

ANEXO 4

COMPROBACIÓN EXPERIMENTAL DE LAS FÓRMULAS PROPUESTAS PARA EL CÁLCULO DE TUBERÍAS A PRESIÓN

- 1. Tubería de PVC (7 formulaciones).***
- 2. Tubería de PEAD (7 formulaciones).***
- 3. Tubería de fibrocemento (11 formulaciones).***

1. Tubería de PVC (7 formulaciones)

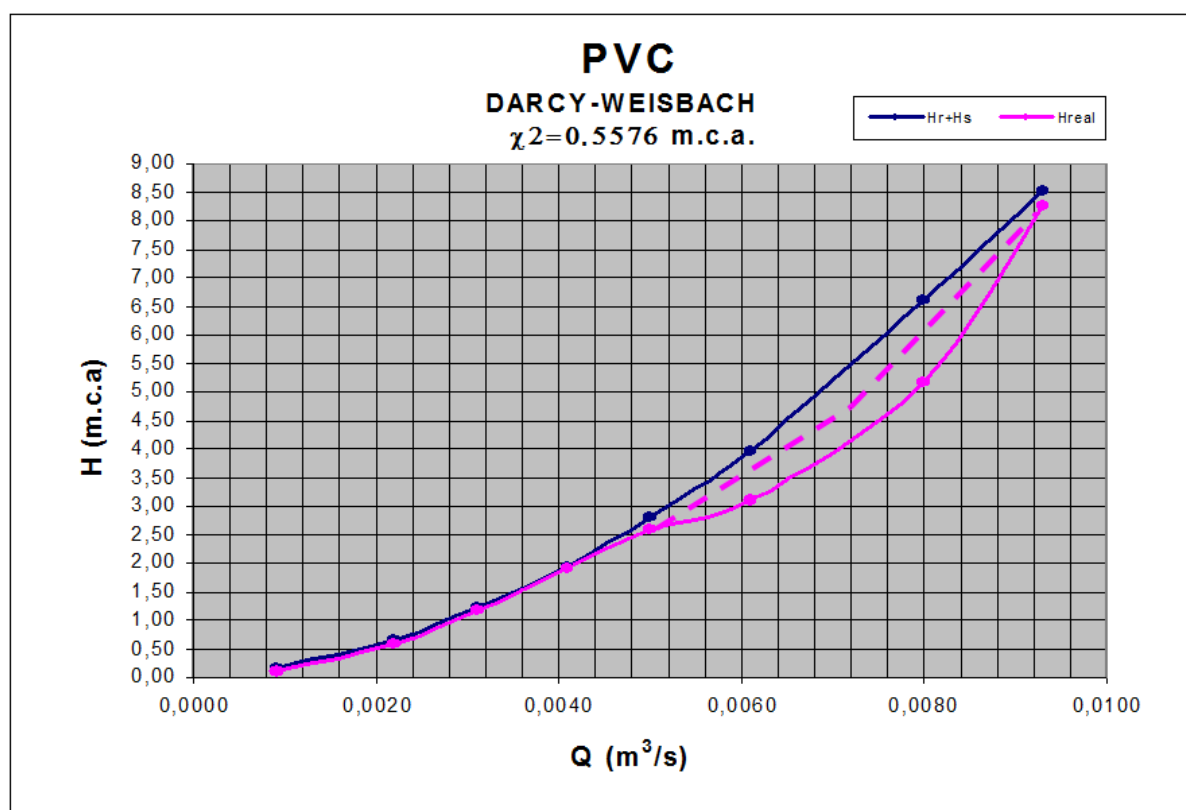
- Formulación de Darcy-Weisbach
- Formulación de Blasius-Flamant
- Formulación de Manning-Strickler-Gaukler
- Formulación de Kütter
- Formulación de Hazen-Williams
- Formulación de Scobey
- Formulación de Franquet

MATERIAL: PVC

FÓRMULA: DARCY-WEISBACH

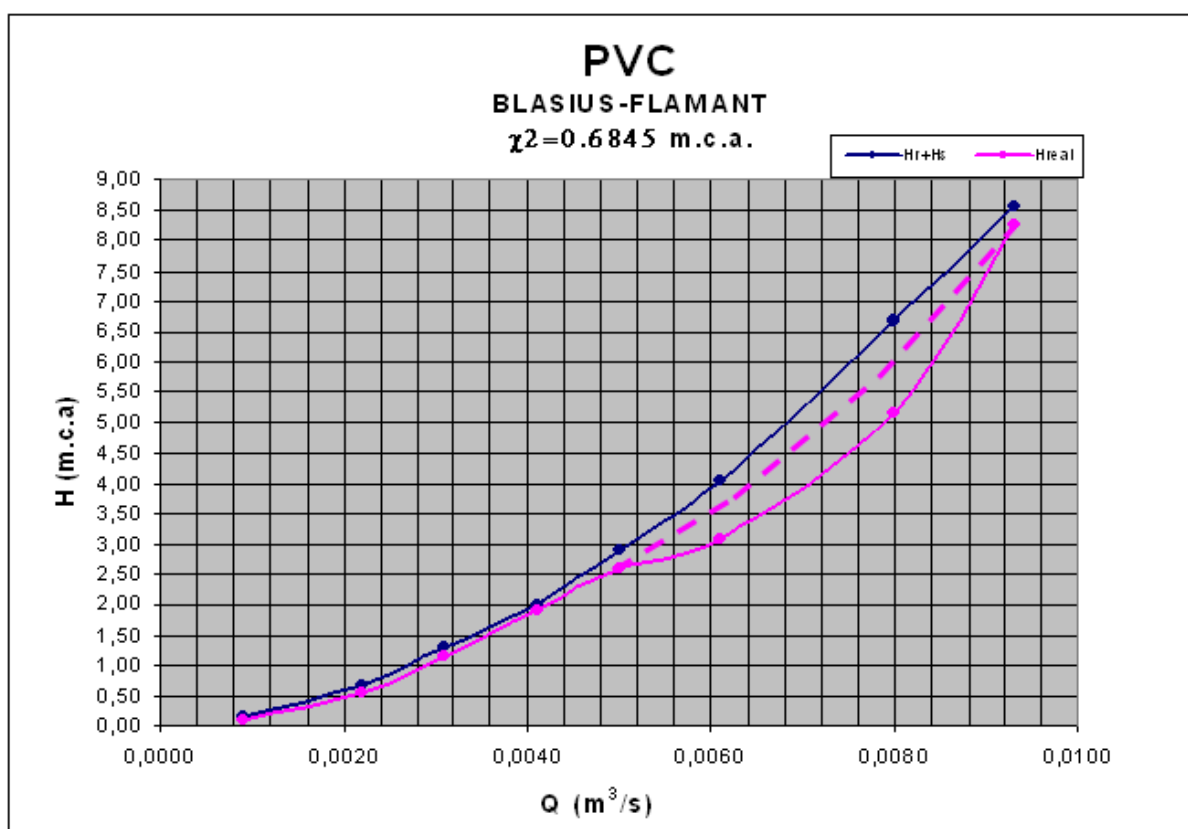
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	R(m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	Re	f	J (m/m)	l (m)	Hr (mca)	Hr+Hs (mca)	Real (mca)	Diferencia (mca)	$\frac{Dif.^2}{Hr + Hs}$ (mca)
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0009	0.3817	20 464	0.0265	0.0035	37	0.1298	0.1493	0.1030	0.0463	0.0144
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0022	0.8932	47 854	0.0214	0.0155	37	0.5749	0.6611	0.5665	0.0946	0.0135
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0031	1.2749	68 358	0.0196	0.0290	37	1.0715	1.2322	1.1531	0.0791	0.0051
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0041	1.6444	88 169	0.0184	0.0452	37	1.6726	1.9235	1.9115	0.0120	0.0001
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0050	2.0301	108 850	0.0176	0.0661	37	2.4448	2.8115	2.5825	0.2290	0.0187
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0061	2.4564	131 709	0.0169	0.0930	37	3.4414	3.9576	3.0990	0.8586	0.1863
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0080	3.2644	175 031	0.0160	0.1551	37	5.7393	6.6002	5.1650	1.4352	0.3121
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0093	3.7597	201 590	0.0155	0.2001	37	7.4040	8.5146	8.2640	0.2506	0.0074

Diferencia media absoluta: 0.3757 m.c.a. $\chi^2 = 0.5576$ m.c.a.



Q	Hr+Hs	Hreal
0.0009	0.1493	0.1030
0.0022	0.6611	0.5665
0.0031	1.2322	1.1531
0.0041	1.9235	1.9115
0.0050	2.8115	2.5825
0.0061	3.9576	3.0990
0.0080	6.6002	5.1650
0.0093	8.5146	8.2640

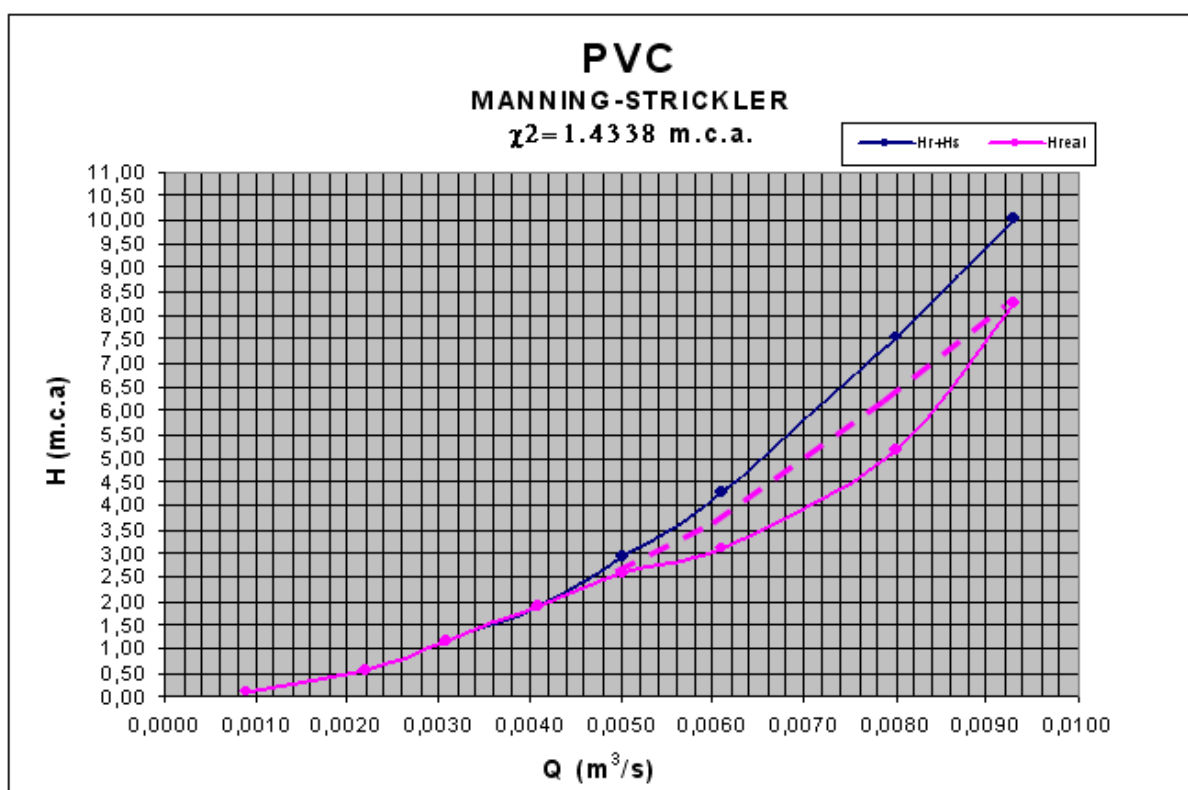
MATERIAL: PVC														
FÓRMULA: BLASIUS-FLAMANT														
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	α	J (m/m)	l (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	9.81	0.0009	0.3817	0.000135	0.0037	37	0.1359	0.1563	0.1030
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	9.81	0.0022	0.8932	0.000135	0.0163	37	0.6019	0.6922	0.5665
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	9.81	0.0031	1.2749	0.000135	0.0303	37	1.1219	1.2902	1.1531
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	9.81	0.0041	1.6444	0.000135	0.0473	37	1.7513	2.0140	1.9115
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	9.81	0.0050	2.0301	0.000135	0.0684	37	2.5323	2.9121	2.5825
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	9.81	0.0061	2.4564	0.000135	0.0955	37	3.5350	4.0653	3.0990
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	9.81	0.0080	3.2644	0.000135	0.1572	37	5.8145	6.6867	5.1650
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	9.81	0.0093	3.7597	0.000135	0.2012	37	7.4454	8.5622	8.2640
														Diferencia media absoluta: 0.4418 m.c.a. $\chi^2 = 0.6845$ m.c.a.
														0.0104



Q	Hr+Hs	Hreal
0.0009	0.1563	0.1030
0.0022	0.6922	0.5665
0.0031	1.2902	1.1531
0.0041	2.0140	1.9115
0.0050	2.9121	2.5825
0.0061	4.0653	3.0990
0.0080	6.6867	5.1650
0.0093	8.5622	8.2640

MATERIAL: PVC																
FÓRMULA: MANNING-STRICKLER-GAUKLER																
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	g (m/s) ²	Q (m ³ /s)	V (m/s)	n	J (m/m)	I (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	$\frac{\text{Dif.}^2}{\text{Hr} + \text{Hs}}$ (mca)
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.0009	0.3817	0.0075	0.0024	37	0.0898	0.1033	0.1030	0.0003	0.0000
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.0022	0.8932	0.0075	0.0133	37	0.4921	0.5659	0.5665	-0.0006	0.0000
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.0031	1.2749	0.0075	0.0271	37	1.0026	1.1530	1.1531	-0.0001	0.0000
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.0041	1.6444	0.0075	0.0451	37	1.6679	1.9181	1.9115	0.0066	0.0000
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.0050	2.0301	0.0075	0.0687	37	2.5421	2.9234	2.5825	0.3409	0.0398
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.0061	2.4564	0.0075	0.1006	37	3.7218	4.2801	3.0990	1.1811	0.3259
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.0080	3.2644	0.0075	0.1777	37	6.5729	7.5588	5.1650	2.3938	0.7581
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.0093	3.7597	0.0075	0.2357	37	8.7191	10.0270	8.2640	1.7630	0.3100

