Supplement

Investigation on Mechanical Behavior of Iron Foams under Different Compression Test Conditions

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A. Structure of the iron foam samples

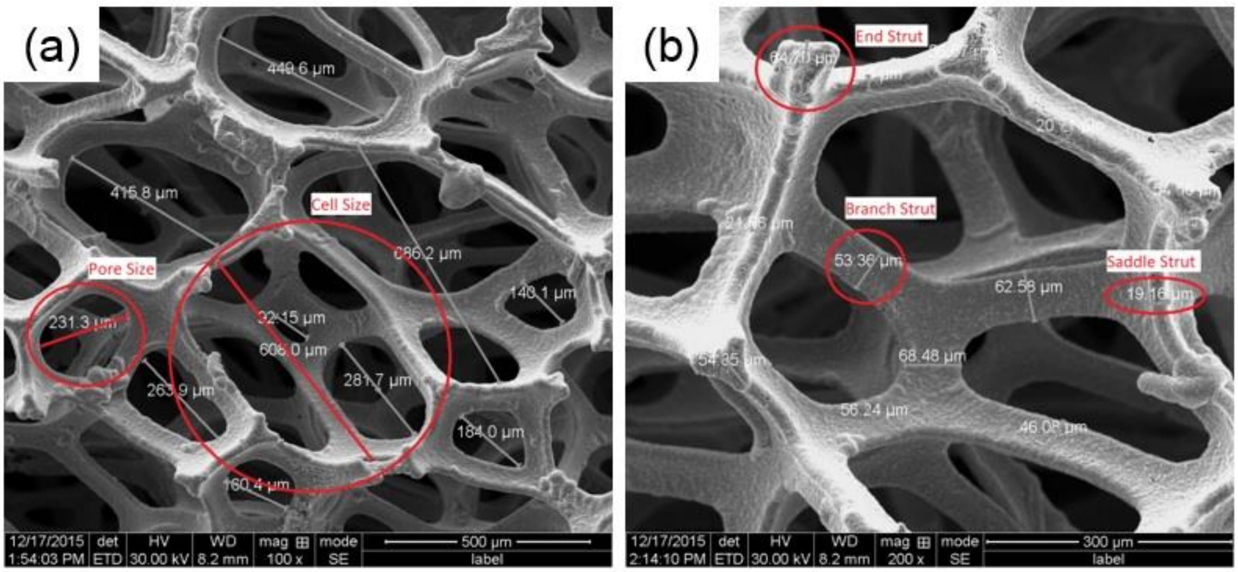

Figure S1: Measurement of cell size, pore size and different strut thicknesses on an IF58 specimen.

Table S1: Results of the measurement

Nominal cell size	Number of measured cells	Mean (μm)	SD	Min (μm)	Median (μm)	Max (μm)
			Cell size			
IF45	81	461.77	72.26	275	455.5	641.3
IF58	113	617.73	76.08	433.6	601.9	836.2
IF80	45	828.11	79.87	691.2	805.2	1008
			Pore size between 40-100 μm			
IF45	24	69.5	17.08	39.23	68.3	99.35
IF58	6	68.01	12.42	59.01	62.73	92.15
IF80	5	66.78	18.72	42.4	67.59	91.16
			Pore size between 100-200 μm			
IF45	43	155.59	27.94	102.3	155	199.3
IF58	31	150.8	29.43	101.2	150.5	198.9
IF80	29	157.33	28.5	100.5	164.8	198.3
			Pore size >200 μm			
IF45	27	238.47	45.03	103.5	244.6	310.2
IF58	94	319.98	71.81	200.4	318.75	525.3
IF80	82	333.61	87.07	213	315.65	546.4
			End-strut thickness			
IF45	86	74.73	10.3	54.92	71.44	103.1
IF58	78	63.62	9.95	42.23	62.41	93.12
IF80	39	97.79	17.54	71.45	95.88	167.3
			Branch-strut thickness			
IF45	52	55.52	6.18	43.71	56.56	78.33
IF58	53	59.88	7.55	44.39	60.88	74.66
IF80	30	80.91	12.27	61.16	76.77	123.8
			Saddle-strut thickness			
IF45	70	25.52	4.8	16.61	25.11	38.45
IF58	51	21.67	4.12	13.82	21.01	30.6
IF80	13	29.066	5.14	20.61	29.14	37.09

B. Determination of the compression tests parameters

Figure S2 shows the experimental design and parameters with the number of specimens used in each group. For each cell-size group of iron foam specimens, 20 samples were considered 10 of which had a nominal compression area of 100 mm^2 (A_1 = 10 x 10) and the other 10 had a nominal compression area of 25 mm^2 (A_2 = 5 x 5). For each compression area group, 5 specimens underwent the compression tests with the cross-head speed of 0.001 mm/s (S_1) and the other 5 underwent that of 0.01 mm/s (S_2). Considering all the experimental configurations, 60 trials (or treatments) were carried out. Therefore, the trials contained 12 blocks of 5 specimens where each block had a unique set of configuration, i.e. average cell size, compression area and cross-head speed.

