

DOUBLE LACOSTE CONSTRUCTIONS IN THE STARFISH PREDICTIVE MODEL

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DOUBLE LACOSTE CONSTRUCTIONS IN THE STARFISH PREDICTIVE SYSTEMSUMMARY

As a result of an agreement made between Meridian Fabrics Limited of Nottingham, and IIC, a range of cotton double lacoste fabrics has been produced, and a series of equations has been derived from the measured properties of these fabrics.

These equations can be used to model and predict the general behaviour of double lacoste constructions.

YARNS AND FABRICS

Details of the yarns used in the project are given in Table I.

It was originally envisaged that all the yarns should be obtained using a single blend, KCW from Courtauld's. However, in fact only three of the six yarn counts were produced from this blend, with one in another Courtauld's quality LW; and two were supplied by Italian spinners Manifattura di Gemona. The use of three different fibre blends may have introduced some variability which would not be detected by the analysis described in this report.

Physical data on the yarns, sampled from the packages before knitting are reported in Table II. It should be noted that the 34's yarn appeared to be about 5% heavier than nominal. Deviations of this degree will result in considerable difficulty when STARFISH predictions are being followed. The IIC recommendation is for yarn count to be controlled to within 2.5% of the nominal value.

Details of the knitting machines employed appear in Table I.

Four fabrics were knitted from each yarn count, each with a different stitch length to cover a range of constructions from loose-knit to tight-knit. These constructions are listed in the first column of Table III. The first two digits of the code refer to the yarn count, in tex; while the final three digits show the stitch length so that for example, 16/340 represents a fabric knitted from 16 tex yarn with a stitch length of 0.340 cm.

Tables taken from production data records, showing the order and other details of knitting, are given in Appendix A.

Samples of the greige fabrics were tested at IIC. Shrinkages were evaluated after five wash/rinse and tumble dry cycles (the IIC Reference Relaxation Procedure - Figure 1) and course and wale densities, weight, stitch length and yarn count were also measured. Yarn count and stitch length were additionally measured in the "as received" state (before washing).

Test data on the greige fabrics are given in Table III.

FINISHING

Two finishing routes have been investigated, these being:

1. Bleached and jet-dyed (pale shade)
2. Scoured and jet-dyed (deep shade)

In each case, dyeing was followed by application of softener in the dyeing vessel, hydro-extraction, slitting and stenter drying.

To establish reasonable conditions for stentering these fabrics, the method of "finishing factors" was employed. Representative samples of a commercial Meridian double lacoste quality (Heanor F2006) were obtained in the greige, pre-scoured and jet-dyed (wine), and pre-bleached and jet-dyed (beige) states.

These were tested according to the IIC Reference Relaxation Procedure (Figure 1). Course and wale densities, in the reference state, were measured and the effect of the finishing process assessed (Table IV).

These factors were applied to the measured, reference state course and wale densities for the greige fabrics (Table III) to calculate first the approximate reference state for the finished fabrics, and secondly an appropriate width and course density for finishing to obtain about 8% length x 8% width residual shrinkages.

To simplify matters, average finishing factors for the two processes were calculated and applied to both runs. In addition, fabrics were grouped together for stentering, to minimise width changes. Five widths were chosen: 181, 189, 199, 208, and 215 cms.

The recommended stenter settings for each fabric are given in Tables V and VI.

Although no IIC personnel were present during the wet processing of these fabrics, the following details were obtained.

Finish 1 (Bleached and Dyed)

Machine - Thies Ring-Soft
 Liquor ratio - 11:1
 Process - Soda ash scour
 Peroxide bleach
 Dye at 60 C with 0.092% o.w.f. Cibacron Yellow F3R
 (Ciba-Geigy)
 Soften 2% o.w.f. Persoftal VS (Bayer)
 Hydro-extract
 Slit
 Stenter dry

Finish 2 (Scoured and Dyed)

Machine - Thies Ring-Soft
Liquor ratio - 11:1
Process - Soda ash scour
Dye at 50 C with 16.5% o.w.f. Levafix Black Liquid
(Bayer)
Soften 2% o.w.f. Persoftal VS (Bayer)
Hydro-extract
Slit
Stenter dry

SAMPLING AND TESTING

After stentering, a five-metre sample of each finished fabric was obtained, and submitted to the IIC laboratory for evaluation.

By this time the project was running approximately four weeks behind schedule, and it was therefore decided that testing should be limited to the parameters which were essential to the development of a STARFISH predictive model. These are:-

- courses/cm
- wales/cm
- stitch length
- yarn count (tex)

in the Reference State.

Shrinkages to the Reference Relaxation Procedure, and fabric weight in the reference state, were added in order to provide some cross-checking of the data and reveal any anomalies. Test figures are given in Table V (bleached and dyed) and Table VI (scoured and dyed).

COMMENTS ON THE TEST DATA

Some doubt unfortunately exists as to the validity of several of the test figures obtained in this study.

Figure 2 shows the apparent yarn shrinkage in relaxation, indicated by the stitch length measurements on the greige fabrics. Two are clearly anomalous, indicating severe knitting variations within the test length. It was not possible to carry out repeat tests with fresh samples, and in the case of sample 26/300 all test data have had to be eliminated from the analysis. The other suspect fabric, 16/380, was included in the "before wash" data set, but excluded from the greige "after wash" analysis, the stitch lengths clearly being incompatible.

