Import Substitution of Combination Wire Rope - Part III Comparison of Standard Cift - CWR and Imported Combination Wire Rope

B. MEENAKUMARI and P. A. PANICKER

Central Institute of Fisheries Technology, Cochin - 682 029

Tensile and extension properties of standard Cift-CWR and imported combination wire ropes from Japan, Norway and Denmark are studied and the analysis is presented in the paper. Tensile and chemical properties of steel wire, tensile and abrasive properties of PP covering, effect of twist on material at different stages are worked out and reported.

The specification and standardisation of combination rope form aspects of studies undertaken for introducing indigenously made combination wire rope for the fishing industry (Meenakumari & Panicker, 1988; 1989). Comparison with existing samples of the product already in use forms an integral part of the programme to evaluate in detail the properties of the standard Cift-CWR. The samples compared did not possess equivalent specification but this disparity was made up by comparing the properties in terms of unit area of cross section and breaking factor of the respective samples. A critical analysis was taken up vis-a-vis the tensile and other properties of the standard Cift - CWR and five imported samples.

Materials and Methods

Six combination ropes, namely, 17 mm dia Cift-CWR, 16 mm dia Japanese, 17 mm dia Norwegian, 18 mm dia Norwegian, 19 mm dia Danish and 19 mm dia Danish (with fibre core) were taken for this study. Only one rope type had PP fibre core and the others are with steel core. The tensile properties of ropes, strands (covered and uncovered), rope core, rope strands and the central core of the ropes were recorded by Zwick 1484 Universal Testing Machine, and abrasion resistance by rubbing against oil stone for specified period and recording the residual strength of the material. The percentage composition of the constituent elements of the steel wire was estimated using 8410 Plasma Scan except for carbon. The carbon analysis is carried out by gasometric method in Strohlein Apparatus.

Results and Discussion

The specification details worked out for the different combination ropes studied are given in Table 1. The composition of the

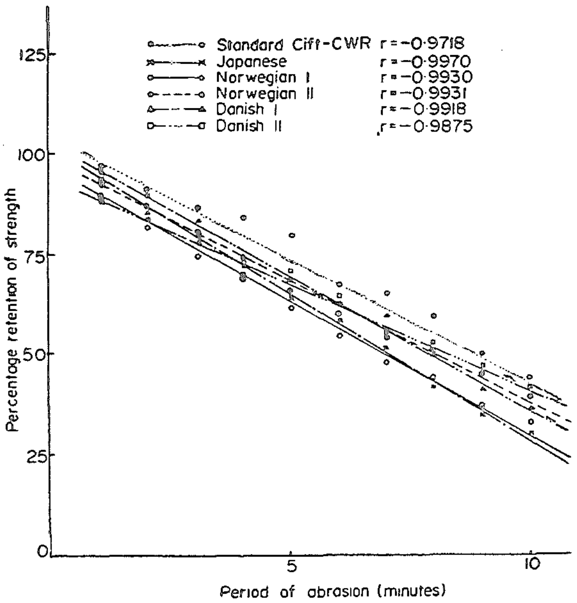

Fig. 1. Relation between strength retention and period of abrasion of PP covering materials of different combination ropes.

steel wires and the tensile strength are presented in Table 2. The copper content in the imported steel wires is less when compared with the standard Cift-CWR, which has resulted in a lower percentage of extension for the imported ones than the Indian rope indicating that they are less flexible. The 1 mm dia Danish steel wire had the least tensile strength with maximum flexibility and extension, may be due to very low carbon and silicon contents (Table 2). The load elongation curve of imported samples (Figs. 2 to 6) and Cift-CWR (Meenakumari & Panicker, 1989) indicated similar pattern for all the wires. The steel wire used for standard Cift-CWR had a comparatively high content of Fe, Cu, Mn and C than the steel wires used for the preparation of prototype combination wire rope. The increase in carbon content has resulted an increase of tensile strength from 1.6 KN/mm^2 of the prototype to 1.7 KN/mm^2, without affecting the flexibility which may be due to the presence of more Cu and Mn.

