CHAPTER-6

PRESENTATION AND DISCUSSION OF RESULTS

6.1 General

In this chapter experimental results of the test on the reinforced concrete beams without fibres, with fibres over the whole section and with fibres in lower half depth of the section are presented and discussed in detail. The effect of the inclusion of steel fibres in reinforced concrete deep beams and moderate deep beams on the variation of maximum compressive strain in concrete, strain in tensile steel, deflection, first cracking load, modes of failure, cracking characteristics and ultimate capacity are critically discussed. Findings pertaining to partially fibrous concrete sections and fully fibrous concrete sections are appraised. Different methods for calculating shear capacity and flexure capacity of fibre reinforced concrete deep beams and moderate deep beams are presented in brief. Various ultimate shear load formulae are used to compute theoretical ultimate shear loads of fully fibre reinforced concrete deep beams. These loads have been compared with their test results. Theoretical ultimate shear loads are also calculated by the proposed formula developed in this study to show that they are in good agreement with the test results. Further, flexural formulae proposed for various conditions of fibres in concrete member are applied to the results of test beams available in literature and the values thus obtained are compared with their test resutls. Finally, considering the effect of strain hardening of tension steel, ultimate flexural loads for moderate deep beams of de Paiva and Siess have been calculated by considering without fibre conditions. [illegible] chapter

6.2 Comparison of Test Results

It is evident from direct tension test results that due to the presence of fibres, brittle matrix transforms into a ductile one which shows significant enhancement in tensile strain capacity. An engineering parameter, t_f identified as tensile strain capacity enhancement factor t_f of the fibrous concrete is the only parameter required to be determined in the design. Once this parameter is known for a given grade of concrete, aspect ratio of fibre, volume fraction of fibre, the other associated parameters required for the design can be obtained from their relationships with t_f which have been established in the **Table-5.2**. The variation of depth factor h_f of the fibrous zone with respect to t_f has been critically examined in detail in Chapter-5. Variation of moment capacity enhancement factor β_f, with respect to t_f has been shown in **Fig.5.2.** The rate of increase in β_f decreases rapidly with increase in t_f. For t_f = 100, h_f approaches unity which indicates that a partially fibrous section tends towards a fully fibrous section. Here very large values of t_f in the range of 50 to 80 are only hypothetical. This means that β_f can not increase indefinitely in case of fully fibrous section.

With the scope of this investigation, an upper limit of h_f = 0.6 for partially fibrous section is suggested. Lower limit of h_f is governed by volume of fibre and length of fibre. Looking to **Table-5.2**, t_f = 20 gives corresponding h_f = 0.724 thus it is partially fibrous section. This can be achieved with high values of V_f about 3%. Ofcourse such volume may not necessarially lead to practically viable situation. **Figure-5.2** makes it evident that providing fibres beyond certain value does not result in any increase in moment capacity enhancement.

In addition to the realization of strength comparable to those of fully fibrous concrete members, the composite material should also exhibit appropriate load-deflection responses. Only then such members can be rated as satisfactory and adoptable. Fully fibrous and partially fibrous concrete beams have been tested to obtain these responses. An examination of these responses reveals comparable performances of fully and half depth fibrous concrete beams. Thus, the concept of partially fibre reinforced concrete section has been suggested in this investigation. This concept can be fully exploited for optimum utilization of steel fibres which results in a cost-effective and economical propostion.

Steel fibres dispersed in the concrete modify crack control and deformation characteristics in a much desirable way all along the loading range from the beginning right upto failure. Henager (68), Swamy and Al Noori (166), Swamy and Al Taan (167) have investigated the effect of the presence of fibres in concrete shallow beams. A review of these works does not indicate analytical approach to quantify the effect of fibres.

In the case of plain fibrous sections, the failure will take place on the tension side and concrete in the compression zone is not compressed to its full capacity. The tensile strains are comparatively low in such cases, whereas in the presence of conventional reinforcement, these strains are relatively of higher order and quite large in magnitude so as to exhaust the pullout strength of the fibres across the cracks. Due to increase in load, fibres nearer to the neutral axis are called into play to pull across the cracks, as more and more fibres become ineffective.