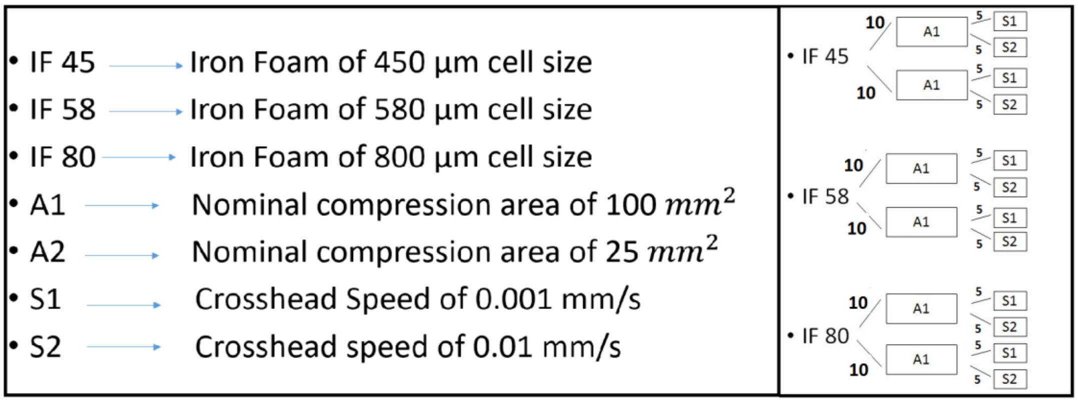

Figure S2: Experimental design and parameters with the number of specimens used in each group.

Evaluating the results of different cell-size group indicated that in most cases the stress-strain curves associated to the larger compressed area (A_1) and the cross-head speed (S_1) were either more consistent or steadier and easier to evaluate (due to the presence of more clear compression strength, longer plateau region, or more linear densification regime) than other groups of curves associated with the same cell-size but different areas and strain rates. Therefore, specimens with compression area of A_1=100 mm^2 (A = 10x10 mm^2) and the cross-head speed of S_1= 0.001 mm/s were chosen for all the tests and analyses. Another reason for using the slower cross-head speed is the small thickness of the specimens, making it difficult to verify the reaction of the samples to compression loads of higher speeds. Stress-strain curves of iron foam samples of different dimensions and under different cross-head speeds are shown in Figures S3-S5.