In the scoured and dyed series sample 20/340 gave variable results, eventually traced to a repeating fault throughout the test length, attributable to a periodic variation in course length. All the data from this sample also has had to be excluded from the analysis.

CONSTRUCTION OF A PREDICTIVE MODEL

The STARFISH system for the production of a predictive model for knitted fabric shrinkage is built up by means of the following procedure.

1. Determine the yarn count (tex) and the stitch length (in cm) used in the construction of the greige fabric.
2. Determine the Reference State of the fabric after a specified finishing treatment. The Reference State is the configuration assumed by the fabric after having been subjected to the IIC Reference Relaxation Procedure (Figure 1), and is defined in terms of courses per cm., wales per cm., yarn count (tex) and stitch length (cm.).
3. Derive equations relating the final Reference State yarn count and stitch length to the original yarn count and stitch length in the knitted fabric (STEP ONE).
4. Derive equations relating the course and wale densities to yarn count and stitch length, all in the Reference State (STEP TWO).

For the determination of yarn count in the greige state, two sets of data are available in this case, measurements from the yarn packages and measurements on yarns taken from the knitted fabric.

For the purposes of this analysis, these sets of data were averaged, and the average (before wash) values shown in Table VII were used in the analysis.

Regression analysis gave the coefficients shown in Table VIII. Values for the regression coefficients (r^2) showed an excellent level of correlation in each case.

Fabric weight can be calculated from the predicted course and wale densities using the equation:

$$\text{Weight (gsm)} = \frac{\text{courses/cm} \times \text{wales/cm} \times \text{tex} \times \text{stitch length}}{10}$$

COLOUR MEASUREMENT

One sample of each yarn/dyelot combination was selected for colour measurement. A summary of the main results are given in Table IX.

From the L (lightness) data, the yellow would be classed as a pale shade, and the black, of course, is a deep shade.

The data were studied to see if any colour differences could be attributed to the different yarn sources already reported. The Gemona yarns (Ne 24 and 34) are slightly deeper than the Courtaulds in each dyelot, while the yellow LW (Ne 30) is the palest. The differences are hardly noticeable, however, the maximum delta-E being about 0.6 for each dyelot.

The conclusion may be rather fortunate. It indicates that, although three completely independent fibre blends have been included in this study, they may, by accident or design, be similar in fibre properties and characteristics. Large differences in fibre characteristics could have been expected to have added significantly to the overall variability within the database, and affected the reliability of the conclusions.

CONCLUSIONS

A series of equations has been derived whereby the behaviour of cotton double Lacoste structures when subjected to a five-cycle wash/tumble dry laundering treatment (the IIC Reference Relaxation Procedure), can be modelled by means of a computer programme.

TO ACHIEVE THE IIC REFERENCE STATE

1. **WASH** IN AUTOMATIC DOMESTIC WASHING MACHINE AT 60°C
2. **TUMBLE DRY** UNTIL DRY
3. **WET OUT** IN WASHING MACHINE (RINSE CYCLE)
4. **TUMBLE DRY** UNTIL DRY
5. **REPEAT** STEPS 3 AND 4 THREE MORE TIMES
6. **CONDITION**

Figure 2. Greige fabrics – Change in stitch length on relaxation.