The compressive strength of concrete is usually obtained from cylinders with a height to diameter ratio of 2.0. The maximum compressive stress reached in the concrete of a flexural member may differ from the cylinder strength because of the difference in size and shape of the compressed concrete. Several alternative relationships are employed for this purpose and different recommendations have been made by the CEB-FIP Model Code-90 (32), the ACI Building Code-318-89 (5) and the British Codes CP-110 (36). All these recommendations are aimed at providing a reliable and simpler stress-strain curve for concrete to define the magnitude and distribution of compressive stress which is necessary to assess the realistic behaviour of the section.

Deformation Characteristics : The experimental results pertaining to the structural characteristics which are related to the deformational behaviour of beams are furnished in **Table-4.1**, for each individual beam of each series. Modifications in a given characteristics can be studied comparatively for a given volume fraction of the fibres viz, full depth inclusion, half depth inclusion and without inclusion of fibres.

From experimentaly obtained graphs (see **Fig. 4.5 to 4.20**) for two volume fractions of fibres and for the two locations of fibres, it is revealed that fully fibrous and paratially fibrous conventionally reinforced concrete beams have practically the same modifying effect on the deformational characterstics of deflection and steel strain at all stages of loading. These characteristics are considerably reduced, thereby increasing the stiffness of members right from the beginning upto the ultimate. A large fibre content has a greater influence in modifying these characteristics. Full depth fibre inclusion is more advantageous in improving the ductility characteristcs at the ultimate as per **Table-4.1**.

Fibre inclusion is found to increase the ultimate ductility characteristcs. The order of improvement in these characteristics is virtually absent when the fibres are added only in the half depth portion of the beams. For any improvement in the ductility, the fibres should be provided over the entire depth. Addition of more fibres has a larger effect in improving the ductility characteristics.

Under-reinforced beams by themselves are adequately ductile and the fibres when added to concrete in such beams are expected to improve their stiffness characteristics in terms of deflection, curvature and steel strain. These improvements should bring about substaintial reductions in crack width.

Deflection : Variation of central deflection with load for beams with fibres over the whole section is compared with that of beams with fibres over half depth and without fibres in **Fig. 4.5 to 4.20** . A detailed exmaination of curves reveals that fibre inclusion reduces deflection. Both half depth and full depth fibre inclusions show almost identical performaces in reducing these deformations at all stage of loading. Full depth fibre inclusion results in imparting ductility and structural integrity to the beam upto the ultimate stage. A reduction in deflection is obtained due to the inclusion of fibres. This depends on the fibre parameters. Lakshman (98), Swamy and others (165) have reported a reduction in deflection. The order of reduction in deflection or increase in service load based on deflection, is not to the extent obtained in crack width criteria. So, it can be concluded that the fibres are more efficient in the crack control than in increasing the stiffness of a beam.

Ductility and Rotational Capacity : An examination of the curves given in **Fig. 4.5 to 4.20** clearly indicates that ductility is imparted by the fibres in deep beams and moderate deep beams. The ductility factor 'μ' obtained in **Table-4.1** also indicates the same. This factor can be obtained by taking ratio of ultimate deflection to yield deflection. The values are very near to the moment capacity enhancement factor β_f for different conditions of fibres in the section.

Strain in Tension Steel : Tension steel strains of some typical beams with fibres over the whole section are compared with those of the same beams containing fibres over the lower half depth. See **Figs. 4.21 to 4.28** and **Tables-C1 to C8** in **Appendix-C**. The figures show clearly the reduction in the tension steel strain due to the addition of steel fibres. Similar reduction in steel strain was also observed by Swamy and Al-Taan (167) and Sabapathi and

Achyutha (148) at all stages of loading. This reduction implies the additional tensile force contribution of the fibres in the tension zone. The same effect was not observed in the beams with fibres in lower half depth. Steel strains measured and calculated by method as explained in Chapter-5, agree fairly well.

Strain in Compression Concrete : The variation of extreme layer compressive strain in concrete deep beams and moderate deep beams for full depth and half depth conditions of fibres are shown in **Table-6.1**. It shows a reduction in the strain compared to the beams without fibres. Nearly the same order of reduction in compressive strain of concrete at the working load is seen for most of the beams. Values of extreme layer compressive strains at ultimate moment, obtained from test results of beams for different conditions of fibre and without fibres, are presented in **Table-6.1** . The maximum compressive strain in concrete at ultimate does not increase in under-reinforced beams. In fact,there is a trend of reduction only.