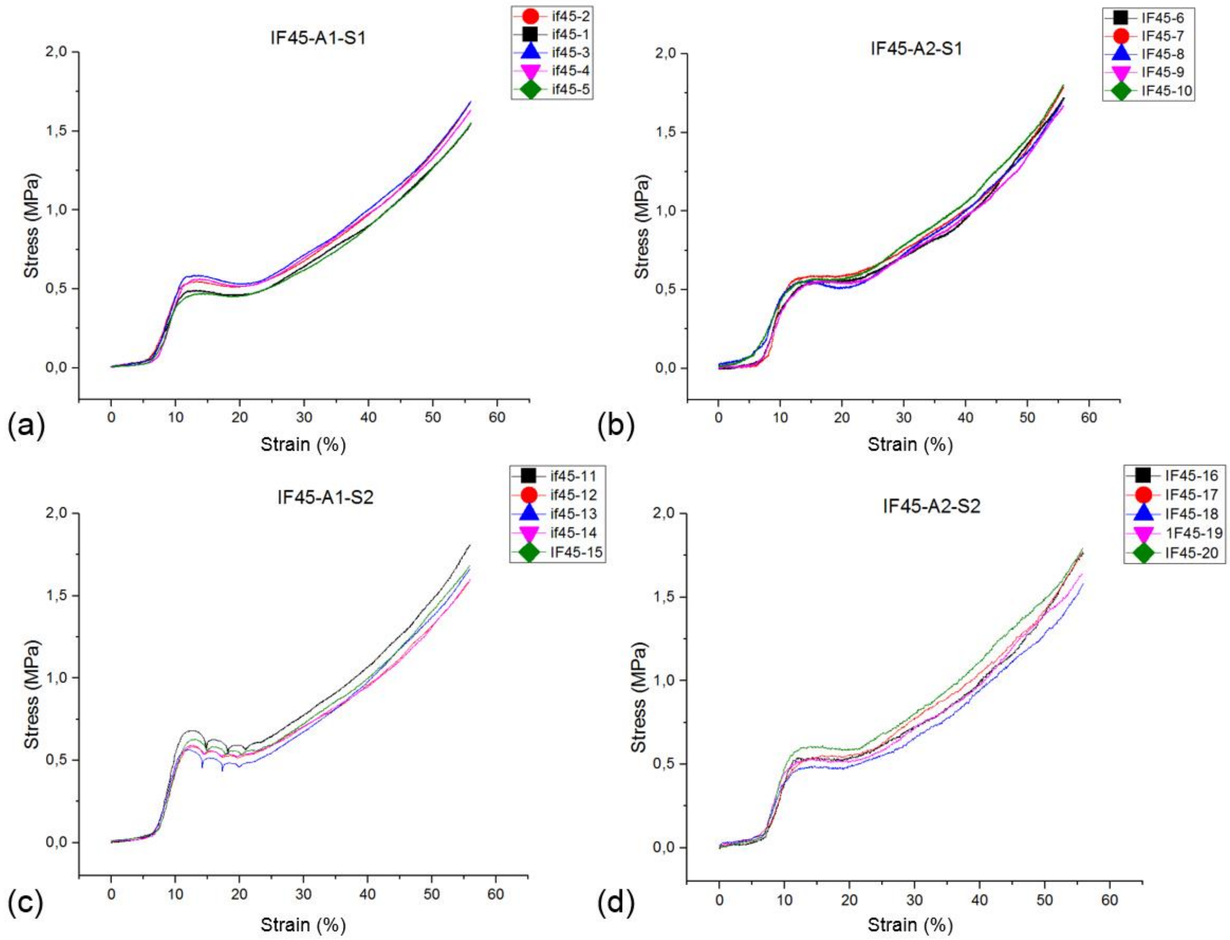

Figure S3: Stress-strain curves of IF45 samples under compression: (a) compression area A_1 and cross-head speed S_1, (b) compression area A_2 and cross-head speed S_1, (c) compression area A_1 and cross-head speed S_2, (d) compression area A_2 and cross-head speed S_2.

