

English translation of Untersuchungsbericht Nr. 3360-03-96 by Dr. R.E. Beddoe in

TECHNISCHE UNIVERSITÄT MÜNCHEN

**INSTITUT FÜR BAUKONSTRUKTION UND BAUSTOFFE
LEHRSTUHL FÜR BAUSTOFFKUNDE UND WERKSTOFFPRÜFUNG
UND PRÜFAMT FÜR BITUMINÖSE BAUSTOFFE UND KUNSTSTOFFE**

Dir.: Univ.-Prof. Dr. R. Springenschmid

Baumbachstraße 7, D-81245 München - Telefon 089/8895-311 - Telefax 089/8895-347

E-Mail: Baustoffinstitut@lrz.tu-muenchen.de

REPORT

No.: 3360-03-96

Commissioned by: DuPont de Namours (Luxembourg) S.A.
DuPont Nonwovens
L-2894 Luxembourg

Subject: Comparison of concrete surfaces made
with the formwork liners
"Zemdrain" and "Zemdrain MD"

Reference: Order placed on 4.12.95

This report contains 8 pages including enclosures

Munich, 25.09.96 / Be

This report may only be reproduced in its complete form. Reproductions of a shortened version, exacts thereof or printed publication is only permissible with the prior written consent of the Prüfamt.

1 Commission

On 4.12.95 we received a fax from F.L. Serafini, DuPont de Namours (Luxembourg) S.A., in which we were commissioned in accordance with our quote of 23.11.95 to investigate the effect of the formwork liners "Zemdrain" and "Zemdrain MD" on the depth of carbonation, the surface strength (rebound hammer according to Schmidt, DIN 1048 Part 2) and the water impermeability (DIN 1048 Part 5) of surface concrete. The specimens were to be made using two concrete compositions with blast furnace cement at w/c ratios of 0.45 and 0.55. For comparison, the same tests were to be performed on concrete surfaces which had not been prepared using formwork liners. Measurements were also required on the amount of water drained out of the fresh concrete with the formwork liners.

2 Material

On 21.11.95 F.L. Serafini handed us over a roll of the formwork liner "Zemdrain MD" for the investigations. This material was a composite comprising a 0.4 mm thick grey polymer fibre mat backed by a plastic net 2 mm in thickness. A roll of the formwork liner "Zemdrain" was supplied in mid-December 1995 by Max Frank GmbH & Co. KG, Leiblfing, Germany. This material was a 0.5 mm thick mat made of thermally bonded polypropylene fibres. One side of the mat was black and textured, the other side grey with less texture.

3 Specimen Preparation

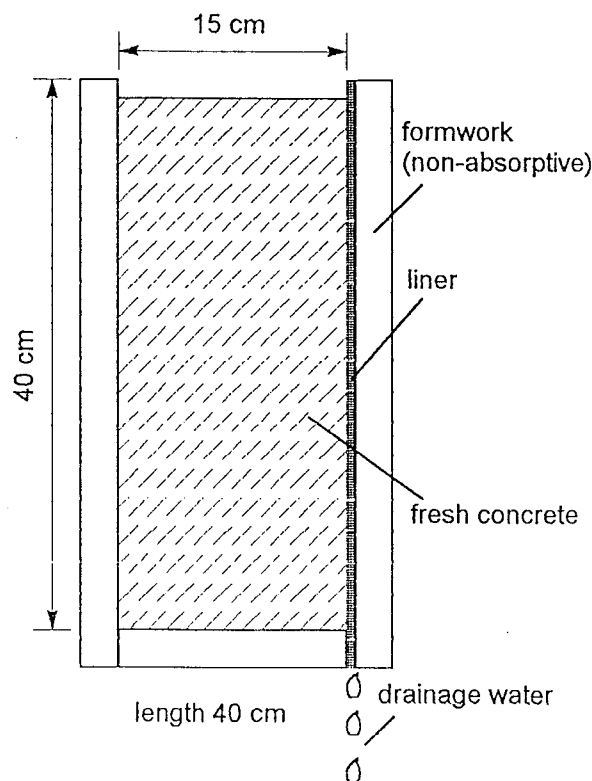
The following concrete compositions were used:

Concrete 1:	Cement:	CEM III/A 32,5 according to DIN 1164 Part 1
	w/c ratio:	0.55
	Cement content:	355 kg/m ³
	Aggregate:	Munich gravel and sand with grading curve A/B 16 according to DIN 1045
	Consistency:	KR (regular consistency, DIN 1045), slump test according to DIN 1048 Part 1
Concrete 2:	Cement:	CEM III/A 32,5 according to DIN 1164 Part 1
	w/c ratio:	0.45
	Cement content:	402 kg/m ³
	Aggregate:	Munich gravel and sand with grading curve A/B 16
	Plasticizer (FM):	1% (with respect to cement content)
	Consistency:	KR (regular consistency), adjusted with plasticizer (FM)

A formwork made of non-absorptive plastic-coated plywood, measuring $40 \times 40 \times 15 \text{ cm}^3$, was used for each type of concrete. One vertical $40 \times 40 \text{ cm}^2$ side of the formwork was lined with "Zemdrain MD" so that the grey fibre mat was adjacent to the fresh concrete. The opposite side was left without a liner as a control surface. The joints were sealed with silicone so that the drainage water could only leave the formwork through the liner. Two more formworks were also assembled using the liner "Zemdrain" with the grey side next to the fresh concrete. In addition, specimens ($40 \times 40 \times 15 \text{ cm}^3$) were prepared from each concrete in formworks which were completely without liners.