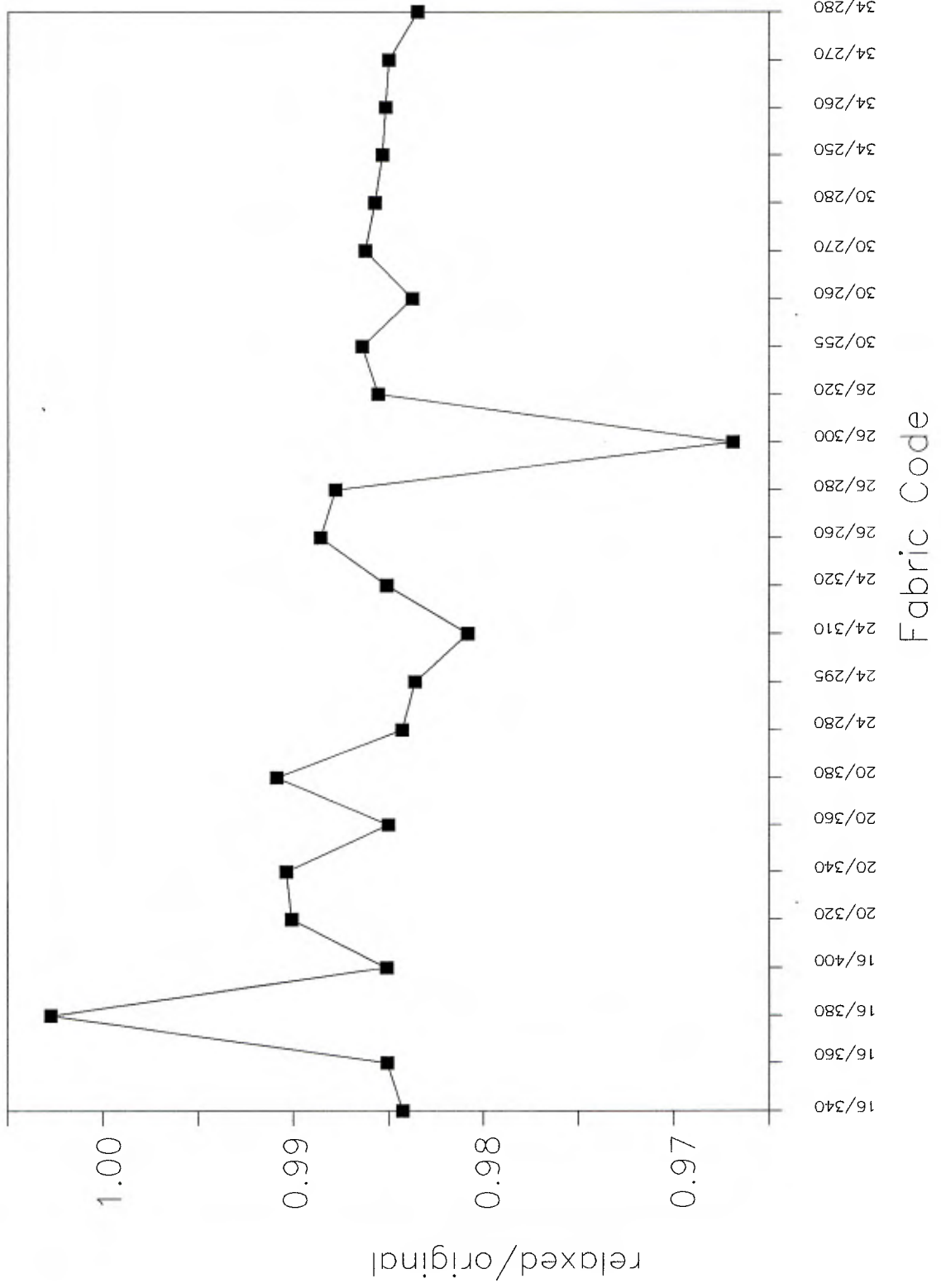


Table I - Yarns & Knitting Machines.

YARN	MACHINE	GAUGE	DIAMETER	NEEDLES	FEEDERS
Ne16, KCW	Camber Quattro	3 18	26"	1500	76
Ne20, KCW	Camber Quattro	3 18	26"	1500	76
Ne24, Gemona	Camber Quattro	3 24	25"	1932	76
Ne26, KCW	Camber Quattro	3 24	25"	1932	76
Ne30, LW	Camber Cheminit	28	24"	2112	72
Ne34, Gemona	Camber Cheminit	28	24"	2112	72

KCW - Courtauld's Mars Mill
 LW - Courtauld's Caleb Wright
 Gemona - Manifattura di Gemona

Table II - Measured Yarn Data

Nominal count	Measured Tex	Ne	Turns/ metre	Twist Factor
Ne16	37.43	15.8	559.0	3.57
Ne20	28.89	20.5	615.0	3.45
Ne24	24.92	23.7	687.5	3.58
Ne26	22.41	26.4	718.5	3.55
Ne30	19.89	29.7	790.0	3.68
Ne34	18.31	32.3	836.0	3.74

Table III. Greige fabric data.

	Weight	Courses	Wales	Stitch	Stitch	Yarn	Yarn
	g/sq m AW	per 3cm AW	per 3cm AW	len. (mm) BW	len. (mm) AW	Tex BW	Tex AW
16/340	366.0	99.4	26.8	3.430	3.376	36.40	36.95
16/360	345.8	94.1	25.7	3.647	3.593	37.63	37.25
16/380	324.7	86.4	24.3	3.839	3.850!	37.58	37.32
16/400	306.9	80.9	23.2	4.062	4.002	37.84	37.09
					Av	37.3632	37.1520
20/320	273.9	100.7	28.1	3.230	3.198	28.67	28.00
20/340	259.8	94.0	26.9	3.429	3.396	28.59	27.89
20/360	243.1	86.7	25.5	3.672	3.617	28.31	28.14
20/380	231.4	83.4	24.0	3.838	3.803	28.44	27.90
					Av	28.5036	27.9824
24/280	273.8	113.4	32.4	2.829	2.785	24.62	24.49
24/295	262.5	110.0	31.1	2.959	2.910	24.72	24.42
24/310	251.5	103.7	29.6	3.159	3.099	24.47	24.40
24/320	241.9	99.4	29.1	3.225	3.177	24.84	24.33
					Av	24.6614	24.4096
26/260	273.5	127.5	34.7	2.589	2.560	22.79	22.20
26/280	253.8	115.4	32.4	2.825	2.790	22.86	22.23
26/300	221.8	99.5	29.5	3.171!	3.066	22.78	22.57
26/320	220.0	98.9	28.6	3.257	3.210	22.47	22.33
					Av	22.7229	22.3343
30/255	250.6	126.4	36.8	2.571	2.536	19.54	19.18
30/260	243.4	122.1	36.5	2.618	2.576	19.95	19.47
30/270	231.6	116.4	35.1	2.720	2.683	19.65	19.54
30/280	224.3	112.1	33.7	2.802	2.762	19.99	19.61
					Av	19.7819	19.4507
34/250	225.3	125.7	37.1	2.524	2.487	18.26	17.67
34/260	214.5	119.9	35.7	2.627	2.588	17.98	17.85
34/270	202.3	112.0	33.9	2.728	2.687	18.04	17.93
34/280	196.0	111.5	33.2	2.812	2.765	17.95	17.53
					Av	18.0601	17.7430

BW - Before washing
 AW - After washing
 ! - Anomalous result

Table IV. Finishing factors.

