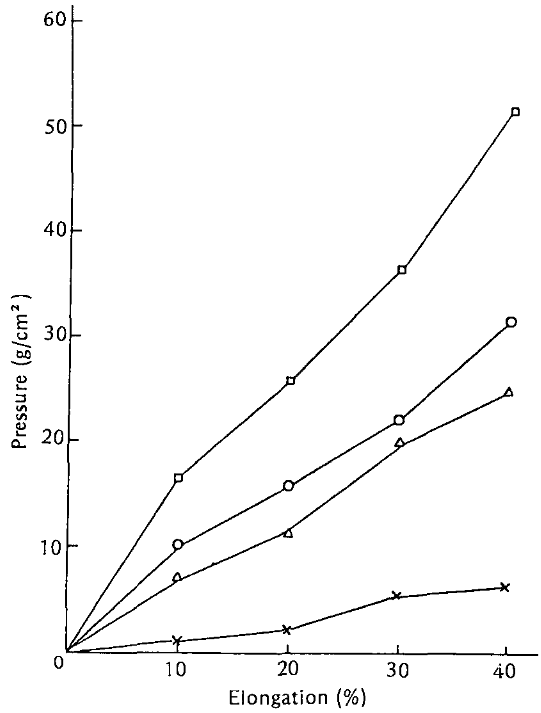

Fig. 3. Changes in pressure for rigid body by A, B, A + B, and C samples after 3 hours with various elongations.
Sample : ○ A △ B □ A+B X C

the fabric structures were knitted ones but also the high elastic spandex filaments were inserted along the weft direction of fabrics. On the other hand, the period of time occupied on equilibration of pressure distribution will be shortened much by moving condition in the case of being worn.

Fig. 3 shows the change of the pressure for rigid body after 3 hours with increase of elongation. Generally, the pressures were increased approximately in proportion to the elongations (coefficients of correlation for A, B, (A+B), and C samples were 0.994, 0.990, 0.994, and 0.949, respectively), and the tendencies for A, B, and (A+B) samples, whose elasticity and fabric count were relatively high, were superior to those for C sample.

The fact that the relation between pressure for rigid body and fabric elongation is proportional had been reported by other studies[1,2] too.

Change of Elastic Solid Ratio

The changes of pressures by A and C samples with passage of time by elastic solid ratios were indicated in Table 3.

The canges of pressure with passage of time were next to nothing except beginning of 1~2 hours also in this case. So the changes of pressure after 3 hours with the increase of elongation were illustrated in Fig. 4.

The pressure for the rigid body was increased approximately in proportion to the elongation. But in the other cases, the pressures were not changed until 30% of elongation, and increased a little at 40% of elongation. These facts may be resulted from the

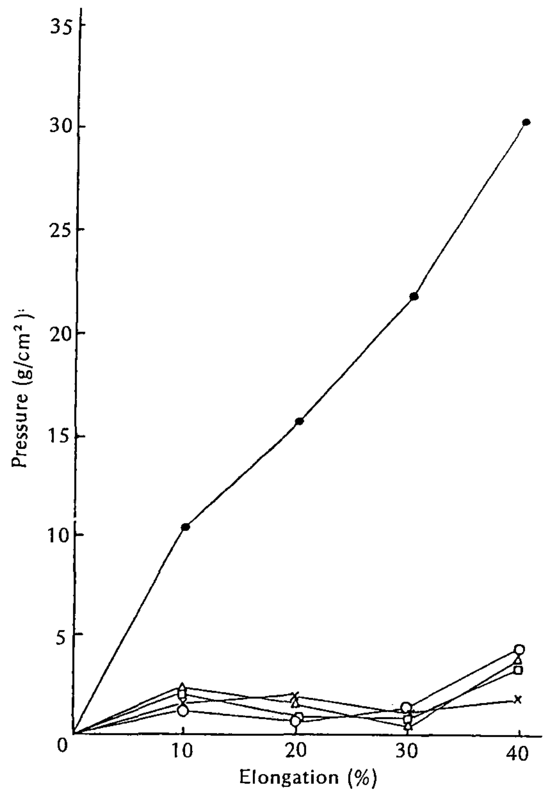

Fig. 4-a. Changes in pressure for rigid, elastic, and rigid-elastic bdoies by A sample after 3 hours with various elongations.
Elastic solid ratio : ● 0.00 ○ 0.25 △ 0.50 □ 0.75 X 1.00