Table 1. *Details of Cift-CWR and imported combination wire ropes*

Details	Cift–CWR	Japanese	Norwegian I	Norwegian II	Danish I	Danish II
Construction	6S (7C + 8+1Scr)+ 6Crs (6+ 1+1Crc)	6S (7C+ 8+1Scr)+ 6Crs (6+ 1+1Crc)	6S (6C+ 6+1Scr)+ 6Crs (6+ 1+1Crc)	6S (7C+ 8+1Scr)+ 6Crs (6+ 1+1Crc)	6S (7C+ 12+1Scr)+ 6Crs (6+ 1+1Crc)	6S (7C+ 8+1Scr)+ 3Crsf (6F)
Diameter, mm	17.00	16.00	17.00	18.00	19.00	19.00
Pitch, mm	107.00	93.8	103.50	115.40	122.40	125.00
Mass, kg/100m	43.60	37.82	42.16	52.00	52.45	40.00
Rope strand covered						
Diameter, mm	6.00	5.20	5.30	5.60	7.00	6.50
Pitch, mm	48.00	26.90	31.58	33.01	35.00	33.33
Rope strand uncovered						
Diameter, mm	3.50	3.20	2.60	3.20	3.50	3.40
Pitch, mm	32.00	27.58	32.00	30.76	36.36	33.30
Rope core						
Diameter, mm	7.00	6.20	7.00	7.40	7.20	8.20 (fibre)
Pitch, mm	52.00	47.60	50.00	56.00	60.60	38.46
Core strand						
Diameter, mm	2.40	2.00	2.50	2.50	3.00	
Pitch, mm	22.10	21.40	23.20	28.50	27.27	
Steel wire diameter, mm	9.80	0.70	0.80	0.80	0.70/1.00	1.00
PP cover diameter, mm	2.50	3.00	3.00	3.00	3.00	3.00
HDPE central core diameter, mm	4.00	4.00	4.00	4.00	4.00	

Table 2. *Percentage composition of metals and non-metals in steel wires used for combination wire ropes*

Combination wire ropes	Metals								Non-metals			
	Fe	Cr	Cu	Mn	Mo	Ni	Sn	Zn	C	P	S	Si
Cift-CWR 1	91.74	0.08	0.11	0.57	1.52	0.11	0.007	2.95	0.57	0.0009	0.012	2.19
Standard Cift-CWR	94.53	0.04	0.37	0.83	0.85	0.07	0.005	1.09	0.72	0.0001	0.009	2.10
Japanese	93.24	0.01	0.03	0.77	2.63	0.06	0.001	1.90	0.51	0.0004	0.009	2.06
Norwegian I	95.71	0.12	0.36	0.72	0.95	0.09	0.002	1.56	0.74	0.0004	0.009	0.80
Norwegian II	93.68	0.01	0.03	1.12	1.86	0.02	0.004	1.95	0.60	0.0003	0.014	1.15
Danish I	95.12	0.08	0.06	0.98	0.83	0.09	0.002	1.43	0.60	0.0004	0.0017	1.13
Danish II	95.96	0.09	0.14	0.37	0.42	0.11	0.008	1.41	0.52	0.005	0.0014	1.11

Table 3. *Tensile properties of Cift-CWR and imported combination wire ropes*

(1) *Full rope*	F-max KN	E–B %	F–R KN	E–R %	S_2 mm	F KN/mm²	a/do mm
A. Cift-CWR	66.15	12.67	65.76	12.71	226.98	0.291	17.00
B. Japanese	57.36	10.83	56.34	10.97	201.06	0.285	16.00
C. Norwegian I	60.23	11.01	59.39	11.15	226.98	0.265	17.00
D. Norwegian II	71.39	14.37	70.50	14.43	254.46	0.280	18.00
E. Danish I	74.77	13.54	73.24	13.59	283.52	0.264	19.00
F. Danish II	53.42	13.80	52.78	13.84	283.52	0.190	19.00
(2) *Rope strand covered*							
A.	7.07	6.87	7.06	6.88	28.27	0.250	6.00
B.	7.21	5.81	7.20	5.80	21.23	0.339	5.20
C.	7.08	2.76	7.07	2.76	22.06	0.321	5.30
D.	8.65	4.91	8.64	4.90	24.63	0.350	5.60
E.	11.08	6.97	11.08	6.98	38.48	0.264	7.00
F.	9.36	5.78	9.35	5.79	33.18	0.400	6.50
(3) *Rope strand uncovered*							
A.	6.29	3.79	6.29	3.80	9.62	0.656	3.50
B.	5.46	3.57	5.45	3.57	8.04	0.679	3.20
C.	5.24	3.26	5.23	3.25	5.30	0.990	2.60
D.	6.81	2.66	6.80	2.66	8.04	0.847	3.20
E.	8.17	3.71	8.15	3.70	9.62	0.850	3.50
F.	8.07	4.12	8.07	4.12	9.07	0.890	3.40
(4) *Rope core*							
A.	30.84	4.00	30.82	4.02	38.48	0.800	7.00
B.	25.42	3.26	25.50	3.25	30.19	0.845	6.20
C.	—	—	—	—	—	—	7.00
D.	31.13	3.83	31.00	3.82	43.00	0.704	7.40
E.	38.44	5.06	38.89	5.06	40.71	0.940	7.20
F.	9.84	3.56	9.83	13.56	52.81	0.186	8.20