GREIGE		Courses per 3cm	Wales per 3cm		
	1	108.3	30.90		
	2	106.7	30.45		
	3	108.3	30.60		
	4	109.7	30.90		
	5	107.8	30.95		
				AVERAGE	
				Courses	Wales
				per 3cm	per 3cm
				108.2	30.76
FINISHED					
Pre-scoured	1	101.7	31.25		
	2	101.1	31.15		
	3	102.5	30.85		
				101.77	31.08
Pre-bleached	1	98.5	32.55		
	2	99.1	31.80		
	3	99.8	31.95		
				99.13	32.10
FINISHING					
FACTORS (Finished/greige)					
Pre-scoured				0.94	1.01
Pre-bleached				0.92	1.04
AVERAGE				0.93	1.03

Table V. Bleached & dyed fabric data.

	Stenter (cm)	Shrinkage		Weight g/sq m	Courses/3cm		Wales/3cm		St. len.	
		length %	width %		BW	AW	BW	AW	mm.	AW
16/340	181	15.5	8.7	343.3	80.9	95.4	24.6	26.8	3.350	
16/360	181	16.1	5.3	326.6	74.0	88.4	24.4	25.6	3.574	
16/380	199	17.4	8.4	308.2	69.6	82.6	22.5	24.7	3.735	
16/400	208	16.7	7.8	286.6	63.8	78.3	21.4	23.5	3.937	
20/320	181	17.2	12.2	254.4	76.5	91.3	24.9	28.5	3.166	
20/340	181	17.2	9.0	239.9	71.8	86.3	24.6	27.2	3.350	
20/360	189	20.1	9.3	223.6	63.3	78.1	23.2	25.8	3.584	
20/380	199	22.9	9.8	210.2	57.7	73.9	22.5	25.0	3.746	
24/280	189	16.0	7.9	254.3	89.8	107.4	30.0	32.8	2.782	
24/295	199	15.6	9.4	247.7	87.3	102.2	28.7	31.6	2.883	
24/310	208	16.4	7.7	234.9	79.6	97.7	27.4	30.0	3.073	
24/320	208	16.8	6.4	224.4	75.0	92.5	27.4	29.6	3.159	
26/260	181	11.7	8.1	253.1	106.7	119.0	31.6	34.6	2.548	
26/280	189	15.7	8.3	234.6	92.8	108.4	30.2	33.0	2.792	
26/300	208	14.9	14.6	215.3	81.2	96.5	26.9	32.1	2.965	
26/320	215	18.1	7.4	204.9	76.0	92.0	26.7	29.0	3.186	
30/255	181	13.7	7.9	230.5	100.9	117.0	33.6	36.6	2.512	
30/260	181	15.2	7.3	224.6	97.7	115.2	33.5	36.2	2.567	
30/270	189	16.8	8.1	212.4	89.5	106.6	32.5	35.7	2.660	
30/280	199	15.8	8.9	206.6	87.4	102.8	30.9	34.3	2.749	
34/250	181	11.8	9.6	207.0	102.7	116.0	33.7	36.8	2.476	
34/260	189	15.1	10.1	196.1	93.1	111.2	31.9	35.9	2.583	
34/270	199	15.0	10.9	184.0	89.0	103.3	30.7	34.7	2.675	
34/280	199	16.4	8.2	183.4	84.5	102.4	31.0	34.4	2.751	

BW - Before washing
 AW - After washing

Table VI. Scoured & dyed fabric data.

	Stenter (cm)	Shrinkage		Weight g/sq m	Courses/3cm		Wales/3cm		St.len.	
		length %	width %		BW	AW	BW	AW	mm.	AW
16/340	181	11.8	7.5	357.5		94.3		27.0		3.365
16/360	181	16.2	3.8	335.2		87.4		25.8		3.583
16/380	199	15.1	8.7	310.0		81.9		24.9		3.767
16/400	208	14.8	8.2	295.9		76.3		23.3		3.980
20/320	181	13.5	12.6	264.0		92.4		28.4		3.168
20/340	181									
20/360	189	16.9	9.8	230.9		77.0		26.0		3.611
20/380	199	17.9	9.7	217.7		73.9		24.6		3.748
24/280	189	11.4	8.0	268.5		107.8		32.6		2.774
24/295	199	13.0	8.1	258.4		102.7		31.7		2.886
24/310	208	14.0	9.2	241.7		95.6		29.8		3.098
24/320	208	15.9	7.6	235.3		92.4		29.1		3.192
26/260	181	9.8	8.4	259.1		119.9		34.2		2.558
26/280	189	11.3	8.6	243.5		105.7		32.4		2.799
26/300	208	13.6	12.1	227.0		98.2		31.4		2.992
26/320	215	12.0	9.8	209.5		91.7		29.4		3.201
30/255	181	11.5	7.5	233.9		115.0		36.6		2.530
30/260	181	12.7	6.8	233.3		112.7		36.8		2.576
30/270	189	13.0	7.4	219.4		106.3		35.3		2.681
30/280	199	14.0	9.2	214.1		100.4		34.5		2.756
34/250	181	13.0	8.8	212.6		114.4		37.6		2.492
34/260	189	13.6	9.6	204.7		106.0		36.8		2.597
34/270	199	15.1	10.6	193.4		101.3		35.3		2.687
34/280	199	14.3	7.8	187.2		100.9		33.8		2.775

BW - Before washing
 AW - After washing

Table VII. Yarn tex data.

