4 New Characteristics of Textile Reinforced Concrete (TRC) by Titanium Dioxide Modification

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1. INTRODUCTION

In the past the focus of innovations in the concrete technology was characterized by increasing the strength niveau or improving the workability. A new aspect in developing new building materials is to add nano-particles like TiO_2 to the cementitious matrix to get new functionalities.

Concrete buildings are often not good looking, as they are dirty by pollution or overgrown by alga, moos etc.
Now there are developments to create concrete multi-functional by new additives. The effect can be used in several ways for air purification, antibacterial, anti algae and for self-cleaning surfaces too. The self-cleaning-effect by using TiO_2 is supported by its suprahydrophilie properties, dirt particles are undermined and removed.

The new functional properties of cement bonded building materials are consequence of activating a photocatalytic substance. It is added to the matrix but must to be find near to the surface as it has to be activated by the radiation of the sun light.

Titandioxid is a photocatalytic substance with the functions of semi conductors. It works in a cement matrix. There are three modifications of TiO_2, but Anatas is most photocatalytic efficient.

2. DEVELOPMENT PROJECT

The investigation of new functional properties of TRC by adding Titandioxid modifications to the matrix is subject of a research project. Institutes of Aachen University, the cement industry and private companies are partners. It is partly financed by the German Gouverment (Bundesministerium für Bildung und Forschung - BMBF).

The research work is running for three years till the end of 2012. Therefore the research work is not finished, there are three main points:

- purification
- self-cleaning
- gluing properties of TRC by using the superhydrophilie

all in combination with the glass fibre reinforced concrete / TRC.

TRC with the components cementitious matrix and the reinforcement of AR – glassfibres as textiles or chopped strands is produced normally thin walled. In respect to the economy is that important, the amount of TiO_2 is not high. You can spare this semi conducting material if you produce in layers – it is sufficient to place TiO_2 only in the surface layer.

3. RESEARCH WORK

3.1 Matrix

A lot of tests were made to develop a grey and a white matrix with excellent matrix properties: a good workability and optimal bonding of the glassfibre textiles.

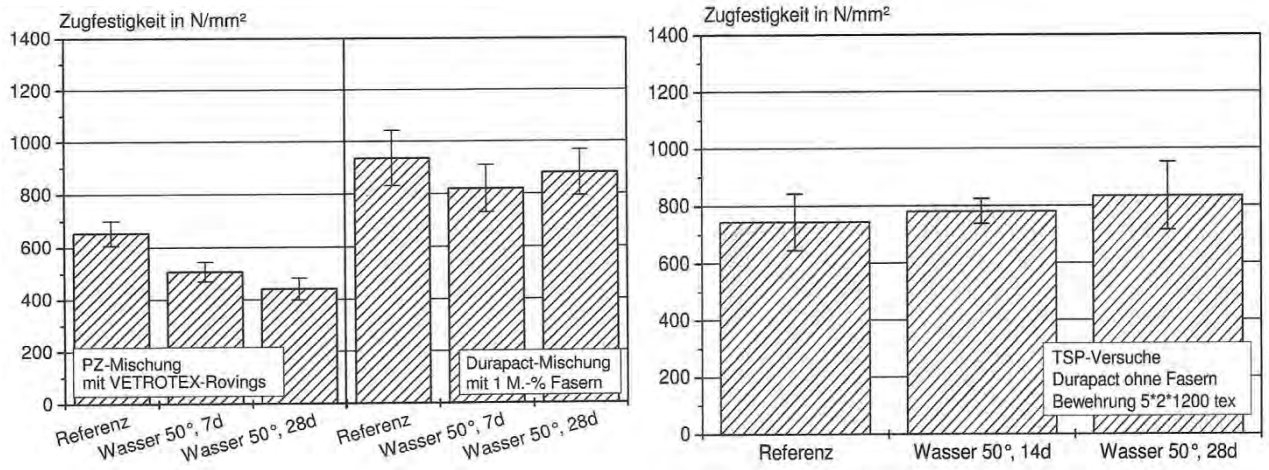
Matrix 1 “grey”:

Ausgangsstoffe	Einheit	Laminieren und Gießen
CEM I 52,5 N (z)	kg/m³	490
CEM I 42,5 R-HS (z)		-
Flugasche (f)		175
Silikastaub (s)		35
Quarzitische Gesteinskörnung 0-0,6 mm		1214
Fließmittel	M.-% vom Binde-mittel	0,65
Kurzfasern (AR-Glas)	Vol.-%	-
Methylzellulose	M.-% vom Feststoff	-
w/z	-	0,57
w/b[1)]		0,47
[1)] w/b = w/(z+0,4·f+s)		

