International Institute for Cotton

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The Effect of Applying Lengthways and Widthways Stretch During the Drying & Curing Stage on the Fully Relaxed Structure of Interlock Fabrics

by

Robert D. Leah

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Contents

1. Introduction

The purpose of this small study is to determine what effect, if any, different degrees of stretch imparted at the crosslinking stage have on the fully relaxed structure of crosslinked knitted fabrics.

During the next few months, a considerable amount of crosslinking work will be carried out on knitted fabric on the small-scale Benz equipment. For knitted fabrics, it is necessary to utilise the pin-frames during the operations of drying and curing (flash curing).

The operation of placing the wet (wet pick-up 90-100%) impregnated fabric onto the pin frames is rather an inaccurate operation, since the fabric invariably becomes distorted during impregnation and it is extremely difficult to imitate regular overfeeding in a controllable manner. Furthermore, if the fabric being treated is a single jersey construction, the additional problem of severe edge curling is present.

In the experiments described in this report, fabrics have been deliberately distorted by known amounts during the pinning operation, and the crosslinking agent cured whilst the distortion was maintained. The fabrics were then fully-relaxed and the course and wale spacings, in the fully relaxed state, were determined.

2. Experimental

In the commercial situation, it is usual to overfeed the fabric onto the stenter pins and then, in the entry zone of the stenter, increase the width of the chains gradually, thus exerting widthways stretch to the fabric. This results in a deformation of the knitted loops and consequently the ripple caused by overfeeding is reduced until the fabric is completely flat. At this point, the stenter chains should be at the desired fabric width. If the fabric is still rippled at this stage, too much overfeed has been applied and must consequently be reduced. Flash curing can then take place. To try to imitate this operation with a pin frame is virtually impossible and, therefore, rather than attempt to apply overfeed it was decided to apply stretch in the length and width direction independently, and allow the fabric to move in the width and length directions, respectively, unrestricted.

Three levels of length and width stretch were considered to be adequate, these being 10%, 15% and 20% in the length direction and 60%, 80% and 100% in the width direction, the reference point being the bleached and dried structure. Three levels of crosslinker were used, namely 1%, 3% and 5% crosslinker solids on fabric weight. In addition, a control was included at each level of stretch, the control impregnation using water and a little wetting agent. Each variant was carried out three times.

3. Method

3.1 Lengthways Stretch

A length of bleached standard Marks and Spencer interlock fabric (1/38's with a stitch length of 0.34cm) purchased from Meridian was used for the experiment. A batch of fabric approximately 33cm wide was prepared and lines perpendicular to the fabric length were drawn at distances of 50 cm. The normal Benz mangle impregnation thread-up was utilised. The fabric was padded through water and nipped off in the usual manner (wet pick up ~100%). Sufficient fabric was run so that a sample containing two of the perpendicular markings was obtained. The sample was cut off and transported to the Benz flue. The fabric was attached to the pins on the frame such that the pins penetrated the fabric at the marked line. On the pin frame, one set of pins is fixed whilst the parallel set is adjustable. The distance between the rows of pins, and hence the marked lines, was adjusted to give the required degree of stretch, i.e.

55 cm	10% length stretch
57.5 cm	15% length stretch
60 cm	20% length stretch

The pin frame was passed through the Benz flue to give a delay of 60 seconds. The temperature was set at 170°C and the air velocity adjusted to 18 metres/second. The operation was repeated three times in all for each degree of stretch.

The operation was then repeated with the following formulations:-

Recipe	1 1% o.w.f.	2 3% o.w.f.	3 5% o.w.f.
Fixapret CPU, g/l	22	66	111
$MgCl_2.6H_2O$, g/l	3.5	10	16.5
Synperonic NX, g/l	1	1	1

Water pick-up ~100%

Again, three degrees of stretch ware applied and three replications carried out. The samples were submitted for testing for conditioned structure and also fully-relaxed structure.

3.2 Widthways Stretch

A number of widthways strips (approximately 33cm wide) were cut from the batch of prepared fabric and, on these, 50cm-spaced lines were drawn.

These strips were sewn together, selvedge to selvedge, to give a batch of fabric which, when processed, would run perpendicular to the normal direction (i.e. courses would be parallel to direction of fabric travel).

The same procedure of impregnation and drying was carried out as for the lengthways stretching, with the exception that the original 50cm markings were adjusted to give the required degree of widthways stretch: i.e.