	Tex (before wash)			Tex (after wash)		
	Package	Greige	Average	Greige	Bleached	Scoured
Ne16	37.43	37.36	37.40	37.15	36.70	37.62
Ne20	28.89	28.50	28.70	27.98	27.61	28.78
Ne24	24.92	24.66	24.79	24.41	24.05	24.73
Ne26	22.41	22.72	22.57	22.33	21.74	22.57
Ne30	19.89	19.78	19.84	19.45	19.06	19.60
Ne34	18.31	18.06	18.19	17.74	17.36	17.85

Table VIII - Coefficients

Equation $Y=aX$

	a	r squared
Tex		
- Greige	0.98523	0.999
- Bleached & dyed	0.96936	0.999
- Scoured & dyed	0.99962	0.999
Stitch length		
- Greige	0.98593	0.9997
- Bleached & dyed	0.97776	0.999
- Scoured & dyed	0.97781	0.999

X = Tex(BW) or Stitch length(BW)
 Y = Tex(AW) or Stitch length(AW)

Equation $Y=a+bX(1)+cX(2)$

	a	b	c	r squared
Courses per cm.				
- Greige	-16.0988	12.2300	2.1475	0.989
- Bleached & dyed	-25.2455	12.5437	3.2337	0.977
- Scoured & dyed	-26.7123	12.5498	3.4066	0.970
Wales per cm.				
- Greige	1.0972	2.9374	-0.1412	0.988
- Bleached & dyed	3.8226	2.5336	-0.4128	0.988
- Scoured & dyed	3.6832	2.5823	-0.4089	0.980

X(1) = 1/(stitch length(AW))
 X(2) = root (tex(AW))
 Y = Courses or wales (AW)

Table IX. Colour measurement.

YELLOW

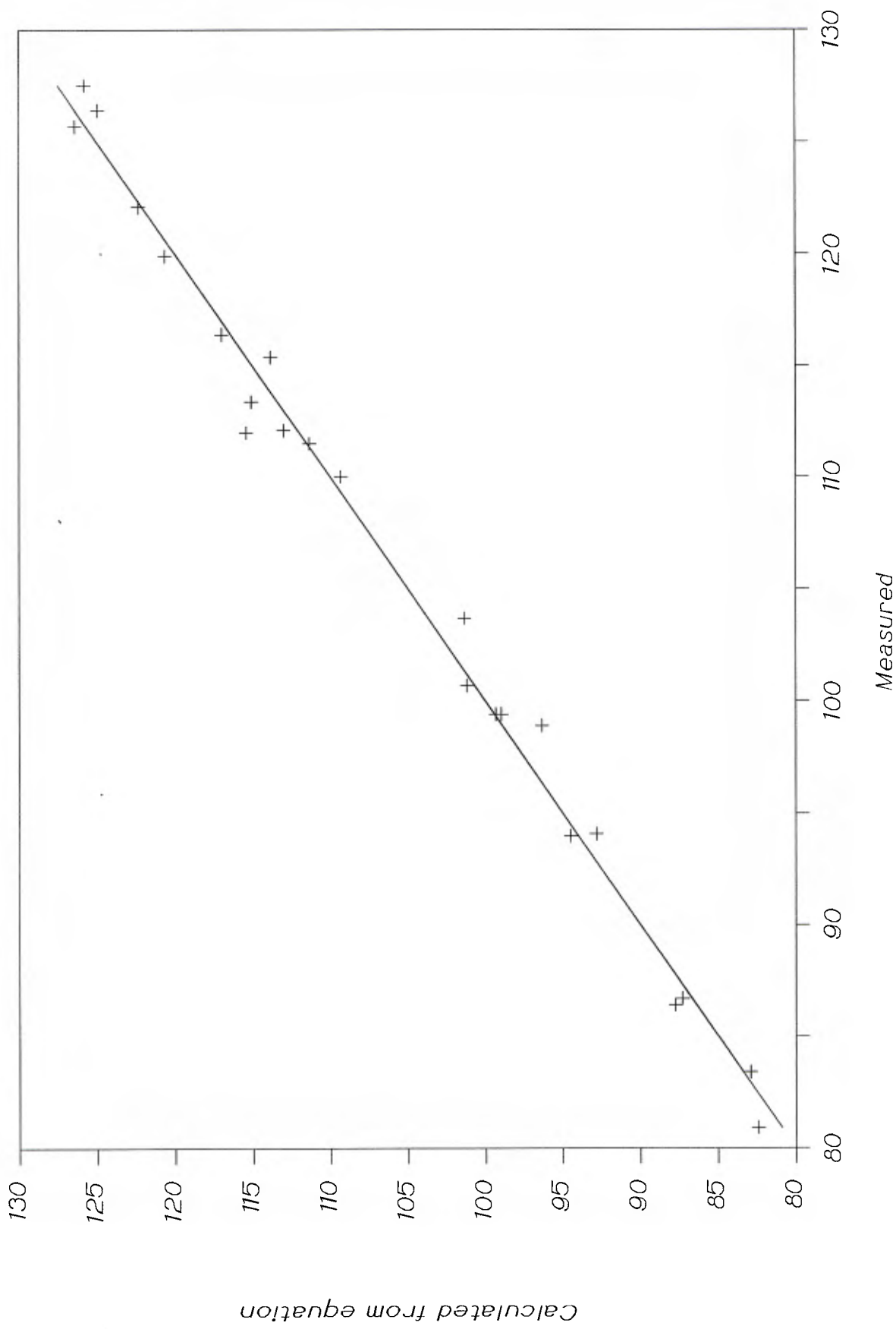
	L	a	b	K/S
16/380	86.2	8.42	41.83	1007
20/360	86.1	7.93	41.19	1003
24/310	86.1	7.85	41.52	1003
26/300	86.1	8.55	42.90	1002
30/270	86.6	8.34	42.62	1015
34/270	86.1	8.12	43.01	1000