Matrix 2 “white”:

12,5	kg	DuraPact – Konzentrat
25,0	kg	Cement
>37,5	kg	Sand 0,1 – 2,0 mm
0,5	kg	Flow Agent
13,5	kg	Water

Of Interest is the long time behavior of GRC with DuraPact – Matrix



The diagram shows the results of a accelerated test, specimen were deposited in water 50° C.
The following modifications of Anatas are used

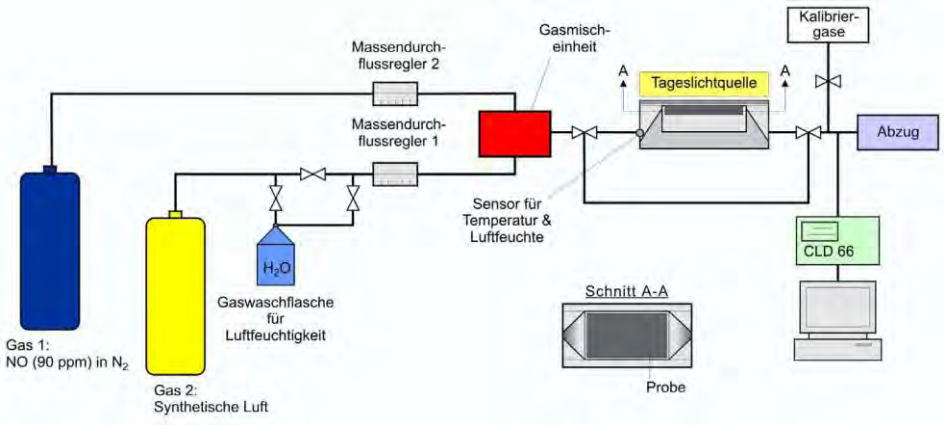
- TiO_2 BET 330 m² / g
- TiO_2 BET 6 m² / g
- TiO_2 BET 100 m² / g
- TiO_2 with Wolfram BET 100 m² / g

The amount of TiO_2 was 5 M.-% and 10 M.-% of the cement.

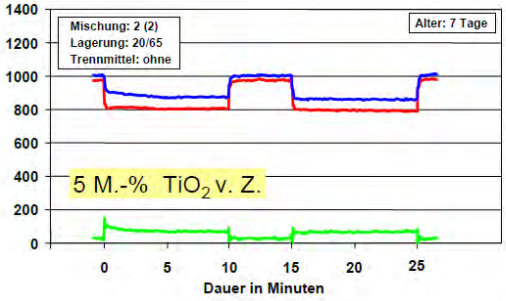
For both matrices the pressure strength had the niveau of 80 N / mm² and the bending strength between 8 N/ mm² and 10 N / mm².

3.2 Purification

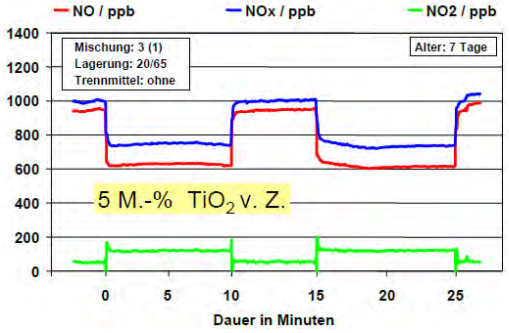
The purification of pollution that is in contact with a photocatalytic TRC surface is measured by the apparatus that is shown in the picture.



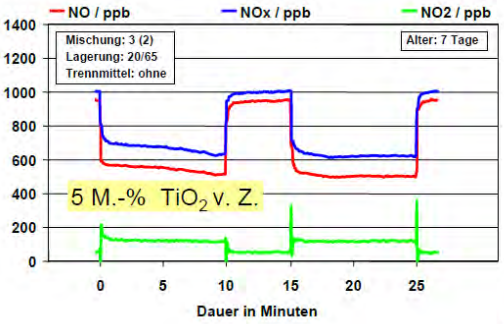
The air – purifying capability of TRC was evaluated by a controlled degradation of nitric oxid (NO) along the reactive surface of the specimen (15 x 10 x 1) cm. The reactor cell is so built that a UV – source can activate the photo catalytic properties. The pictures show the results.