After placement, the fresh concrete was compacted with an internal vibrator. The specimens were demoulded after 24h and stored until testing at 20°C and a relative humidity of 65%.

Fig. 1:
Formwork



4 Measurement of the Drainage Water

The amount of water was recorded which drained out of the fresh concrete through the form-work liner over a period of 2 hours after placement and compaction. The drainage water volumes are listed in Tab. 1. The values are normalized to a fresh concrete surface of 1 m² next to the liner.

Tab. 1:
Water removed from fresh concrete with "Zemdrain MD" and "Zemdrain"

Liner	Concrete 1: w/c=0.55 [Litre/m ²]	Concrete 2: w/c=0.45 [Litre/m ²]
Zemdrain MD	1.22	0.40
Zemdrain	1.75	0.25

5 The Concrete Surfaces

On demoulding, both the liners "Zemdrain MD" and "Zemdrain" could be removed without any problems from the concrete surfaces for both compositions (Concrete 1 or Concrete 2). In all cases, the surfaces were smooth and almost without surface voids.

Fig. 2:
Comparison between concrete surfaces made with (left) and without "Zemdrain MD" (right), Concrete 1



A pale area several centimetres in width was visible directly beneath the top edge of surfaces which had been made with the liners "Zemdrain MD" or "Zemdrain" in the formwork. Using the rebound hammer, no difference in strength was found between the pale area and the rest of the surface produced by the liners. The discolouration could be removed with a steel wire brush.

6 Testing Surface Strength with the Rebound Hammer

The Schmidt (Model N) rebound hammer was used according to DIN 1048 Part 2 to compare the effect of the formwork liners on the strength of the surface concrete. In order to reduce the scatter of the results as much as possible, an average over 16 measurements was taken for each specimen. The specimens were approximately 4 months old. Individual values were recorded at points distributed over an area of $22 \times 22 \text{ cm}^2$ in centre of the test surface. Data were recorded in the same manner for the specimen surfaces which had been made without a formwork liner. The rebound distance is given in terms of scale divisions (sd). The standard deviation of the recorded values was 2.6 sd.

Tab. 2:

Rebound distances for concrete surfaces made using "Zemdrain MD" and "Zemdrain"

Liner	Concrete 1: w/c=0.55		Concrete 2: w/c=0.45	
	Side with liner [sd]	Side without liner [sd]	Side with liner [sd]	Side without liner [sd]
Zemdrain MD	46.3	36.2	45.5	36.8
Zemdrain	41.0	36.0	41.5	40.1

According to DIN 1048 Part 2, a rebound distance of at least 43 sd corresponds to a concrete in strength class B35, at least 33 sd corresponds to B15.