Table 3. *(Contd.)*

	F-max KN	E-B %	F–R KN	E–R %	S_2 mm	F KN/mm^2	a/do mm
(5) *Core strand*							
A.	5.49	3.46	5.49	3.46	4.52	1.210	2.40
B.	4.49	3.97	4.49	3.96	3.14	1.430	2.00
C.	—	—	—	—	—	—	2.50
D.	5.86	3.41	5.86	3.41	4.90	1.200	2.50
E.	6.69	4.00	6.68	3t97	7.06	0.900	3.00
F.	—	—	—	—	—	—	—
(6) *Steel wire*							
A.	0.852	5.21	0.852	5.21	0.50	1.700	0.80
B.	0.698	5.40	0.698	3.45	0.38	1.850	0.70
C.	0.889	3.65	0.889	3.67	0.50	1.770	0.80
D.	0.865	4.16	0.865	4.16	0.50	1.730	0.80
E.	0.685	3.95	0.685	3.95	0.38	1.820	0.70
	0.999	4.96	0.999	4.96	0.78	1.280	1.00
F.	1.021	5.82	1.021	5.82	0.78	1.280	1.00
(7) *PP cover*							
A.	0.390	30.60	0.390	30.60	4.90	0.078	2.50
B.	0.536	14.78	0.516	15.25	7.06	0.076	3.00
C.	0.615	8.91	0.607	8.97	7.06	0.087	3.00
D.	0.633	12.74	0.630	12.80	7.06	0.090	3.00
E.	0.760	12.72	0.743	12.96	7.06	0.107	3.00
F.	0.503	10.56	0.484	10.73	7.06	0.071	3.00
(8) *PP central core*							
A.	2.48	22.27	2.26	22.27	12.56	0.197	4.00
B.	2.12	19.64	2.01	19.66	12.56	0.168	4.00
C.	1.64	15.07	1.63	15.26	12.56	0.130	4.00
D.	1.54	40.88	1.52	42.45	12.56	0.122	4.00
E.	2.42	19.27	2.40	19.40	12.56	0.192	4.00
F.	—	—	—	—	—	—	—

F = Tensile strength; E–B = Extension at break; F–R = Tensile strength at rupture; E–R = Extension at rupture; S_2 = Area of cross section; a/do = Diameter.

Table 4. *Relation between the aggregate strength of components and the strength at different stages of rope formation of combination wire ropes*

Details	Cift-CWR	Japanese	Norwegian I	Norwegian II	Danish I	DanishII
Aggregate breaking strength of wire components, KN	76.68	62.82	69.34	75.15	91.27	49.01
Aggregate breaking strength of PP cover & strand core, KN	18.72	25.73	25.83	30.38	36.40	24.14
Breaking strength of central PP core, KN	2.48	2.12	1.64	1.54	2.42	9.84
Total of 1 to 3, KN	97.88	90.67	96.81	107.07	130.09	82.99
Aggregate strength of covered rope strands, KN	42.42	43.26	42.48	50.50	66.48	56.16
Breaking strength of rope core, KN	30.84	25.42	—	31.13	38.44	9.84
Total of 5 & 6, KN	73.26	68.68	—	81.63	104.92	66.00
Aggregate strength of uncovered rope strands, KN	37.74	32.76	31.44	40.86	49.02	48.42
Aggregate strength of rope core strands, KN	32.94	26.94	—	36.15	40.14	—
Total of 8 & 9, KN	70.68	59.70	—	76.04	89.16	—
Breaking strength of combination wire rope, KN	66.15	57.36	60.23	71.39	74.77	53.42
Reduction of strength at various stages, %						
Aggregate strength of wire component to full rope	13.73	8.69	13.14	5.00	18.08	(+) 8.25
Total of all components to full rope	31.41	36.73	37.78	33.32	42.52	35,63
Aggregate of covered strand and rope core to full rope	9.70	16.48	—	12.54	28.73	19.06
Aggregate of uncovered rope strands and core strands to full rope	6.41	3.92	—	6.11	16.14	—
Aggregate of wires to uncovered rope strand	7.71	2.22	1.76	1.59	0.0061	1.20
Aggregate of wire to core strand	11.77	8.10	—	3.22	4.33	—

The covering material of standard Cift-CWR, though maintains almost same tensile strength has shown a very high extensibility of 30.6% when compared to 8.91 to 14.78% in the imported samples (Table 3). The abrasive property in terms of strength retention (Fig. 1) of standard Cift-CWR PP cover is next to Danish II. The abrasion resistance for the period studied formed a linear regression in all cases (Fig. 2). The correlation coefficients for the different samples are-0.9718 for standard Cift-CWR and between -0.9895 to -0.9970 for the imported samples.