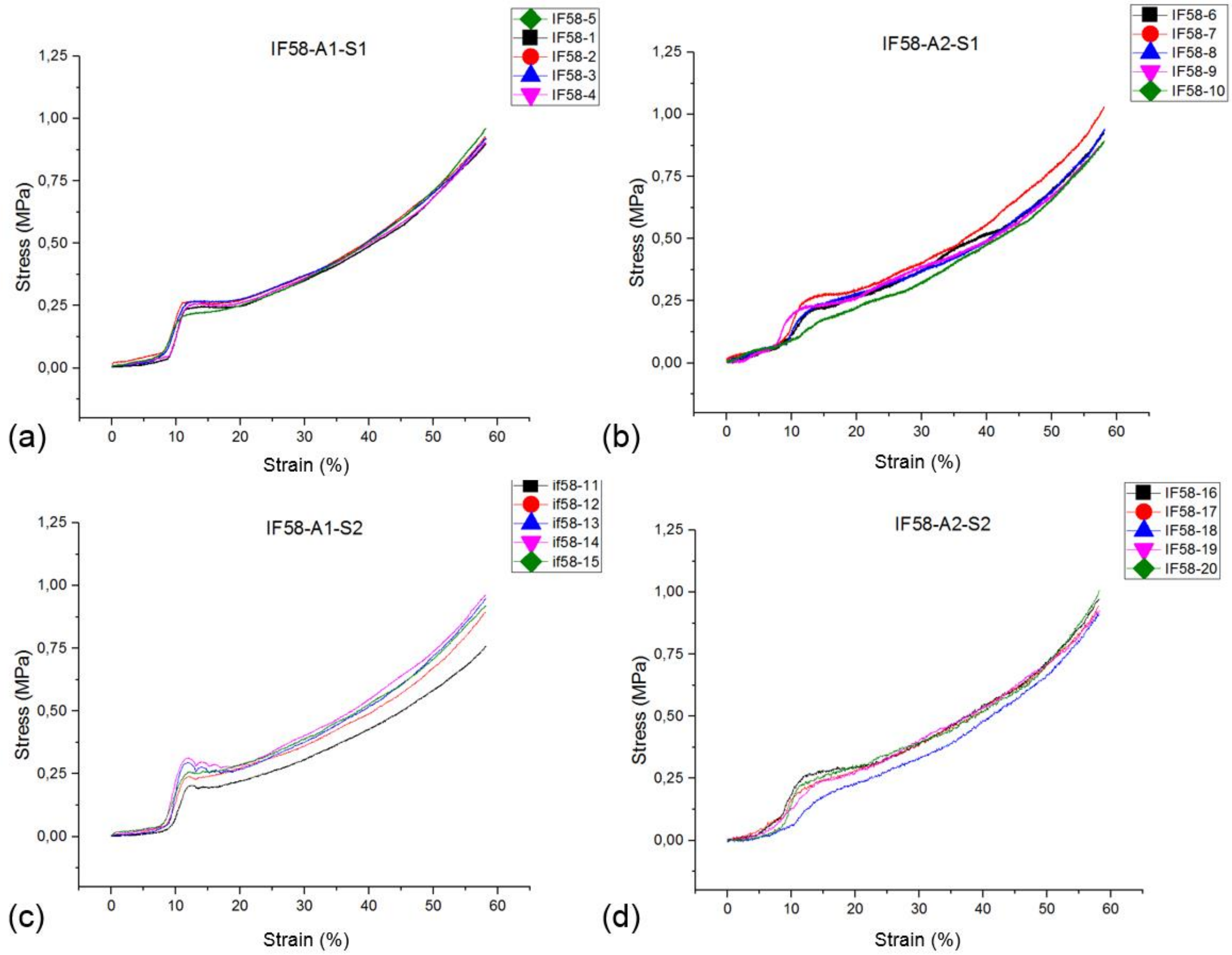

Figure S4: Stress-strain curves of IF58 samples under compression: (a) compression area A_1 and cross-head speed S_1, (b) compression area A_2 and cross-head speed S_1, (c) compression area A_1 and cross-head speed S_2, (d) compression area A_2 and cross-head speed S_2.