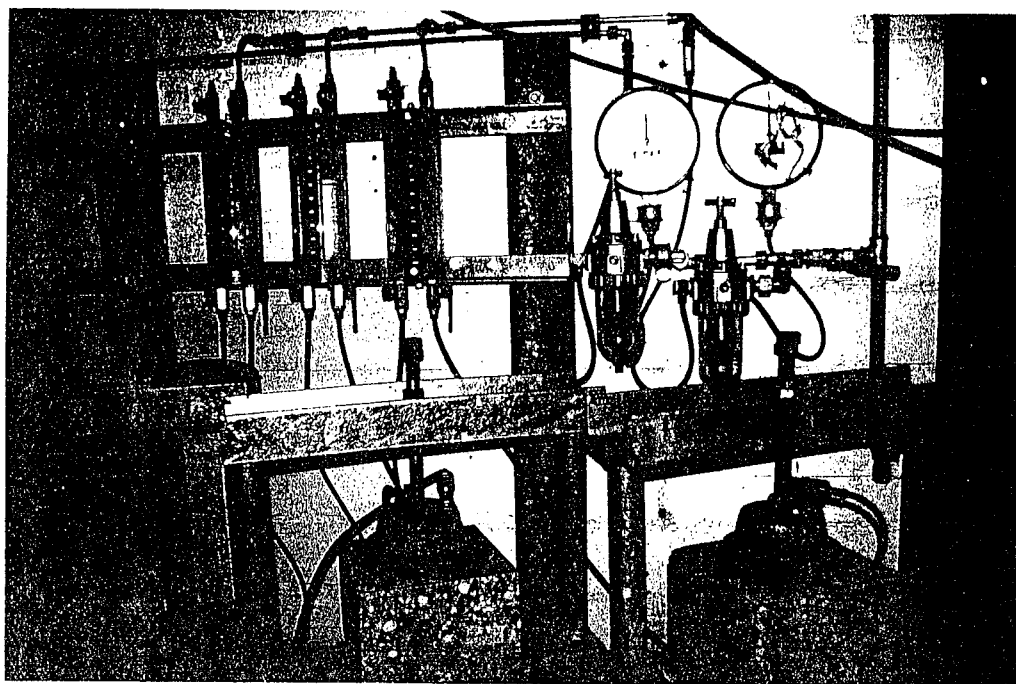
7 Water Impermeability

To determine the degree of water penetration (see DIN 1048 Part 5), specimens measuring $22 \times 22 \times 15 \text{ cm}^3$ were sawn out of the centre of the $40 \times 40 \times 15 \text{ cm}^3$ blocks.

After storing the specimens for approximately 1 week under water, a constant water pressure of 0.5 N/mm^2 was applied to a circular area, 100 mm in diameter, on each test surface (Fig. 3). After 3 days, the reduction of the amount of water in the reservoirs was measured. This is

equivalent to the amount of water which had penetrated into the specimens. Since only a small quantity of water had entered the specimens, the testing period was extended and the amount of water was measured after 6 days. In Tab. 3 the results are compared with the appropriate control values.

*Fig. 3:
Specimens undergoing testing for water penetration*



*Tab 3:
Effect of "Zemdrain MD" and "Zemdrain" on the volume of penetrated water.
Specimen age: ca. 5 months*

Liner	Concrete 1: w/c=0.55		Concrete 2: w/c=0.45	
	After 3 days [cm ³]	After 6 days [cm ³]	After 3 days [cm ³]	After 6 days [cm ³]
Zemdrain MD	10	10	10	15
Zemdrain	70	90	10	15
Without liner	410	550	60	70

The specimens were approximately 8 months old when the depths of water penetration were measured (renewed subjection to water pressure 0.5 N/mm^2 for 3 days).

Tab 4:

Effect of "Zemdrain MD" and "Zemdrain" on the depth of water penetration according to DIN 1048 Part 5. Specimen age: ca. 8 months

Liner	Concrete 1: w/c=0.55	Concrete 2: w/c=0.45
	[cm]	[cm]
Zemdrain MD	2.0	1.0
Zemdrain	2.5	1.0
Without liner	8.0	4.0

8 Depth of Carbonation

The depth of carbonation was determined according to the guideline of the "Deutscher Ausschluß für Stahlbeton" (DAfStb, Volume 422, Point 2.5) by spraying a phenolphthalein solution on freshly fractured surfaces. At the time of testing, the specimens made from Concrete 1 and Concrete 2 had been stored for 7 and 5 months, respectively, at atmospheric CO_2 concentration under standard climatic conditions $20^\circ\text{C}/65\% \text{RH}$.

Tab 5:

Effect of the formwork liners "Zemdrain MD" and "Zemdrain" on the depth of carbonation

Liner	Concrete 1: w/c=0.55		Concrete 2: w/c=0.45	
	Side with liner [mm]	Side without liner [mm]	Side with liner [mm]	Side without liner [mm]
Zemdrain MD	3	11	3	6
Zemdrain	3	10	2	4

9 Summary

Smooth surfaces with very few visible pores were made with both the formwork liners "Zemdrain MD" and "Zemdrain" for the two concrete compositions which were used. The concretes were mixed at w/c ratios of 0.55 and 0.45.

In the case of Concrete 1 (w/c ratio 0.55) more water dripped out of the formwork with "Zemdrain" than with "Zemdrain MD". Since the net backing of "Zemdrain MD" could retain water, it can not be concluded that the effectiveness of the liners is different. The strength of the surface produced with "Zemdrain MD" was above that of the surface made with "Zemdrain". Both surfaces had a higher strength than the surfaces made without formwork liners. In both cases, the degree of water penetration was considerably reduced in comparison with the control surfaces. "Zemdrain MD" and "Zemdrain" proved to be equally effective in reducing the carbonation of surface concrete. After 7 months, the depth of carbonation was roughly one third of the value for surfaces which had been produced without formwork liners.

In the case of the higher strength Concrete 2 (w/c ratio 0.45), the amount of water which drained out of the formwork was comparably low and, regarding the accuracy of the measurements, approximately equal for both formwork liners. Here too, surface strength was increased by the use of the formwork liners "Zemdrain MD" and "Zemdrain". The degree of water penetration is clearly lower. The depth of carbonation of the surface concrete was only half the value for surfaces made without formwork liners.