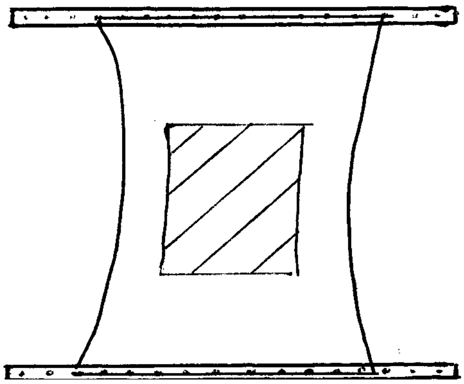
80 cm	60% width stretch
90 cm	80% width stretch
100 cm	100% width stretch

Once again, three replications were carried out for each variable. Samples were submitted to the lab for conditioned and fully-relaxed structure.

4. Observations

One of the limitations of this experiment is that it is extremely difficult to study the effect of stretch in one direction and obtain a consistent effect in the perpendicular direction. This is particularly the case when it is the length direction which is being stretched.

At the higher extension levels the samples become distorted as shown in the sketch.



During testing therefore, measurements of courses and wales were limited to the shaded area. With its greater extensibility however, this distortion was not too apparent when stretching in the widthways direction. Test results are given in the Appendix.

The sample coding used consists of the following information:

Crosslinker concentration / Extension / Replication No.

e.g. 2/15/3 = 2% crosslinker solids o.w.f.
15% extension applied
3rd replication

The results are shown graphically in Figures 1 - 4.

From the graphs, the following observations can be made.

<u>Figure 1: Effect of Lengthways Stretch on Course Spacings</u>

1) In the absence of crosslinking agent (control sample) the effect of stretching during the drying/curing stage on the course spacings is only apparent whilst the fabric is in the unrelaxed state. After relaxation, the course spacing is the same, even though a considerable stretch was applied.

2) In the presence of crosslinking agent, the effect of stretch during drying/curing begins to have an effect on the course spacing. This effect increases with an increase in crosslinker solids.

3) The setting effect of the crosslinking agent on the relaxed course spacing is very apparent.

Figure 2: Effect of Lengthways Stretch on Wale Spacings

1) The effect observed is very similar to that observed with the courses. In the absence of crosslinking agent, any alteration in the wale spacings caused by length stretching is temporary. After relaxation, the wale spacing is virtually the same, even though considerable distortion at the drying stage was imparted.

2) The effect of crosslinking agent is clear to see, especially at the higher levels.

3) This situation is unlikely to happen in commercial practice, unless of course the crosslinking is being carried out on tubular fabric, and the fabric is being flash cured on a drum dryer without width restraint.

Figure 3: Effect of Widthways Stretch on Wale Spacings

1) With the greater extensibility of knitted structures in the width direction, it was necessary to impart considerably higher degrees of stretch to the width than was imparted to the length. It is perhaps worth noting that, even at 100% width stretch, there was very little tension imparted to the fabric and even greater degrees of distortion would have been possible.

2) It was also noted that, once the fabrics were removed from the pin frame after drying/curing, the samples snapped back to some degree.

3) In the absence of crosslinking agent, there is a slight suggestion that excessively stretching the fabric in the width direction affects the relaxed wale spacing, but this is relatively small: e.g. stretching from 60% to 100% makes a difference of 1½ wales on 40 (3.7%).

4) In the presence of crosslinking agent, the effect of stretching has a more permanent effect.

Figure 4: Effect of Widthways Stretch on Course Spacings

1) This particular situation is perhaps the nearest to the actual situation met in practice. It is perhaps fair to assume that if a fabric is overfed sufficiently, it is to all intents and purposes unrestrained in the length direction. Stretching the fabric in the width direction does result in a packing of the courses in the unrelaxed state, which would be apparent in the residual length shrinkage figure. However, there is very little effect on the course spacing after relaxing. The permanent alteration in course spacing by stretching the width from 60% to 100% is only 1 course on 48.5 (2%).

2) This is only true in the absence of crosslinking agent. The effect becomes more pronounced as the concentration of crosslinking agent is increased.

5. Conclusions

This limited series of trials has shown that fabric distortion during the operation of placing fabric on the Benz pin frame can have an effect on the fully-relaxed structure of crosslinked fabric. This is not the case when crosslinking agents are not being used. The effect becomes more apparent at the higher levels of crosslinking agent on the fabric.

However, at the levels of crosslinking agent that are likely to be used in the forthcoming trials (maximum 3% o.w.f.), considerable distortion would have to be imparted at the drying/curing stage to have a marked influence on the fully relaxed structure. It is perhaps fair to conclude that, with reasonable care taken when the fabrics are being handled wet, slight distortions at the pinning stage will not be a contributory factor to alterations in the fully-relaxed structure brought about by cross-linking treatments.

Appendix

INTERNATIONAL INSTITUTE FOR COTTON. KNITTING REF. RDL 501 LAB. REF. 652 SUBMITTED BY: RDL DATE: 12/2/79.

