REUSE OF FRESH CONCRETE BY ADDING A RECYCLING AID

FRISCHBETONRECYCLING DURCH ZUGABE EINER RECYCLINGHILFE

RECYCLAGE DU BETON FRAIS PAR AJOUT D'UN RETARDATEUR

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SUMMARY

At present fresh concrete which is not needed any more on the construction site has to be washed with a lot of highly technical and expensive energy to separate the aggregate and wastewater. The aggregate and wastewater which has thus been recovered can be used for further concrete mixes.

A new method of fresh concrete recycling is the use of a recycling aid with which the hydration process in the fresh concrete can be retarded by up to 3 days. When the concrete is reactivated after a predetermined rest phase it can be delivered and used on the construction site. In these cases the retarded concrete behaves in the same way as a comparative concrete without a recycling aid. The recycling aid can also be used to clean the inside walls of mixing drums.

ZUSAMMENFASSUNG

Frischbeton, der nicht mehr auf der Baustelle gebraucht wird, muss derzeit meist mit einem hohen technischen und kostenintensiven Aufwand ausgewaschen und in Zuschlag und Restwasser getrennt werden. Der hierbei zurückgewonnene Zuschlag und das Restwasser darf bei nachfolgenden Betonmischungen wieder verwendet werden.

Eine neue Art des Frischbetonrecyclings ist die Verwendung einer Recyclinghilfe, durch deren Zugabe der Hydratationsfortschritt im Frischbeton bis zu 3 Tagen gestoppt werden kann. Wird der Beton nach einer vorher bestimmten Ruhezeit wieder aktiviert, kann er ausgeliefert und verarbeitet werden. Dabei verhält sich der verzögerte Beton wie ein Vergleichsbeton ohne Recyclinghilfe. Die Recyclinghilfe kann zudem zur Reinigung der Innenwandung von Mischtrommeln eingesetzt werden.

RESUME

Le béton frais qui n'est pas utilisé sur le chantier doit à présent d'une manière générale être lavé avec des dispositions techniques et financières importantes afin de séparer l'agrégat de l'eau résiduelle. L'agrégat ainsi récupéré et l'eau résiduelle peuvent à nouveau être utilisé dans le mélange du béton.

Une nouvelle façon de recyclage du béton frais est d'utiliser un retardeur qui permet d'arrêter jusqu'à 3 jours l'hydratation du béton frais.

Si le béton après un temps de repos convenu d'avance est à nouveau réactivé, il peut être livré et mis en œuvre. Dans ce cas le béton retardé se comporte comme un béton similaire sans retardateur. Le retardateur peut être utilisé pour le nettoyage des parois internes de tambours malaxeurs.

KEYWORDS: *Returned Concrete* (Fresh concrete returned from the construction site to the concrete plant),
Recycling Concrete (Returned concrete after the addition of a recycling aid),
Loading Concrete (Fresh concrete which has had recycling concrete mixed with it. Generally prepared with a reduced water content),
RB-Concrete (Fresh concrete which has been specially prepared through the mixing of recycling concrete and loading concrete)

1 INTRODUCTION

Ready mix trucks sometimes have large amounts of not required fresh concrete in their mixing drums when they return to the concrete plant after a working day or during a delay at the construction site. This returned concrete is defined as a waste and the precepts in the prevention and reduction of waste laws apply [1].

The same applies to the washing water which is needed in large amounts for cleaning the inside walls of the mixing drums. This washing water is an industrial effluent and cannot be put into the sewage system or any other drainage system [2].

Thus for these reasons a method of reusing these products in the concrete plant has to be found [3].

2 WASHING METHODS ACCORDING TO DAFSTB-GUIDELINE

At present in Germany the term "fresh concrete recycling" is understood as the separation of aggregate and wastewater form concrete which has not hardened [4].

According to the DAfStb-guideline [5] the concrete aggregate in returned fresh concrete can be washed out and used as returned concrete aggregate in the production of concrete. The wastewater can, within limits, be used in the production of concrete. The same applies to wastewater used for cleaning the insides of mixing drums. For this method which is often used in Germany one needs a recycling plant.

Advantageous is that not every concrete mixing plant needs such a recycling plant. A communal plant can be used by concrete plants in a given area. Also there is sufficient experience in Germany that a purposeful production of recycled concrete is possible.