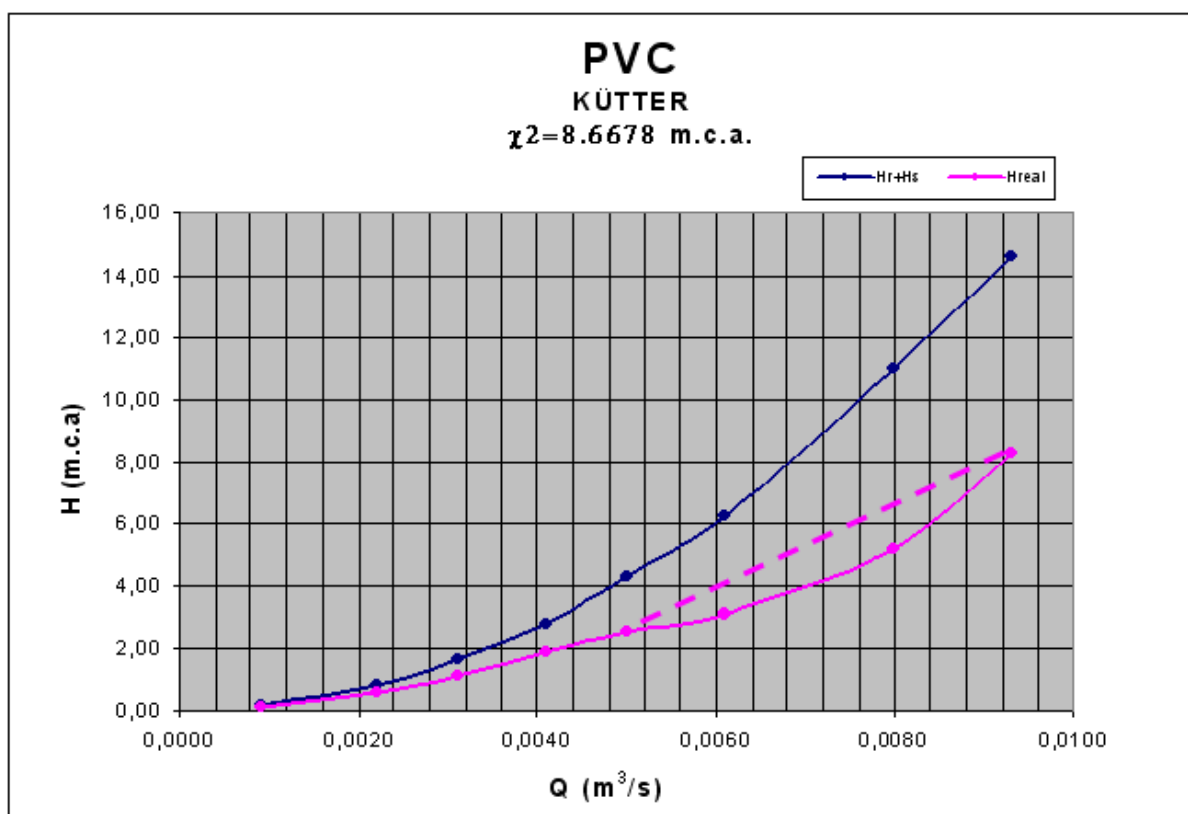
Diferencia media absoluta: 0.7108 m.c.a. $\chi^2 = 1.4338$ m.c.a.



Q	Hr+Hs	Hreal
0.0009	0.1033	0.1030
0.0022	0.5659	0.5665
0.0031	1.1530	1.1531
0.0041	1.9181	1.9115
0.0050	2.9234	2.5825
0.0061	4.2801	3.0990
0.0080	7.5588	5.1650
0.0093	10.0270	8.2640

MATERIAL: PVC																		
FÓRMULA: KÜTTER																		
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	R (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	α	K	J (m/m)	I (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	Dif. ² Hr + Hs (mca)
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0009	0.3817	0.1000	54.1960	0.0035	37	0.1311	0.1508	0.1030	0.0478	0.0152
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0022	0.8932	0.1000	54.1960	0.0194	37	0.7179	0.8256	0.5665	0.2591	0.0813
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0031	1.2749	0.1000	54.1960	0.0395	37	1.4625	1.6818	1.1531	0.5287	0.1662
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0041	1.6444	0.1000	54.1960	0.0658	37	2.4330	2.7980	1.9115	0.8865	0.2809
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0050	2.0301	0.1000	54.1960	0.1002	37	3.7083	4.2645	2.5825	1.6820	0.6634
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0061	2.4564	0.1000	54.1960	0.1467	37	5.4293	6.2437	3.0990	3.1447	1.5839
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0080	3.2644	0.1000	54.1960	0.2591	37	9.5884	11.0267	5.1650	5.8617	3.1160
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0093	3.7597	0.1000	54.1960	0.3437	37	12.7101	14.6166	8.2640	6.3526	2.7609
Diferencia media absoluta: 2.3454 m.c.a.χ ² = 8.6678 m.c.a.																		

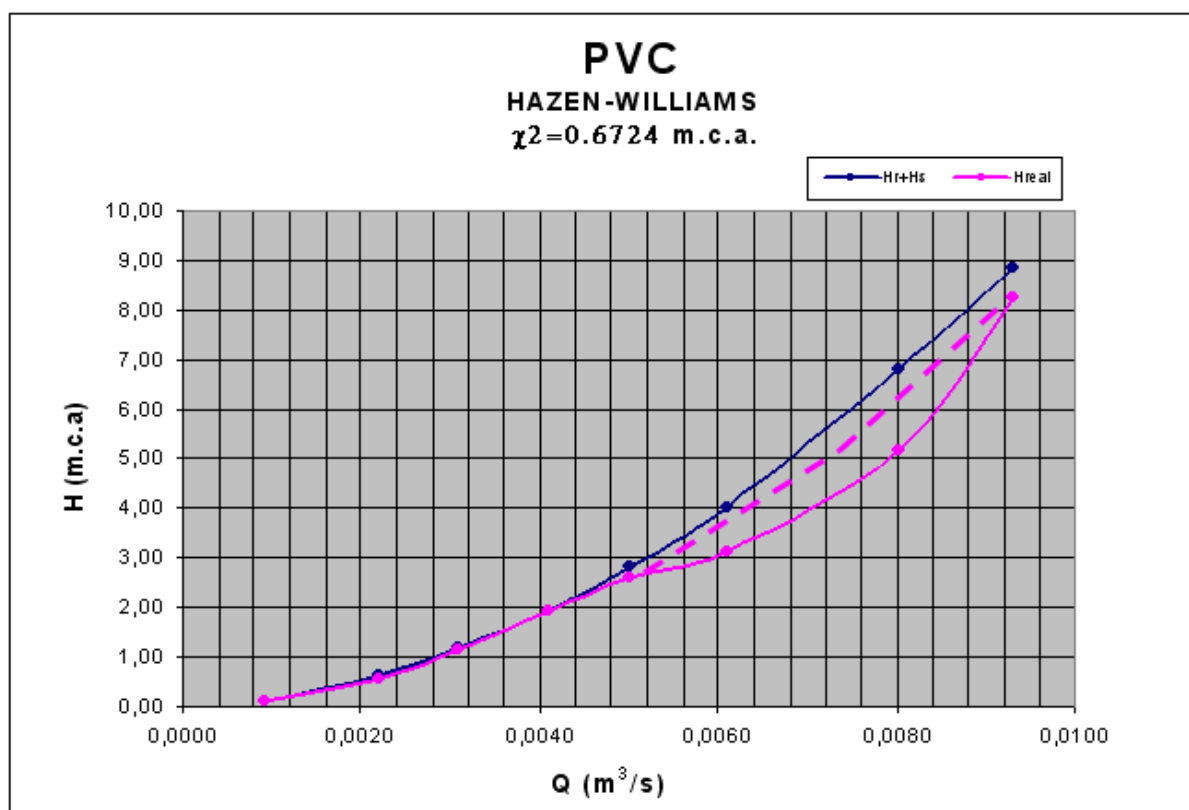
Diferencia media absoluta: 2.3454 m.c.a. $\chi^2 = 8.6678$ m.c.a.



Q	H _r +H _s	H _{real}
0.0009	0.1508	0.1030
0.0022	0.8256	0.5665
0.0031	1.6818	1.1531
0.0041	2.7980	1.9115
0.0050	4.2645	2.5825
0.0061	6.2437	3.0990
0.0080	11.0267	5.1650
0.0093	14.6166	8.2640

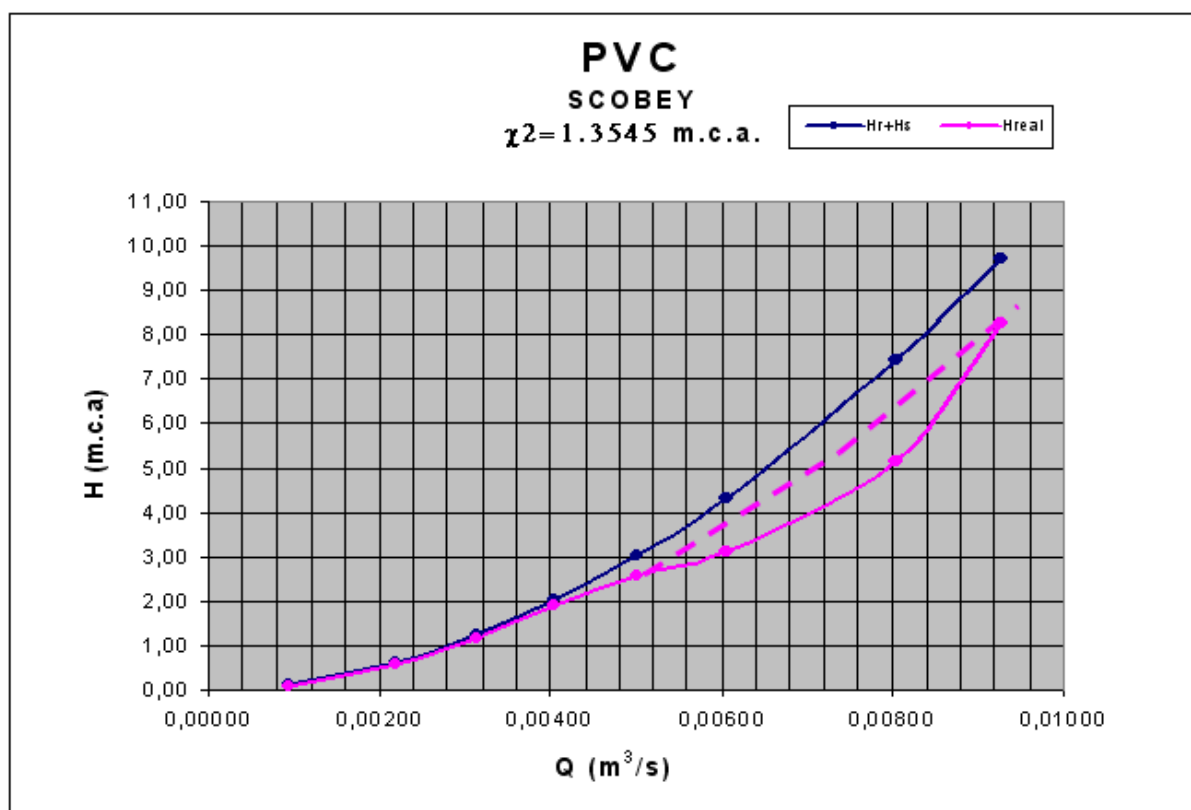
MATERIAL: PVC																	
FÓRMULA: HAZEN-WILLIAMS																	
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	R (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	C	J (m/m)	I (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	$\frac{\text{Dif}^2}{\text{Hr} + \text{Hs}}$ (mca)
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0009	0.3817	150	0.0030	37	0.1111	0.1278	0.1030	0.0248	0.0048
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0022	0.8932	150	0.0145	37	0.5367	0.6172	0.5665	0.0507	0.0042
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0031	1.2749	150	0.0280	37	1.0371	1.1927	1.1531	0.0396	0.0013
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0041	1.6444	150	0.0449	37	1.6616	1.9108	1.9115	-0.0007	0.0000
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0050	2.0301	150	0.0663	37	2.4546	2.8228	2.5825	0.2403	0.0205
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0061	2.4564	150	0.0944	37	3.4938	4.0179	3.0990	0.9189	0.2101
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0080	3.2644	150	0.1599	37	5.9156	6.8029	5.1650	1.6379	0.3943
Agua	19	$1.0444 \cdot 10^{-6}$	0.0630	0.0035	0.0560	0.0140	9.81	0.0093	3.7597	150	0.2077	37	7.6845	8.8372	8.2640	0.5732	0.0372

Diferencia media absoluta: 0.4358 m.c.a. $\chi^2 = 0.6724$ m.c.a.



Q	Hr+Hs	Hreal
0.0009	0.1278	0.1030
0.0022	0.6172	0.5665
0.0031	1.1927	1.1531
0.0041	1.9108	1.9115
0.0050	2.8228	2.5825
0.0061	4.0179	3.0990
0.0080	6.8029	5.1650
0.0093	8.8372	8.2640

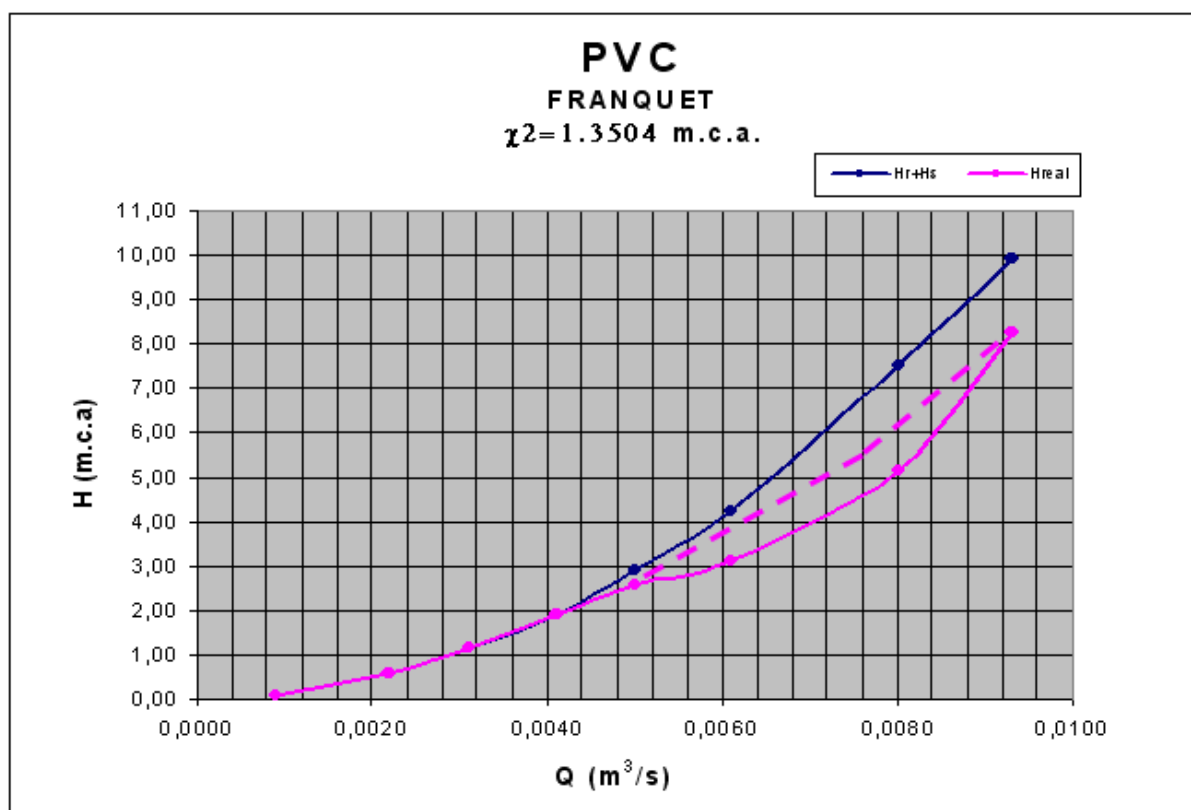
MATERIAL: PVC																
FÓRMULA: SCOBEY																
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	Ks	J (m/m)	I (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	Dif. ² Hr + Hs (mca)
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.00094	0.3817	0.3000	0.0030	37	0.1096	0.1260	0.1030	0.0230	0.0042
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.0022	0.8932	0.3000	0.0149	37	0.5514	0.6341	0.5665	0.0676	0.0072
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.00314	1.2749	0.3000	0.0293	37	1.0840	1.2466	1.1531	0.0935	0.0070
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.00405	1.6444	0.3000	0.0475	37	1.7580	2.0217	1.9115	0.1102	0.0060
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.005	2.0301	0.3000	0.0709	37	2.6235	3.0170	2.5825	0.4345	0.0626
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.00605	2.4564	0.3000	0.1019	37	3.7686	4.3339	3.0990	1.2349	0.3519
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.00804	3.2644	0.3000	0.1748	37	6.4689	7.4392	5.1650	2.2742	0.6952
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	9.81	0.00926	3.7597	0.3000	0.2287	37	8.4607	9.7298	8.2640	1.4658	0.2208
Diferencia media absoluta: 0.713 m.c.a. $\chi^2 = 1.3545$ m.c.a.																