TESTS REQUIRED			CONTROL - 10% STRETCH (LENGTH)						SAMPLE CONTROL - 15% STRETCH (LENGTH)					
		✓	C/10/1	95%CL	C/10/2	95%CL	C/10/3	95%CL	C/15/1	95%CL	C/15/2	95%CL	C/15/3	95%CL
% SHRINKAGE	length													
	width													
FABRIC WEIGHT	BW													
	AW													
C/3 CM	BW	✓	33.0	0.34	33.1	0.40	33.5	0.38	31.8	0.56	32.1	0.63	31.7	0.34
	AW	✓	44.4	0.37	44.7	0.69	44.4	0.50	44.5	0.17	43.8	0.66	44.7	0.35
W/3 CM	BW	✓	49.7	0.89	49.7	0.83	49.9	0.53	51.0	1.62	51.0	1.63	51.4	0.69
	AW	✓	45.0	0.67	44.3	0.59	44.3	0.59	44.6	0.37	44.6	0.37	44.9	0.53
STITCH LENGTH	BW													
	AW													
BURST STRENGTH	BW													
	AW													
SPIRALITY ANGLES	BW													
	AW													

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TESTS REQUIRED			CONTROL - 20% STRETCH (LENGTH)						SAMPLE 1% CROSSLINKER - 10% STRETCH (LENGTH)					
		✓	C/20/1	95%CL	C/20/2	95%CL	C/20/3	95%CL	1%/10/1	95%CL	1%/10/2	95%CL	1%/10/3	95%CL
% SHRINKAGE	length													
	width													
FABRIC WEIGHT	BW													
	AW													
C/3 CM	BW	✓	30.0	0.58	30.1	0.23	30.6	0.50	32.7	0.48	32.2	0.45	32.7	0.59
	AW	✓	43.2	0.56	43.9	0.63	44.9	0.23	40.7	0.48	42.7	0.59	41.5	0.51
W/3 CM	BW	✓	54.7	1.12	52.3	2.02	51.7	1.58	50.1	0.71	51.7	0.48	51.6	0.37
	AW	✓	45.1	1.28	45.2	0.66	44.6	0.60	45.3	0.53	44.7	0.83	46.4	0.37
STITCH LENGTH	BW													
	AW													
BURST STRENGTH	BW													
	AW													
SPIRALITY ANGLES	BW													
	AW													

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TESTS REQUIRED			1% CROSSLINKER - 15% STRETCH (LENGTH)						SAMPLE 1% CROSSLINKER - 20% STRETCH (LENGTH)					
		✓	1%/15/1	95%CL	1%/15/2	95%CL	1%/15/3	95%CL	1%/20/1	95%CL	1%/20/2	95%CL	1%/20/3	95%CL
% SHRINKAGE	length													
	width													
FABRIC WEIGHT	BW													
	AW													
C/3 CM	BW	✓	31.8	0.45	31.1	0.40	31.1	0.41	30.3	0.59	30.1	0.48	30.6	0.37
	AW	✓	41.3	0.35	42.5	0.91	40.7	0.48	40.8	0.66	41.2	0.30	40.7	0.59
W/3 CM	BW	✓	52.8	0.45	53.9	0.23	52.0	0.48	55.1	0.86	54.8	0.74	53.9	0.63
	AW	✓	46.2	0.45	46.9	0.63	46.6	0.50	46.6	0.84	47.8	0.56	46.5	0.51
STITCH LENGTH	BW													
	AW													
BURST STRENGTH	BW													
	AW													
SPIRALITY ANGLES	BW													
	AW													

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TESTS REQUIRED		3% CROSSLINKER - 10% STRETCH (LENGTH)					SAMPLE 3% CROSSLINKER - 15% STRETCH (LENGTH)						
	✓	3%/10/1	95%CL	3%/10/2	95%CL	3%/10/3	95%CL	3%/15/1	95%CL	3%/15/2	95%CL	3%/15/3	95%CL
% SHRINKAGE length													
width													
FABRIC WEIGHT BW													
AW													
C/3 CM BW	✓	32.4	0.37	32.6	0.37	32.3	0.34	31.2	0.30	30.6	0.50	30.1	0.34
AW	✓	37.6	0.37	37.3	0.35	38.1	0.53	36.0	0.48	36.3	0.35	36.5	0.38
W/3 CM BW	✓	49.5	0.50	50.1	0.79	49.7	0.68	51.5	0.97	51.8	0.94	51.8	0.55
AW	✓	47.6	0.37	47.9	0.63	47.4	0.60	48.6	0.50	48.8	0.45	49.0	0.48
STITCH LENGTH BW													
AW													
BURST STRENGTH BW													
AW													
SPIRALITY ANGLES BW													
AW													

