Cement and sulphate free autoclaved aerated concrete

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Abstract: New laws are likely which will make putting autoclaved aerated concrete (AAC) into landfills more difficult in the future. Consequently, a project was launched at Xella to reduce the sulphate content in AAC to almost zero.

Positive side effects are no risk of thaumasite, agglomeration residue of lime and grey stains.

The biggest source of sulphate besides cement is the pure calcium sulphate, which is added either as gypsum or anhydrite to the mixture. Additional calcium sulphate has been used in AAC to improve its material properties for many years. The reduction of calcium sulphate in ordinary cementitious AAC recipes leads to high shrinkage and less compressive strength of the material.

Sulphate free AAC with a low bulk density is not yet being made in mass production. Due to the lag of the hydraulic binder cement, completely sulphate free recipes could not be handled in technologies like Durox, Hebel or Ytong yet. Cement and sulphate free AAC cakes tend to collapse either in the demoulding or autoclaving process, and especially low densities are difficult to process.

Technological solutions and recipes were found to produce cement and sulphate free AAC with low bulk densities in moulds with the size of 5.4 m^3. The material meets the requirements for the German bulk density class PP2/0.35 with λ 0.09 W/(mK). The shrinkage tests show values under 0.20 mm/m according to DIN EN 680. Finally, it was shown that cement free recipes lead to fewer transportation damages due to less brittle surfaces. Further research is currently in progress.

Keywords: calcium sulphate, cement substitution, environment, thaumasite, green cake, autoclaving

1. INTRODUCTION

Autoclaved aerated concrete (AAC) is mostly produced from the natural inorganic raw materials sand, quick lime, cement, calcium sulphate, water and the rising agent aluminium, which makes it one of the most sustainable building materials.

Nevertheless, it is likely that new laws will make the deposition of autoclaved aerated concrete more difficult in the future. Consequently, a project was launched at Xella to reduce the sulphate content in AAC to almost zero.

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Additional calcium sulphate has been used in AAC to improve its material properties for many years [1]. The reduction of calcium sulphate in ordinary cementitious AAC recipes leads to high shrinkage and less compressive strength of the material [2].

Sulphate free AAC with a low bulk density is not yet being made in mass production. Due to the lag of the hydraulic binder cement, completely sulphate free recipes could not be handled in technologies like Durox, Hebel or Ytong yet. Cement and sulphate free AAC cakes tend to collapse either in the demoulding or autoclaving process [Fig. 1], and especially low densities are difficult to process.

In this project we searched for technological solutions and recipes to produce cement and sulphate free AAC with low bulk densities in moulds with the size of 5.4 m^3.

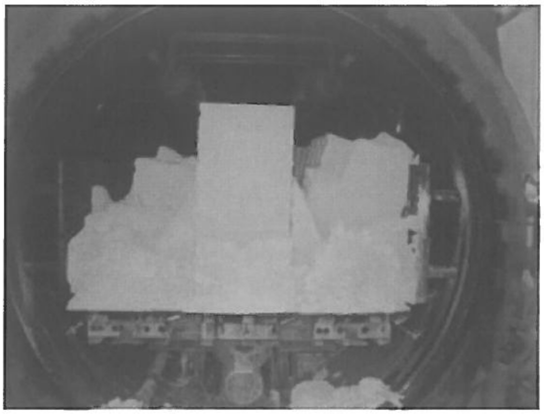

Fig. 1. Collapsed AAC blocks with a bulk density of 320 kg/m^3

2. EXPERIMENTAL

Various cement and sulphate free mixtures [Table 1.] with bulk densities between 320 and 440 kg/m^3 were produced.

As raw materials quartz sand, fumed silica, quick lime, inert fillers and/or AAC powder, hydrated limes, waste slurry and the rising agent aluminium were used.

Due to the low green cake strength, a normal Ytong production site was modified to produce cement and sulphate free material [Fig. 2].

The raw materials were batched from the silos into a mixer. After homogenisation the slurry was casted into 5.4 m^3 moulds. After a rising process of 3.5 to 4.5 hours, the cakes were tilted by 90° and demoulded. Finally, the green cakes were cut horizontally and vertically, fitted with groove, tongue and grip holes.

Before autoclaving, the material was tilted back from the vertical to the horizontal position and hydrothermally cured at 190°C for 6 hours.

After autoclaving the material was tilted back again. The danger of collapsing cakes had been avoided.

The final products were tested for compressive strength according to DIN EN 772-1, for thermal conductivity according to DIN EN 12664 and for the shrinkage behaviour according to DIN EN 680.