A disadvantage is that cement amounts in the returned concrete are lost during the washing out of aggregates. The cement particles in the wastewater are ineffective. Another point is that with a recycling plant the investment and running costs must be quite high [6].

3 RECYCLING AID FOR RETURNED CONCRETE AND WASTEWATER MANAGEMENT[1]

With this new method, which is up to now hardly used in Germany, a liquid additive a so called recycling aid is added to the returned concrete in the ready mix trucks and mixed with the concrete. The amount added depends essentially on the amount of returned concrete and the waiting time of the truck. With this method the setting time of the concrete which has not yet solidified can be retarded up to 3 days e.g. over a weekend. When the ready mix truck is used again the returned concrete and the loaded concrete is mixed together and a so called RB-Concrete with a class strength of B 25 acc. to DIN 1045 can be delivered.

The recycling aid can also be used to improve the cleaning of mixing drums of the ready mix trucks. When the drums are cleaned in the normal way

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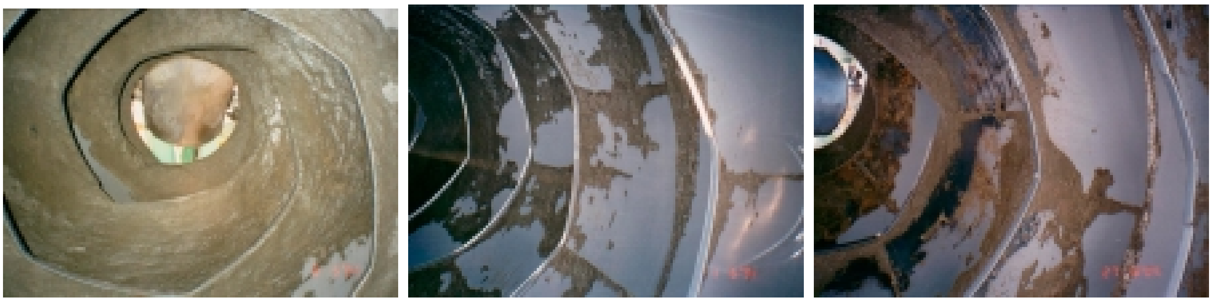
[1] A test of authorisation for the recycling additives for the reuse of returned concrete and wash water has been carried out at the OGI and a general authorisation has been granted by the DIBt in Berlin.

1,0 up to 1,2 m³ water are needed. When a recycling aid is used only 150 litres of water are required for a regular size drum.

Depending on the waiting time of the truck a certain amount of recycling aid is put into the mixing drum and thoroughly mixed so that the inside walls of the drum are covered with the wash water. The washing process is then finished. The next time the ready mix truck is used the wash water is mixed with the loaded concrete and can be used as concrete of the strength B 25 acc. to DIN 1045. Through the consequent use of the recycling aid a recognisable cleansing effect can be achieved (Fig. 1).



Original condition.

View of the inside of a mixing drum. Large amounts of attached concrete on the snail plates can be seen.

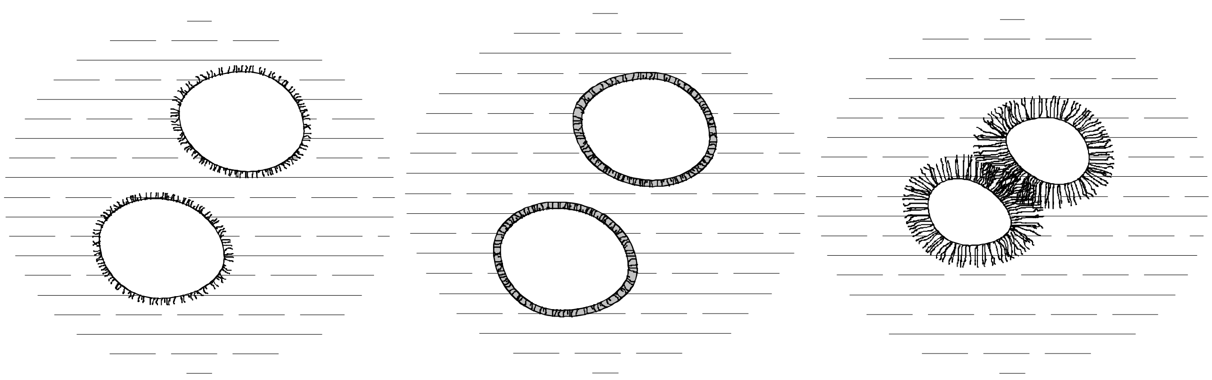
After 4 weeks use of the recycling aid.
An appreciable decrease in concrete attachments is discovered.