Q	Hr+Hs	Hreal
0.00094	0.1260	0.1030
0.00220	0.6341	0.5665
0.00314	1.2466	1.1531
0.00405	2.0217	1.9115
0.00500	3.0170	2.5825
0.00605	4.3339	3.0990
0.00804	7.4392	5.1650
0.00926	9.7298	8.2640

MATERIAL: PVC																		
FÓRMULA: FRANQUET																		
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	R (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	K	β	J (m./m.)	I (m)	Hr (m)	Hr+Hs (m)	HReal (m.c.a)	Diferencia (m.c.a.)	Dif. ² Hr + Hs (m.c.a.)
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0009	0.3817	86.8500	0.62150	0.0024	37	0.0898	0.1033	0.1030	0.0003	0.0000
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0022	0.8932	86.8500	0.62150	0.0133	37	0.4921	0.5659	0.5665	-0.0006	0.0000
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0031	1.2749	86.8500	0.62150	0.0269	37	0.9940	1.1431	1.1531	-0.0100	0.0000
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0041	1.6444	86.8500	0.62150	0.0447	37	1.6537	1.9018	1.9115	0.0097	0.0000
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0050	2.0301	86.8500	0.62150	0.0681	37	2.5204	2.8985	2.5825	0.3160	0.0344
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0061	2.4564	86.8500	0.62150	0.0997	37	3.6901	4.2437	3.0990	1.1447	0.3088
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0080	3.2644	86.8500	0.62150	0.1761	37	6.5171	7.4946	5.1650	2.3296	0.7241
Agua	19	1.0444·10 ⁻⁶	0.0630	0.0035	0.0560	0.0140	9.81	0.0093	3.7597	86.8500	0.62150	0.2336	37	8.6448	9.9415	8.2640	1.6775	0.2831

Diferencia media absoluta: 0.686 m.c.a. $\chi^2 = 1.3504$ m.c.a.



Q	Hr+Hs	Hreal
0.0009	0.1033	0.1030
0.0022	0.5659	0.5665
0.0031	1.1431	1.1531
0.0041	1.9018	1.9115
0.0050	2.8985	2.5825
0.0061	4.2437	3.0990
0.0080	7.4946	5.1650
0.0093	9.9415	8.2640

2. Tubería de PEAD (7 formulaciones)

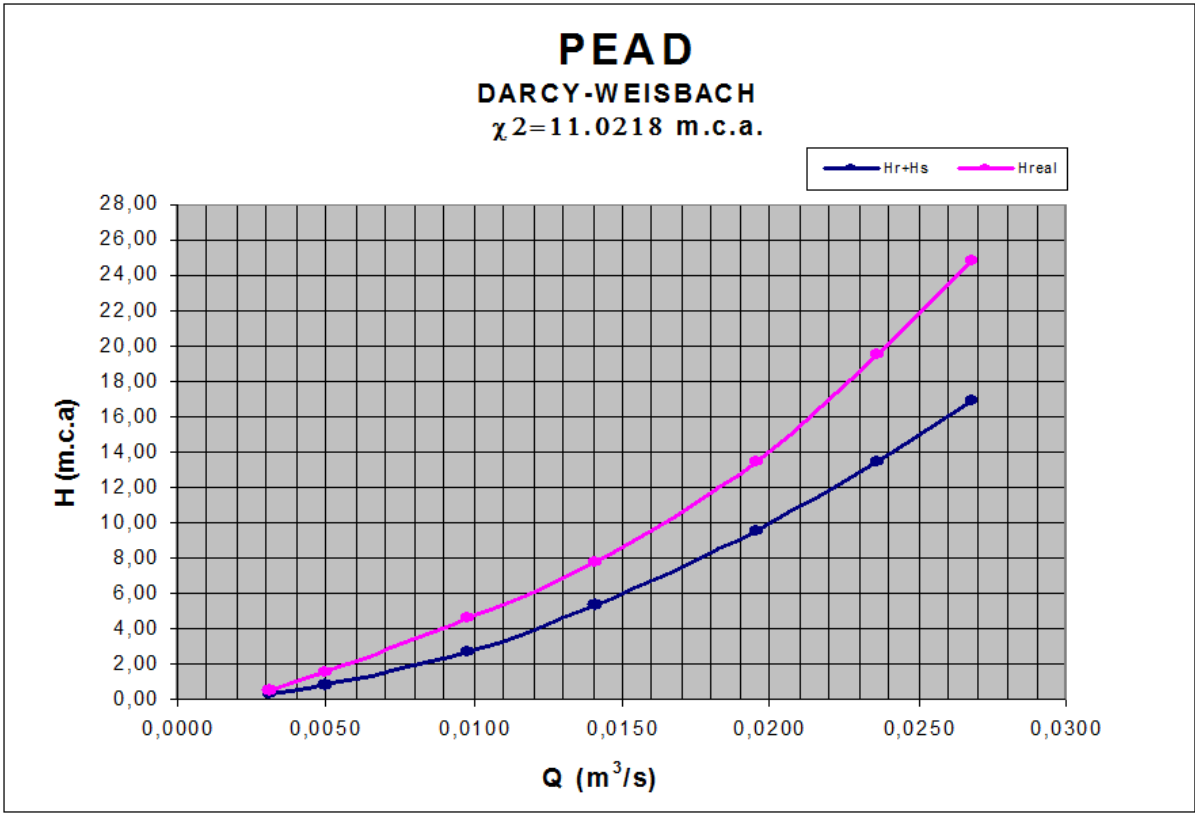
- Formulación de Darcy-Weisbach
- Formulación de Blasius-Flamant
- Formulación de Manning-Strickler-Gaukler
- Formulación de Kütter
- Formulación de Hazen-Williams
- Formulación de Scobey
- Formulación de Franquet

MATERIAL: PEAD

FÓRMULA: DARCY-WEISBACH

FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	R (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	Re	f	J (m/m)	l (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	Dif. ² Hr + Hs (mca)
Agua	19	$1.0444 \cdot 10^{-6}$	0.1250	0.0060	0.1130	0.0283	9.81	0.0031	0.3041	32 905	0.0235	0.0010	316	0.3098	0.3563	0.5165	-0.1602	0.0720
Agua	19	$1.0444 \cdot 10^{-6}$	0.1250	0.0060	0.1130	0.0283	9.81	0.0050	0.4986	53 943	0.0208	0.0023	316	0.7359	0.8464	1.5495	-0.7031	0.5841
Agua	19	$1.0444 \cdot 10^{-6}$	0.1250	0.0060	0.1130	0.0283	9.81	0.0098	0.9772	105 729	0.0177	0.0076	316	2.4122	2.7740	4.6485	-1.8745	1.2667
Agua	19	$1.0444 \cdot 10^{-6}$	0.1250	0.0060	0.1130	0.0283	9.81	0.0141	1.4060	152 120	0.0164	0.0147	316	4.6345	5.3297	7.7475	-2.4178	1.0968
Agua	19	$1.0444 \cdot 10^{-6}$	0.1250	0.0060	0.1130	0.0283	9.81	0.0195	1.9445	210 379	0.0154	0.0263	316	8.3124	9.5592	13.4290	-3.8698	1.5666
Agua	19	$1.0444 \cdot 10^{-6}$	0.1250	0.0060	0.1130	0.0283	9.81	0.0236	2.3533	254 613	0.0149	0.0371	316	11.7351	13.4954	19.6270	-6.1316	2.7859
Agua	19	$1.0444 \cdot 10^{-6}$	0.1250	0.0060	0.1130	0.0283	9.81	0.0268	2.6724	289 136	0.0145	0.0467	316	14.7227	16.9311	24.7920	-7.8609	3.6497

Diferencia media absoluta: 3.2883 m.c.a. $\chi^2 = 11.0218$ m.c.a.



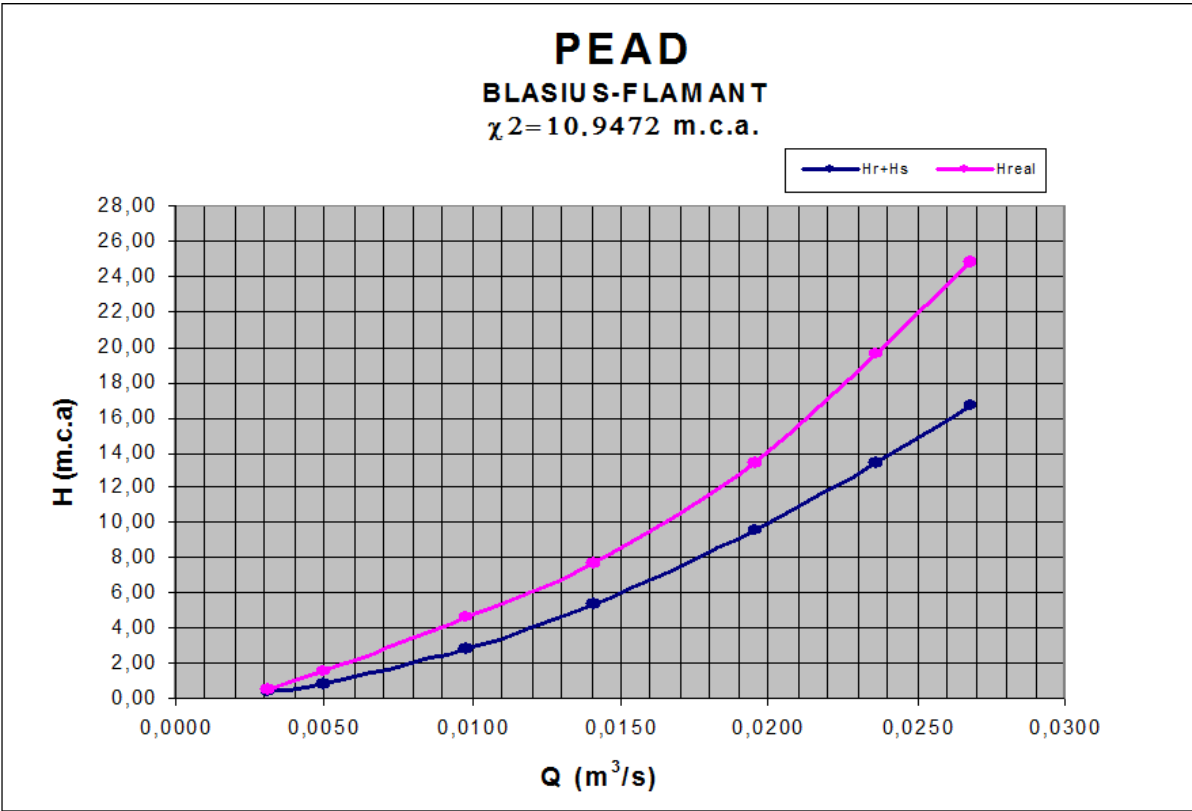
Q	Hr+Hs	Hreal
0.0031	0.3563	0.5165
0.0050	0.8464	1.5495
0.0098	2.7740	4.6485
0.0141	5.3297	7.7475
0.0195	9.5592	13.4290
0.0236	13.4954	19.6270
0.0268	16.9311	24.7920

MATERIAL: PEAD

FÓRMULA: BLASIUS-FLAMANT

FLUIDO	t (°C)	ν (m ² /s)	D (m)	e (m)	d (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	α	J (m/m)	l (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	$\frac{Dif^2}{Hr + Hs}$ (mca)
Agua	19	$1.0444 \cdot 10^{-6}$	0.1250	0.0060	0.1130	9.81	0.0031	0.3041	0.000135	0.0010	316	0.3244	0.3731	0.5165	-0.1434	0.0551
Agua	19	$1.0444 \cdot 10^{-6}$	0.1250	0.0060	0.1130	9.81	0.0050	0.4986	0.000135	0.0024	316	0.7705	0.8861	1.5495	-0.6634	0.4967
Agua	19	$1.0444 \cdot 10^{-6}$	0.1250	0.0060	0.1130	9.81	0.0098	0.9772	0.000135	0.0079	316	2.5016	2.8768	4.6485	-1.7717	1.0911
Agua	19	$1.0444 \cdot 10^{-6}$	0.1250	0.0060	0.1130	9.81	0.0141	1.4060	0.000135	0.0150	316	4.7283	5.4376	7.7475	-2.3099	0.9812
Agua	19	$1.0444 \cdot 10^{-6}$	0.1250	0.0060	0.1130	9.81	0.0195	1.9445	0.000135	0.0264	316	8.3394	9.5903	13.4290	-3.8387	1.5365
Agua	19	$1.0444 \cdot 10^{-6}$	0.1250	0.0060	0.1130	9.81	0.0236	2.3533	0.000135	0.0369	316	11.6458	13.3927	19.6270	-6.2343	2.9021
Agua	19	$1.0444 \cdot 10^{-6}$	0.1250	0.0060	0.1130	9.81	0.0268	2.6724	0.000135	0.0460	316	14.5482	16.7304	24.7920	-8.0616	3.8845

