

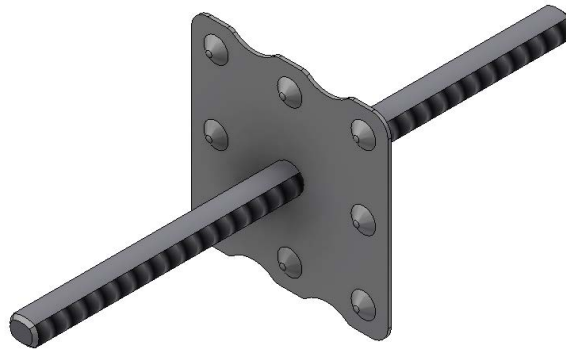
The Formwork Experts.

Water stop G 15,0

Art.-Nr.: 581818000

Test Report

Gas impermeability
00 25 79 0126/1



Test report

Client: Doka Industrie GmbH
Reichsstrasse 23

A - 3300 Amstetten

Subject: Testing of gas permeability of concretes with
embedded form-ties:
Water stop 15.0
Water stop G 15.0

Report n°:	00 25 79 0126/1	Date:	22.01.2001
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Extension:	608-3894	Annexes:	4

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1 Procedure

In its letter dated 9th Feb. 2000 and its order of 11th Feb. 2000, Doka Industrie GmbH commissioned the Institute of Solid Building and Construction-Material Technology of the University of Karlsruhe (TH) to test the gas permeability of concretes with embedded *Water stop 15.0* and *Water stop G 15.0* form-ties.

In its letter of 18th Oct. 2000, Doka Industrie GmbH commissioned the Institute of Solid Building and Construction-Material Technology of the University of Karlsruhe (TH) to undertake further testing of the gas permeability following more prolonged storage of the test specimens.

2 Test equipment and testing programme

On 30.03.2000, the client supplied 6 formworks with inside dimensions of 1645 mm x 150 mm x 600 mm, to be used for casting the model walls. The following items were mounted in each of 3 formworks:

3x5 *Water stops 15.0* and 3x5 Tie-rods 15.0 mm, galvanised

3x5 *Water stops G 15.0* and 3x5 Tie-rods 15.0 mm, non-treated

The formwork and form-tie set-ups are illustrated in Annex 1 and Annex 2, Figs. 1 -3.

The form-ties to be investigated may be described as follows:

Water stop 15.0 consists of an untreated Tie-rod 15.0mm (cam-threaded rod) onto the middle of which a $\varnothing$ 70 mm, 20 mm thick fibre-cement disc is glued by means of epoxy-resin adhesive (cf. Annex 2, Fig. 1)

Water stop G 15.0 consists of an untreated Tie-rod 15.0mm (cam-threaded rod) and an untreated, profiled metal plate measuring 120 mm x 120 mm x 2 mm that is welded onto the middle of the rod (cf. Annex 2, Fig 2).

The agreed testing programme was structured as follows:

- embedding the *Water stop 15.0* and the *Water stop G 15.0* in 3 different types of concrete in each case
- characterising the 3 types of concrete used (fresh and solid concrete properties)
- determining the pore structure of the fibre cement for the *Water stop 15.0* by means of mercury pressure porosimetry on the basis of the procedure described in DAfStb (German Reinforced-Concrete Committee) booklet n° 422 (Testing of Concrete – Recommendations and Instructions as Addenda to DIN 1048, Beuth Verlag, 1991), Section 4.3.5
- testing the gas permeability on specimens with and without form-ties as stipulated by DAfStb booklet n° 422, Section 3.6, after storage in a climate as defined by DIN 50 014-2/65-2 until the specimens reached an age of 70 or 210 days.

3 Production and storage of the test specimens

A total of 6 model walls were cast on 31.03.2000, using 3 different types of concrete. The composition of these concretes is shown in Table 1. After pouring, the formwork was covered with PE film and stored for the first 7 days at a temperature of approx. 20 °C. On the 7th day, the model walls were stripped and placed in a DIN 50 014-20/65-2 compliant climate. During the period between the 28th and 42nd days, a total of 54 drilling cores with a diameter of 151-152 mm were drilled from the model walls in such a way that in each case, the projecting tie-rod constituted the drilling centre-line (cf. Annex 1 and Annex 2, Figs. 5 and 6). Reference specimens (cores) were drilled from the upper, non-tied part of the model walls (undisturbed concrete). Discs with a thickness of 49 - 52 mm were sawn from the middle of the (150 mm long) drilling cores in such a way that the *Water stop 15.0* or *Water stop G 15.0* was always exactly in the middle of the test specimen used for determining the gas permeability. The same was done with the drilling cores from the non-tied, undisturbed concrete, and with the drilling cores which had a barrier-less tie-rod (non-treated or galvanised) in their longitudinal axis (Figs. 7 and 8 in Annex 2). After the specimens had been prepared in this manner, the cylindrical circumferential surfaces of the test specimens (discs with a diameter of 151-152 mm and a thickness of 49 - 52 mm, taken from the middle zones of the model walls) were tightly wrapped in PE film. The test specimens were stored in this way – stood on their circumferential surfaces in a DIN 50 014-20/65-2 compliant climate – for another 28 days, until the beginning of the 1st series of gas-permeability tests (age of specimens: 70 days).

After testing, all specimens were stored once again in a DIN 50 014-20/65-2 compliant climate, this time with no sealing of the cylindrical circumferential surfaces (Fig. 9 in Annex 2), in order to permit further drying and moisture equalisation across the cross-section of the specimen.

The 2nd series of tests of all specimens began when the specimens had aged for 210 days.

Table 1: Composition of the concretes used for casting the model walls

Components	Origin/designation	Density [kg/dm ³]	Concrete n°		
			1	2	3
Cement [kg/m ³]	CEM I 32.5 R HeidelbergCement, Leimen,	3.15	270	330	420
Water [kg/m ³]	Karlsruhe tap water	1.00	162	165	147
Plasticiser [Mass-% rel. to cement]	FM26 Woermann	1.18	-	0.59	1.83
Aggregates [kg/m ³]	Rhine sand and Rhine gravel with a grading curve of AB 16 (cf. Annex 3)	2.63	1932	1874	1846
Water/cement ratio ¹⁾ [-]	-		0.6	0.5	0.36

¹⁾ including the water component in the plasticiser

4 Tests and results

4.1 Characteristic values of the fresh and solid concrete

The characteristic values of the fresh concrete were determined in accordance with DIN 1048-1: 1991.06, while the tests on the solid concrete were carried out to DIN 1048-5: 1991.06. The results (expressed as the means of 3 single values) are set out in Table 2.