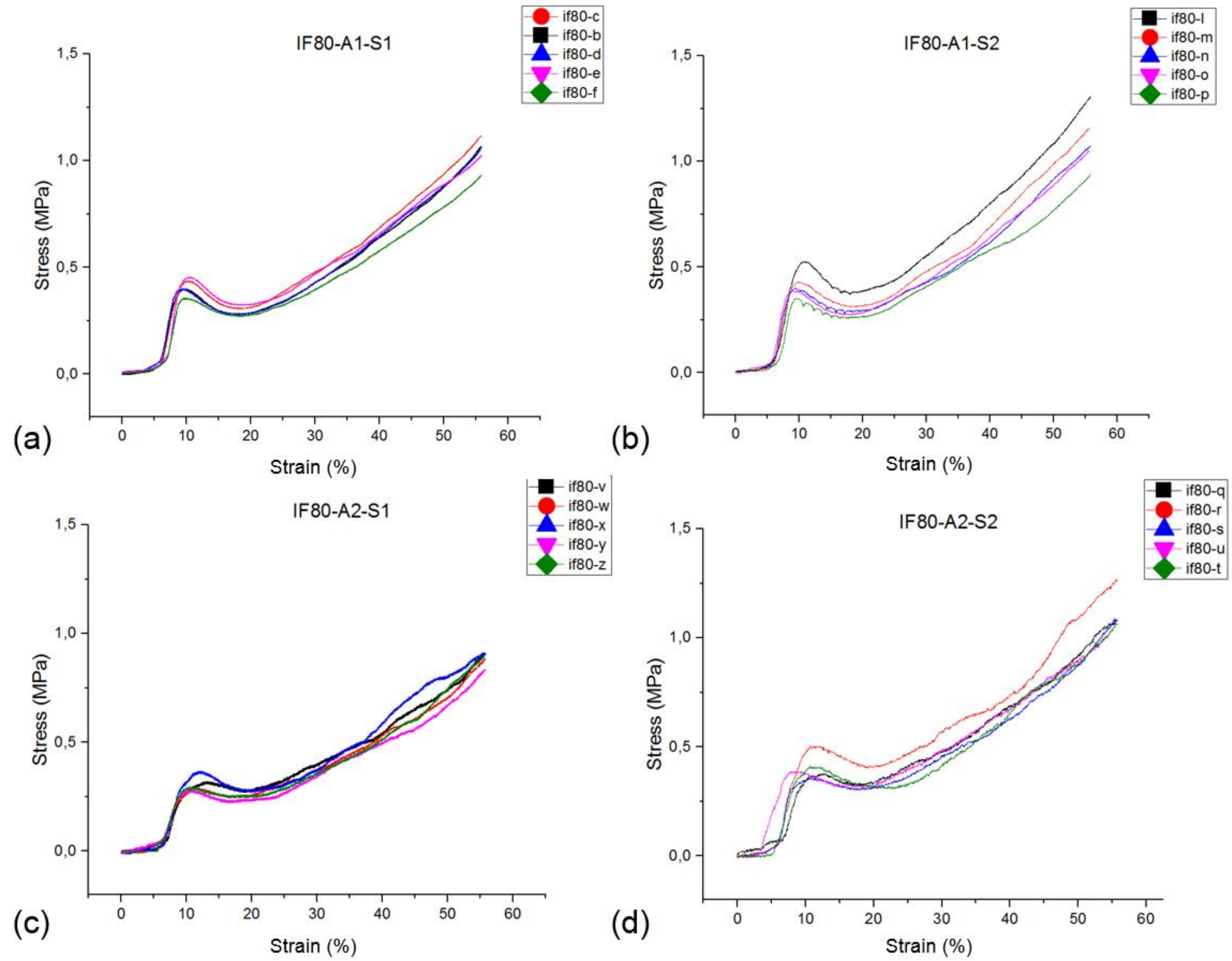

Figure S5: Stress-strain curves of IF80 samples under compression: (a) compression area A_1 and cross-head speed S_1, (b) compression area A_1 and cross-head speed S_2, (c) compression area A_2 and cross-head speed S_1, (d) compression area A_2 and cross-head speed S_2.

C. Calculations of the points for the proposed tabular method (Relative density data from the main document, other data from Table S1)

C1. Cell size effect values (EVs)

IF45: 100

IF58: $\frac{461.77}{617.73} = 0.7475 \rightarrow 74.75$

IF80: $\frac{461.77}{828.11} = 0.5576 \rightarrow 55.76$

C2. Relative density EVs

IF45: 100

IF58: $\frac{(\rho*/\rho s)\ IF58}{(\rho*/\rho s)\ IF45} = \frac{0.027}{0.038} = 0.7105 \rightarrow 71.05$

IF80: $\frac{(\rho*/\rho s)\ IF80}{(\rho*/\rho s)\ IF45} = \frac{0.025}{0.038} = 0.6579 \rightarrow 65.79$

C3. Pore size EVs (pore size > 200 μm)

IF45: 100

IF58: $\frac{238.47}{319.98} = 0.7453 \rightarrow 74.53$

IF80: $\frac{238.47}{333.61} = 0.7148 \rightarrow 71.48$

Mean value of the measured pore sizes, IF45

Mean value of the measured pore sizes, IF58

Mean value of the measured pore sizes, IF80

C4. Pore size EVs (pore size between 100 μm and 200 μm)

IF58: 100

IF45: $\frac{150.8}{155.59} = 0.9692 \rightarrow 96.92$

IF80: $\frac{150.8}{157.33} = 0.9582 \rightarrow 95.85$

EV = 100 is assigned for IF58 sample group as it has the smallest mean value of pore sizes between 100 μm and 200 μm. (we assumed that smaller pore size leads to higher compression strength)

C5. Final EVs for pore size

IF45: 196.92/2 = 98.46

IF58: 174.53/2 = 87.265

IF80: 0.5(71.48+95.85) = 83.66

Average values of the EVs calculated in C3 and C4

C6. Pore number EVs (using ppi data provided by Alantum)

IF80: 65/65=1 → 100

IF45: 65/105= 0.6190 → 61.9

IF58: 65/95= 0.6842 → 68.42

EV=100 is assigned for IF80 sample group as it has the highest value of mean end-strut thicknesses. (We assumed that thicker struts lead to higher compression strength)

C7. End-strut thickness

IF80: 100

IF45: $\frac{74.73}{97.79} = 0.7642 \rightarrow 76.42$

IF58: $\frac{63.62}{97.79} = 0.6506 \rightarrow 65.06$

Mean value of the measured end-strut thicknesses, IF45

Mean value of the measured end-strut thicknesses, IF80

C8. Branch-strut thickness

IF80: 100

IF45: $\frac{55.52}{80.91} = 0.6862 \rightarrow 68.62$

IF58: $\frac{59.88}{80.91} = 0.7401 \rightarrow 74.01$

C9. Final EV for strut thickness

IF80: 100

IF45: 0.5(76.42+68.62) = 72.52

IF58: 0.5(74.01+65.06) = 69.535