The behaviour of fibre reinforced concrete in the compression zone of either full depth or half depth beam is not in conformity with the behaviour of fibrous concrete cylinder in compression test. The possible reason for this discrepancy is that in a cylinder the fibres tend to orient in a direction favourable to arrest the vertical splitting cracks occuring in the cylinder at the ultimate stage. The tendency of the fibre to orient almost in a horizontal plane in the cylinder is due to the vertical casting. But in beam, the fibres tend to align nearly parallel to the direction of compressive stress, due to horizontal casting. Moreover,the failure of the compression concrete in a beam is purely by crushing and not by the formation of any spliting crack. So the fibres are not able to offer any resistance against a crushing failure as they are very slender. However, the presence of fibres in the compression zone prevents the spalling of concrete at the time of crushing and helps to maintain the integrity of the concrete. Ref.(148)

Crack Details : The first visible crack appeared within the central region of the constant moment zone in most of the beams. The values of the ratio of the load at which the first crack was observed to ultimate load, for the beams without fibres and with fibres over the whole section and fibres over the lower half depth of the section, are given in **Table 4.2**. In most of the beams with fibres, the first visible crack has occured at loads greater than the corresponding values of the identical beams without fibres.The same observation is reported by some earlier investigators (148,164,167)

Crack Height: The height of cracks was generally less by a considerable amount in the beams with fibres than in beams without fibres. It is quite evident that the crack height has to be smaller because of the extra tensile resistance offered by the fibres spanning the cracks which brings down the netural axis. For some of the beams with fibres over the whole section alongwith that of an identical beam with half depth fibres and without fibres, a reduction of about 25% in maximum crack height is seen. See **Plates [4 to 8]**.

Crack Spacing: Maximum spacing was generally adjacent to the first crack. Both maximum and mean spacing values have larger scatter irrespective of the presence of fibres or not. Hence, any conclusion regarding the crack spacing has to be based on statistical considerations. The maximum and mean crack spacing values for the tested beams with and without fibres can be observed from **Table 6.2 and Plates [4 to 8]**.

It can be concluded from this that the presence of fibres does not decrease the maximum or mean crack spacing. This conclusion is further confirmed from the results of other investigators (166). The above conclusion implies that the role of fibres across a crack in the tension zone is to contribute an extra tensile resistance locally at the cracked section resulting in a reduction of the crack width only and not crack spacing. This fact justifies the assumption made by Ibrahim and Luxmoore (75) also in their method of crackwidth assessment.

Crack Width : Maximum crack width only has been discussed in detail in this part and not the minimum or mean widths as they have no practical significance.

Crack width variations with loads for beams having full depth fibres, half depth fibres and beams without fibres, are given in **Fig.4.29 to 4.36**. These figures show a reduction of about 50% to 90% in the maximum crack width of beams without fibres. Similarly, the increase in service load at 0.3 mm crack width is seen to vary between 15% and 90%. The general trend is that an increase in the fibre content increases the percentage reduction in crack width and percentage increase in service load.

From the data of maximum crack widths of beams presented by Sabapati (147), maximum crack widths are calculated by the proposed maximum crack width formula of Eq.(5.46) and presented in **Table-6.3**. The results indicate that the calculated values of measured maximum crack widths are within $\pm$ 20% of the experimental values. The degree of agreement seen confirms the validity of the proposed modification for calculation and estimation of fibre contribution.

Ultimate Capacity: Calculated and observed ultimate loads of beams with fibres over the whole section and for lower half depth section are compared in **Table-6.4**. Values of experimental and calculated ultimate loads of moderate beams tested by **de Pavia and Siess (45), Untrauer (177), Slight (156)** are compared in **Table 6.5** considering without fibre condition i.e. β_f = 1 in proposed flexural formula of Chpater-5 alongwith the values calculated by them assuming moderate deep beam conditions. Values of experimental and calculated ultimate loads of the deep beams tested by Shanmugam (151) and Roberts and Ho (140) are compared in **Table-6.6**.

Calculated ultimate loads agree well with the experimental loads as seen from the ratios of experimental loads to calculated loads in **Table-6.4**. Furthermore it clearly indicates that the contribution of plain round steel fibres for full depth and half depth, towards the ultimate moment capacity of the section is very marginal. From the results shown in Tables (6.5,6.6) it is seen that the fourmulae proposed in this study for the ultimate loads give good values which are [illegible] to the test loads obtained by other investigators.