Small drilling cores – of 15 mm in diameter and approx. 20 mm in length – were used for determining the pore distribution of the different types of concrete and of the fibre cement of the *Water stop 15.0*. The drilling cores from the different types of concrete were taken from the middle of the model walls. Before testing, the specimens were dried at $(110 \pm 3)^\circ\text{C}$. The mercury pressure porosimetry process used here is described in Section 4.3.5 of DAfStb booklet n° 422. The results are shown in Annex 4.

Table 2: Characteristic values of fresh and solid concrete for the model walls

Characteristic values		Concrete n°		
		1	2	3
Fresh concrete				
Slump-flow a_{10}	[cm]	37	39	40
Bulk density	[kg/dm ³]	2.356	2.368	2.406
Air content	[vol.-%]	1.8	2.2	2.2
Fresh concrete aged 28 days				
Bulk density	[kg/dm ³]	2.335	2.345	2.369
Compressive strength:				
• Cube, $a = 150$ mm	[N/mm ²]	46.7	54.2	67.0
• Cylinder, $\varnothing = 150$ mm and $h = 300$ mm	[N/mm ²]	39.2	49.6	59.8
Static modulus of elasticity:				
• Cylinder, $\varnothing = 150$ mm and $h = 300$ mm	[N/mm ²]	27265	29000	30765
Pore structure (mercury pressure porosimetry):				
Detected pore volume	[vol.-%]	13.5	12.0	9.7
Maximum in pore radius distribution	[μm]	0.055	0.044	0.033

4.2 Determination of gas permeability

The gas permeability was determined in accordance with the process described in Section 3.6 of DAfStb booklet Nr. 422, following specimen preparation and storage as outlined in Section 4.3 of the test report. The period during which the tests were carried out was approx. 14 days in duration.

The test gas used was oxygen (purity: O₂ > 99.995 vol.-%), which acted upon the specimen at inlet pressure levels of 1.5, 2.5 and 3.0 bar (absolutely), i.e. testing under increasing pressure. Three measurements (of gas through-flow volume and time) were performed at each pressure level. The sealing sleeve was applied to the circumferential surface of the specimens in the test-cell with a pressure of 9 bar.

The permeability coefficient K [m²] was calculated in accordance with the following equation (1).

$$K = \eta \cdot \frac{Q \cdot h}{A} \cdot \frac{2p_{at}}{p_e^2 - p_a^2} \quad (1)$$

The meanings of the symbols used in equation (1) are as follows:

- η = viscosity of the test gas [N • s/m²]
oxygen at 20 °C: $2.02 \cdot 10^{-5}$
- Q = Flow-rate of the test gas [m³/s]
- h = Height of specimen [m]
- A = Test area [m²]
- p_{at} = Atmospheric pressure [N/m²]
- p_e = Inlet pressure of the test gas, absolute [N/m²]
- p_a = Outlet pressure of the test gas, absolute [N/m²]

The results are set out in Table 3.

Table 3: Results of the gas permeability tests – 1st series of tests, commenced when specimens were aged 70 days.
The permeability coefficients are stated in the table in: Numerical value • 10⁻¹⁸ m²

Type of form-tie	P _e	Concrete n° 1					Concrete n° 2					Concrete n° 3							
		Specimen n°					Specimen n°					Specimen n°							
		1	2	3	4	5	Mean	1	2	3	4	5	Mean	1	2	3	4	5	Mean
None (i.e. zero specimen)	[bar]																		
	1.5	16.4	13.0	21.0	22.7	-	18.3	8.5	9.9	21.2	11.4	-	12.8	23.0	10.2	5.7	17.6	-	14.1
	2.5	11.8	10.5	18.1	17.6	-	14.5	6.3	7.2	14.7	8.9	-	9.3	16.1	8.4	4.8	11.9	-	10.3
	3.0	10.7	10.1	16.9	16.8	-	<u>13.6</u> 15.5	4.8	6.9	13.7	8.5	-	<u>8.5</u> 10.2	14.9	7.7	4.5	11.0	-	<u>9.5</u> 11.3
Water stop G 15.0	1.5	11.9	27.7	24.9	13.8	23.3	20.3	25.3	32.4	29.5	73.6	105	53.1	10.4	12.3	19.0	31.3	25.9	19.8
	2.5	10.3	22.5	24.5	11.0	15.6	16.8	21.2	32.9	22.3	67.4	94.5	47.6	8.6	9.2	14.7	28.4	16.8	15.5
	3.0	9.8	22.4	19.0	10.5	14.4	<u>15.2</u> 17.5	21.2	34.5	21.2	67.6	90.4	<u>47.0</u> 49.2	7.8	8.8	14.2	28.7	16.3	<u>15.2</u> 16.8
Water stop 15.0	1.5	32.4	16.2	36.3	30.4	45.5	32.1	10.7	25.1	10.1	19.4	24.3	17.9	29.6	24.7	22.3	90.1	25.1	38.4
	2.5	27.3	12.7	26.6	30.1	29.5	25.2	8.5	21.8	8.5	16.1	16.9	14.4	21.7	20.9	16.3	86.7	17.0	32.5
	3.0	26.2	11.9	25.4	29.3	28.4	<u>24.2</u> 27.2	8.1	16.6	8.2	15.8	15.8	<u>12.9</u> 15.0	20.5	21.4	15.6	85.8	16.0	<u>31.8</u> 34.2
Tie-rod, non-treated	1.5	337	86.7	-	-	-	212	269	89.3	-	-	-	179	66.4	20.6	-	-	-	43.5
	2.5	313	87.9	-	-	-	200	263	79.8	-	-	-	171	60.4	12.7	-	-	-	36.5
	3.0	314	93.8	-	-	-	<u>204</u> 205	260	82.1	-	-	-	<u>171</u> 174	61.1	11.7	-	-	-	<u>36.4</u> 38.8
Tie-rod, galvanised	1.5	172	80.2	-	-	-	126	270	291	-	-	-	281	9.3	23.5	-	-	-	16.4
	2.5	173	87.6	-	-	-	130	288	245	-	-	-	266	7.5	15.8	-	-	-	11.6
	3.0	264	113	-	-	-	<u>188</u> 148	319	236	-	-	-	<u>277</u> 275	7.1	14.6	-	-	-	<u>10.8</u> 13.0

Table 4: Results of the gas permeability tests – 2nd series of tests, commenced when specimens were aged 210 days
The permeability coefficients are stated in the table in: Numerical value • 10⁻¹⁸ m²