BLACK

16/380	14.9	-0.86	-2.77	51.8
20/360	14.8	-0.77	-2.83	51.3
24/310	14.5	-0.77	-2.72	50.2
26/300	14.9	-0.89	-2.84	52.1
30/270	14.7	-0.86	-2.82	51.1
34/270	14.4	-0.74	-2.63	49.4

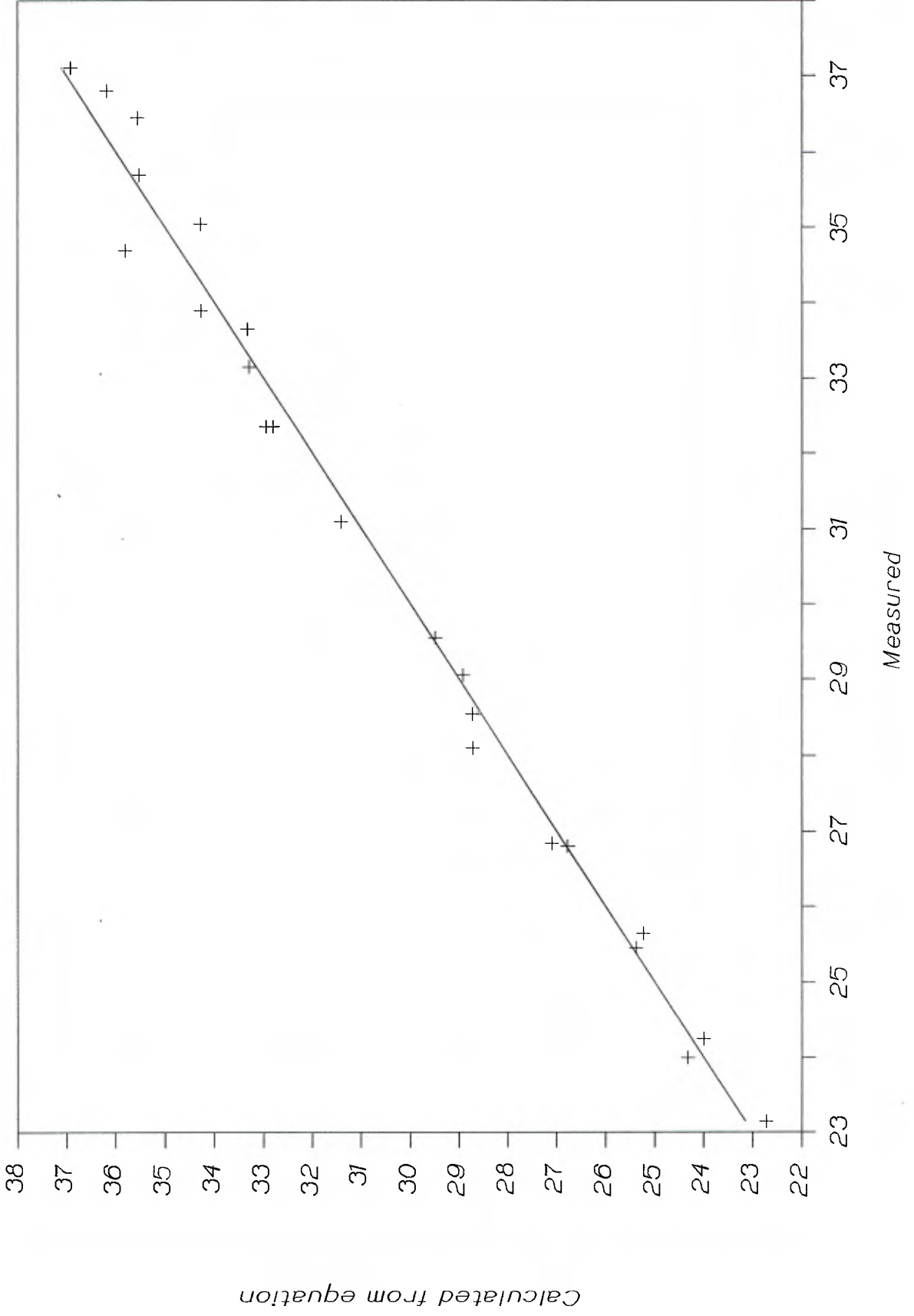
Greige Courses per 3cm (Ref. State).