Moreover, Eqs. (5.10,5.17,5.19) were derived on the realistic stress-strain curve of concrete rather than assuming a uniform compressive stress in concrete or assuming a non-linear stress in concrete and then assigning values to compression block coefficients (k_1, k_2 and k_3). The Eq.(5.27) is further developed to find ultimate flexural moment when the tensile steel goes into strain hardening region. Theoretical values of test beams of moderate depth of de Paiva and Siess have been worked out by finding the actual stress in tensile steel in the strain hardening region. These values show very good agreement with the test results in **Table-6.7.**

TABLE - 6.1

MAXIMUM SURFACE CONCRETE STRAIN

Without Fibre Condition

	V_f	$\in_c$ max x 10^5
P60	0%	10
P50	0%	110
P40	0%	140
P30	0%	142
P20	0%	130
P15	0%	140
P12	0%	110
P10	0%	80

Full Depth Fibre Conditions

	V_f	$\in_c$ max x 10^5		V_f	$\in_c$ max x 10^5
F1.0 D60	1%	50	F1.5 D60	1.5%	30
F1.0 D50	1%	140	F1.5 D50	1.5%	90
F1.0 D40	1%	180	F1.5 D40	1.5%	100
F1.0 D30	1%	160	F1.5 D30	1.5%	120
F1.0 D20	1%	170	F1.5 D20	1.5%	130
F1.0 D15	1%	100	F1.5 D15	1.5%	130
F1.0 D12	1%	150	F1.5 D12	1.5%	110
F1.0 D10	1%	210	F1.5 D10	1.5%	200

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TABLE - 6.1 (Contd).

Lower Half Depth Fibre Conditions

	V_f	$\in_c$ max x 10^5		V_f	$\in_c$ max x 10^5
H1.0 D60	1%	110	H1.5 D60	1.5%	60
H1.0 D50	1%	110	H1.5 D50	1.5%	80
H1.0 D40	1%	118	H1.5 D40	1.5%	104
H1.0 D30	1%	126	H1.5 D30	1.5%	122
H1.0 D20	1%	130	H1.5 D20	1.5%	140
H1.0 D15	1%	210	H1.5 D15	1.5%	180
H1.0 D12	1%	260	H1.5 D12	1.5%	170
H1.0 D10	1%	205	H1.5 D10	1.5%	150

TABLE - 6.2

CRACK DETAILS OF TESTED BEAM

Beam No.	A_s mm^2	V_f	Crack Spacing in mm		Crack Width in mm
			Maximum	Mean	Maximum
P20	---		137.5	100.5	---
F1.0 D20	201	1.0%	125.0	81.5	0.340
H1.0 D20	201	1.0%	132.0	94.0	0.320
F1.5 D20	201	1.5%	123.0	83.0	0.330
H1.5 D20	201	1.5%	130.0	75.0	0.290
P15	---		150.0	150	---
F1.0 D15	113	1.0%	88.0	66.0	0.320
H1.0 D15	113	1.0%	110.0	70.5	0.320
F1.5 D15	113	1.5%	100.0	80.5	0.290
H1.5 D15	113	1.5%	102.0	70.6	0.300
P12	---		100.0	79.5	---
F1.0 D12	113	1.0%	92.0	83.0	0.360
H1.0 D12	113	1.0%	103.0	80.0	0.330
F1.5 D12	113	1.5%	88.0	68.0	0.310
H1.5 D12	113	1.5%	90.0	78.0	0.300
P10	---		126.0	100.5	---
F1.0 D10	113	1.0%	77.0	60.0	0.380
H1.0 D10	113	1.0%	124.0	75.0	0.310
F1.5 D10	113	1.5%	75.0	62.5	0.320
H1.5 D10	113	1.5%	112.0	79.0	0.340