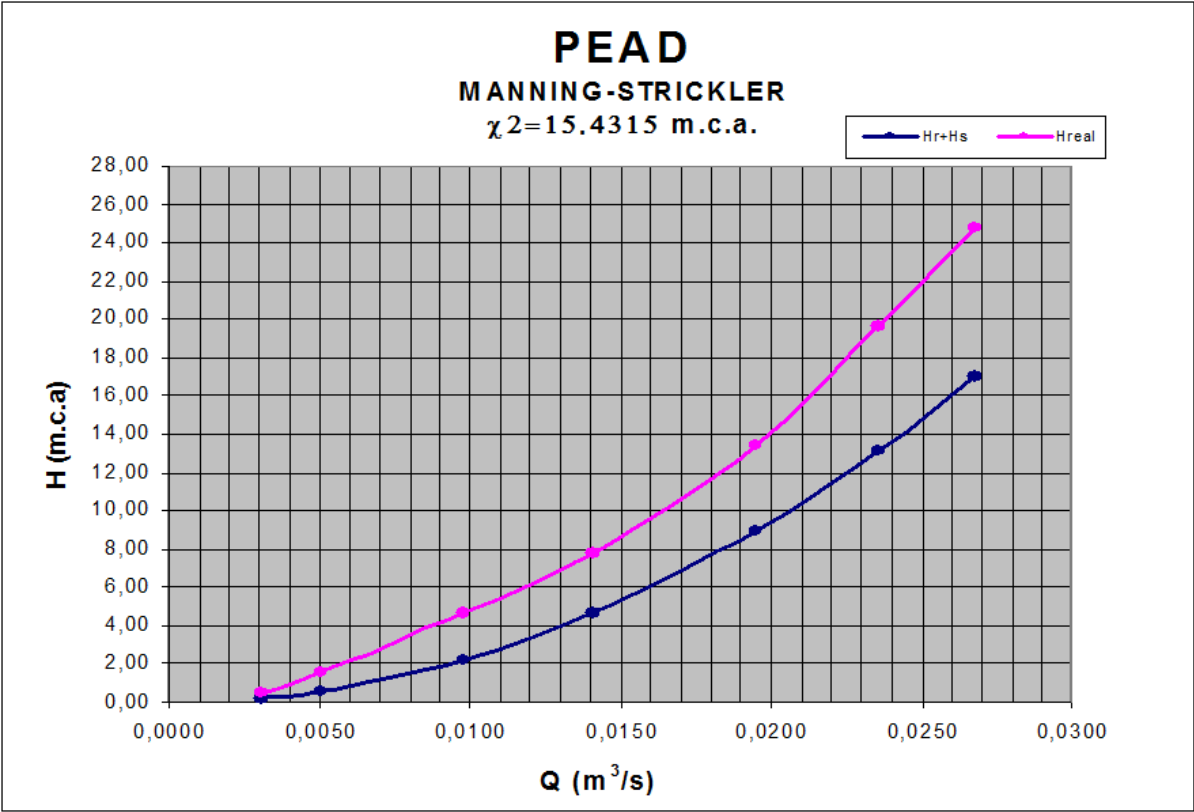
Diferencia media absoluta: 3.289 m.c.a. $\chi^2 = 10.9472$ m.c.a.



Q	Hr+Hs	Hreal
0.0031	0.3731	0.5165
0.0050	0.8861	1.5495
0.0098	2.8768	4.6485
0.0141	5.4376	7.7475
0.0195	9.5903	13.4290
0.0236	13.3927	19.6270
0.0268	16.7304	24.7920

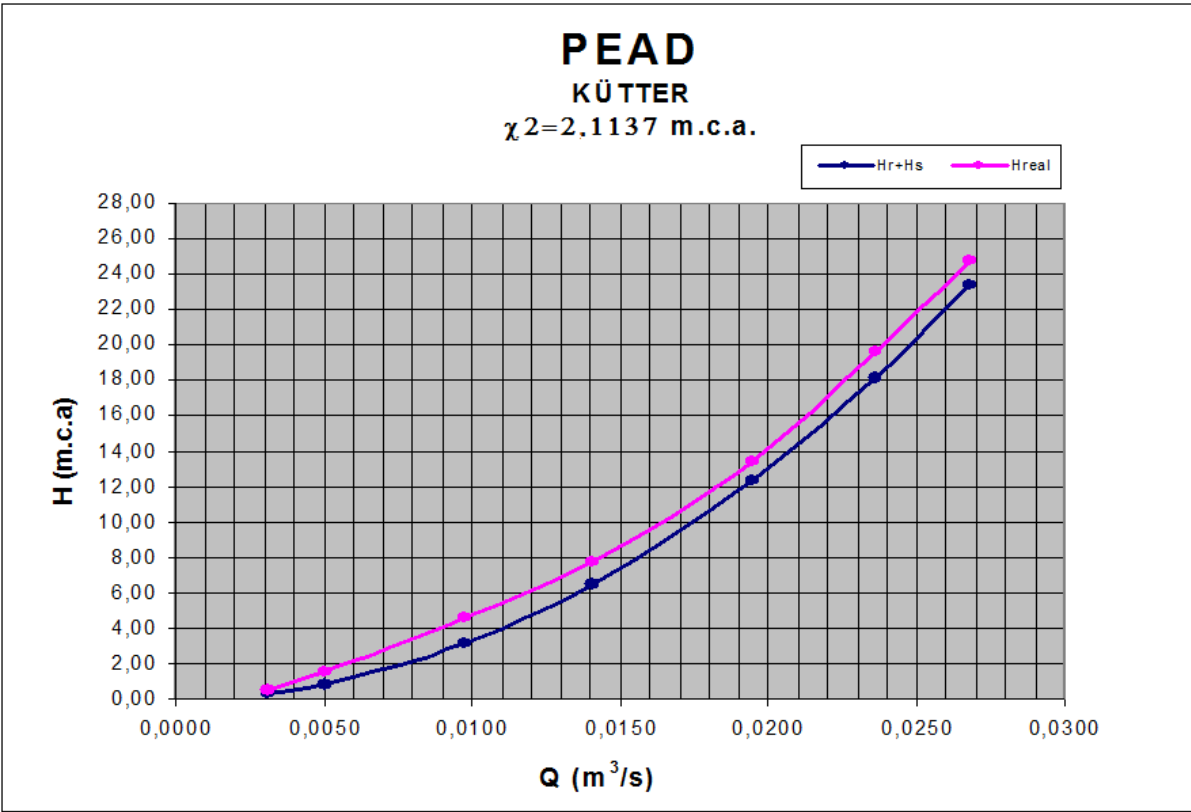
MATERIAL: PEAD																
FÓRMULA: MANNING-STRICKLER-GAUKLER																
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	n	J (m/m)	l (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	Dif. ² Hr + Hs (mca)
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	9.81	0.0031	0.3041	0.0075	0.0006	316	0.1911	0.2198	0.5165	-0.2967	0.4005
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	9.81	0.0050	0.4986	0.0075	0.0016	316	0.5136	0.5906	1.5495	-0.9589	1.5569
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	9.81	0.0098	0.9772	0.0075	0.0062	316	1.9729	2.2668	4.6485	-2.3817	2.5024
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	9.81	0.0141	1.4060	0.0075	0.0129	316	4.0840	4.6966	7.7475	-3.0509	1.9819
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	9.81	0.0195	1.9445	0.0075	0.0247	316	7.8112	8.9829	13.4290	-4.4461	2.2006
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	9.81	0.0236	2.3533	0.0075	0.0362	316	11.4413	13.1575	19.6270	-6.4695	3.1810
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	9.81	0.0268	2.6724	0.0075	0.0470	316	14.7543	16.9675	24.7920	-7.8245	3.6082
Diferencia media absoluta: 3.6326 m.c.a. $\chi^2 = 15.4315$ m.c.a.																

Diferencia media absoluta: 3.6326 m.c.a. $\chi^2 = 15.4315$ m.c.a.



Q	Hr+Hs	Hreal
0.0031	0.2198	0.5165
0.0050	0.5906	1.5495
0.0098	2.2668	4.6485
0.0141	4.6966	7.7475
0.0195	8.9829	13.4290
0.0236	13.1575	19.6270
0.0268	16.9675	24.7920

MATERIAL: PEAD																		
FÓRMULA: KÜTTER																		
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	R (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	α	K	J (m/m)	I (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	Dif.² Hr + Hs (mca)
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0031	0.3041	0.1000	62.6973	0.0008	316	0.2632	0.3027	0.5165	-0.2138	0.1510
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0050	0.4986	0.1000	62.6973	0.0022	316	0.7074	0.8135	1.5495	-0.7360	0.6659
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0098	0.9772	0.1000	62.6973	0.0086	316	2.7174	3.1250	4.6485	-1.5235	0.7427
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0141	1.4060	0.1000	62.6973	0.0178	316	5.6252	6.4690	7.7475	-1.2785	0.2527
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0195	1.9445	0.1000	62.6973	0.0340	316	10.7590	12.3729	13.4290	-1.0561	0.0901
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0236	2.3533	0.1000	62.6973	0.0499	316	15.7589	18.1227	19.6270	-1.5043	0.1249
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0268	2.6724	0.1000	62.6973	0.0643	316	20.3223	23.3707	24.7920	-1.4213	0.0864
Diferencia media absoluta: 1. 1048 m.c.a.χ² = 2.1137 m.c.a.																		



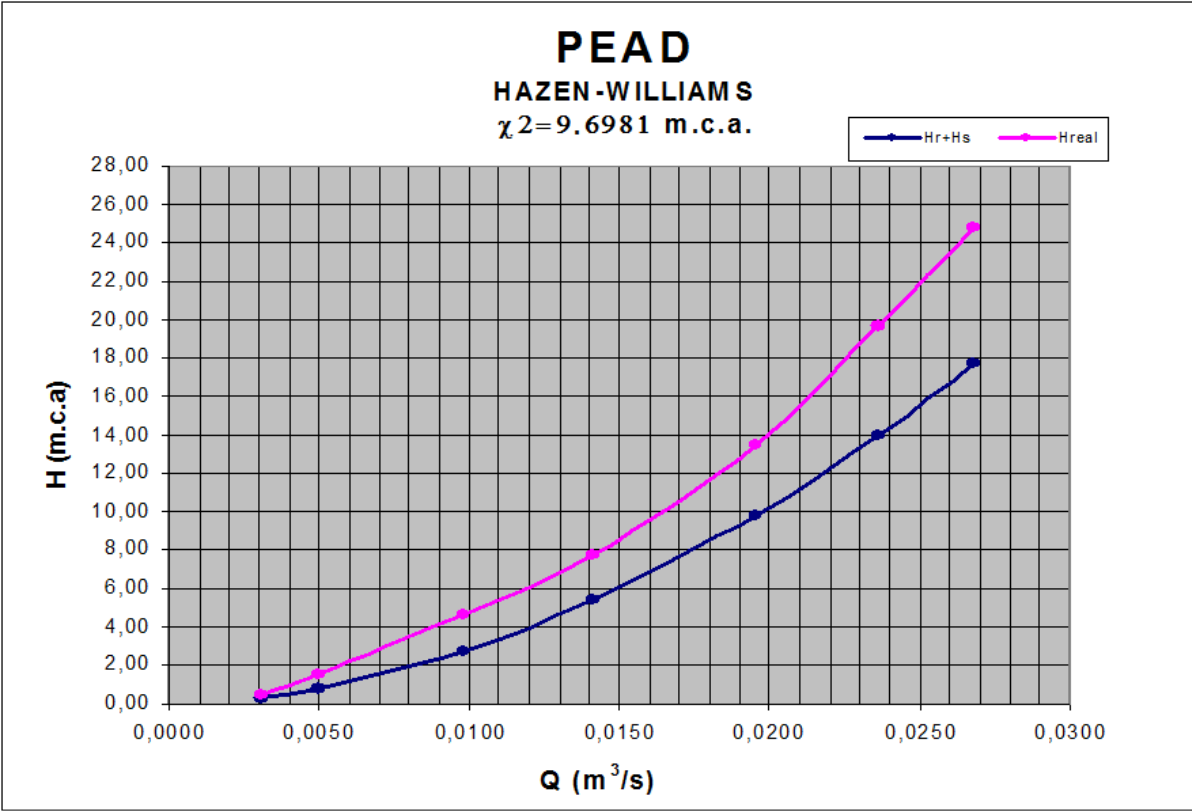
Q	Hr+Hs	Hreal
0.0031	0.3027	0.5165
0.0050	0.8135	1.5495
0.0098	3.1250	4.6485
0.0141	6.4690	7.7475
0.0195	12.3729	13.4290
0.0236	18.1227	19.6270
0.0268	23.3707	24.7920