After 8 weeks use of the recycling aid.
Even in the furthest corners of the metal snail where cleaning is very difficult the concrete attachments have loosened.

Fig. 1. Cleansing effect through the use of a recycling aid.

4 THE WAY THE RECYCLING AID WORKS

Immediately after the addition of water hydration in the cement paste starts. A short time later the first hydration products form on the surface of the cement grains, the so called cement gel (CSH-phases, $Ca(OH)_2$ as well as small amounts of ettringite and monosulfate) [7]. When a recycling aid is put in the plastic mass of returned concrete the still short fibered hydration products are surrounded by a barrier of chelate similar products on the basis of phosphonic derivates. The progress of the hydration of the cement gel is stopped because no water out of the cement paste can get through this barrier to the non-hydrated cement grains (Fig. 2). When loading concrete is added to the retarded concrete the concentration of the recycling aid drops to such a level that the hydration of the incomplete hydrated cement grains can carry on unhindered.



Cement grains shortly after addition of water. A thin layer of cement gel has formed around the cement grains.

The recycling aid forms a chelate similar barrier. The hydration is stopped. The cement grains do not clump together and the concrete remains plastic.

Further hydration after mixing with loading Concrete. Further unhindered formation of cement gel and the cement grains clump together.

Fig. 2. Schematic representation of the hydration of cement grains with the use of a recycling aid.

5 CONCRETE TESTS ON RB-CONCRETE

In order to investigate whether disadvantageous concrete technological properties occur in retarded RB-Concrete, comparative tests on concrete mixes with recycling aid and without recycling aid were carried out at the OGI.

The mix proportions of the investigated RB-Concrete and the comparative concrete were similar except that the RB-Concrete was retarded by the recycling aid 3 hrs after mixing. With the recycling aid so much additional water was mixed in the concrete until the flow consistency reached about 60 cms. After approx. 20 hrs. at 20°C and 30°C storage temperature loading concrete was mixed with the retarded concrete. The amount of water added in order to achieve a flow consistency of 60 cms was taken into account by mixing with the loading concrete so that the water/cement ratio remained constant (Table 1).

Table 1. Mix proportions

Mix-Nr.:	1a	1b	2a [1)]	2b [1)]
	comparative concrete	RB-Concrete	comparative concrete	RB-Concrete
Aggregate	gravely sand A/B 32		gravely sand C 8, finegrain- &. finesand content approx. 680 kg/m^3	
w/c	0,60	0,60	0,60	0,60
Cement type	CEM I 32,5 R	CEM I 32,5 R	CEM I 32,5 R	CEM I 32,5 R
Cement content	300 kg/m^3	300 kg/m^3	360 kg/m^3	360 kg/m^3
Aggregate content	1840 kg/m^3	1840 kg/m^3	1700 kg/m^3	1700 kg/m^3
Water content	180 kg/m^3	175 kg/m^3	215 kg/m^3	210 kg/m^3
Dosage Recycling aid	--	16 ml/kg cement of returned concrete	--	16 ml/kg cement of returned concrete

[1)] For investigations on the ability to resist cracking

The flow consistency of the comparative concrete did not differ very much from that of the RB-Concrete. In the process of setting [8] there were differences in the initial setting. The time of setting of both concretes at 20°C were however equal (Fig. 3).