The specification and tensile properties of ropes and components are presented in Table 3 and Figs. 2 to 6. The tensile strength of standard Cift-CWR showed a maximum of 2.29 KN/mm², while Japanese, Norwegian I and II and Danish I showed 0.285, 0.265, 0.28 and 0.264 KN/mm² respectively and Danish II with PP core 0.19 KN/mm² (Table 3). The lower tensile strength shown by Danish II rope is due to the lower tensile designation of the wire used and also the incorporation of fibre core. The percentage extension of imported ropes ranged between 10.83 and 14.37 and that of the standard Cift-CWR is 12.6%, which falls well with in the range of 10–15% observed for the imported samples.

The computed value of breaking factor is 16.25 for standard Cift-CWR, 15.1 for Japanese, 14.3 for Norwegian I, 13.73 for

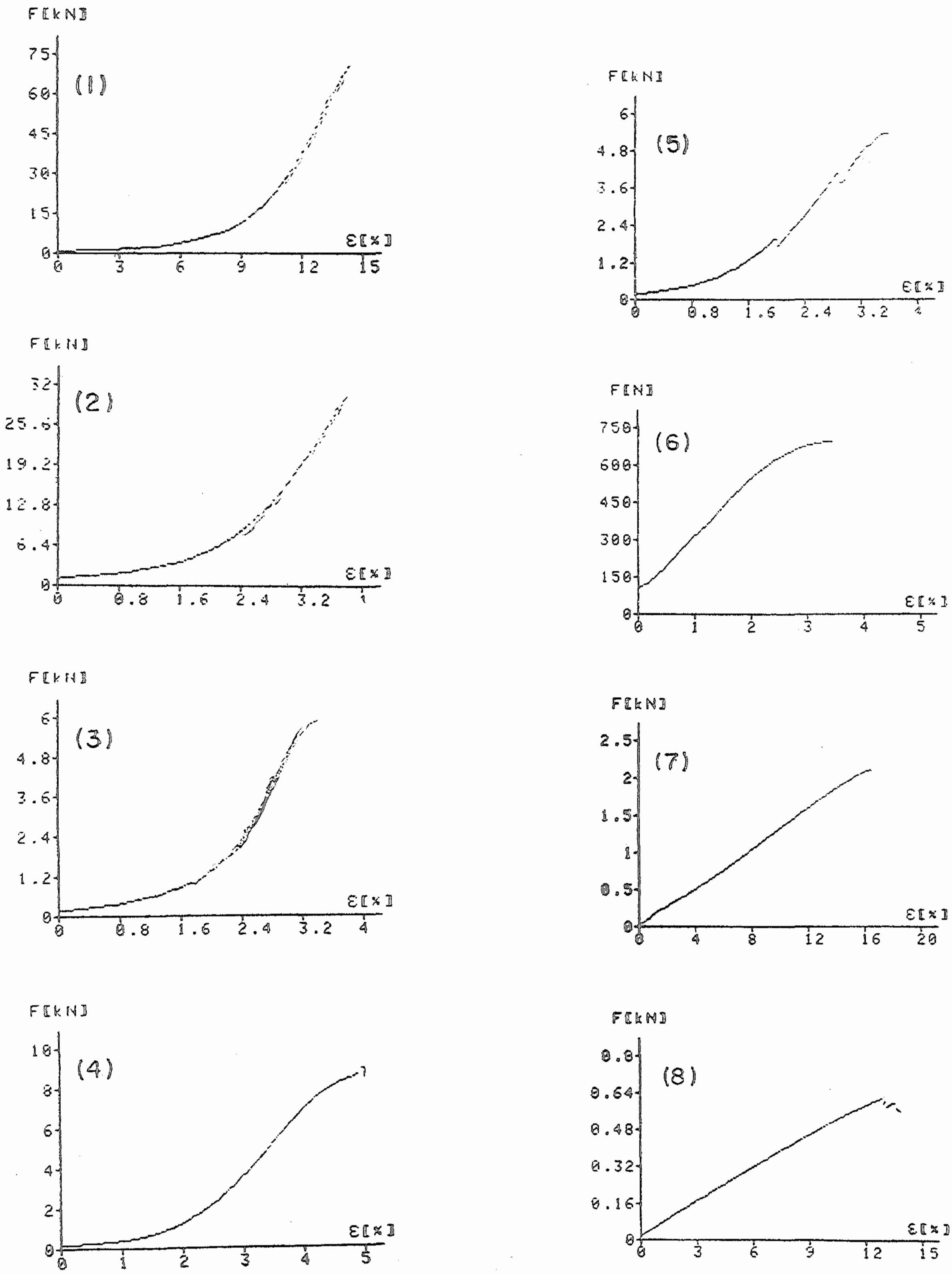

Fig. 2. Load elongation curve of Japanese combination wire rope and components.
1. full rope. 2. rope core. 3. core strand. 4. PP covered rope strand.
5. uncovered rope strand. 6. steel wire. 7. central PP core. 8. PP cover.