Type of form-tie	P _e	Concrete n° 1					Concrete n° 2					Concrete n° 3							
		Specimen n°					Specimen n°					Specimen n°							
		1	2	3	4	5	Mean	1	2	3	4	5	Mean	1	2	3	4	5	Mean
None (i.e. zero specimen)	[bar]																		
	1.5	42.2	25.4	31.7	46.1	-	36.3	24.6	15.6	14.2	23.5	-	19.5	13.9	18.8	18.4	8.8	-	15.0
	2.5	26.9	18.0	22.2	28.5	-	23.9	17.5	10.2	11.0	18.9	-	14.4	8.1	14.4	9.9	6.3	-	9.7
	3.0	28.9	19.3	24.6	31.0	-	26.0	18.3	10.7	11.8	20.9	-	15.5	9.1	16.8	10.3	6.8	-	10.8
						28.7							16.4						11.8
Water stop G 15.0	1.5	65.6	65.4	38.1	34.5	18.1	44.3	82.7	81.8	41.1	151	231	118	27.9	88.1	17.8	56.8	19.1	41.9
	2.5	35.3	59.0	31.5	28.3	15.2	33.9	65.5	70.8	37.5	127	201	100	20.9	32.8	14.8	53.4	14.5	27.2
	3.0	39.4	68.2	31.9	44.9	16.1	40.1	75.6	86.3	43.0	144	231	116	23.9	281	15.8	70.7	16.3	81.6
							39.4						111						50.3
Water stop 15.0	1.5	64.0	40.0	56.8	55.7	37.2	50.7	26.1	24.3	18.9	28.2	18.5	23.2	17.2	30.6	12.9	109	5.0	34.7
	2.5	49.2	30.7	38.8	43.0	31.9	38.7	16.7	17.6	14.6	23.7	13.1	17.2	17.7	23.2	10.1	93.4	5.9	30.0
	3.0	54.6	33.7	42.1	46.6	35.9	42.6	17.8	19.3	19.0	26.2	14.3	19.3	19.6	26.1	11.0	111	7.6	35.1
							44.0						19.9						33.3
Tie-rod, non-treated	1.5	314	172	-	-	-	243	289	126	-	-	-	207	79.0	8.8	-	-	-	43.9
	2.5	244	139	-	-	-	191	256	115	-	-	-	186	66.7	6.6	-	-	-	36.7
	3.0	250	154	-	-	-	202	289	151	-	-	-	220	75.7	6.9	-	-	-	41.3
							212						204						40.6
Tie-rod, galvanised	1.5	478	165	-	-	-	322	390	227	-	-	-	309	8.0	9.8	-	-	-	8.9
	2.5	523	182	-	-	-	353	347	176	-	-	-	262	10.9	7.0	-	-	-	9.0
	3.0	619	213	-	-	-	416	424	191	-	-	-	307	13.2	7.5	-	-	-	10.3
							363						293						9.4

5 Evaluation of the test results

5.1 Results of the 1st series of tests

The form-ties *Water stop G 15.0* and *Water stop 15.0* were embedded in model walls made of 3 different types of concrete. The characteristic values of these concretes are set out in Table 2. From this, it may be seen that the fresh concretes all have comparable plastic consistency as defined in DIN 1045 (slump-flow 37 - 40 cm). Substantial differences were found in the solid concrete properties, however, as was to be expected in view of the selected water/cement ratios of 0.6, 0.5 and 0.36. The cylinder compressive strengths at a concrete-age of 28 days are gradated as follows: approx. 40 N/mm² (Concrete n° 1), approx. 50 N/mm² (Concrete n° 2) and approx. 60 N/mm² (Concrete n° 3). In terms of both the pore volume that is detectable using mercury pressure porosimetry (13.5 vol.-% for Concrete n° 1, 12.0 vol.-% for Concrete n° 2, 9.7 vol.-% for Concrete n° 3) and of the location of the maximum in the pore radius distribution (0.055 µm for Concrete n° 1, 0.044 µm for Concrete n° 2, 0.033 µm for Concrete n° 3), the pore structure of the concretes (which must be regarded as a significant factor influencing the gas permeability) also exhibits a pronounced gradation. The location of the maximum in the pore radius distribution is crucially influenced here by the water/cement ratio. The results of the investigations into the pore-structure are outlined in Annex 4. This Annex (4) also contains the result of the pore-structure investigation carried out on the fibre-cement disc used for the *Water stop 15.0*. A maximum in the pore radius distribution is apparent at approx. 0.030 µm, with a second peak at approx. 2 -3 µm, which may result from e.g. pouring-related air inclusions. The detected pore volume is 23.5 vol.-%, which may be regarded as a typical value for this material (fibre cement).

The influence of the Water stops and the tie-rods without any extra barriers may be read off from the results of the gas permeability tests conducted using oxygen as the test gas, as set out in Table 3 in the form of the permeability coefficients [$\bullet 10^{-18} \text{ m}^2$]. When evaluating these results, it must be remembered that the values are generally subject to relatively high variance. Consequently, permeability coefficients of concretes should be considered and evaluated mainly in terms of their order of magnitude (decimal power).

Although in principle it is not intended to deviate from this procedure in the task in hand, a more differentiated approach to examining the results nevertheless appears justified. Accordingly, it should first of all be noted that on all the concretes tested, the mean values of the zero specimens and of the specimens with the *Water stop 15.0* and the *Water stop G 15.0* lie within the same order of magnitude (10^{-17} m^2). On the other hand, with concretes n° 1 and n° 2, the values for the specimens with tie-rods without any barrier are higher by one whole order of magnitude (10^{-16} m^2), i.e. these specimens are more permeable for the test gas. With Concrete n° 3, which was mixed with a water/cement ratio of 0.36, matters are rather different: In this case, too, the specimens with tie-rods that have no barrier achieve the same order of magnitude (10^{-17} m^2) as the zero specimens and the specimens with a *Water stop 15.0* or a *Water stop G 15.0*. This must be regarded as a result of the reduced contact-zone porosity in the region between the steel surface and the concrete matrix, and as a characteristic property of concretes with a low water/cement ratio (< 0.4).

A more differentiated view of the results in Table 3 suggests that – at least for Concrete n° 1, and with one limitation (tie-rod, galvanised) also for Concrete n° 3 – there is a clear ranking-order for the influence which each type of form-tie exercises upon the gas permeability. Starting from the respective value of the undisturbed zero specimen, which none of the specimens with a form-tie falls below, this ranking – in order of increasing gas permeability – is as follows:

- *Water stop G 15.0* (tie-rod with quadratic metal sheet)
- *Water stop 15.0* (tie-rod with fibre-cement disc)

- Tie-rod, galvanised
- Tie-rod, non-treated.

The difference between the two Water stops is evidently to do with the material that the barrier is made from. Compared to the metal sheet, the fibre-cement disc itself is porous and thus gas-permeable. In the case of the tie-rods without any barrier, the reaction of the zinc with the alkaline pore solution of the concrete must be regarded as the cause of the lower gas permeability found with galvanised form-ties as opposed to untreated form-ties.