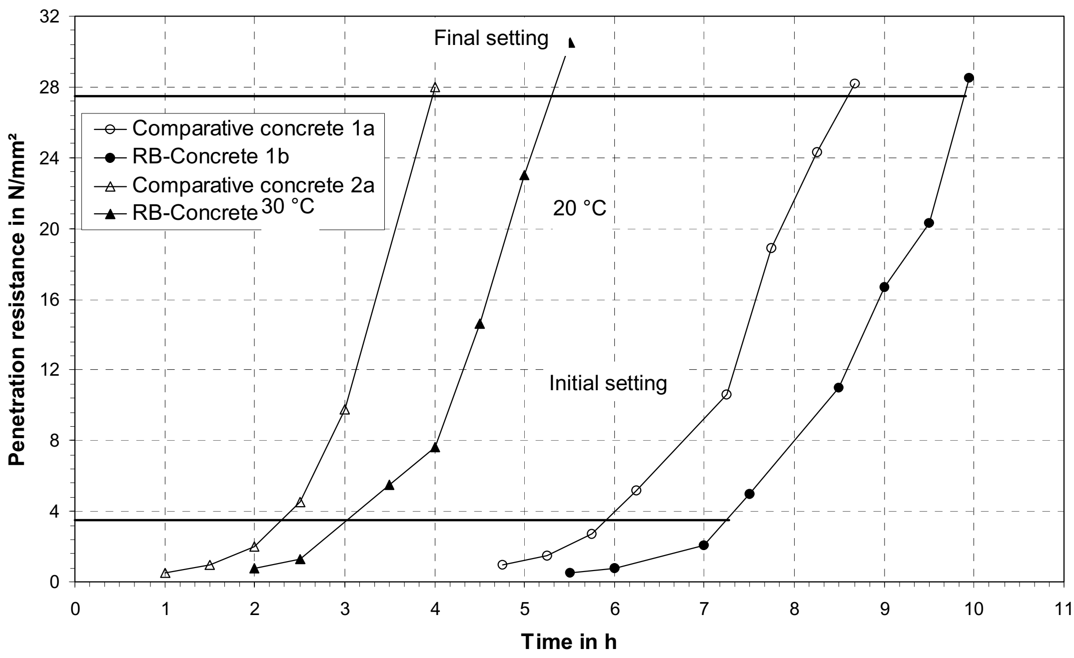


Fig. 3. Process of setting.

Table 2. Time of setting, taken from Fig. 3.

Concrete	Storage temp. °C	Initial setting h:min	Final setting h:min	Time of setting [1)] h:min
Comparative concrete 1a	20	5:53	8:37	2:44
RB-Concrete 1b		7:13	9:52	2:39
Comparative concrete 2a	30	3:01	5:18	2:17
RB-Concrete 2b		2:18	3:59	1:41
[1)] Time of setting = Time between initial setting and final setting				

The compressive strength and creep of both the hardened comparative concrete and the hardened RB-Concrete are almost identical (Figs. 4 and 5).

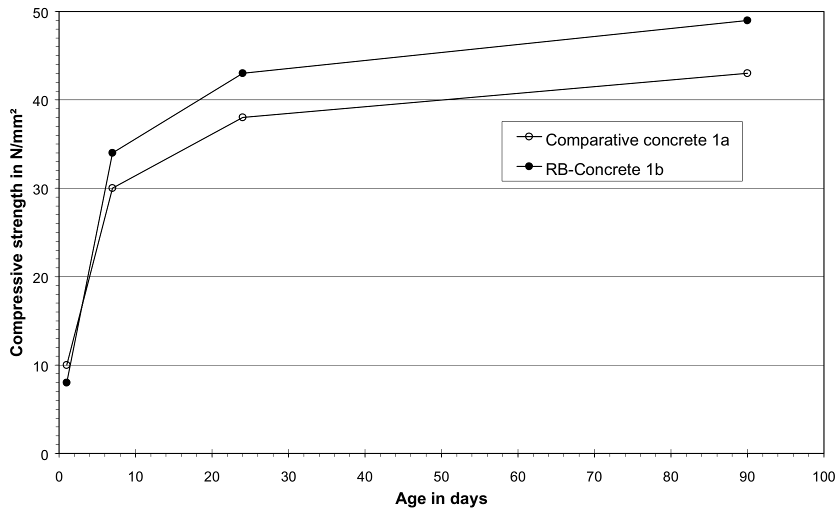


Fig. 4. Strength development.