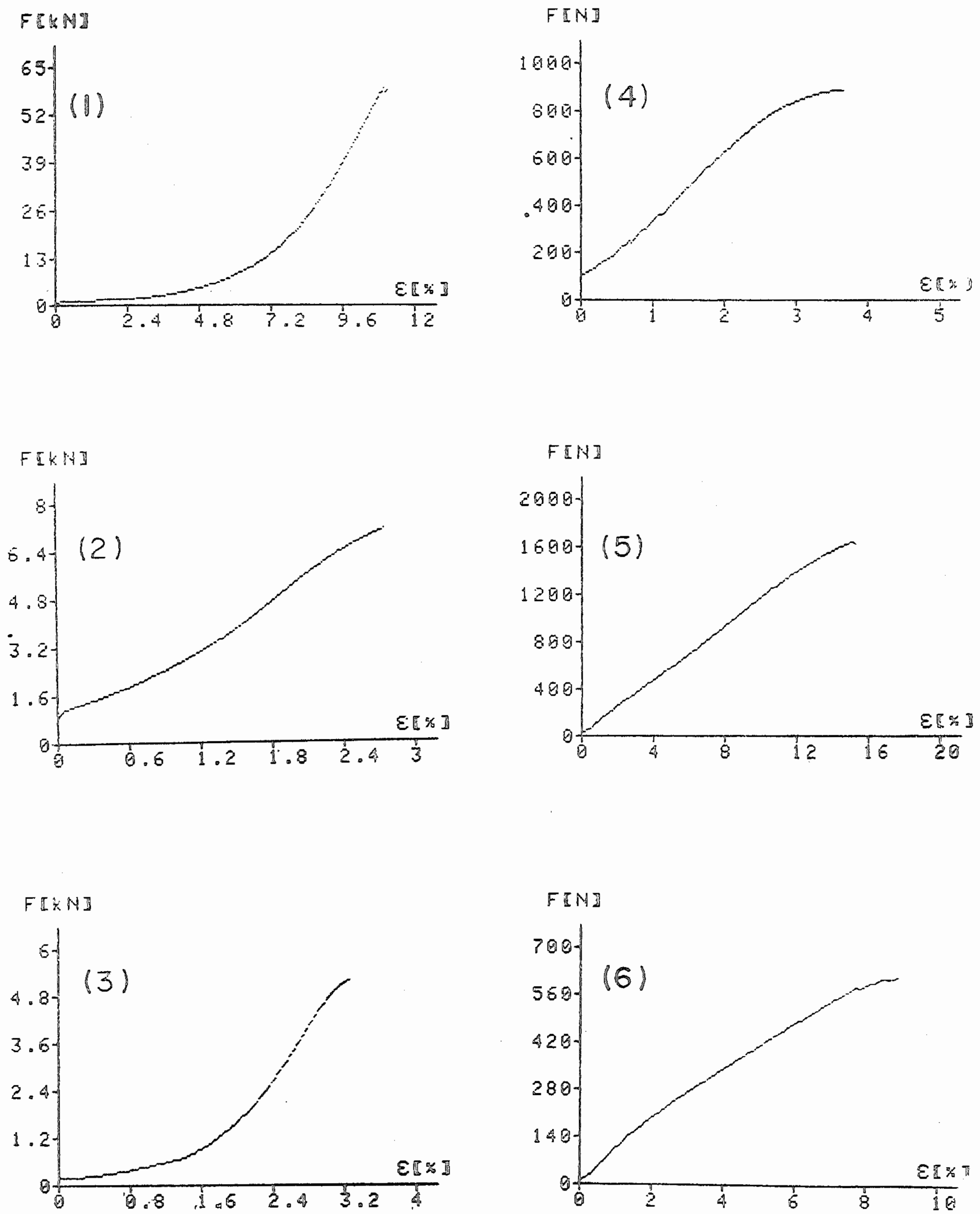

Fig. 3. Load elongation curve of Norwegian I combination wire rope and components.
1. full rope. 2. PP covered rope strand. 3. uncovered rope strand. 4. steel wire.
5. central PP core. 6. PP cover.