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TESTS REQUIRED		3% CROSSLINKER - 20% STRETCH (LENGTH)					SAMPLE 5% CROSSLINKER - 10% STRETCH (LENGTH)						
	✓	3%/20/1	95%CL	3%/20/2	95%CL	3%/20/3	95%CL	5%/10/1	95%CL	5%/10/2	95%CL	5%/10/3	95%CL
% SHRINKAGE length													
width													
FABRIC WEIGHT BW													
AW													
C/3 CM BW	✓	29.3	0.34	29.7	0.35	29.8	0.45	32.7	0.68	32.1	0.40	32.1	0.63
AW	✓	35.4	0.37	35.4	0.37	35.3	0.48	36.0	0.34	35.8	0.56	36.9	0.63
W/3 CM BW	✓	54.9	1.28	53.8	1.16	53.3	1.72	49.5	0.69	49.7	0.83	49.7	0.59
AW	✓	50.6	0.84	49.6	0.37	49.7	0.59	47.8	0.45	47.5	0.51	48.2	0.30
STITCH LENGTH BW													
AW													
BURST STRENGTH BW													
AW													
SPIRALITY ANGLES BW													
AW													

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TESTS REQUIRED		5% CROSSLINKER - 15% STRETCH (LENGTH)					SAMPLE 5% CROSSLINKER - 20% STRETCH (LENGTH)						
	✓	5%/15/1	95%CL	5%/15/2	95%CL	5%/15/3	95%CL	5%/20/1	95%CL	5%/20/2	95%CL	5%/20/3	95%CL
% SHRINKAGE length													
width													
FABRIC WEIGHT BW													
AW													
C/3 CM BW	✓	30.7	0.48	31.0	0.58	31.2	0.30	29.8	0.45	29.8	0.45	29.6	0.37
AW	✓	34.3	0.35	34.5	0.38	34.4	0.37	33.3	0.35	33.4	0.37	33.6	0.37
W/3 CM BW	✓	52.7	1.12	53.5	1.08	51.3	1.31	54.6	1.22	50.7	1.39	53.2	1.61
AW	✓	50.7	0.48	49.6	0.50	48.8	0.94	50.4	0.97	50.9	0.71	51.4	0.50
STITCH LENGTH BW													
AW													
BURST STRENGTH BW													
AW													
SPIRALITY ANGLES BW													
AW													

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TESTS REQUIRED		CONTROL - 60% STRETCH (WIDTH)						SAMPLE CONTROL - 80% STRETCH (WIDTH)					
	✓	C/60/1	95%CL	C/60/2	95%CL	C/60/3	95%CL	C/80/1	95%CL	C/80/2	95%CL	C/80/3	95
% SHRINKAGE length													
width													
FABRIC WEIGHT BW													
AW													
C/3 CM BW	✓	42.8	0.56	43.4	0.40	43.8	0.45	45.7	0.83	45.5	0.77	46.1	0.40
AW	✓	47.2	0.74	48.8	0.83	48.7	1.01	48.1	0.71	48.9	0.53	49.4	0.90
W/3 CM BW	✓	31.6	0.58	31.1	0.36	30.3	0.53	27.8	0.30	27.5	0.66	27.2	0.25
AW	✓	40.8	0.56	40.4	0.58	39.7	0.48	40.4	0.51	39.5	0.57	38.4	0.50
STITCH LENGTH BW													
AW													
BURST STRENGTH BW													
AW													
SPIRALITY ANGLES BW													
AW													

KNITTING REF. RDL 504 LAB. REF. SUBMITTED BY: RDL DATE: 12/3/79.

TESTS REQUIRED		CONTROL - 100% STRETCH (WIDTH)						SAMPLE 1% CROSSLINKER - 60% STRETCH (WIDTH)					
	✓		95%CL		95%CL		95%CL		95%CL		95%CL		95
% SHRINKAGE length		C/100/1		C/100/2		C/100/3		1/60/1		1/60/2		1/60/3	
width													
FABRIC WEIGHT BW													
AW													
C/3 CM BW	✓	49.2	0.45	49.9	0.23	50.2	0.56	43.4	0.50	42.9	0.49	43.3	0.45
AW	✓	49.5	0.54	49.5	0.46	49.4	0.71	47.5	0.34	46.7	0.83	47.1	049
W/3 CM BW	✓	24.3	0.35	24.2	0.24	23.9	0.15	29.9	0.23	29.8	0.25	29.6	0.33
AW	✓	38.3	0.42	38.5	0.51	38.6	0.40	37.9	0.28	37.9	0.26	38.2	0.25
STITCH LENGTH BW													
AW													
BURST STRENGTH BW													
AW													
SPIRALITY ANGLES BW													
AW													