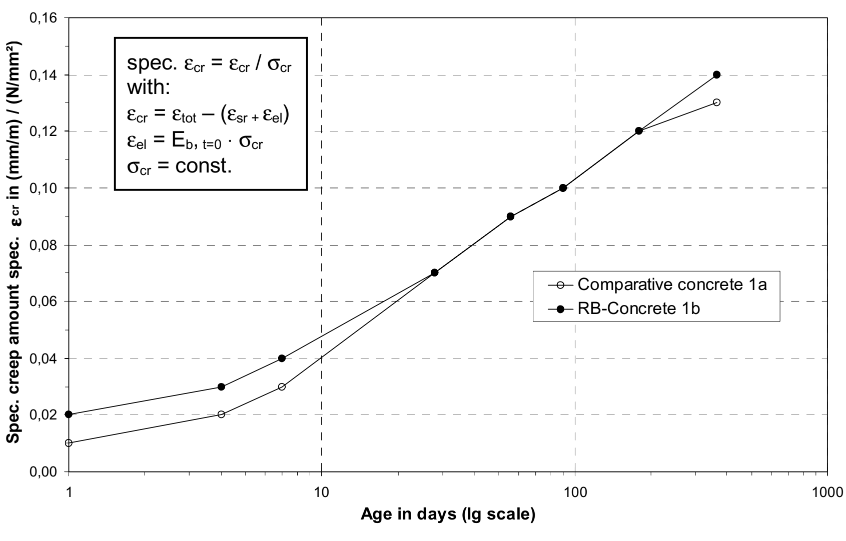


Fig. 5. Comparison of creep deformation under constant loading.

Additives which produce a delay in setting can often have negative effects on the ability to resist cracking in young concrete [9]. Under unfavourable conditions such as rapid drying out they can also contribute to the formation of shrinkage cracks at an early stage [10]. In order to investigate the cracking properties of retarded RB-Concrete test plates 8 cm thick, 160 cm long and 60 cm wide were placed under a transparent wind tunnel in which a steady air stream with a speed of 5 m/s was created using a ventilator. The test plates were observed continually from the start of the test until crack development was complete or no further cracked development was to be expected (Fig. 6). In addition the setting and drying out processes were observed (Figs. 3 and 7). After the test there were no cracks in either concrete.

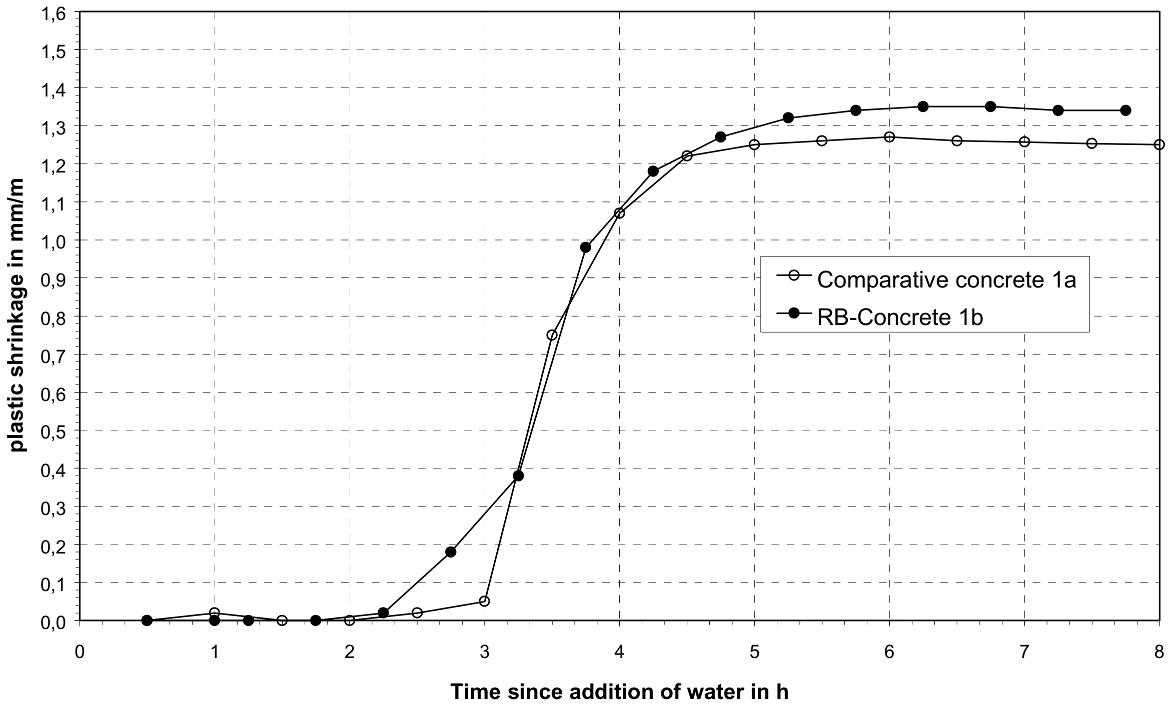


Fig. 6. Plastic shrinkage in wind tunnel at 30 °C / 65 % rel. h.