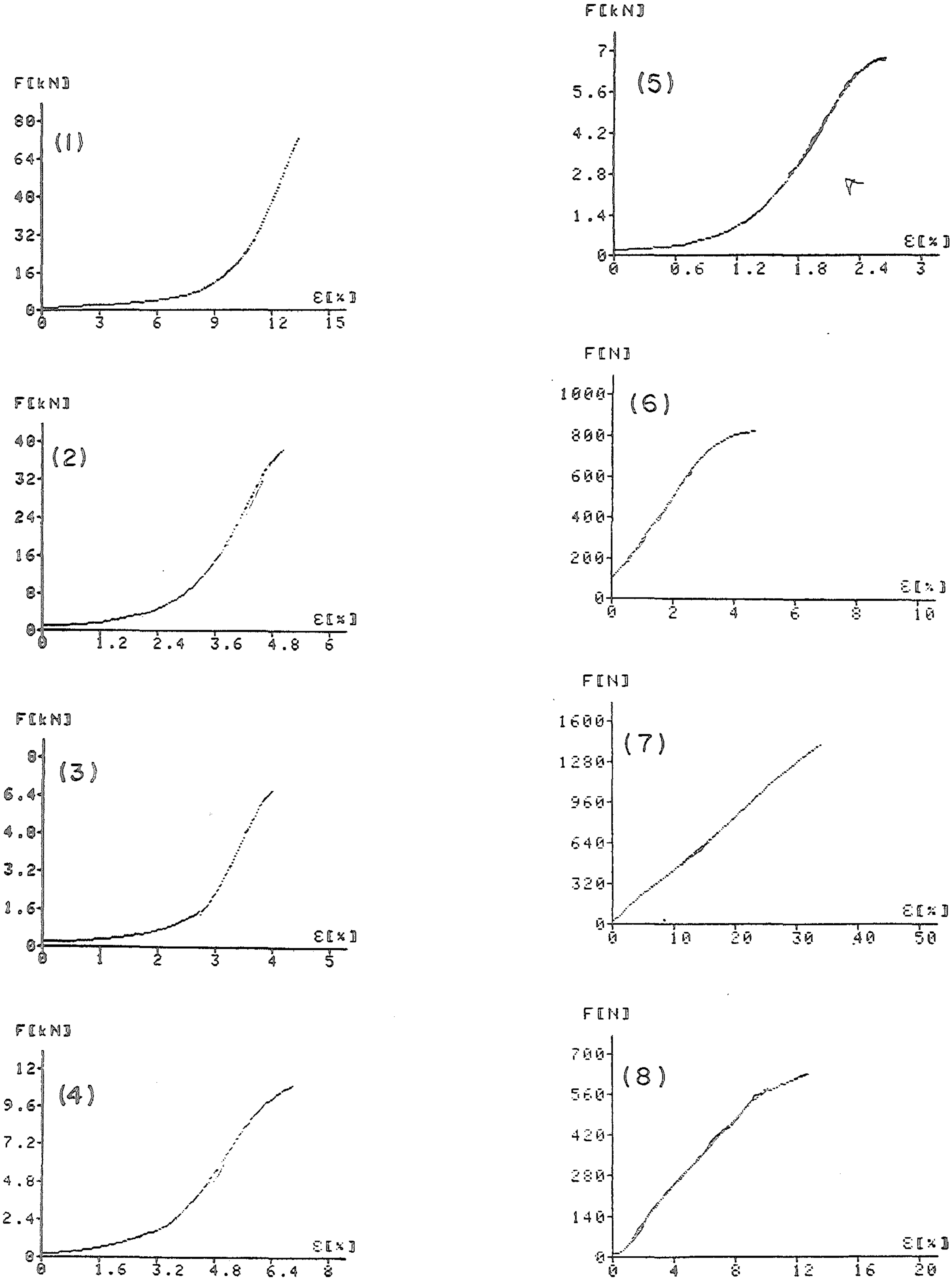

Fig. 4. Load elongation curve of Norwegian II combination wire rope and components.
1. full rope. 2. rope core. 3. core strand. 4. PP covered strand. 5. uncovered strand.
6. steel wire. 7. central PP core. 8. PP cover.