MATERIAL: PEAD

FÓRMULA: HAZEN-WILLIAMS

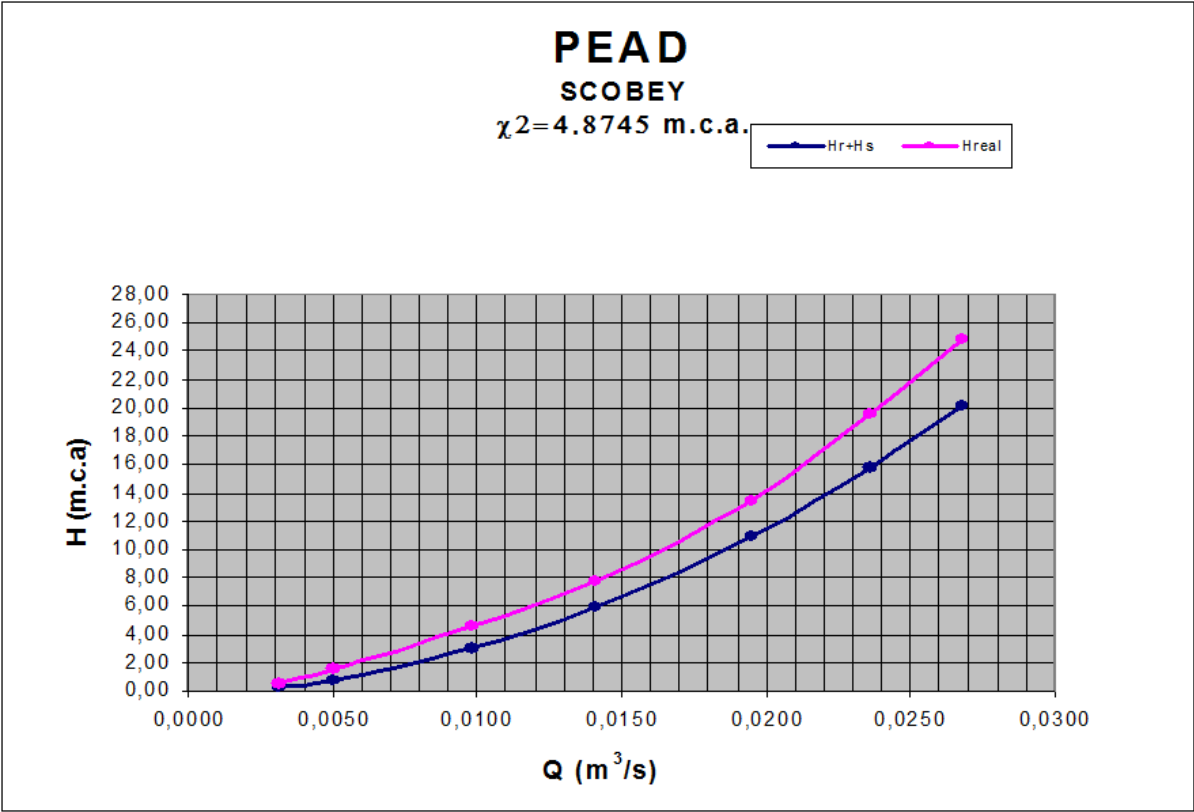
FLUIDO	t (°C)	v (m ² /seg.)	D (m)	e (m)	d (m)	R (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	C	J (m/m)	I (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	Dif. ² Hr + Hs (mca)
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0031	0.3041	150	0.0009	316	0.2747	0.3159	0.5165	-0.2006	0.1274
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0050	0.4986	150	0.0022	316	0.6863	0.7892	1.5495	-0.7603	0.7325
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0098	0.9772	150	0.0076	316	2.3865	2.7445	4.6485	-1.9040	1.3209
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0141	1.4060	150	0.0148	316	4.6810	5.3832	7.7475	-2.3643	1.0384
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0195	1.9445	150	0.0270	316	8.5331	9.8131	13.4290	-3.6159	1.3324
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0236	2.3533	150	0.0385	316	12.1502	13.9727	19.6270	-5.6543	2.2881
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0268	2.6724	150	0.0487	316	15.3762	17.6826	24.7920	-7.1094	2.8584

Diferencia media absoluta: 3.087 m.c.a. $\chi^2 = 9.6981$ m.c.a.



Q	Hr+Hs	Hreal
0.0031	0.3159	0.5165
0.0050	0.7892	1.5495
0.0098	2.7445	4.6485
0.0141	5.3832	7.7475
0.0195	9.8131	13.4290
0.0236	13.9727	19.6270
0.0268	17.6826	24.7920

Diferencia media absoluta: 2.2102 m.c.a. $\chi^2 = 4.8745$ m.c.a.



Q	Hr+Hs	Hreal
0.0031	0.3230	0.5165
0.0050	0.8263	1.5495
0.0098	2.9676	4.6485
0.0141	5.9235	7.7475
0.0195	10.9681	13.4290
0.0236	15.7614	19.6270
0.0268	20.0688	24.7920

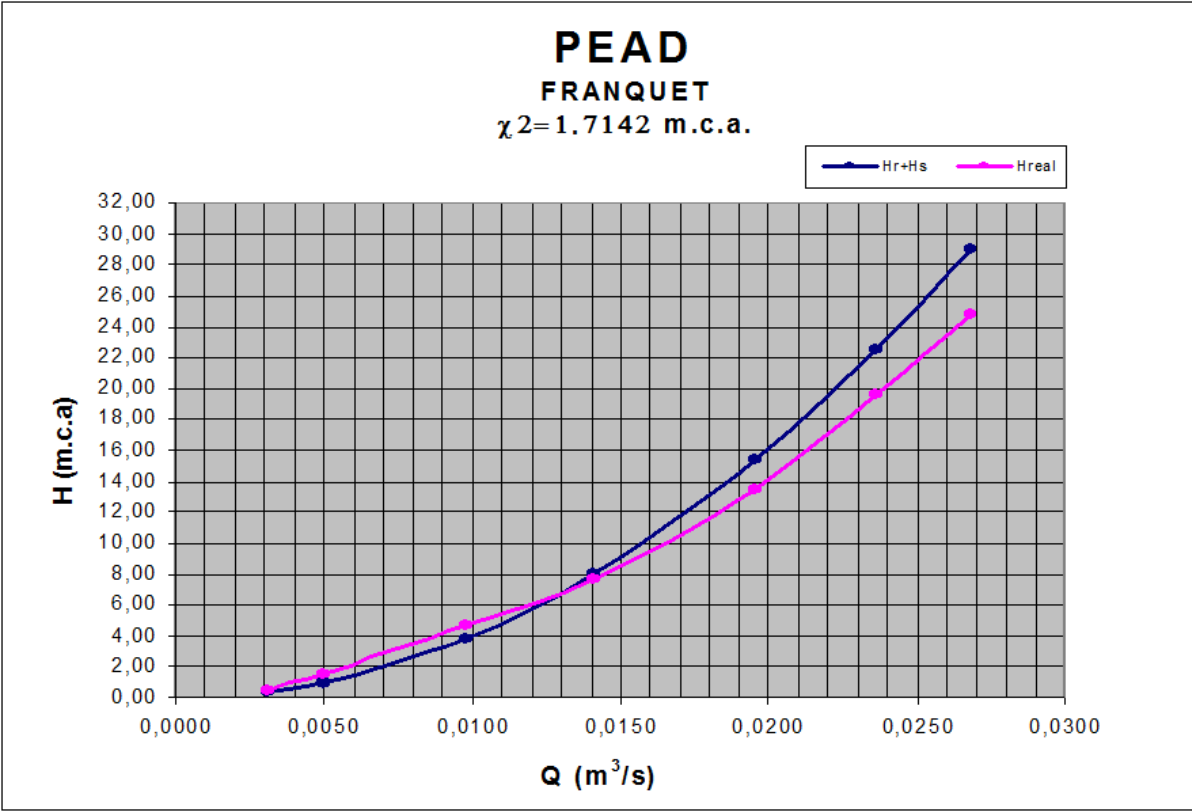
MATERIAL: PEAD

FÓRMULA: FRANQUET

FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	R (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	K	β	J (m/m)	I (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	Dif. ² Hr + Hs (mca)
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0031	0.3041	86.8500	0.62150	0.0010	316	0.3265	0.3755	0.5165	-0.1410	0.0529
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0050	0.4986	86.8500	0.62150	0.0028	316	0.8773	1.0089	1.5495	-0.5406	0.2897
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0098	0.9772	86.8500	0.62150	0.0107	316	3.3704	3.8760	4.6485	-0.7725	0.1540
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0141	1.4060	86.8500	0.62150	0.0221	316	6.9770	8.0236	7.7475	0.2761	0.0095
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0195	1.9445	86.8500	0.62150	0.0422	316	13.3445	15.3462	13.4290	1.9172	0.2395
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0236	2.3533	86.8500	0.62150	0.0619	316	19.5459	22.4778	19.6270	2.8508	0.3616
Agua	19	1.0444·10 ⁻⁶	0.1250	0.0060	0.1130	0.0283	9.81	0.0268	2.6724	86.8500	0.62150	0.0798	316	25.2058	28.9867	24.7920	4.1947	0.6070

Diferencia media absoluta: 1.5276 m.c.a. $\chi^2 = 1.7142$ m.c.a.

OBSERVACIONES: Debe considerarse que, en este caso, la tubería en cuestión estaba bastante deteriorada por el uso, estado de conservación y elevada presencia de piezas especiales. Por esta razón, hemos aplicado directamente la fórmula de las tuberías en servicio que se deduce de nuestro estudio.



Q	Hr+Hs	Hreal
0.0031	0.3755	0.5165
0.0050	1.0089	1.5495
0.0098	3.8760	4.6485
0.0141	8.0236	7.7475
0.0195	15.3462	13.4290
0.0236	22.4778	19.6270
0.0268	28.9867	24.7920

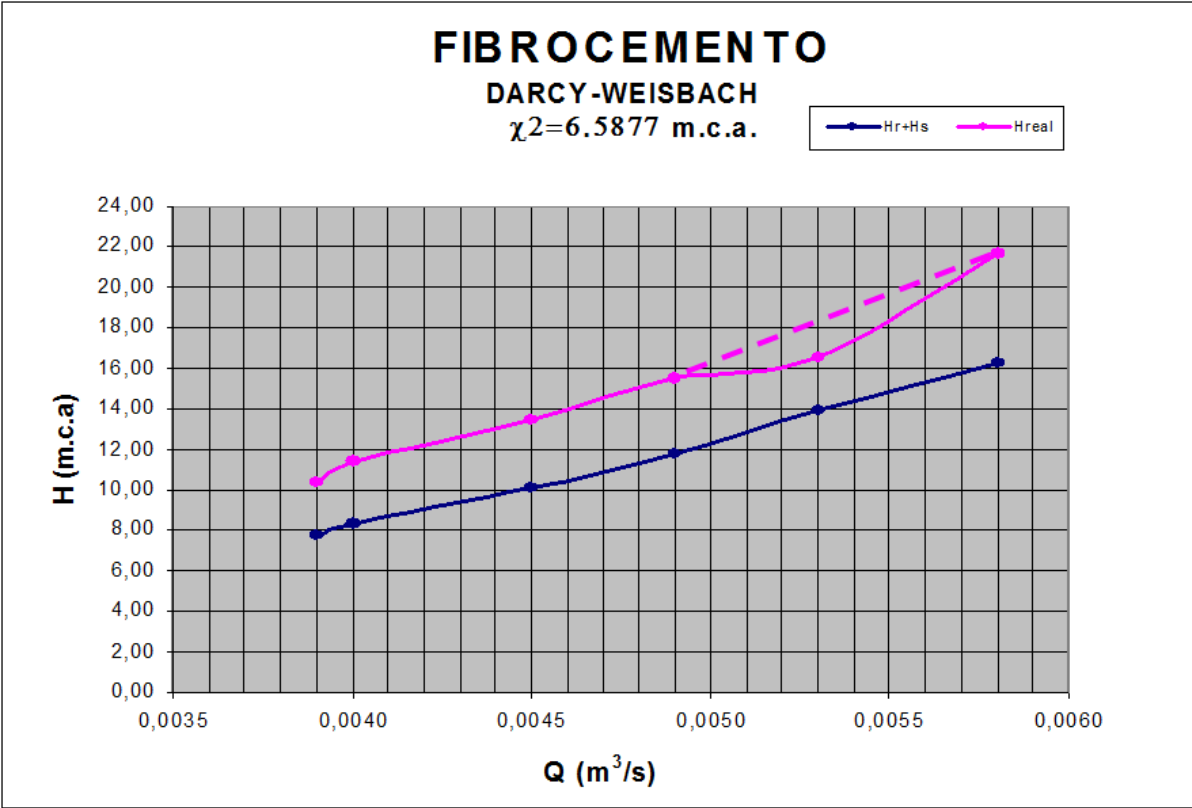
3. Tubería de fibrocemento (11 formulaciones)

- Formulación de Darcy-Weisbach
- Formulación de Blasius-Flamant
- Formulación de Manning-Strickler-Gaukler
- Formulación de Kütter
- Formulación de Hazen-Williams
- Formulación de Scobey
- Formulación de Franquet
- Formulación de Scimemi
- Formulación de Meyer-Peter
- Formulación de Ludin
- Formulación de Stucky

MATERIAL: fibrocemento																		
FÓRMULA: DARCY-WEISBACH																		
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	R (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	Re	f	J (m/m)	l (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	$\frac{Dif^2}{Hr + Hs}$ (mca)
Agua	19	⁻⁶ 1,0444·10	0.0680	0.0090	0.0500	0.0125	9.81	0.0039	1.9608	93 872	0.0181	0.0709	95	6.7332	7.7432	10.3300	-2,5868	0.8642
Agua	19	⁻⁶ 1,0444·10	0.0680	0.0090	0.0500	0.0125	9.81	0.0040	2.0474	98 017	0.0179	0.0764	95	7.2621	8.3514	11.3630	-3,0116	1.0860
Agua	19	⁻⁶ 1,0444·10	0.0680	0.0090	0.0500	0.0125	9.81	0.0045	2.2664	108 502	0.0176	0.0923	95	8.7684	10.0837	13.4290	-3,3453	1.1098
Agua	19	⁻⁶ 1,0444·10	0.0680	0.0090	0.0500	0.0125	9.81	0.0049	2.4702	118 255	0.0173	0.1077	95	10.2314	11.7661	15.4950	-3,7289	1.1818
Agua	19	⁻⁶ 1,0444·10	0.0680	0.0090	0.0500	0.0125	9.81	0.0053	2.7095	129 714	0.0170	0.1271	95	12.0787	13.8905	16.5280	-2,6375	0.5008
Agua	19	⁻⁶ 1,0444·10	0.0680	0.0090	0.0500	0.0125	9.81	0.0058	2.9540	141 418	0.0167	0.1485	95	14.1061	16.2220	21.6930	-5,4710	1.8451

Diferencia media absoluta: 3.4635 m.c.a. $\chi^2 = 6.5877$ m.c.a.