Table 3-a. Pressures for 5 types of body by A sample with various elongations (unit : g/cm²)

Elastic solid ratio	Elongation (%) \ Time (hr)	0	1	2	3	4	5	6	7	8	9	10	11	12
0.00	10	10.20	10.34	10.20	10.20	10.20	10.20	10.20	10.06	10.06	9.93	9.93	9.93	9.93
	20	15.37	15.64	15.64	15.64	15.50	15.50	15.50	15.50	15.37	15.23	15.23	15.23	15.23
	30	22.40	22.03	21.76	21.76	21.62	21.62	21.62	21.49	21.49	21.35	22.22	22.22	21.08
	40	32.64	32.10	31.55	31.28	31.28	31.01	30.87	30.74	31.01	31.01	31.01	31.01	30.60
0.25	10	0.95	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
	20	0.68	0.82	0.68	0.68	0.68	0.68	0.68	0.68	0.54	0.54	0.54	0.54	0.54
	30	1.63	1.50	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36
	40	3.26	4.22	4.22	4.08	4.08	4.08	3.94	3.94	3.94	3.94	3.94	3.94	3.94
0.50	10	1.90	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31
	20	1.09	1.50	1.50	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.77	1.77
	30	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
	40	2.72	3.67	3.81	3.81	3.67	3.81	3.67	3.67	3.67	3.67	3.67	3.81	3.81
0.75	10	1.63	1.90	2.04	2.04	20.4	2.04	2.04	1.90	1.90	1.90	1.90	1.90	1.90
	20	0.54	0.68	0.68	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
	30	0.95	0.95	0.95	0.95	0.95	0.95	0.95	1.09	0.95	1.09	1.09	1.09	0.95
	40	1.77	3.13	3.26	3.26	3.26	3.26	3.26	3.26	3.13	3.26	3.26	3.26	3.13
1.00	10	1.50	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.50	1.63
	20	0.95	1.50	1.63	1.63	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77
	30	0.82	0.95	0.95	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09
	40	1.77	1.77	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.77	1.77	1.77	1.77

Table 3-b. Pressures for 5 types of body by C sample with various elongatons (unit : g/cm²)

Elastic solid ratio	Elongation (%) \ Time (hr)	0	1	2	3	4	5	6	7	8	9	10	11	12
0.00	10	0.54	1.36	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.63
	20	0.68	1.63	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90
	30	4.76	5.30	5.44	5.44	5.30	5.44	5.44	5.44	5.44	5.30	5.30	5.30	5.44
	40	6.53	6.53	6.39	6.26	6.26	6.12	6.12	5.98	6.12	6.12	6.12	6.12	5.98
0.25	10	0.54	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
	20	0.27	0.27	0.27	0.27	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
	30	0.27	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
	40	1.09	2.31	2.45	2.31	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18
0.50	10	0.41	0.82	0.95	0.82	0.95	0.82	0.82	0.82	0.82	0.82	0.82	0.95	0.95
	20	0.68	0.82	0.82	0.82	0.95	0.95	0.95	0.95	0.95	0.95	1.09	1.22	1.09
	30	0.41	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.68	0.82	0.68
	40	1.09	2.45	2.58	2.72	2.72	2.72	2.72	2.72	2.58	[illegible]	2.72	2.86	2.86
0.75	10	0.14	0.14	0.27	0.27	0.27	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
	20	0.27	0.41	0.54	0.68	0.68	0.68	0.68	0.68	0.82	0.82	0.82	0.82	0.82
	30	0.41	0.54	0.54	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
	40	1.09	1.36	1.36	1.50	1.36	1.36	1.22	1.22	1.36	1.36	1.36	1.36	1.36
1.00	10	0.54	0.82	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	20	0.14	0.54	0.54	0.54	0.68	0.68	0.68	0.68	0.82	0.82	0.82	0.82	0.82
	30	0.95	1.63	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77
	40	1.22	1.90	2.04	2.18	2.18	2.04	2.04	2.04	2.04	2.04	1.90	1.90	1.90

stress-relaxation of the elastic solid, *i.e.* the decrease of actual elongations by the decrease of body diameters due to the contraction of elastic solids.

Therefore, the decreasing quantities of body diameter and the actual-elongations (the elongations in the state of the body diameter decreased) for A sample were indicated in Table 4, the changes of actual-elongations by elastic solid ratio with increase of the expressed-elongations (the planned elongations=elongations) were illustrated in Fig. 5.