The fact that the above-mentioned classification of the tested types of form-ties did not apply in the case of Concrete n° 2 is attributable to a special aspect which must be allowed for in investigations of the gas permeability of different types of concrete, and which has considerable influence on the measurement results. This aspect relates to the moisture content and moisture distribution in the concrete cross-section. Even after the prior storage carried out here on the specimens at 20 °C and 65 % rel. humidity over a period of at least 9 weeks (cf. Section 3), it must be assumed that a constant state of equilibrium moisture content across the entire cross-section of the test specimens had still not been reached. Consequently, the measuring result is also determined by the moisture content in the pore space, as well as by the concrete structure and the embedded form-ties. If this moisture content is not the same in all test specimens, the influence of the form-ties (which is the object of the investigation) may be badly falsified. This is also highly significant with regard to the negligible differences between the permeability coefficients of the three types of concrete, each of which has a very different water/cement ratio.

As a consequence of the influence of the concrete moisture content (as described above) on the results of gas-permeability measurements, it was concluded that the specimens would have to be tested again at a later stage, e.g. after being stored for at least another 12 weeks at 20 °C and 65 % rel. humidity (at the beginning of October 2000).

5.2 Results of the 2nd series of tests

Between the 1st and 2nd series of tests, the specimens were stored for a further 20 weeks at 20 °C and 65 % rel. humidity (in a DIN 50 014-20/65-2 compliant climate). Due to moisture transport processes (water-vapour diffusion), a more uniform moisture distribution was able to establish itself throughout the cross-section of the specimens, as compared with the condition of the specimens at the time of the 1st test series.

It may be seen from the results given in Table 4 (2nd series of tests) that the gas permeability of the specimens made from Concrete n° 1 (water/cement ratio 0.6) and Concrete n° 2 (water/cement ratio 0.5) rose, as was to be expected. In the case of Concrete n° 3 (water/cement ratio 0.36), both higher and lower gas permeability values are found. As in the 1st series of tests, the values for the undisturbed zero (i.e. non-tied) specimens made from concretes n° 1 and n° 2, were below those for the specimens incorporating various different types of form-tie. In the case of Concrete n° 3, the specimens with a galvanised tie-rod even delivered values beneath those for the reference specimens.

An overview of the percentage changes in gas permeability between the 1st and 2nd series of tests (increase or decrease) is given in Table 5 below.

Table 5: Percentage changes in gas permeability in 2nd series of tests compared to 1st test series

Type of form-tie	Concrete n° 1	Concrete n° 2	Concrete n° 3
None (i.e. zero specimen)	+ 85%	+ 61%	+ 4%
<i>Water stop G 15.0</i>	+ 123%	+ 126%	+ 199%
<i>Water stop 15.0</i>	+ 62%	+ 33%	- 3%
Tie-rod, non-treated	+ 3%	+ 17%	+ 5%
Tie-rod, galvanised	+ 145 %	+ 7%	- 28%

It may be seen from Table 5 that the biggest changes in all the concretes tested occurred in the specimens incorporating a *Water stop G 15.0* (tie-rod with quadratic metal sheet). The smallest changes occurred in the specimens with untreated tie rods.

Compared to the 1st series of tests, there were also changes in the ranking-order for the influence exercised by each type of form-tie upon the gas permeability. Based on the results of the 2nd series of tests, Table 6 below gives the order in which the different types of form-tie cause increasing gas permeability.

Table 6: Order of the influence of form-tie type upon gas permeability
(1 = smallest increase, 4 = biggest increase)

Type of form-tie	Concrete n° 1	Concrete n° 2	Concrete n° 3
<i>Water stop G 15.0</i>	1	2	4
<i>Water stop 15.0</i>	2	1	2
Tie-rod, non-treated	3	3	3
Tie-rod, galvanised	4	4	1

6 Summary

On behalf of Doka Industrie GmbH, gas-permeability measurements were performed on three different types of concrete incorporating *Water stop 15.0* and *Water stop G 15.0* form-ties, and on specimens without any form-tie.

The results of the 1st series of tests, on 70-day old specimens, as set out in Section 4 of the test report (Table 3), show that in the case of two of the three concretes tested, the increase in gas permeability as against a non-tied concrete specimen (zero specimen) was practically negligible (increase by a factor of 1.1 to 1.5), especially when a *Water stop G 15.0* (tie-rod with welded-on quadratic sheet) was used. For the *Water stop 15.0* (tie-rod with adhesive-bonded fibre-cement disc), permeability coefficients were determined which exceed the value of the respective zero specimen by a factor of 1.5 - 3. In the case of specimens incorporating form-ties with no *Water stop*, an influence of the water/cement ratio of the different types of concrete may be discerned. An increase in gas permeability, by one order of magnitude (i.e. by a factor of 10) was found in specimens incorporating form-ties with no *Water stop* in concretes that had a water/cement ratio

of 0.6 and 0.5. On the other hand, the permeability coefficients for the concrete specimens with a water/cement ratio of 0.36 and in which form-ties with no Water stop were embedded were in the same region as those for the non-tied concretes and/or the specimens which did incorporate a Water stop.

Due to the significant influence of the specimens' moisture content on the measurement results (permeability coefficients), supplementary measurements were performed on the specimens after extended storage at 20 °C and 65 % rel. humidity. These results of the 2nd series of tests are given in Table 4 of the test report. From this it will be seen that the *Water stop G 15.0* leads to an increase in gas permeability by a factor of between 1.4 and 6.8, while the *Water stop 15.0* leads to an increase by a factor of between 1.2 and 2.8, in each case as measured against the zero specimen for each of the three tested concretes. Accordingly, and in view of comparison of the two test series (Tables 5 and 6), the recommendation that on constructions that are subject to more stringent gas-permeability requirements, the *Water stop 15.0* form-tie should be used, appears entirely appropriate.

In the light of these test results, consideration should only be given to using tie-rods without any extra barrier (metal sheet or fibre-cement disc) in cases where concretes with a very low water/cement ratio (< 0.36) are to be placed.

Director of the Institute

Official in charge

o.Prof. Dr.-Ing. H. S. Müller

Dr. Ing. U. Guse

Formwork plan for the model walls

GERMAN	ENGLISH
Abmessung	Dimensions
Alle Schweißnähte soweit nicht anders angegeben	All welds, unless otherwise stated
Änderung	Modification
Artikelbez.	Name of article
Ausführungen mit Wassersperre 15,0	versions with Water stop 15.0
Ausführungen mit Wassersperre G 15,0	versions with Water stop G 15.0
Bemerkg.	Remark
Benennung	Designation
Bohrkern	Drilling core
Bohrungen d18 für Ankerstab	Drilled holes, ø18, for tie-rod
Dat.	Date
Detail Spreitze	Close-up of spreader
dick	thick
Einbauplan – gasdichte Ankerstellen	Installation plan for gas-tight wall-ties
fein	fine
Gepr.	Reviewed
Gew.	Weight
Gez.	Signed
grob	coarse
Herstellerzeichen	Manufacturer's trade mark
Lieferumfang	Scope of supply
Maß-stab	Scale
mittel	medium
Norm Nr.	Standard n°
Ober-fläche	Surface
Pos.	Item
Prod. Gruppe	Product group
Prüffläche	Test area
Qualitäts-ziffer	Quality digit
Schalungsplatte	Formwork sheet
Schlagzahl	Stamped-on number
schraffierter Teil abnehmbar, restliche Positionen fix verschraubt	Hatched parts are detachable, all other items permanently screwed together
Schutzvermerk nach DIN 34 beachten	Observe the proprietary notice pursuant to DIN 34
sehr grob	very coarse
Stk.	N° of units
Teilebez.	Designation of parts
Wassersperre 15,0	Water stop 15.0
Werkstoff	Material
Werk-stoff	Material
Zeichnungs Nr.	Drawing n°
Zeichnungs-nummer	Drawing number