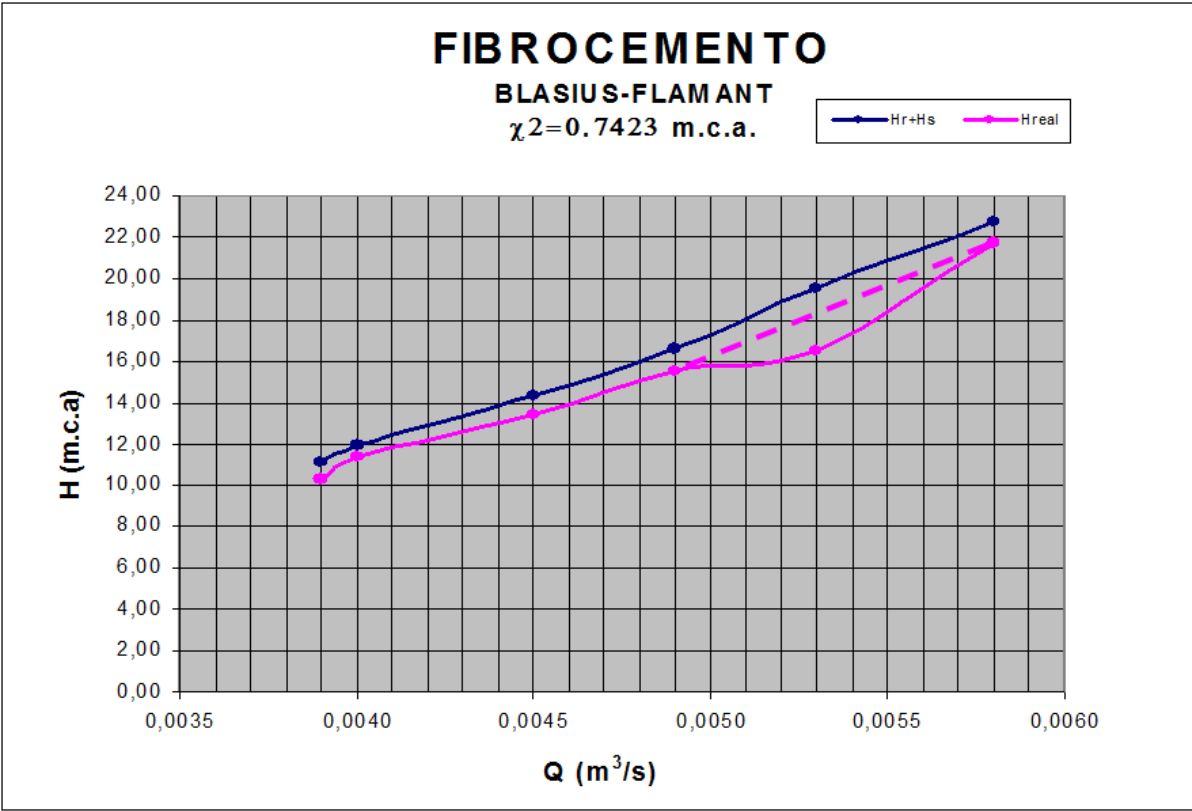
NOTA: En este caso, la tubería era de diámetro nominal Φ 50 mm.



Q	Hr+Hs	Hreal
0.0039	7.7432	10.3300
0.0040	8.3514	11.3630
0.0045	10.0837	13.4290
0.0049	11.7661	15.4950
0.0053	13.8905	16.5280
0.0058	16.2220	21.6930

MATERIAL: fibrocemento																
FÓRMULA: BLASIUS-FLAMANT																
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	g (m/s ²)	Q (m ³ /seg)	V (m/s)	α	J (m/m)	l (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	Dif. ² Hr + Hs (mca)
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	9.81	0.0039	1.9608	0.000185	0.1017	95	9.6609	11.1100	10.3300	0.7800	0.0548
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	9.81	0.0040	2.0474	0.000185	0.1097	95	10.4198	11.9828	11.3630	0.6198	0.0321
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	9.81	0.0045	2.2664	0.000185	0.1310	95	12.4478	14.3150	13.4290	0.8860	0.0548
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	9.81	0.0049	2.4702	0.000185	0.1523	95	14.4714	16.6421	15.4950	1.1471	0.0791
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	9.81	0.0053	2.7095	0.000185	0.1791	95	17.0141	19.5662	16.5280	3.0382	0.4718
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	9.81	0.0058	2.9540	0.000185	0.2083	95	19.7907	22.7593	21.6930	1.0633	0.0497

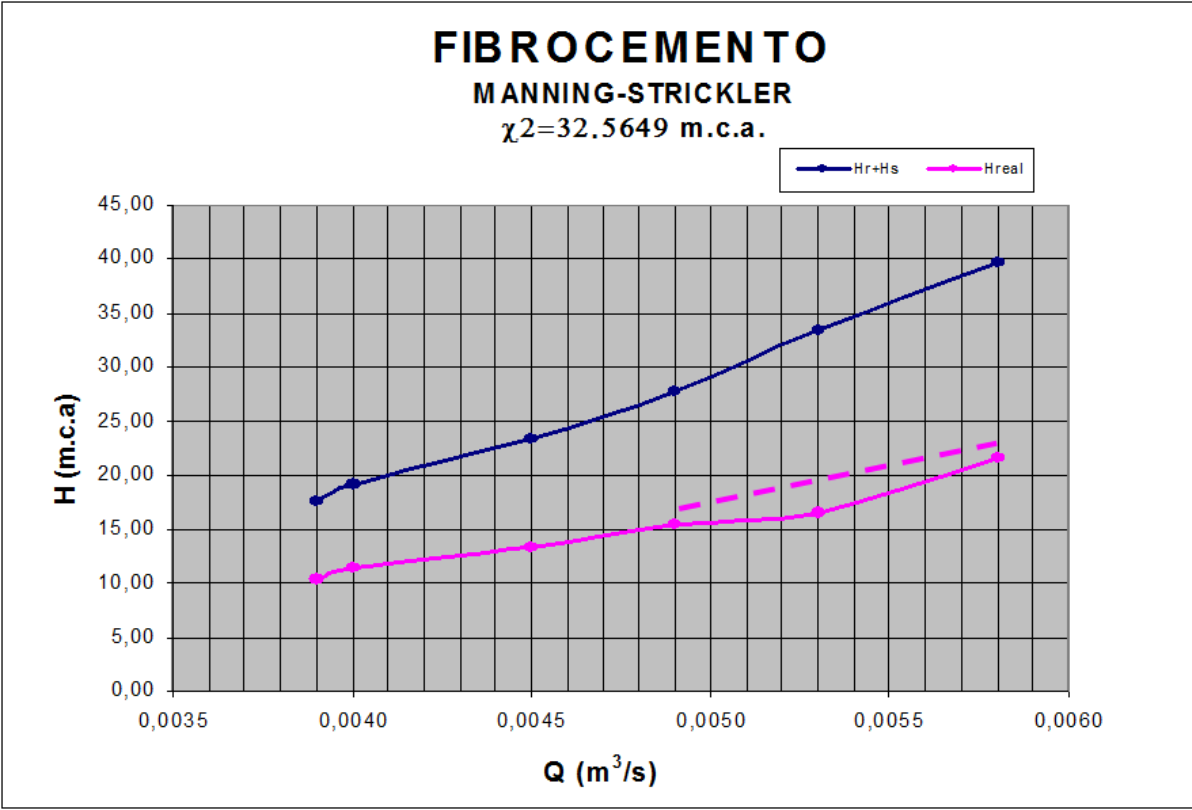
Diferencia media absoluta: 1.2562 m.c.a. $\chi^2 = 0.7423$ m.c.a.



Q	Hr+Hs	Hreal
0.0039	11.1100	10.3300
0.0040	11.9828	11.3630
0.0045	14.3150	13.4290
0.0049	16.6421	15.4950
0.0053	19.5662	16.5280
0.0058	22.7593	21.6930

MATERIAL: fibrocemento																
FÓRMULA: MANNING-STRICKLER-GAUKLER																
FLUIDO	t (°C)	v (m ² /seg.)	D (m)	e (m)	d (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	n	J (m/m)	l (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	$\frac{Dif^2}{Hr + Hs}$ (mca)
Agua	19	$1.0444 \cdot 10^{-6}$	0.0680	0.0090	0.0500	9.81	0.0039	1.9608	0.0110	0.1634	95	15.2353	17.5206	10.3300	7.1906	2.9511
Agua	19	$1.0444 \cdot 10^{-6}$	0.0680	0.0090	0.0500	9.81	0.0040	2.0474	0.0110	0.1748	95	16.6104	19.1020	11.3630	7.7390	3.1354
Agua	19	$1.0444 \cdot 10^{-6}$	0.0680	0.0090	0.0500	9.81	0.0045	2.2664	0.0110	0.2143	95	20.3539	23.4070	13.4290	9.9780	4.2534
Agua	19	$1.0444 \cdot 10^{-6}$	0.0680	0.0090	0.0500	9.81	0.0049	2.4702	0.0110	0.2545	95	24.1775	27.8041	15.4950	12.3091	5.4493
Agua	19	$1.0444 \cdot 10^{-6}$	0.0680	0.0090	0.0500	9.81	0.0053	2.7095	0.0110	0.3062	95	29.0905	33.4541	16.5280	16.9261	8.5638
Agua	19	$1.0444 \cdot 10^{-6}$	0.0680	0.0090	0.0500	9.81	0.0058	2.9540	0.0110	0.3640	95	34.5767	39.7632	21.6930	18.0702	8.2119

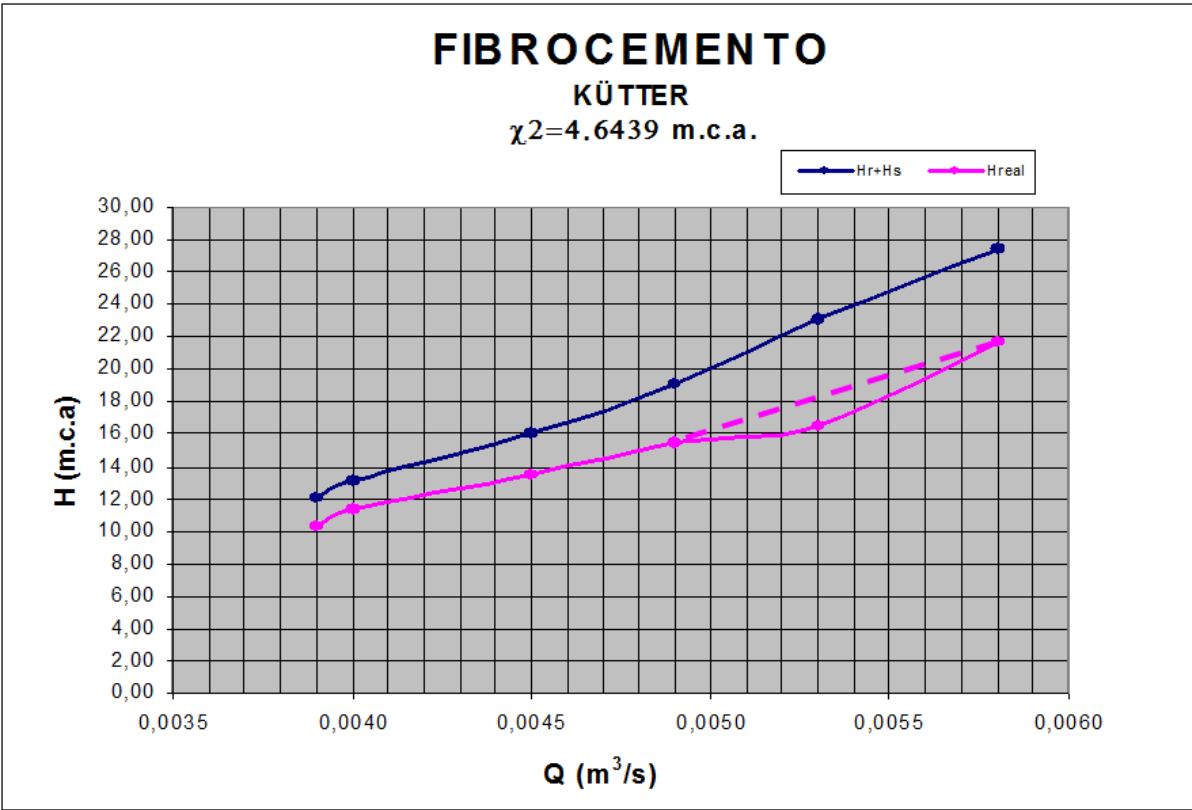
Diferencia media absoluta: 12.0355 m.c.a. $\chi^2 = 32.5649$ m.c.a.



Q	Hr+Hs	Hreal
0.0039	17.5206	10.3300
0.0040	19.1020	11.3630
0.0045	23.4070	13.4290
0.0049	27.8041	15.4950
0.0053	33.4541	16.5280
0.0058	39.7632	21.6930

MATERIAL: fibrocemento																		
FÓRMULA: KÜTTER																		
FLUIDO	t (°C)	v (m ² /s)	D (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	α	K	J (m/m)	l (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	Dif ² Hr + Hs (mca)			
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0039	1.9608	0.1000	52.7864	0.1104	95	10.4871	12.0602	10.3300	1.7302	0.2482
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0040	2.0474	0.1000	52.7864	0.1204	95	11.4337	13.1488	11.3630	1.7858	0.2425
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0045	2.2664	0.1000	52.7864	0.1475	95	14.0106	16.1122	13.4290	2.6832	0.4468
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0049	2.4702	0.1000	52.7864	0.1752	95	16.6425	19.1389	15.4950	3.6439	0.6938
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0053	2.7095	0.1000	52.7864	0.2108	95	20.0244	23.0281	16.5280	6.5001	1.8348
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0058	2.9540	0.1000	52.7864	0.2505	95	23.8008	27.3709	21.6930	5.6779	1.1778
Diferencia media absoluta: 3.6701 m.c.a $\chi^2 = 4.6439$ m.c.a.																		

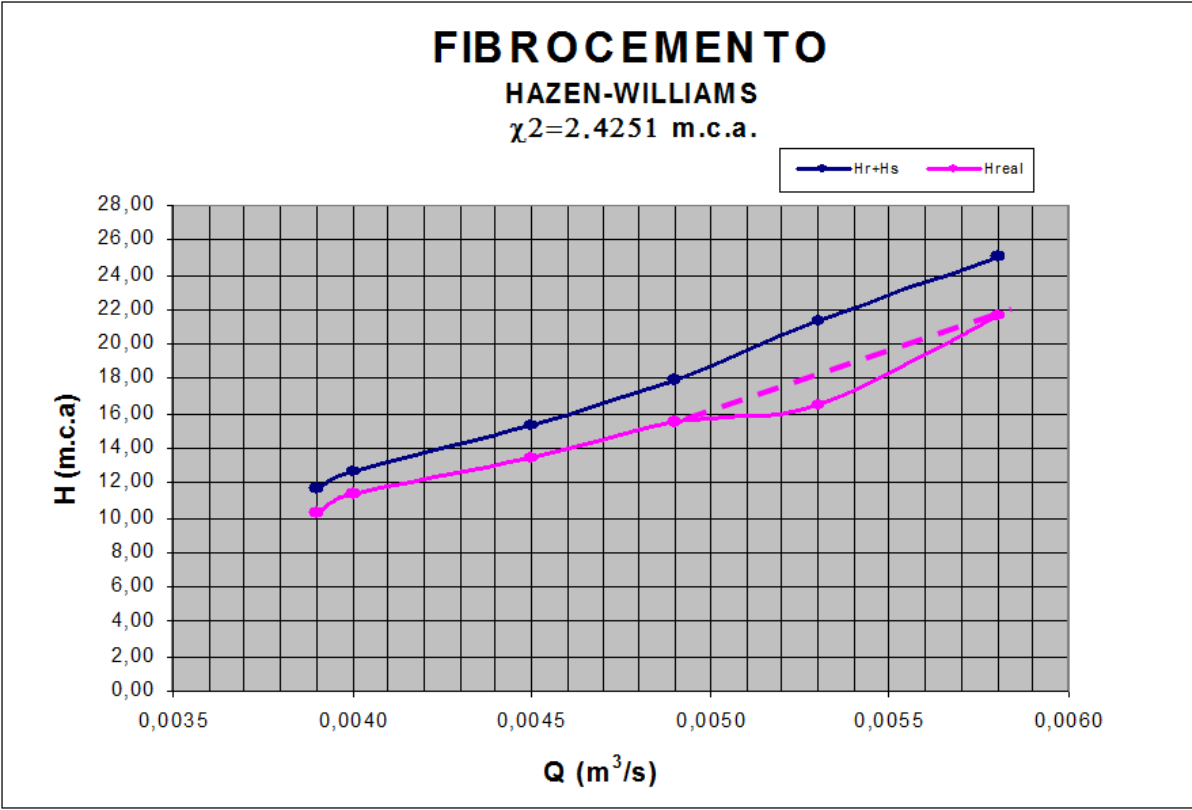
Diferencia media absoluta: 3.6701 m.c.a. $\chi^2 = 4.6439$ m.c.a.