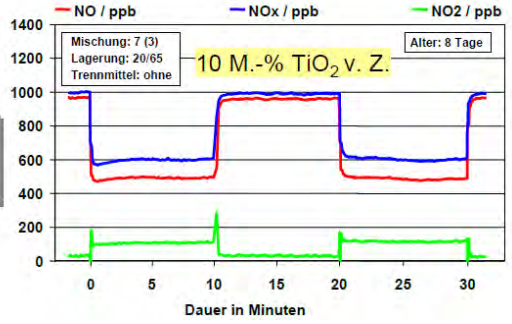
Abbaurate: ~ 12 %
BET: 330 m²/g



Abbaurate: ~ 26 %
BET: 6 m²/g



Abbaurate: ~ 38 %
BET: 6 m²/g

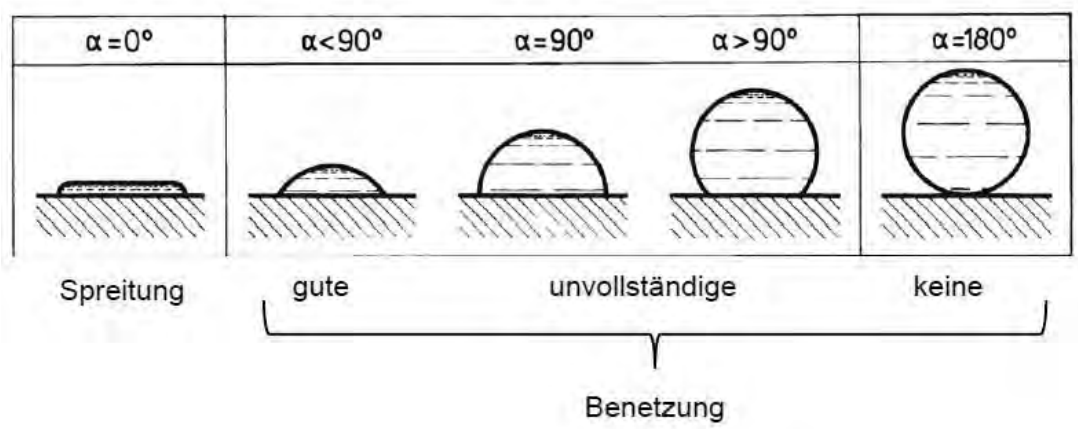


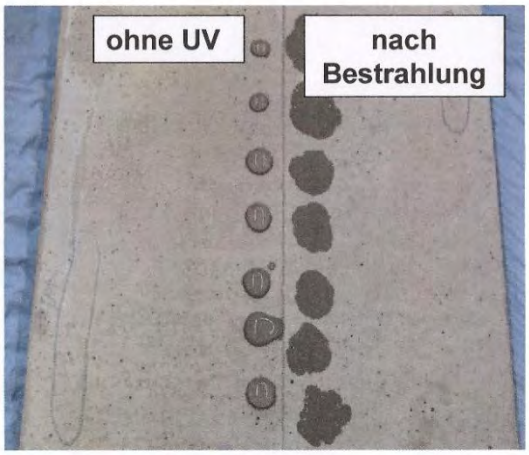
Abbaurate: ~ 39 %
BET: 6 m²/g

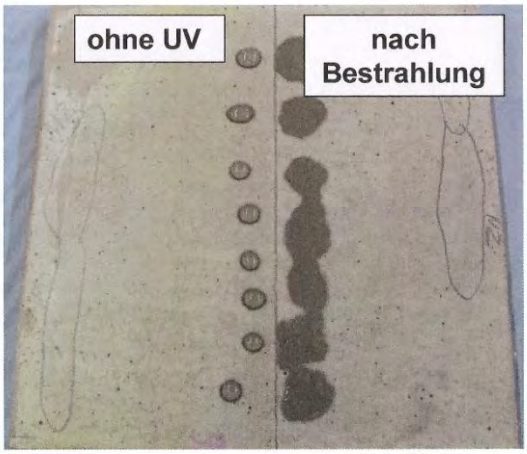
Generally a white matrix shows more degradation of air-purifying and the w/c – ratio has influence too. Is that ratio higher the degradation rate is less. Other factors of influence are the time of demoulding and the curing. For example there was no degradation rate measured when the specimen were stored 7 days in water.