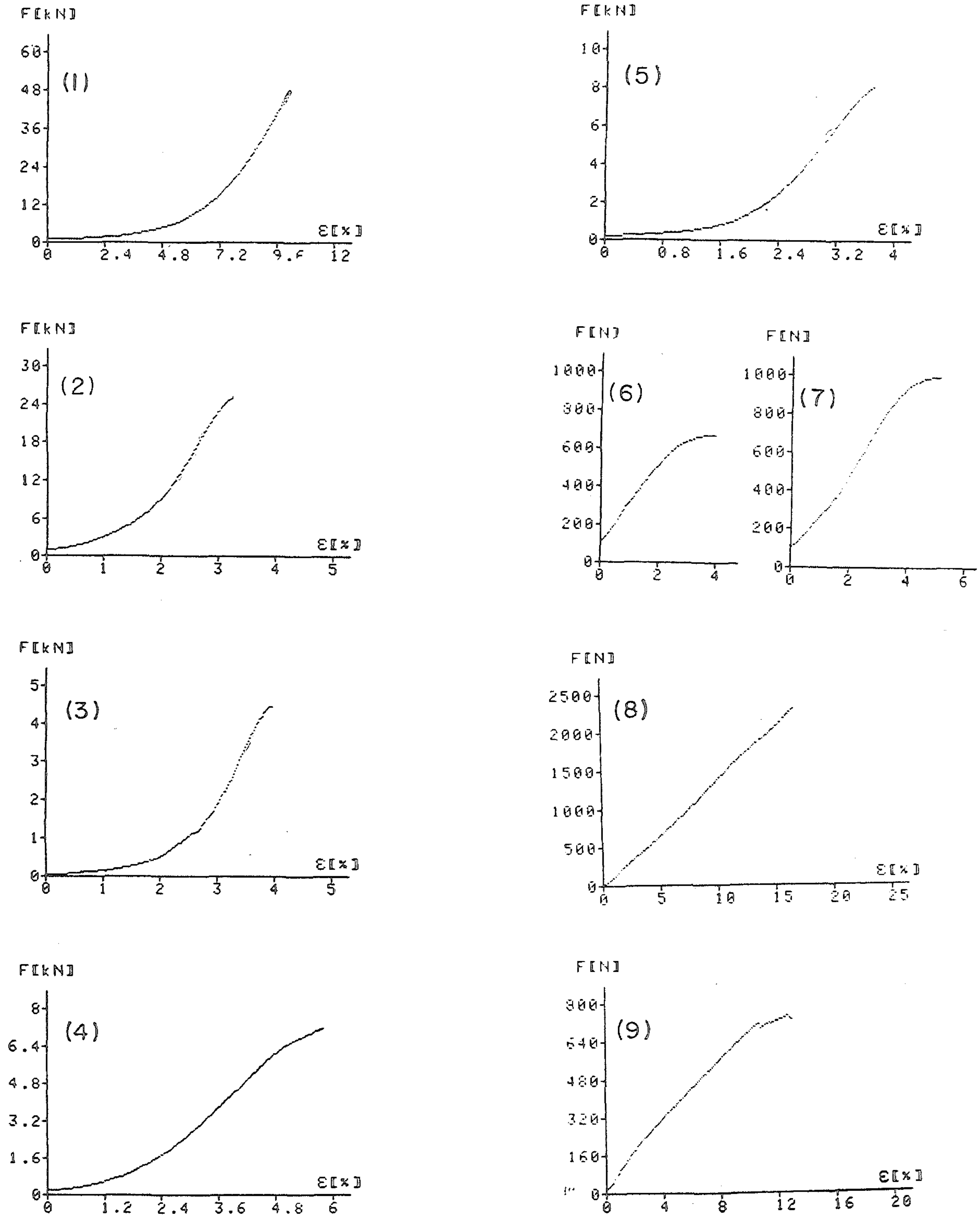

Fig. 5. Load elongation curve of Danish I combination wire rope and components. 1. full rope. 2. rope core. 3. core strand. 4. PP covered strand. 5. uncovered strand. 6 & 7. steel wires. 8. central PP core. 9. PP cover.