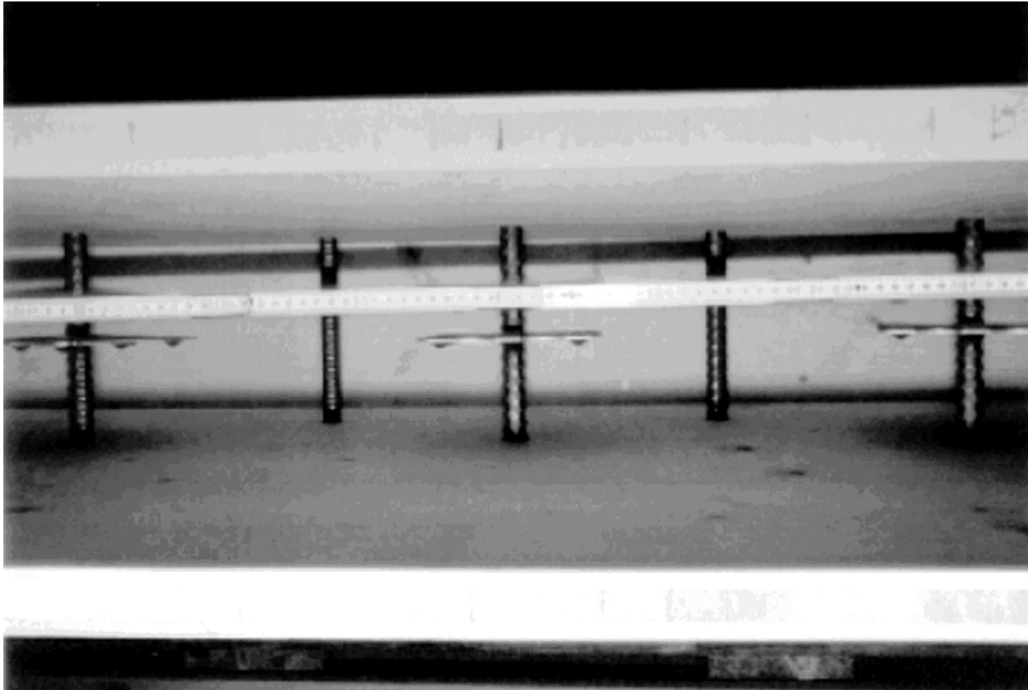


Fig. 1: View into the formwork with the *Water stop G 15.0*

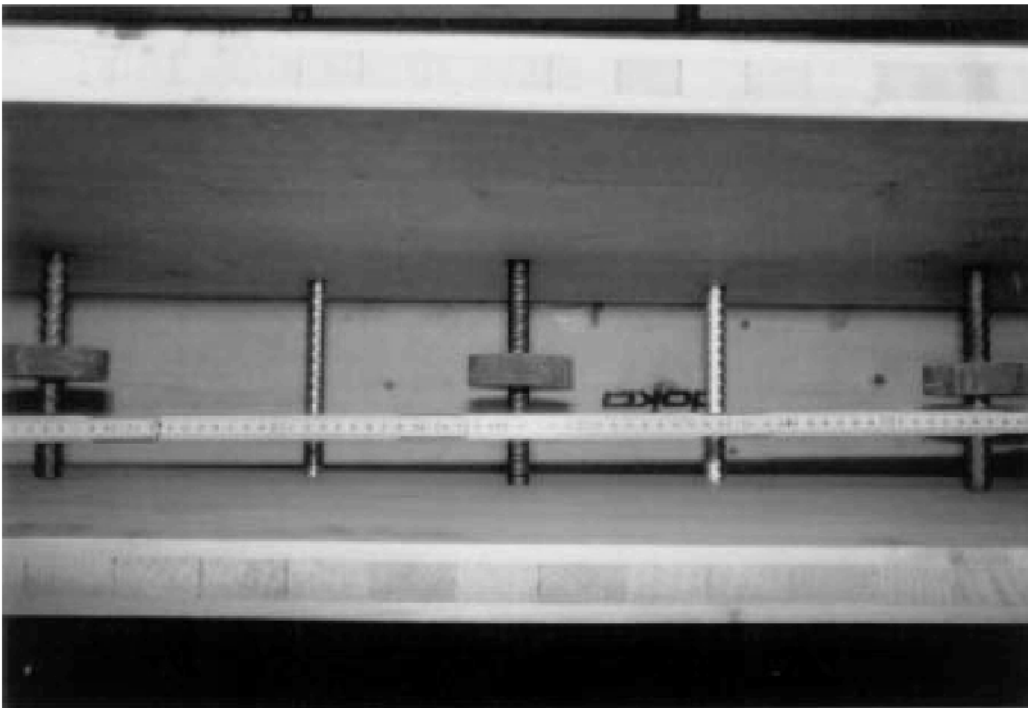


Fig 2: View into the formwork with the *Water stop 15.0*

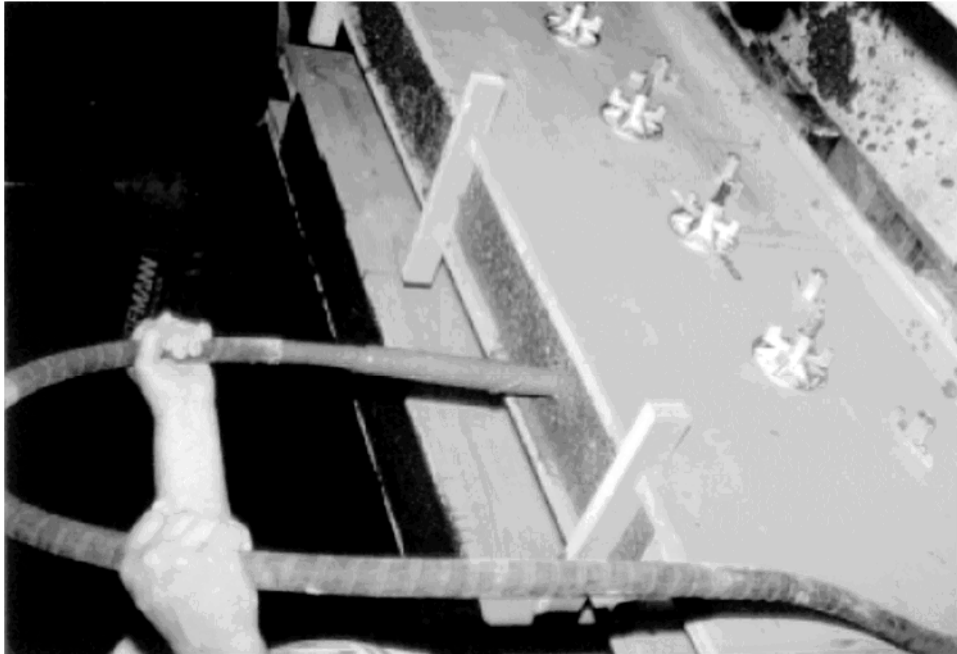


Fig. 4: Pouring the model walls



Fig. 3: View into the formwork showing the different types of form-tie (at left: Water stop 15.0 and tie-rods, galvanised; at right: Water stop G 15.0 and tie-rods, non-treated)

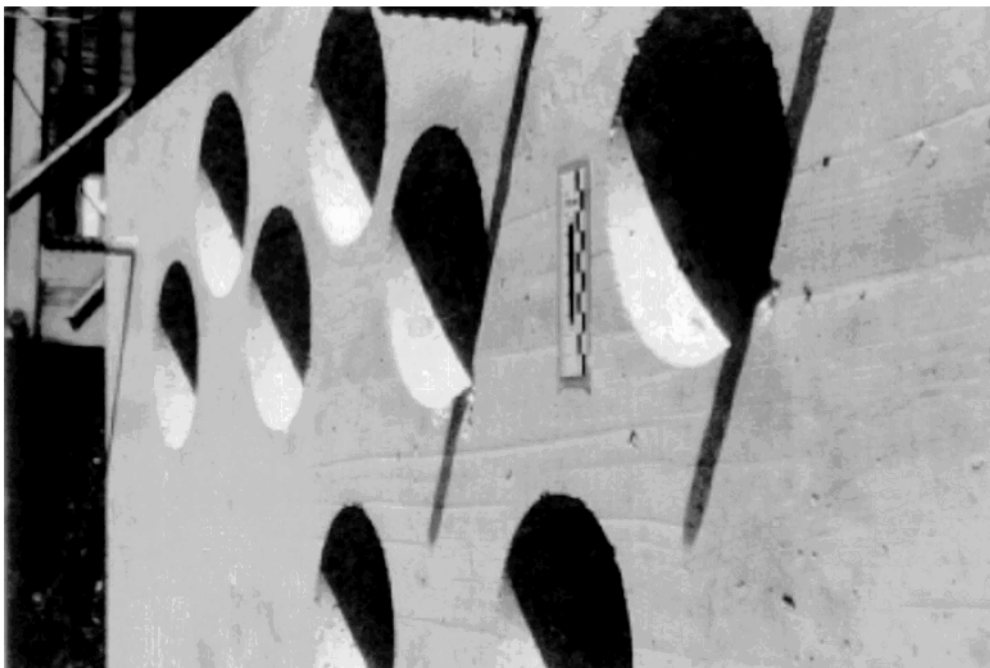


Fig. 6: Close-up of Fig. 5
Drilling core at left: zero specimens
Drilling core in middle:
Drilling core at right:



Fig. 5: Model walls with drilling-core withdrawal locations

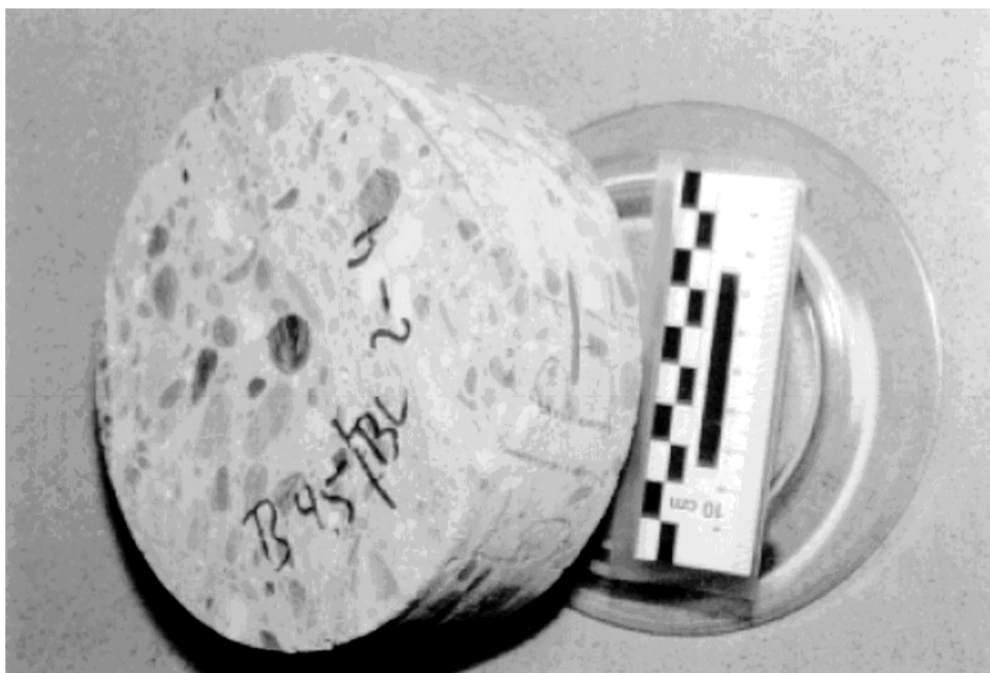


Fig. 8: Specimen for testing gas permeability with the Water stop G 15.0. The cut-off corner of the metal sheet welded onto the tie-rod can be seen in the cylindrical circumferential surface.



Fig. 7: Specimen for testing gas permeability with no form-tie (zero specimen).



Fig 9: Storage arrangements for the gas-permeability test specimens at 20 °C and 65 % rel. humidity from the 70th day (end of 1st test series) until the 210th day (beginning of 2nd series of tests).