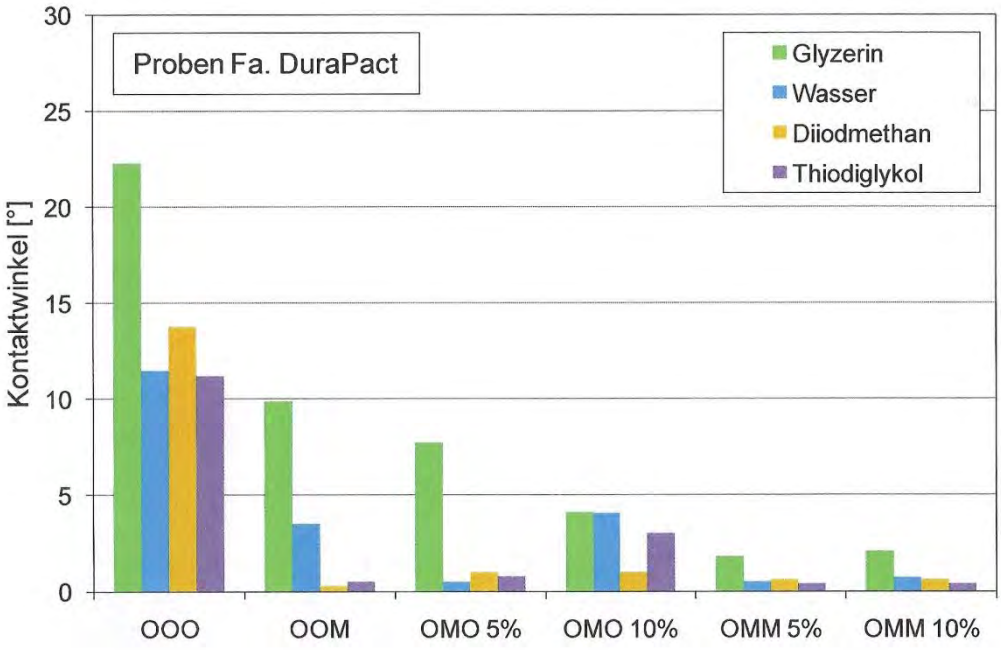
3.3 Self – Cleaning - Effect

Beside the degradation of air pollutants is the self-cleaning-effect another additional characteristic by using a certain TiO_2 – modification. The exposure to UV – light causes in the concrete with TiO_2 – particles in the surface to become superhydrophilic, that means that the angle of contact to water and to other liquid becomes less than 5°.









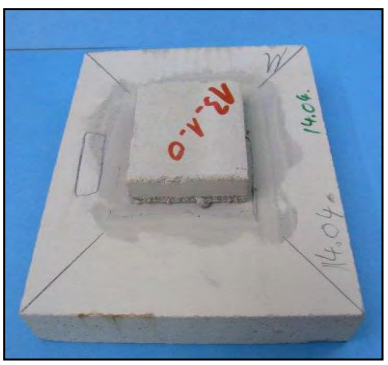
Water for example does not form droplets but spreads extensively in a very thin layer, goes under the dirt and move it away.

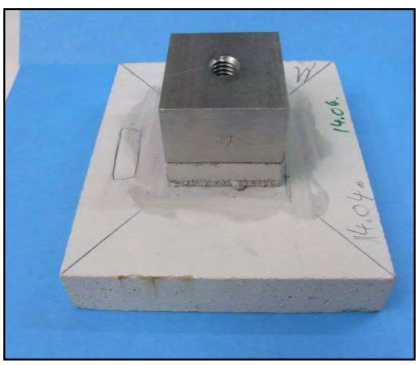
Pictures show a concrete surface half of the area is activated by UV – radiation. Here the water drops spread widely. That effect is responsible for cleaning the surface.

3.4 Gluing properties

A superhydrophilic surface could be the reason for a thin layer with constant thickness of the gluing material

The first tests show no significant difference between concrete that was photocatalytic active or not. The investigations in that field are going on.





4. CONCLUSION

Titandioxid can be used as a semi conductor when it is activated by the energy of the sunlight. Concrete modified by TiO_2 can reduce the amount of gaseous air pollutants occurring as NO_x.

Dirt can be washed off from the surface in addition to the superhydrophilic effect.

The use of TiO_2 for concrete is of ecological interest, but for normal concrete the costs for that material are too high. GRC is normally produced in thin layers. Therefore we see here an interesting market specially when it is used only in the surface.