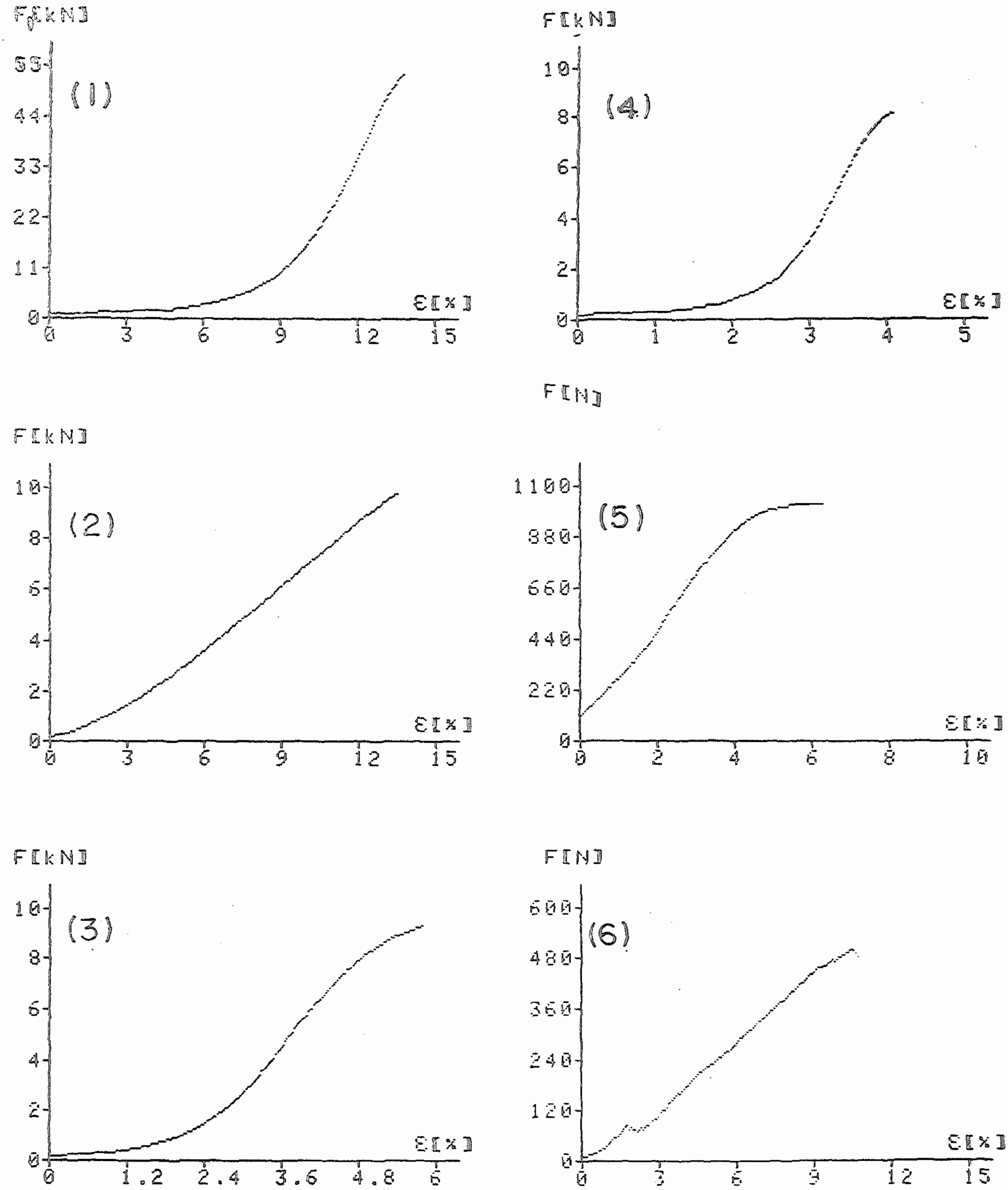

Fig. 6. Load elongation curve of Danish II combination wire rope and components.
1. full rope. 2. fibre rope core. 3. PP covered strand. 4. uncovered strand. 5. steel wire.
6. PP cover.

Norwegian II, 14.23 for Danish I and 13.35 for Danish II.

The rope strands covered and uncovered of standard Cift-CWR showed a tensile strength of 0.25 KN/mm^2 and 0.656 KN/mm^2 respectively which is the lowest among the ropes (Table 3). Regarding the extension, both covered and uncovered strands are almost same for all ropes. The same is the case with core and core strands. Table 4 giving in detail the relation between the aggregate strength of the component and the strength at different stages of rope formation indicates that the reduction of strength from one stage to another is also mostly comparable. It is slightly higher for standard Cift-CWR when the wires are twisted initially to strands. The reduction at this stage is 7.71 and 11.77% respectively for uncovered rope strand and core strand whereas it is 1.2 to 2.22 and 3.32 to 8.10 respectively for imported ropes.

The realisation factor when all the rope components are taken into consideration is 67.59% in the standard Cift-CWR and 57.48 to 66.68% in the imported samples. The tensile strength also is better in the Cift-CWR, due to the adjustment of pitch on the strand cover and at the rope closing stage, which gives better distribution of load for this than the imported ropes. Iron wire of 0.8 mm dia with a steel component of 94.5% and carbon 0.7% can be made into wire ropes in combination with PP tape for rigging trawl nets operated from medium and large vessels. There exists no international standard for the construction of combination ropes but there are some national standards (Klust, 1983). This comparison is made with the materials already in use in other countries with the idea of projecting the desirable qualities of Cift-CWR and assess short-comings if any needing improvement. The study reveals that the standard Cift-CWR compares well with the imported samples with a superiority in tensile strength.

The authors are thankful to Shri M.R. Nair, Director, Central Institute of Fisheries Technology for his permission to publish the paper.

References

Klust, G. (1983) *Fibre Ropes for Fishing Gear,* Fishing News (Books) Ltd., England

Meenakumari, B. & Panicker, P.A. (1988) *Fish. Technol.* 25, 8

Meenakumari, B. & Panicker, P.A. (1989) *Fish. Technol.* 26, 4