Generally, excepting the case of 0.25 of elastic solid ratio the increasing tendencies of actual-elongation became blunt more and more with increase of the exprssed-elongations, and the degrees of them were increased with the elastic solid ratio

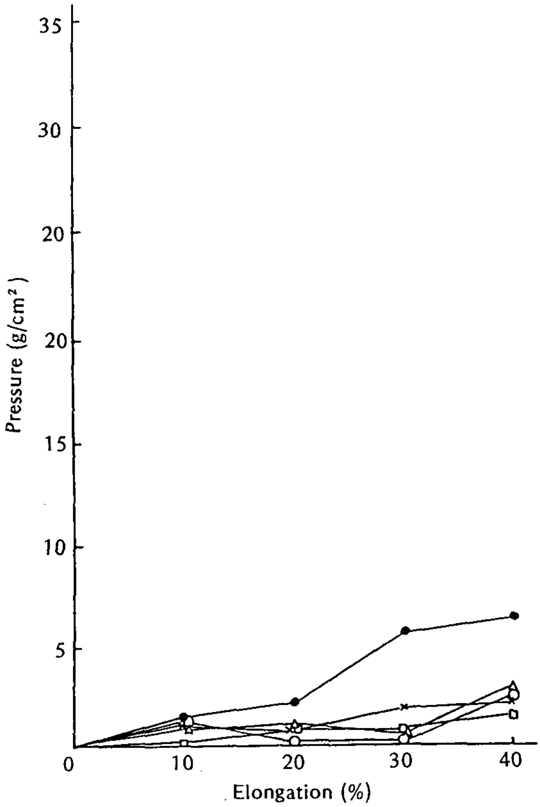

Fig. 4-b. Changes in pressure for rigid, elastic, and rigid-elastic bodies by C sample after 3 hours with various elongations.
Elastic solid ratio : ● 0.00 ○ 0.25 △ 0.50 □ 0.75 X 1.00

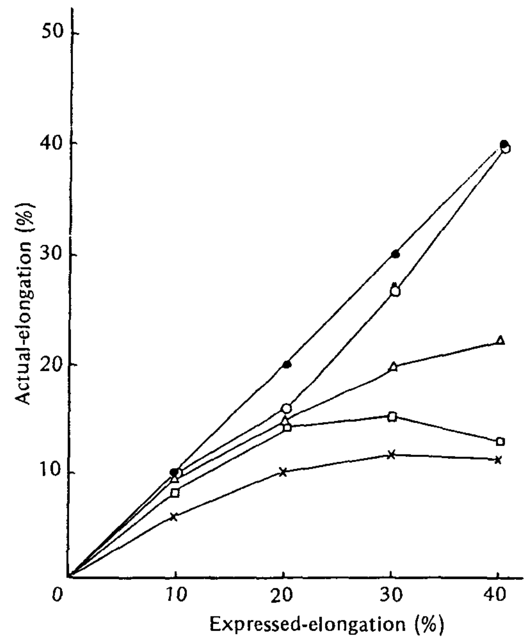

Fig. 5. Relation between actual and expressed elongations of A sample.
Elastic solid ratio : ● 0.00 ○ 0.25 △ 0.50 □ 0.75 X 1.00

Table 4. Shrinkage amounts of body diameter, actual-elongations, and theoretical pressures for elastic and rigid-elastic bodies by A sample with various elongations

Elastic solid ratio	0.25			0.50			0.75			1.00		
Item Elongation (%)	SD (cm)	AE (%)	TP (g/cm²)	SD (cm)	AE (%)	TP (g/cm²)	SD (cm)	AE (%)	TP (g/cm²)	SD (cm)	AE (%)	TP (g/cm²)
10	0.23	10.0	9.29	0.10	9.5	7.60	0.19	7.9	6.50	0.32	5.8	5.03
20	0.51	15.5	11.75	0.54	14.9	11.33	0.58	14.3	10.91	0.80	10.1	8.00
30	0.77	26.5	19.38	1.08	19.7	14.66	1.31	15.0	11.40	1.47	11.6	9.04
40	1.08	39.7	28.53	1.79	22.2	16.39	2.17	12.7	9.81	2.23	11.1	8.69

* SD : shrinkage aomunt of body diameter AE : actual-elongation TP : theoretical pressrue