Q	Hr+Hs	Hreal
0.0039	12.0602	10.3300
0.0040	13.1488	11.3630
0.0045	16.1122	13.4290
0.0049	19.1389	15.4950
0.0053	23.0281	16.5280
0.0058	27.3709	21.6930

MATERIAL: fibrocemento																	
FÓRMULA: HAZEN-WILLIAMS																	
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	R (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	C	J (m/m)	I (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	Dif. ² Hr + Hs (mca)
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0039	1.9608	120	0.1073	95	10.1972	11.7268	10.3300	1.3986	0.1668
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0040	2.0474	120	0.1163	95	11.0467	12.7037	11.3630	1.3407	0.1415
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0045	2.2664	120	0.1404	95	13.3340	15.3341	13.4290	1.9051	0.2367
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0049	2.4702	120	0.1646	95	15.6382	17.9839	15.4950	2.4889	0.3445
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0053	2.7095	120	0.1954	95	18.5599	21.3439	16.5280	4.8159	1.0866
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0058	2.9540	120	0.2293	95	21.7796	25.0465	21.6930	3.3535	0.4490

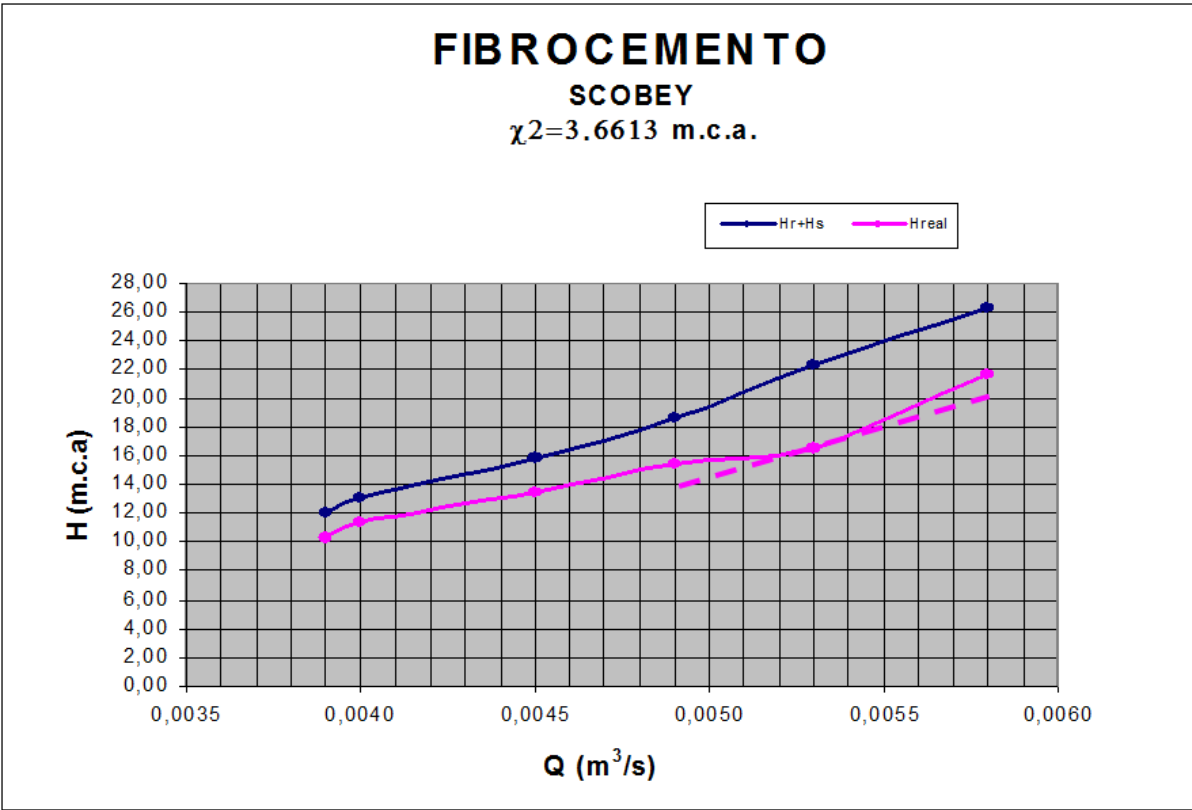
Diferencia media absoluta: 2.5505 m.c.a. $\chi^2 = 2.4251$ m.c.a.



Q	Hr+Hs	Hreal
0.0039	11.7268	10.3300
0.0040	12.7037	11.3630
0.0045	15.3341	13.4290
0.0049	17.9839	15.4950
0.0053	21.3439	16.5280
0.0058	25.0465	21.6930

MATERIAL: fibrocemento																
FÓRMULA: SCOBEY																
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	Ks	J (m/m)	l (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	Dif ² Hr + Hs (mca)
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	9.81	0.0039	1.9608	0.4400	0.1634	95	10.4771	12.0487	10.3300	1.7187	0.2452
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	9.81	0.0040	2.0474	0.4400	0.1748	95	11.3735	13.0795	11.3630	1.7165	0.2253
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	9.81	0.0045	2.2664	0.4400	0.2143	95	13.7959	15.8653	13.4290	2.4363	0.3741
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	9.81	0.0049	2.4702	0.4400	0.2545	95	16.2471	18.6842	15.4950	3.1892	0.5444
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	9.81	0.0053	2.7095	0.4400	0.3062	95	19.3686	22.2739	16.5280	5.7459	1.4822
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	9.81	0.0058	2.9540	0.4400	0.3640	95	22.8233	26.2468	21.6930	4.5538	0.7901

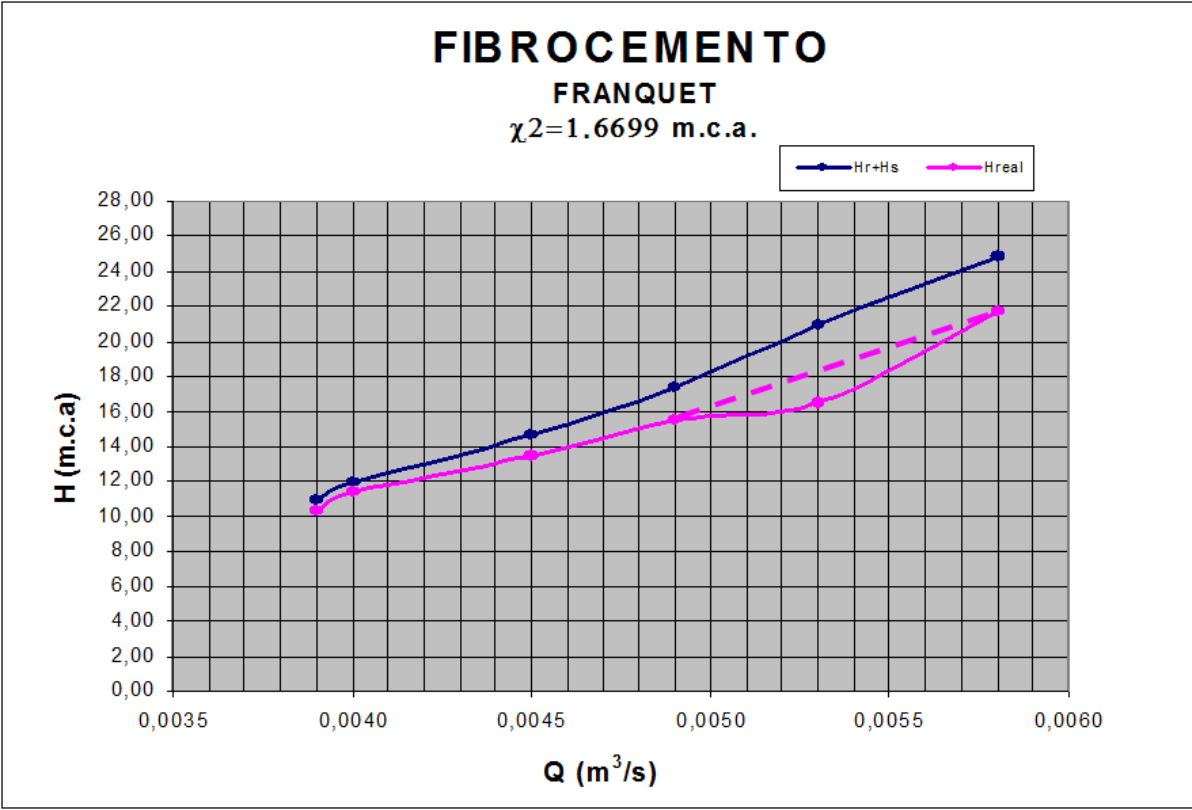
Diferencia media absoluta: 3.2267 m.c.a. $\chi^2 = 3.6613$ m.c.a.



Q	Hr+Hs	Hreal
0.0039	12.0487	10.3300
0.0040	13.0795	11.3630
0.0045	15.8653	13.4290
0.0049	18.6842	15.4950
0.0053	22.2739	16.5280
0.0058	26.2468	21.6930

MATERIAL: fibrocemento																		
FÓRMULA: FRANQUET																		
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	R (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	K	β	J (m/m)	I (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	Dif ² Hr + Hs (mca)
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0039	1.9608	78.2900	0.6346	0.1001	95	9.5152	10.9425	10.3300	0.6125	0.0343
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0040	2.0474	78.2900	0.6346	0.1092	95	10.3742	11.9304	11.3630	0.5674	0.0270
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0045	2.2664	78.2900	0.6346	0.1338	95	12.7123	14.6191	13.4290	1.1901	0.0969
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0049	2.4702	78.2900	0.6346	0.1589	95	15.1013	17.3665	15.4950	1.8715	0.2017
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0053	2.7095	78.2900	0.6346	0.1913	95	18.1689	20.8943	16.5280	4.3663	0.9124
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0058	2.9540	78.2900	0.6346	0.2273	95	21.5959	24.8353	21.6930	3.1423	0.3976

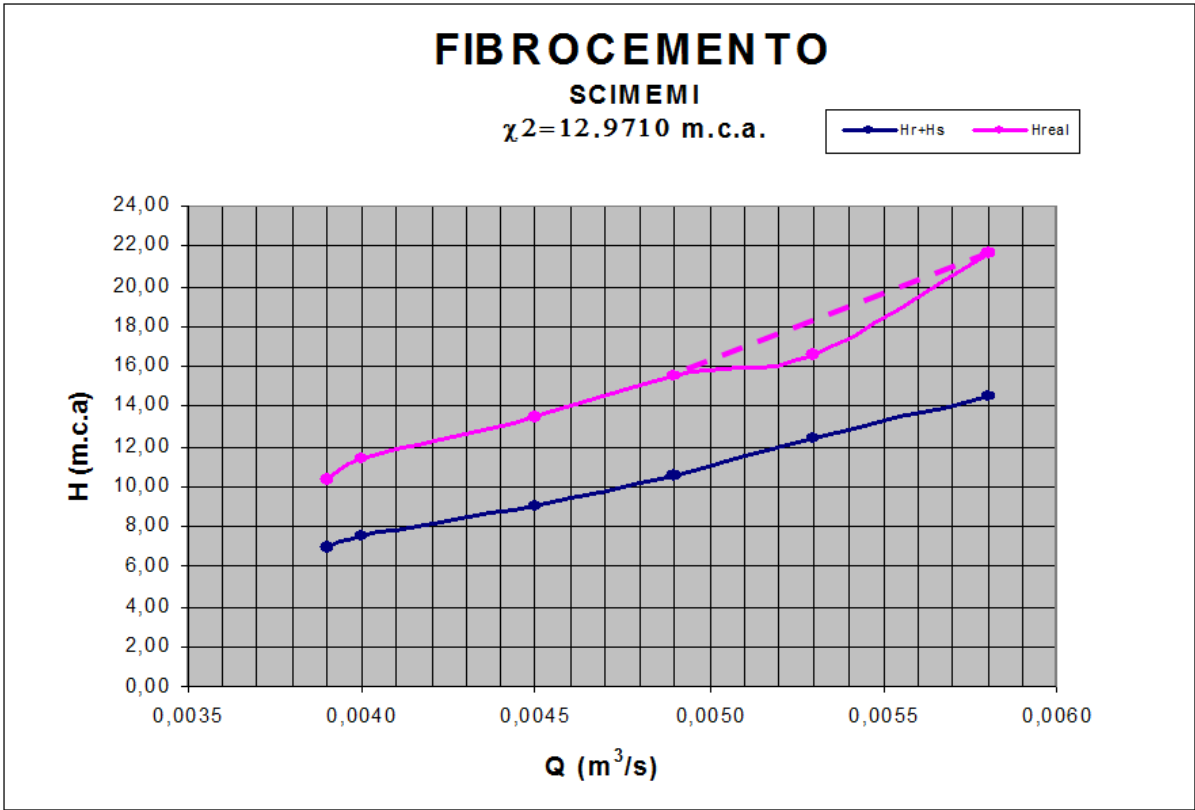
Diferencia media absoluta: 1.9583 m.c.a. $\chi^2 = 1.6699$ m.c.a.