TABLE - 6.3

COMPARISION OF OBSERVED AND COMPUTED MAXIMUM CRACK WIDTH

Investigator	Beam No.	af	vf	wb (Exp.)	wb (Cal.)	wb(Exp)/wb(Cal)
Present Investigations Eq. No.(5.46)	F1.0 D10	100	1	0.380	0.413	0.92
	H1.0 D10	100	1	0.310	0.374	0.83
	F1.5 D10	100	1.5	0.320	0.365	0.88
	H1.5 D10	100	1.5	0.340	0.333	1.02
	F1.0 D12	100	1	0.360	0.354	1.01
	H1.0 D12	100	1	0.330	0.350	0.94
	F1.5 D12	100	1.5	0.310	0.309	1.00
	H1.5 D12	100	1.5	0.300	0.327	0.92
	F1.0 D15	100	1	0.320	0.295	1.08
	H1.0 D15	100	1	0.320	0.285	1.12
	F1.5 D15	100	1.5	0.290	0.257	1.13
	H1.5 D15	100	1.5	0.300	0.273	1.09
	F1.0 D20	100	1	0.340	0.296	1.14
	H1.0 D20	100	1	0.320	0.290	1.10
	F1.5 D20	100	1.5	0.330	0.280	1.17
	H1.5 D20	100	1.5	0.290	0.272	1.06
Sabapti (147)	B1	80	1.6	0.31	0.342	0.90
	B14	80	1.3	0.34	0.378	0.89
	B2	80	1.0	0.39	0.426	0.91
	B15	65	1.6	0.33	0.373	0.88
	B17	65	1.3	0.46	0.421	1.12
	B16	65	1.0	0.58	0.486	1.19
	B7	50	1.5	0.61	0.582	1.05

TABLE - 6.4

(a) COMPARISION OF CALCULATED AND EXPERIMENTAL ULTIMATE LOADS OF BEAMS WITHOUT FIBRES

Beam No.	V_f	W_u (Expt.) kN	W_u (Cal.) kN	W_uExp./W_uCal	Type of Failure
P60	--	261	318.2	0.83	Shear
P50	--	255	277.3	0.92	Flexure-Shear
P40	--	203	219.7	0.92	Flexure-Shear
P30	--	152	146.5	1.04	Flexure-Shear
P20	--	72	73.5	0.98	Flexure
P15	--	45	39.9	1.13	Flexure
P12	--	24	22.72	1.05	Flexure
P10	--	20	14.30	1.39	Flexure

(b) COMPARISION OF CALCULATED AND EXPERIMENTAL ULTIMATE LOADS OF BEAMS

WITH FIBRES OVER THE FULL DEPTH OF SECTION

Beam No.	V_f	W_u (Expt.) kN	W_u (Cal.) kN	W_uExp./W_uCal	Type of Failure
F1.0 D60	1.0%	500	559.2	0.89	Shear
F1.0 D50	1.0%	421	456.0	0.93	Shear
F1.0 D40	1.0%	360	348.0	1.03	Shear
F1.0 D30	1.0%	252	255.8	0.97	Shear
F1.0 D20	1.0%	157	154.63	1.015	Flexure-Shear
F1.0 D15	1.0%	86	80.92	1.06	Flexure-Shear
F1.0 D12	1.0%	52	50.81	1.03	Flexure
F1.0 D10	1.0%	29	33.90	0.86	Flexure
F1.5 D60	1.5%	510	587.66	0.87	Shear
F1.5 D50	1.5%	450	478.88	0.94	Shear
F1.5 D40	1.5%	366	364.90	1.01	Shear
F1.5 D30	1.5%	291	268.00	1.08	Shear
F1.5 D20	1.5%	170	167.80	1.01	Flexure-Shear
F1.5 D15	1.5%	100	87.78	1.14	Flexure-Shear
F1.5 D12	1.5%	61	56.82	1.08	Flexure
F1.5 D10	1.5%	37	37.78	0.98	Flexure

TABLE - 6.4 (Contd.)