Correlation of data



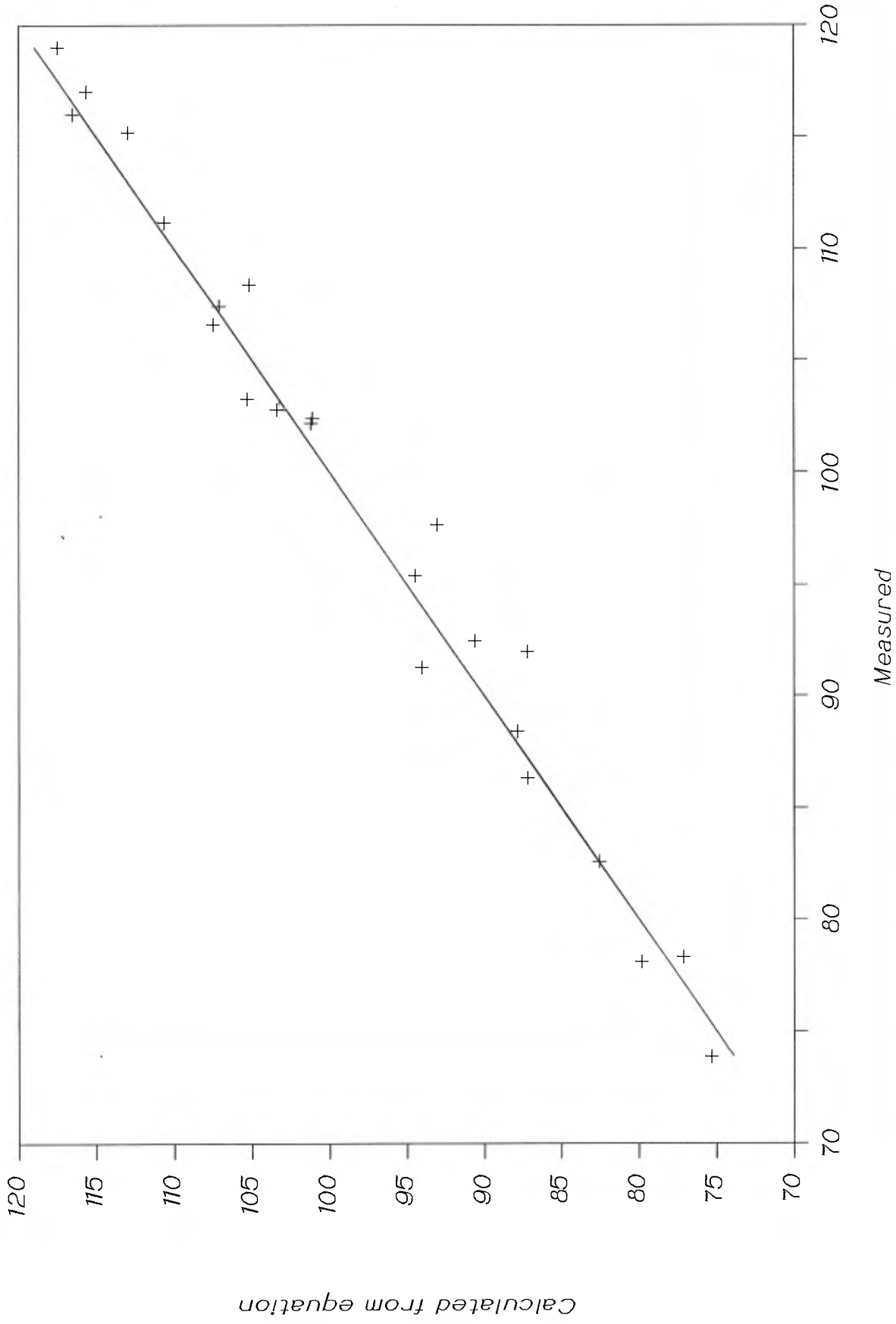
Greige Wales per 3cm (Ref. State).

Correlation of data



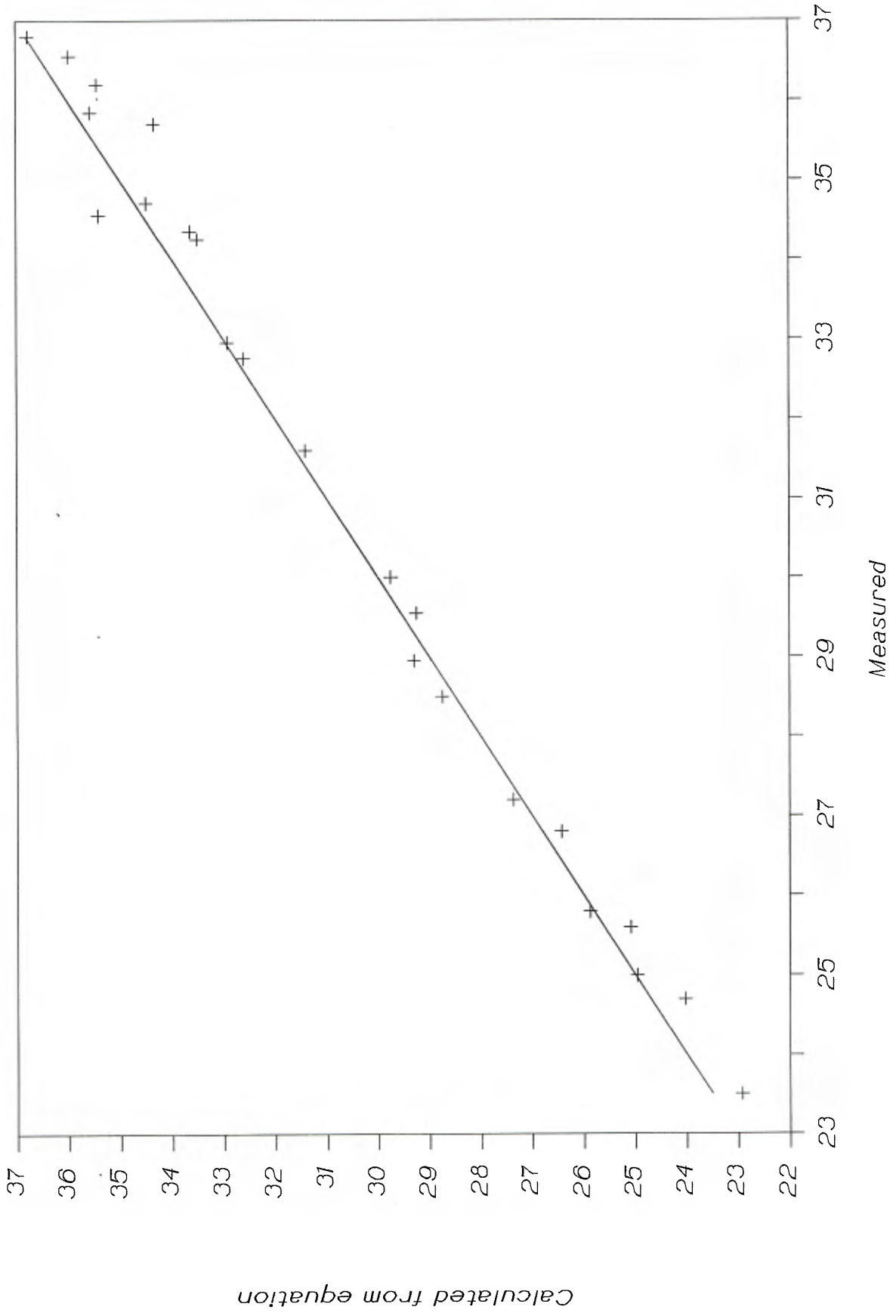
BI.& Dyed Courses per 3cm (Ref. State).