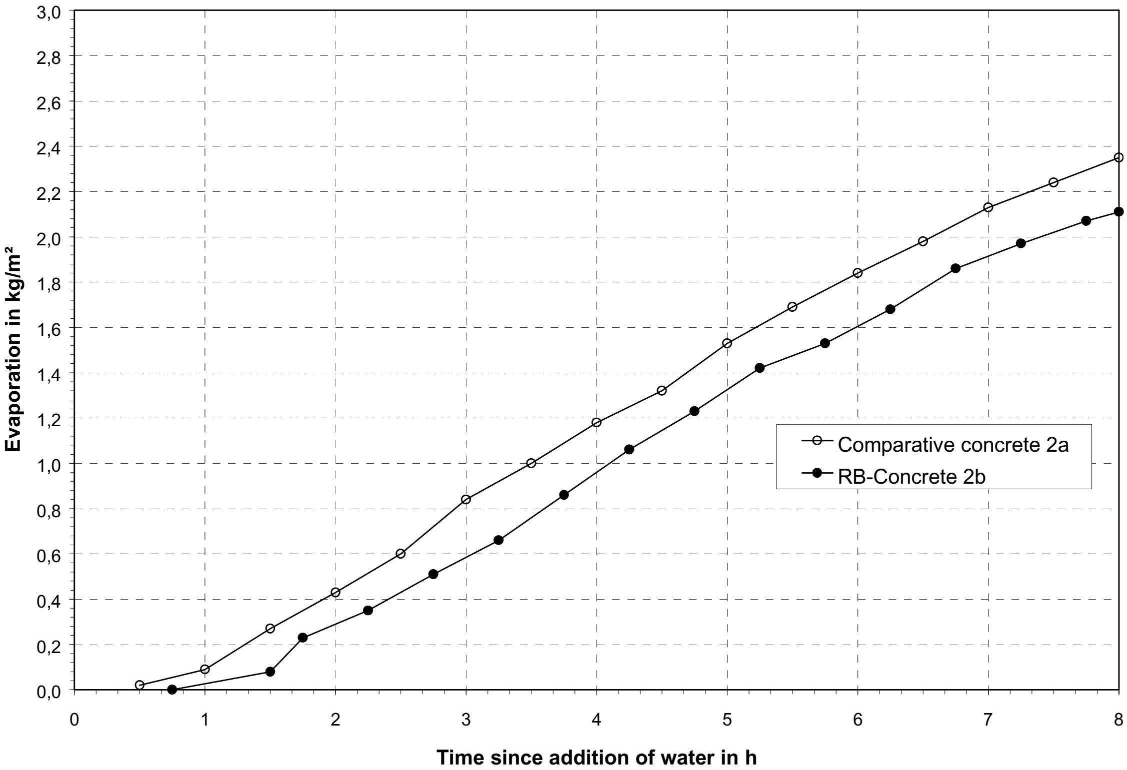


Fig. 7. Evaporation in wind tunnel at 30 °C / 65 % rel. h.

6 TECHNICAL REQUIREMENTS

If the recycling aid is only used for cleaning unloaded mixing drums there is no further technical equipment required at the concrete plant.

If the recycling aid is used for reuse of returned concrete the following items are required:

- Weighbridge to determine amount of returned concrete
- Temperature lance to measure temperature of returned concrete in mixing drum
- Temporary storage place for large amounts of returned concrete
- Computer for dosing

The computer calculates the amount of recycling aid and water which depend on the following 6 parameters:

1. Amount of returned concrete
2. Age of returned concrete
3. Temperature of returned concrete
4. Concrete composition
5. Type of cement
6. Required delay time

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