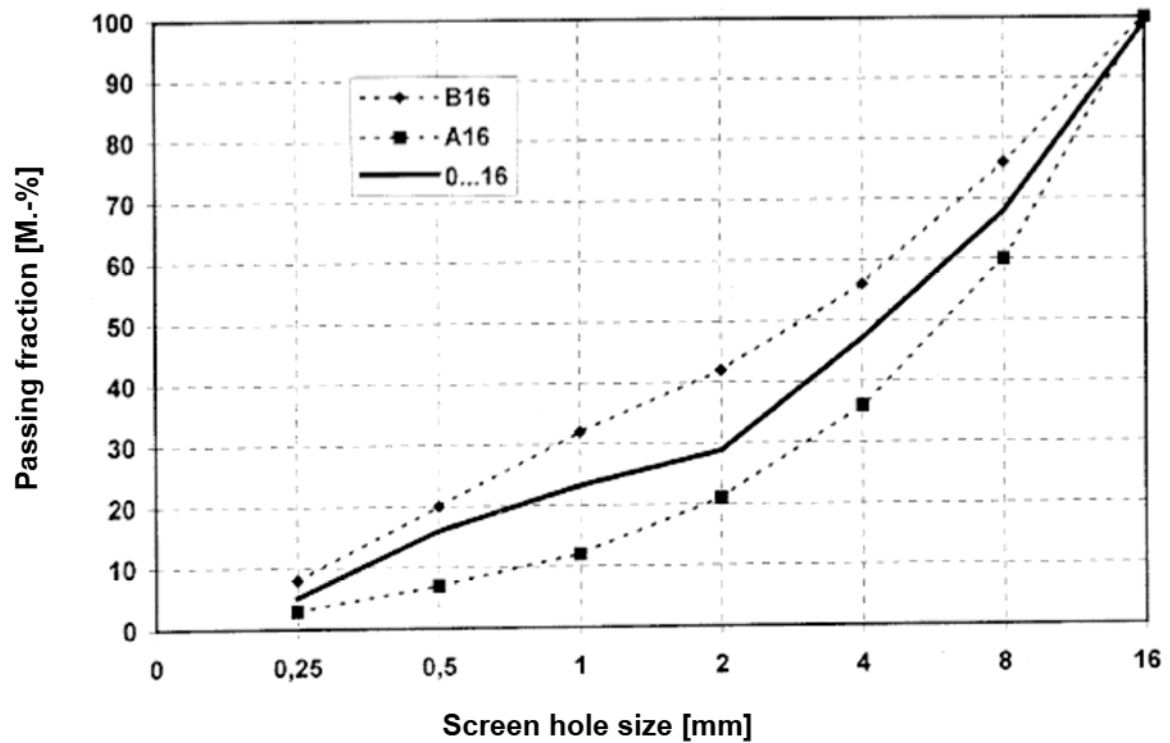


Fig 1: Grading curve of the aggregates (Rhine sand and Rhine gravel AB 16) used in all three concretes (n°s 1, 2 and 3).

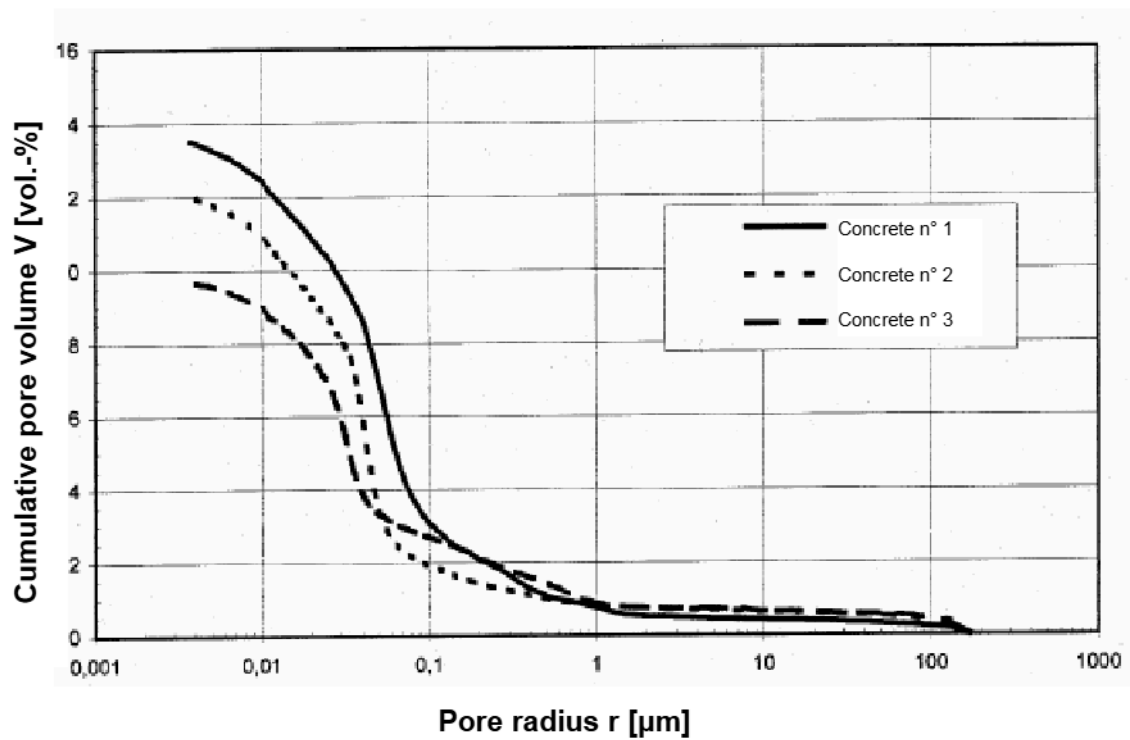


Fig 1: Cumulative pore volume of the concretes used (n°s 1, 2 and 3).