Q	Hr+Hs	Hreal
0.0039	10.9425	10.3300
0.0040	11.9304	11.3630
0.0045	14.6191	13.4290
0.0049	17.3665	15.4950
0.0053	20.8943	16.5280
0.0058	24.8353	21.6930

MATERIAL: fibrocemento																	
FÓRMULA: SCIMEMI																	
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	R (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	Cs	J (m/m)	I (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	Dif. ² Hr + Hs (mca)
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0039	1.9608	158	0.0638	95	6.0634	6.9729	10.3300	-3.3571	1.6163
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0040	2.0474	158	0.0690	95	6.5497	7.5322	11.3630	-3.8308	1.9483
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0045	2.2664	158	0.0827	95	7.8530	9.0310	13.4290	-4.398	2.1418
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0049	2.4702	158	0.0964	95	9.1577	10.5314	15.4950	-4.9636	2.3394
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0053	2.7095	158	0.1137	95	10.8024	12.4228	16.5280	-4.1052	1.3566
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0058	2.9540	158	0.1327	95	12.6041	14.4997	21.6930	-7.1933	3.5686

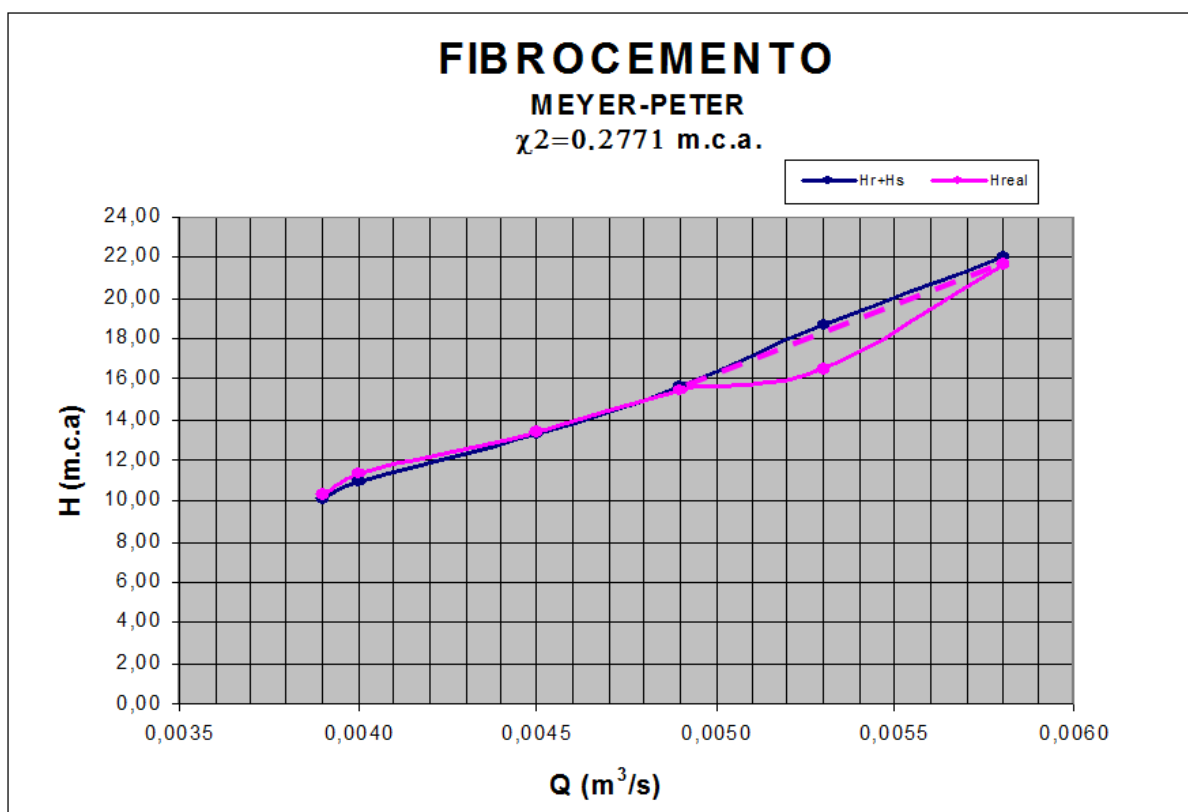
Diferencia media absoluta: 4.6413 m.c.a. $\chi^2 = 12.971$ m.c.a.



Q	Hr+Hs	Hreal
0.0039	6.9729	10.3300
0.0040	7.5322	11.3630
0.0045	9.0310	13.4290
0.0049	10.5314	15.4950
0.0053	12.4228	16.5280
0.0058	14.4997	21.6930

MATERIAL: fibrocemento																	
FÓRMULA: MEYER-PETER																	
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	R (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	C _m (m/m)	J (m/m)	I (m)	H _r (mca)	H _r +H _s (mca)	H _{real} (mca)	Diferencia (mca)	Dif. ² H _r + H _s (mca)
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0039	1.9608	135	0.0925	95	8.7883	10.1065	10.3300	-0.2235	0.0049
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0040	2.0474	135	0.1004	95	9.5407	10.9718	11.3630	-0.3912	0.0139
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0045	2.2664	135	0.1218	95	11.5740	13.3101	13.4290	-0.1189	0.0010
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0049	2.4702	135	0.1435	95	13.6318	15.6766	15.4950	0.1816	0.0021
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0053	2.7095	135	0.1711	95	16.2525	18.6904	16.5280	2.1624	0.2502
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0058	2.9540	135	0.2016	95	19.1534	22.0264	21.6930	0.3334	0.0050

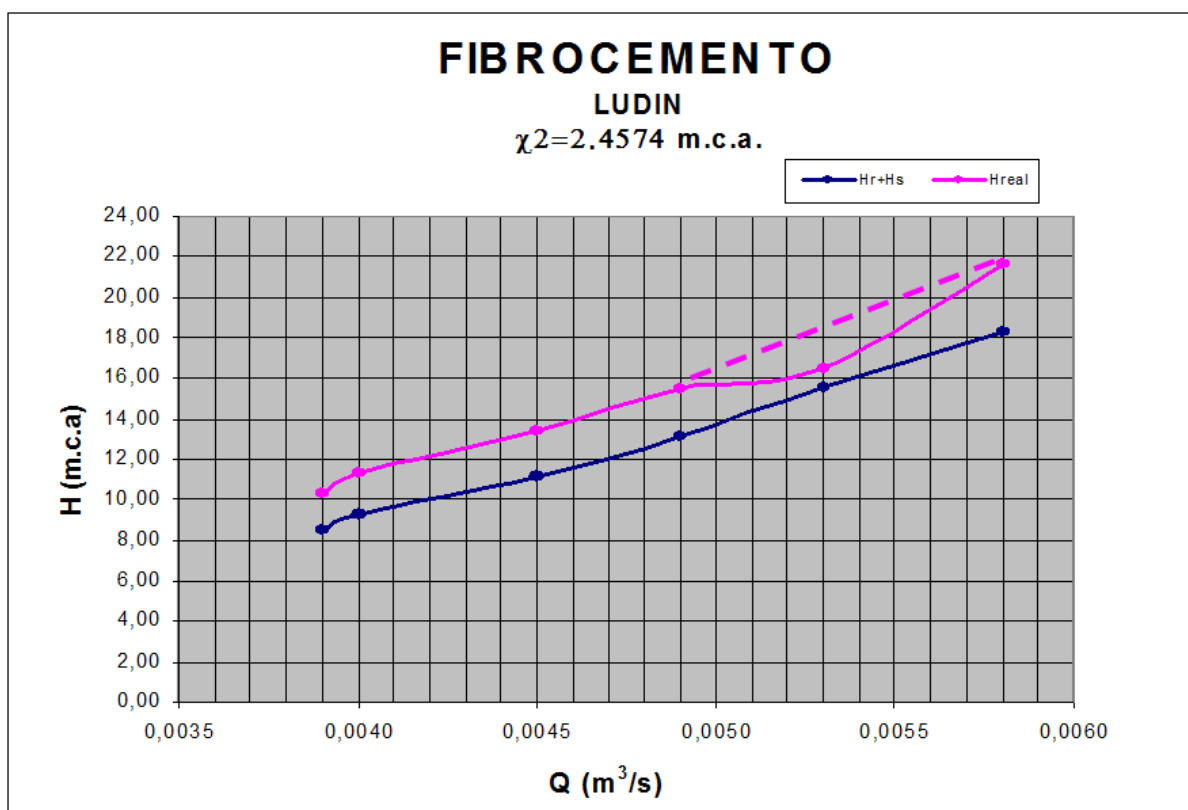
Diferencia media absoluta: 0.5685 m.c.a. $\chi^2 = 0.2771$ m.c.a.



Q	Hr+Hs	Hreal
0.0039	10.1065	10.3300
0.0040	10.9718	11.3630
0.0045	13.3101	13.4290
0.0049	15.6766	15.4950
0.0053	18.6904	16.5280
0.0058	22.0264	21.6930

MATERIAL: fibrocemento																	
FÓRMULA: LUDIN																	
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	R (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	Cs	J (m/m)	I (m)	Hr (mca)	Hr+Hs (mca)	Hreal (mca)	Diferencia (mca)	$\frac{Dif^2}{Hr + Hs}$ (mca)
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0039	1.9608	134	0.0782	95	7.4295	8.5439	10.3300	-1.7861	0.3734
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0040	2.0474	134	0.0847	95	8.0484	9.2557	11.3630	-2.1073	0.4798
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0045	2.2664	134	0.1023	95	9.7149	11.1721	13.4290	-2.2569	0.4559
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0049	2.4702	134	0.1199	95	11.3937	13.1028	15.4950	-2.3922	0.4367
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0053	2.7095	134	0.1423	95	13.5224	15.5508	16.5280	-0.9772	0.0614
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0058	2.9540	134	0.1670	95	15.8682	18.2484	21.6930	-3.4446	0.6502

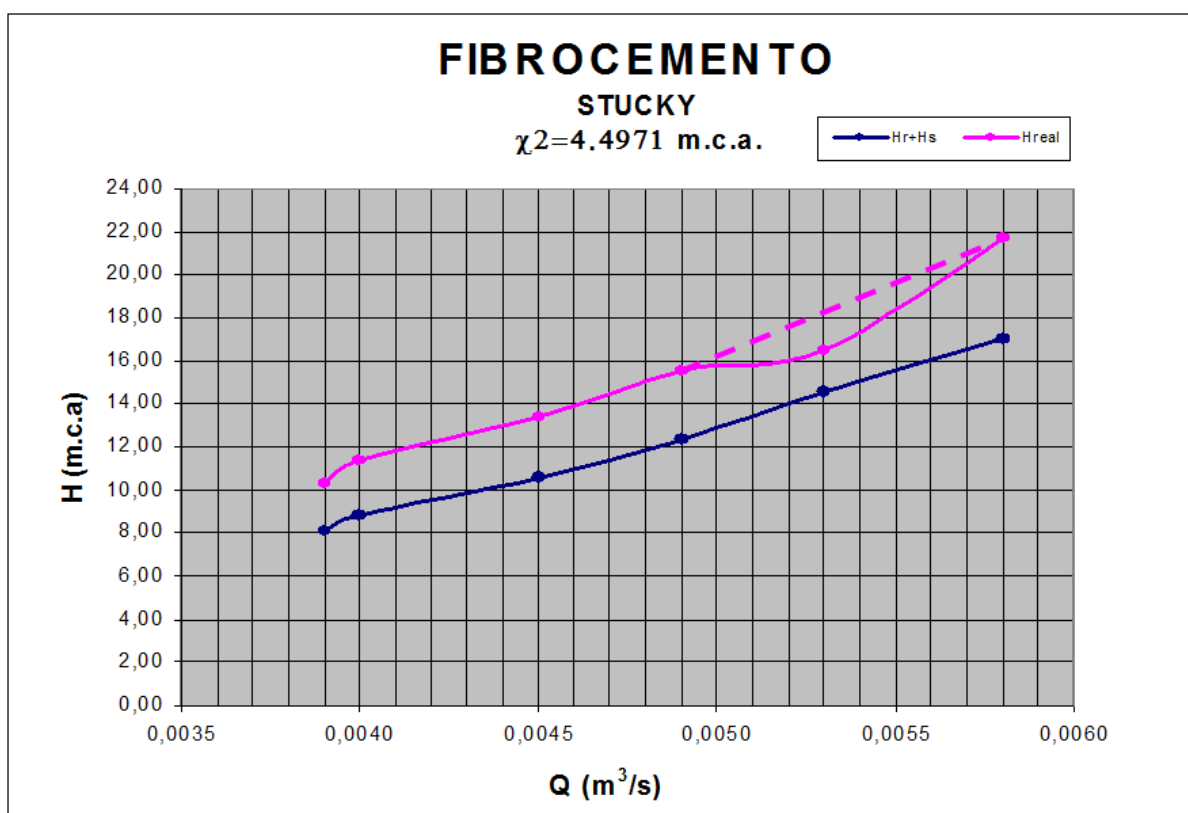
Diferencia media absoluta: 2.1607 m.c.a. $\chi^2 = 2.4574$ m.c.a.



Q	Hr+Hs	Hreal
0.0039	8.5439	10.3300
0.0040	9.2557	11.3630
0.0045	11.1721	13.4290
0.0049	13.1028	15.4950
0.0053	15.5508	16.5280
0.0058	18.2484	21.6930

MATERIAL: fibrocemento																	
FÓRMULA: STUCKY																	
FLUIDO	t (°C)	v (m ² /s)	D (m)	e (m)	d (m)	R (m)	g (m/s ²)	Q (m ³ /s)	V (m/s)	Cs	J (m/m)	l (m)	Hr (mca)	Hr+Hs (mca)	Real (mca)	Diferencia (mca)	Dif. ² Hr + Hs (mca)
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0039	1.9608	140	0.0744	95	7.0705	8.1311	10.3300	-2.1989	0.5947
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0040	2.0474	140	0.0805	95	7.6430	8.7895	11.3630	-2.5735	0.7535
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0045	2.2664	140	0.0966	95	9.1787	10.5555	13.4290	-2.8735	0.7822
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0049	2.4702	140	0.1128	95	10.7186	12.3264	15.4950	-3.1686	0.8145
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0053	2.7095	140	0.1333	95	12.6624	14.5618	16.5280	-1.9662	0.2655
Agua	19	1.0444·10 ⁻⁶	0.0680	0.0090	0.0500	0.0125	9.81	0.0058	2.9540	140	0.1557	95	14.7949	17.0141	21.6930	-4.6789	1.2867
Diferencia media absoluta: 2.9099 m.c.a. $\chi^2 = 4.4971$ m.c.a.																	

Diferencia media absoluta: 2.9099 m.c.a. $\chi^2 = 4.4971$ m.c.a.



Q	Hr+Hs	Hreal
0.0039	8.1311	10.3300
0.0040	8.7895	11.3630
0.0045	10.5555	13.4290
0.0049	12.3264	15.4950
0.0053	14.5618	16.5280
0.0058	17.0141	21.6930

Por último, en el siguiente gráfico se observan, para cada una de las formulaciones empleadas y para todas las tuberías, los valores de las discrepancias medias absolutas registradas entre los valores teóricos resultantes de la aplicación de las diferentes formulaciones y los realmente observados en la experiencia realizada. En él se pone de manifiesto, una vez más, la bondad de la formulación aquí propuesta (que es la que mejor ajusta los resultados, siendo la peor la de Manning-Strickler) para el dimensionamiento de este tipo de conducciones forzadas.