Correlation of data



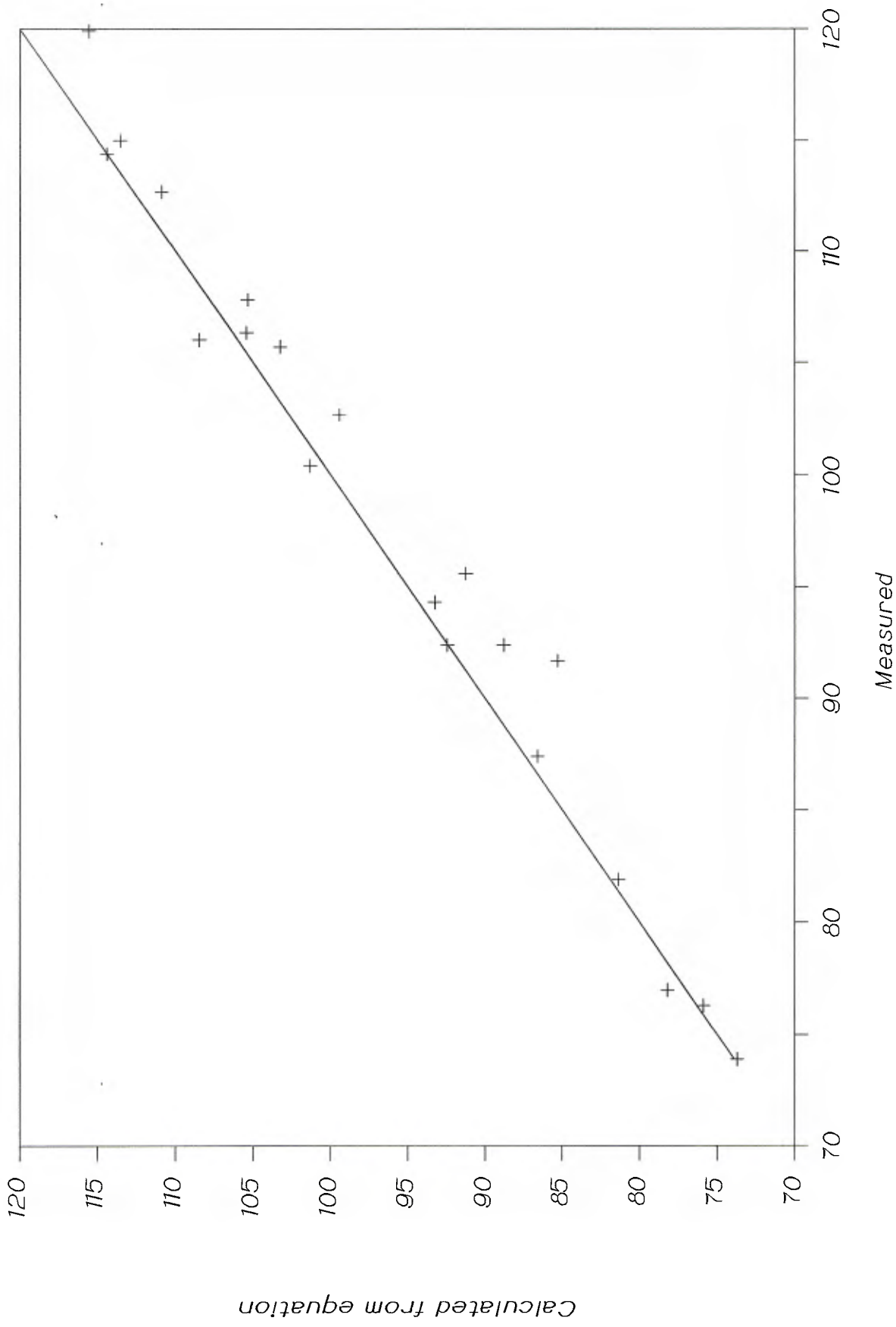
BI.& Dyed Wales per 3cm (Ref. State).

Correlation of data



Sc.& Dyed Courses per 3cm (Ref. State).

Correlation of data



Sc.& Dyed Wales per 3cm (Ref. State).

Correlation of data