(c) COMPARISION OF CALCULATED AND EXPERIMENTAL ULTIMATE LOAD OF BEAMS WITH FIBRES OVER LOWER HALF DEPTH OF SECTION

Beam No.	V_f	W_u (Expt.) kN	W_u (Cal.) kN	W_uExp./W_uCal.	Type of Failure
H1.0 D60	1.0%	444	519.9	0.86	Shear
H1.0 D50	1.0%	408	420.4	0.96	Shear
H1.0 D40	1.0%	353	325.8	1.06	Shear
H1.0 D30	1.0%	284	239.3	1.18	Shear
H1.0 D20	1.0%	184	159.1	1.15	Flexure-Shear
H1.0 D15	1.0%	97	98.94	0.98	Flexure-Shear
H1.0 D12	1.0%	64	77.34	0.82	Flexure-Shear
H1.0 D10	1.0%	38	44.84	0.85	Flexure-Shear
H1.5 D60	1.5%	450	540.0	0.83	Shear
H1.5 D50	1.5%	404	442.8	0.91	Shear
H1.5 D40	1.5%	334	338.4	0.98	Shear
H1.5 D30	1.5%	298	249.0	1.14	Shear
H1.5 D20	1.5%	187	215.0	0.87	Flexure-Shear
H1.5 D15	1.5%	106	101.2	1.05	Flexure-Shear
H1.5 D12	1.5%	69	57.2	1.20	Flexure-Shear
H1.5 D10	1.5%	39	45.2	0.86	Flexure-Shear

TABLE - 6.5

COMPUTATION OF ULTIMATE FLEXURAL MOMENTS FOR MODERATE DEEP BEAMS

Investigator	Beam No.	Mfl t-cm		Experimental / Calculated
		Experimental	Calculated	
de Paiva and Siess (45)	G23S-11	186.0	176.8	1.05
	G23-S21	110.2	133.6	0.82
	G24S-11	188.0	208.8	0.90
	G24S-21	104.0	154.4	0.68
	G33S-21	113.0	110.8	1.02
	G34S-11	226.5	220.7	1.03
	G34S-21	116.0	132.0	0.88
	G43S-11	159.0	140.8	1.12
	G44S-11	173.0	165.2	1.05
Untrauer (177)	F2 S1	199.0	198.6	1.01
	F3 S2	127.0	118.0	1.07
	F3 S3	251.0	219.0	1.14
	F4 S1	97.5	96.3	1.012
	F4 S22	188.6	168.0	1.112
Slight (156)	B5	765.0	795.0	0.96
	B6	722.0	820.0	0.88
	B7	807.0	732.0	1.10
	B8	765.0	835.0	0.92
	B9	782.0	822.0	0.95
	B10	676.0	833.0	0.82
	B11	705.0	820.0	0.86
	B12	708.0	790.0	0.90

* Considering Moment Capacity Enhancement Facotr β_f=1 for Reinforced Concrete Section.

TABLE - 6.6

COMPUTATION OF ULTIMATE SHEAR LOADS FOR DEEP BEAMS

Investigator	Beam No.	Wu Experimental	Wu Calculated	Experimental / Calculated
Roberts and Ho (140)	Pc B1	47.0	51.6	0.91
	F3.0 B1	65.6	60.2	1.09
	F4.5 B1	72.4	67.6	1.07
	Pc B2	90.6	97.2	0.92
	F3.0 B2	101.8	119.2	0.86
	F4.5 B2	108.4	128.6	0.83
	Pc B3	149.0	125.2	1.19
	F3.0 B3	162.4	147.1	1.10
	F4.5 B3	215.2	198.8	1.08
Shanmugan and Swaddiwudhi-opong (151)	P600	85.0	77.0	1.10
	F600	166.0	142.0	1.17
	FS600	*	*	*
	P400	39.0	32.2	1.21
	F400	75.0	67.4	1.12
	FS400	171.0	192.3	0.89
	P300	21.0	17.6	1.19
	F300	37.5	31.2	1.20
	FS300	141.0	162.4	0.87
	P240	16.1	12.5	1.28
	F240	21.0	18.9	1.11
	FS240	81.0	93.6	0.86
	P200	12.0	10.3	1.16
	F200	14.4	11.9	1.21
	FS200	58.0	64.2	0.90
	P170	8.4	7.5	1.18
	F170	11.7	10.1	1.15
	FS170	49.4	55.6	0.88

* Premature failure at load point

TABLE - 6.7

ULTIMATE FLEXURAL MOMENTS OF BEAMS CONSIDERING STRAIN HARDENING OF STEEL

Investigator	Beam mark	Mfl t-cm Experiment	Calculated	Exp./Cal.
de Paiva siess and untrauer (45,177)	F 4 S1	97.50	95.20	1.02
	F 4 S 22	188.60	151.80	1.24
	F 3 S 2	127.00	116.60	1.09
	F 3 S 3	251.00	212.20	1.18
	F 2 S 1	199.00	201.30	0.99