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TESTS REQUIRED		1% CROSSLINKER - 80% STRETCH (WIDTH)						SAMPLE 1% CROSSLINKER - 100% STRETCH (WIDTH)					
	✓	1/80/1	95%CL	1/80/2	95%CL	1/80/3	95%CL	1/100/1	95%CL	1/100/2	95%CL	1/100/3	95
% SHRINKAGE length													
width													
FABRIC WEIGHT BW													
AW													
C/3 CM BW	✓	46.4	0.47	46.5	0.72	45.2	0.66	48.9	0.63	48.8	0.53	49.9	0.40
AW	✓	48.1	0.71	47.9	0.79	48.2	0.41	50.1	0.43	50.0	0.34	50.6	1.02
W/3 CM BW	✓	26.7	0.30	27.0	0.29	26.5	0.49	24.0	0.11	24.5	0.31	24.2	0.38
AW	✓	35.7	0.38	36.0	0.34	36.0	0.44	34.5	0.44	34.8	0.39	34.1	0.63
STITCH LENGTH BW													
AW													
BURST STRENGTH BW													
AW													
SPIRALITY ANGLES BW													
AW													

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TESTS REQUIRED			3% CROSSLINKER - 60% STRETCH (WIDTH						SAMPLE 3% CROSSLINKER - 80% STRETCH (WIDTH)					
		✓	3/60/1	95%CL	3/60/2	95%CL	3/60/3	95%CL	3/80/1	95%CL	3/80/2	95%CL	3/80/3	95
% SHRINKAGE	length													
	width													
FABRIC WEIGHT	BW													
	AW													
C/3 CM	BW	✓	42.9	0.53	42.4	0.60	43.1	0.40	45.7	0.45	45.0	0.48	45.6	0.40
	AW	✓	45.0	0.51	45.7	0.89	45.7	0.45	47.0	0.44	47.9	0.71	47.5	0.38
W/3 CM	BW	✓	29.3	0.30	29.5	0.30	28.6	0.53	26.2	0.54	26.4	0.47	26.1	0.33
	AW	✓	35.1	0.41	34.3	0.59	34.7	0.29	31.8	0.38	33.2	0.56	32.7	0.34
STITCH LENGTH	BW													
	AW													
BURST STRENGTH	BW													
	AW													
SPIRALITY ANGLES	BW													
	AW													

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TESTS REQUIRED			3% CROSSLINKER - 100% STRETCH (WIDTH)						SAMPLE 5% CROSSLINKER - 60% STRETCH (WIDTH)					
		✓	3/100/1	95%CL	3/100/2	95%CL	3/100/3	95%CL	5/60/1	95%CL	5/60/2	95%CL	5/60/3	95
% SHRINKAGE	length													
	width													
FABRIC WEIGHT	BW													
	AW													
C/3 CM	BW	✓	47.9	0.98	48.5	0.61	49.0	0.75	43.9	0.59	43.5	0.48	44.8	0.96
	AW	✓	49.7	1.17	51.3	0.96	50.2	0.98	45.4	0.60	44.9	0.79	44.9	0.54
W/3 CM	BW	✓	23.6	0.26	23.6	0.36	23.5	0.29	28.9	0.35	28.5	0.17	28.2	0.28
	AW	✓	30.1	0.53	30.0	0.48	30.5	0.37	33.0	0.58	33.1	0.36	33.4	0.29
STITCH LENGTH	BW													
	AW													
BURST STRENGTH	BW													
	AW													
SPIRALITY ANGLES	BW													
	AW													

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TESTS REQUIRED			5% CROSSLINKER - 80% STRETCH (WIDTH)						SAMPLE 5% CROSSLINKER 100% STRETCH (WIDTH)					
		✓	5/80/1	95%CL	5/80/2	95%CL	5/80/3	95%CL	5/100/1	95%CL	5/100/2	95%CL	5/100/3	95
% SHRINKAGE	length													
	width													
FABRIC WEIGHT	BW													
	AW													
C/3 CM	BW	✓	48.0	0.44	46.2	0.76	46.2	0.89	49.7	0.68	48.9	0.84	50.0	0.58
	AW	✓	47.8	0.66	47.9	0.53	46.9	1.14	51.5	1.03	50.7	0.48	51.0	0.67
W/3 CM	BW	✓	25.3	0.26	25.5	0.38	25.6	0.59	23.3	0.30	22.9	0.23	23.3	0.85
	AW	✓	30.1	0.55	30.0	0.48	29.9	0.71	27.7	0.48	28.8	0.75	28.0	0.34
STITCH LENGTH	BW													
	AW													
BURST STRENGTH	BW													
	AW													
SPIRALITY ANGLES	BW													
	AW													