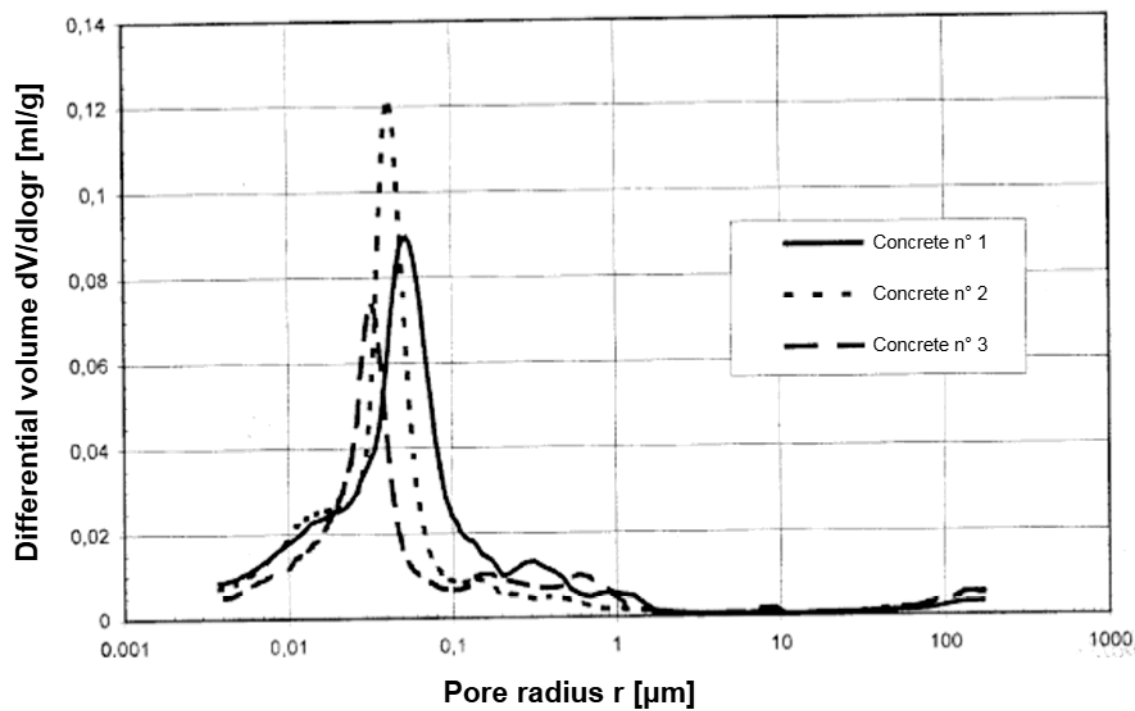


Fig 2: Pore radius distribution of the concretes used (n°s 1, 2 and 3)

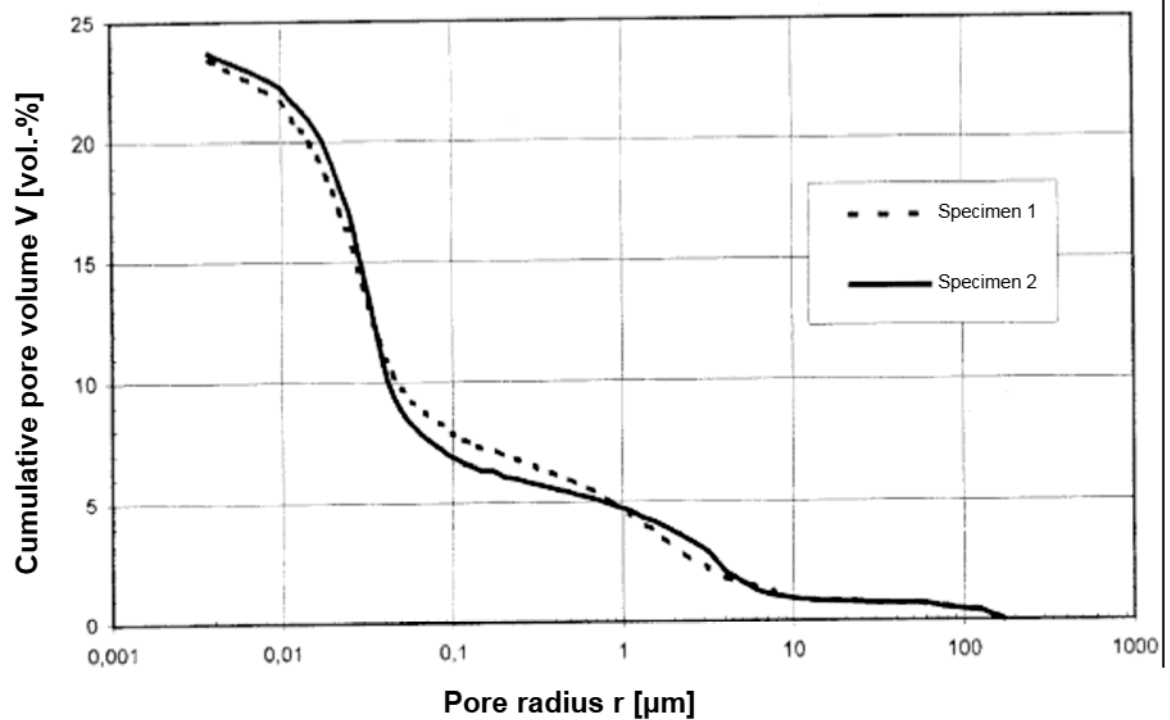


Fig 3: Cumulative pore volume of two *Water stop 15.0* fibre-cement discs.

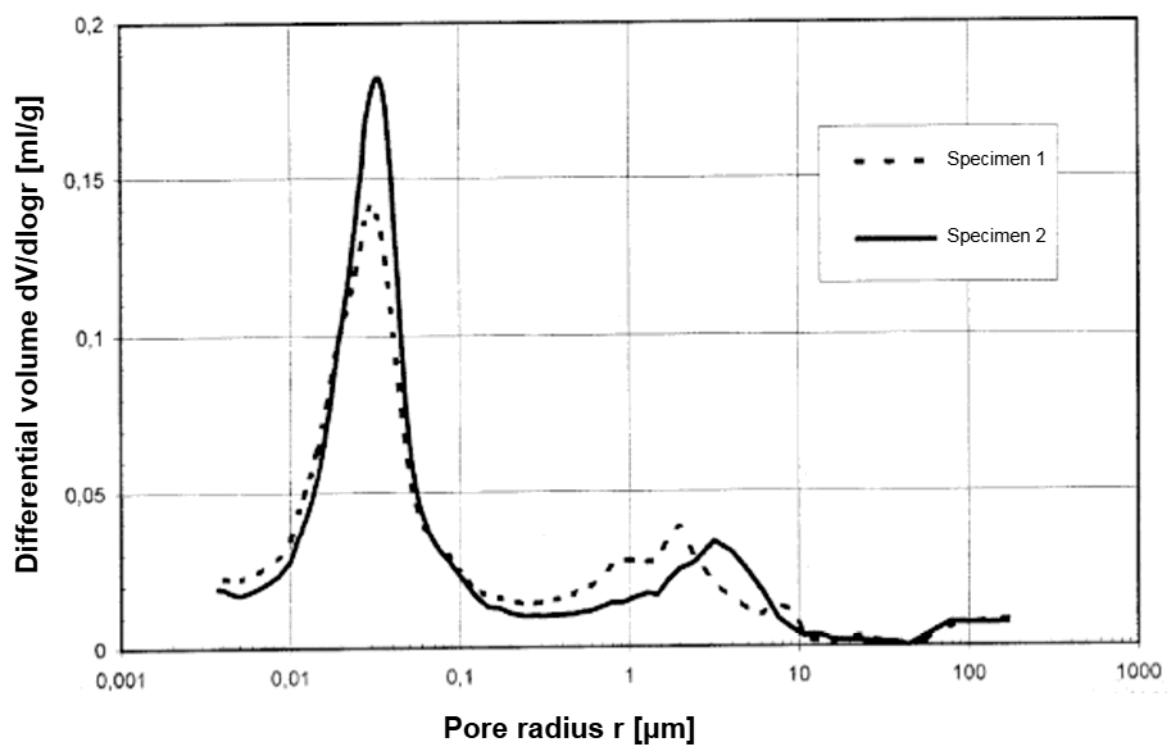


Fig 4: Pore radius distribution of two *Water stop 15.0* fibre-cement discs.