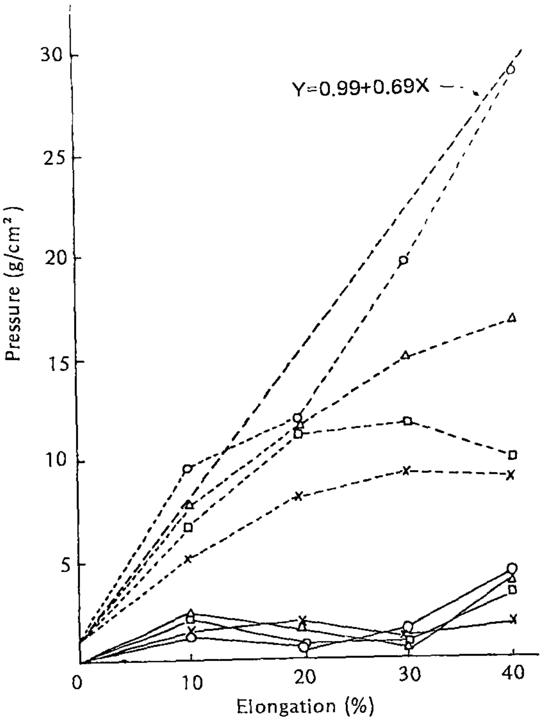

Fig. 6. Changes in theoretical and measured(actual) pressure for rigid, elastic, and rigid-elastic bodies by A sample after 3 hours with various elongations.
Elastic solid ratio : ○ 0.25 △ 0.50 □ 0.75 X 1.00
—— actual ·········· theoretical

and so the actual-elongations at 40% of expressed-elongation for 0.75 and 1.00 of elastic solid ratios were decreased a little than at 30% of expressed-elongation instead. This phenomenon may be resulted from the fact that the body diameters were decreased distinctly by the yielding of elastic solids when the pressure was increased excessively with the expressed-elongation. But for the 0.25 of relatively small ratio of elastic solid, the actual-elongation was increased again at the higher expressed-elongation owing to the great influence of the rigid material commanding a majority in the body.

On the other hand, the theoretical pressures were calculated by the following regression equation obtained from the data of A sample for rigid body, which have high correlation ($r=0.994$) between pressure and fabric elongation, and indicated in Table 4 and Fig. 6.

$$Y=0.99+0.69X$$

where, Y is pressure (g/cm^2) and X is elongation (%).

Here, the theoretical pressures were changed with the actual-elongation and the gaps between the theoretical and measured pressures may correspond to the quantities of pressure relaxed by elastic solids, in other words, the quantities of load which the elastic solids must bear.

In the case of actual wearing condition, two types of results can be assumed as follows;

1) The figure revision will be achieved at some regions of human body being much fat, muscle, or internal organs, which will be shifted a little to other regions where relatively low pressure is putted.

2) Some pressed marks will be left on other regions of human body being few fat or muscle after undressing by temporary loss of those regions' elasticity.

From the fact, indicating in Fig. 5 and 6, that the higher elastic solid ratio was, the lower the actual-elongation and theoretical pressure were, it can be known that the object of foundations will be achieved upon type 1. But generalizing from hygienic point of view, excessive clothing pressure may apply some loads to human body whether upon type 1 (shifting of some regions) or/and type 2 (direct pressure relaxation by some regions).

These phenomena may be related to the facts that, at the study by Watanabe et al.[8], the viscera incased with ribs were affected by the clothing pressure less than the others, and at the study by Ku[13], the clothing pressure for the back was greater than those for the side and front and the unpleasantnesses were indicated at regions of waist, abdomen, and thigh which have much fat or internal organs.

On the other hand, Fig. 4-b shows that the pressure differences of C sample between for whole rigid body and for rigid-elastic solid bodies were very small. This seems that the load of human body by the drawers may be very small.

IV. CONCLUSIONS

The pressure by knitted fabrics for foundation according to the variation of the fabric elongation, the elastic solid ratio in body, and wearing time were measured and discussed in a engineering ground. The results were as follows:

1. For the rigid body, the pressure was increased with the elongation and the tendency of fabric for girdle was much greater than that for drawers.

2. According to the increase of elastic solid ratio in body, the increasing tendency of actual-elongation became blunt with increase of expressed-elongation, especially at 40% of expressed-elongation the actual-elongation was decreased a little instead.

3. For the body including elastic solid, the pressure itself and its variation with fabric elongation was much smaller than those for rigid body.

4. The variation of pressure with passage of wearing time was little except the initial equilibrating period of pressure distribution.

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