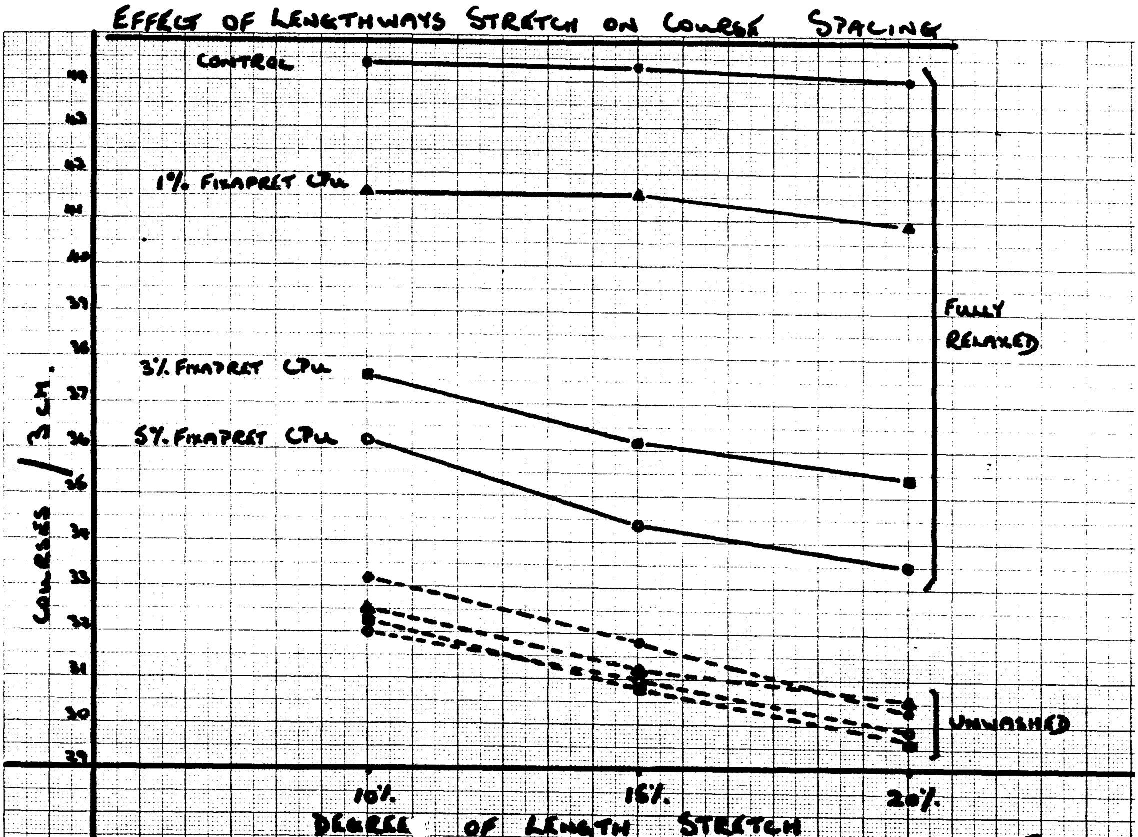

EFFECT OF LENGTHWAYS STRETCH ON COURSE SPACING
CONTROL
1% FIXAPRET CPL
3% FIXAPRET CPL
5% FIXAPRET CPL
FULLY RELAXED
UNWASHED
COURSES / 3 cm.
10%
15%
20%
DEGREE OF LENGTH STRETCH

FIG 1

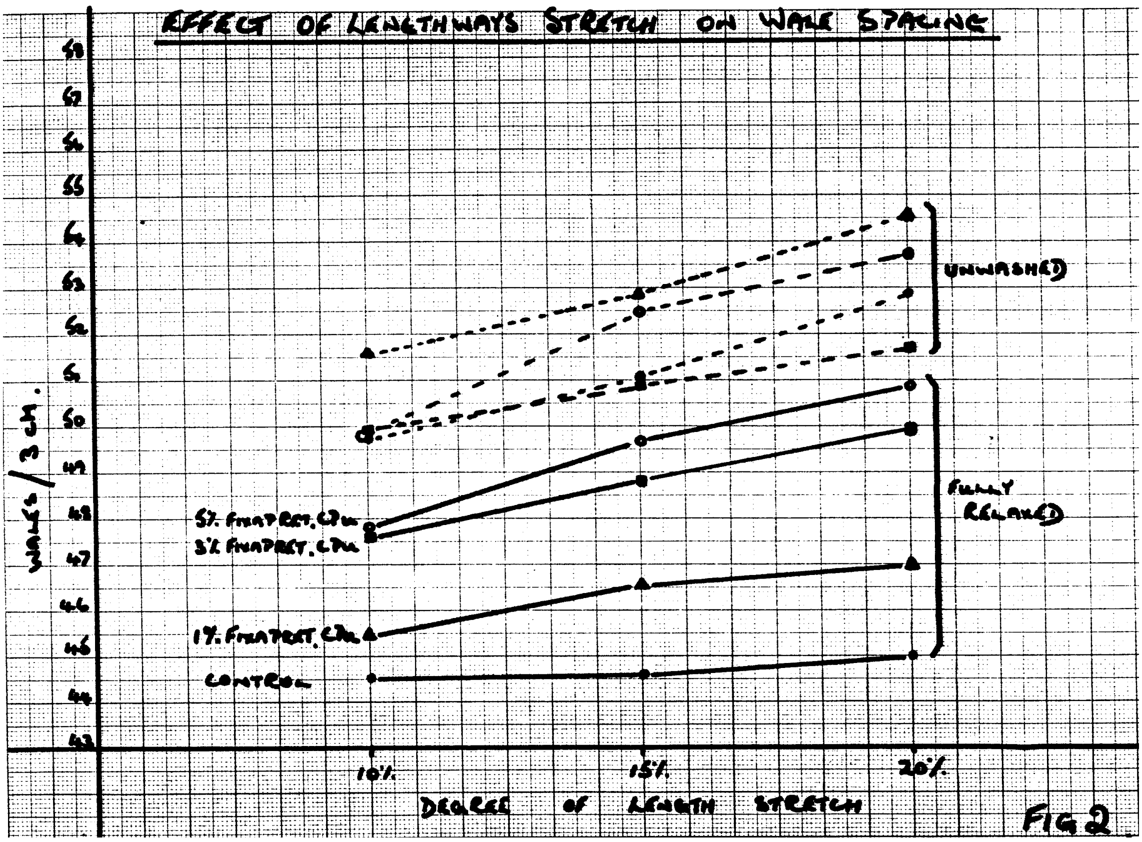
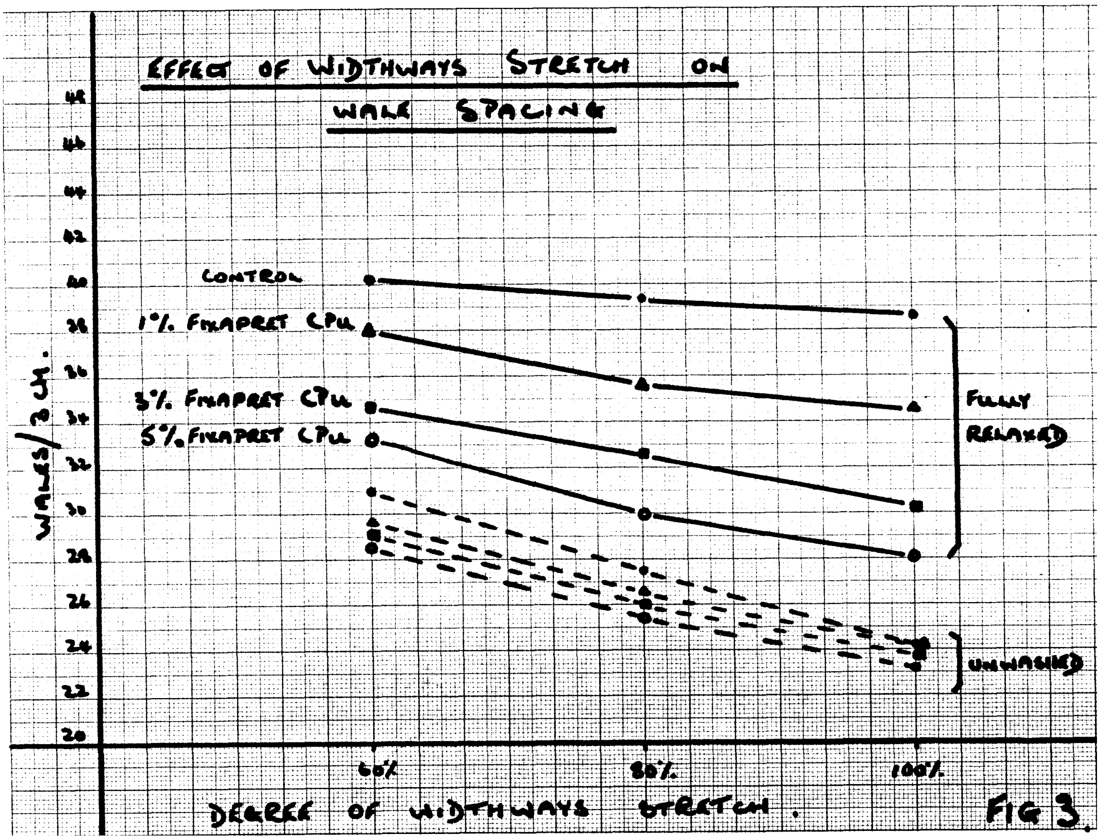
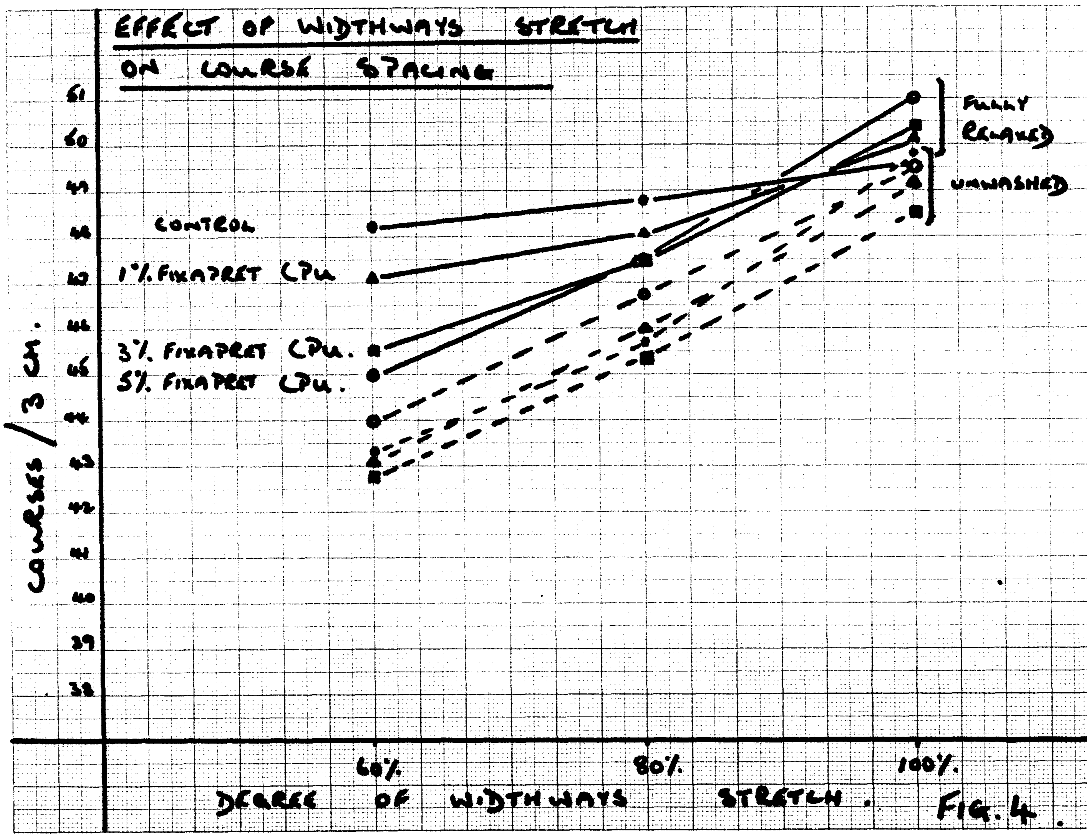

EFFECT OF LENGTHWAYS STRETCH ON WALE SPACING
UNWASHED
FULLY RELAXED
5% FIXAPRET CPL
3% FIXAPRET CPL
1% FIXAPRET CPL
CONTROL
WALES / 3 cm.
10%
15%
20%
DEGREE OF LENGTH STRETCH

FIG 2


EFFECT OF WIDTHWAYS STRETCH ON
WALE SPACING
CONTROL
1% FIXAPRET CPU
3% FIXAPRET CPU
5% FIXAPRET CPU
FULLY RELAXED
UNWASHED
WALES / 3 CM.
60%
80%
100%
DEGREE OF WIDTHWAYS STRETCH.
FIG 3.


EFFECT OF WIDTHWAYS STRETCH
ON COURSE SPACING
CONTROL
1% FIXAPRET CPU
3% FIXAPRET CPU.
5% FIXAPRET CPU.
FULLY RELAXED
UNWASHED
COURSES / 3 CM.
60%.
80%.
100%.
DEGREE OF WIDTHWAYS STRETCH.
FIG. 4.