In this paper the so called A-value is used. The A-value represents a relative level of the strength of AAC. The bigger the A-value, the better the level of stability. The A-value [3] depends on the bulk density and the compressive strength and can be described as followed: A-value = CS / BD^2 x 0.016; with: CS = compressive strength [N/mm^2], BD = bulk density [kg/dm^3], 0.016 = experimentally determined constant. An A-value of about 1500 is needed to meet the requirements for the German quality class PP2/0.35.

Table 1. Recipes

Component / raw material	Amount [wt. %]
CaO (quick lime, hydrated lime)	20 - 40
SiO_2 (sand powder, fumed silica)	40 - 60
Inert filler	0 - 30
AAC - powder	0 - 30
Waste slurry	0 - 30
Aluminium component	0.2 - 1

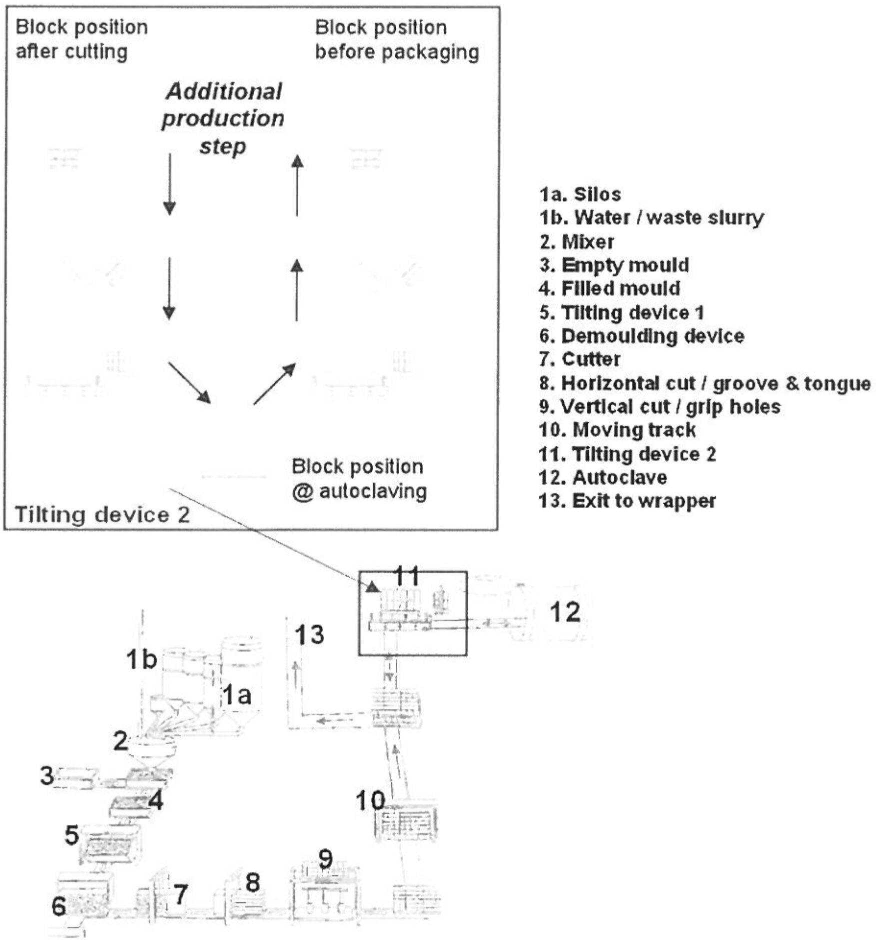

Fig. 2. New Ytong production layout

3. RESULTS AND DISCUSSION

Cement and sulphate free autoclaved aerated concrete with bulk densities between 320 and 440 kg/m^3 was produced. The results of the thermal conductivity and compressive strength tests are shown in fig. 3. The compressive strength varied between 2.5 N/mm^2 for the lowest and 4.5 N/mm^2 for the highest bulk density. The average A-value was 1500. The $\lambda_{10,dry}$ varied between 0.08 and 0.11 W/(mK). The experimentally identified extrapolation factor for the thermal conductivity is 0.002 W/(mK) per 10 kg and therefore comparable to cementitious recipes. All shrinkage values (fig. 4.) fulfil the normative requirements.

The final products meet the requirements for the German quality classes PP2/0.35 with λ 0.09 W/(mK), PP2/0.40 W/(mK) with λ 0.10 W/(mK) and PP2/0.45 with λ 0.11 W/(mK).

The material shows rough surfaces compared to ordinary cementitious recipes [fig. 5.]. But due to the less brittle quality, cement free AAC surfaces are less prone to transportation damages.

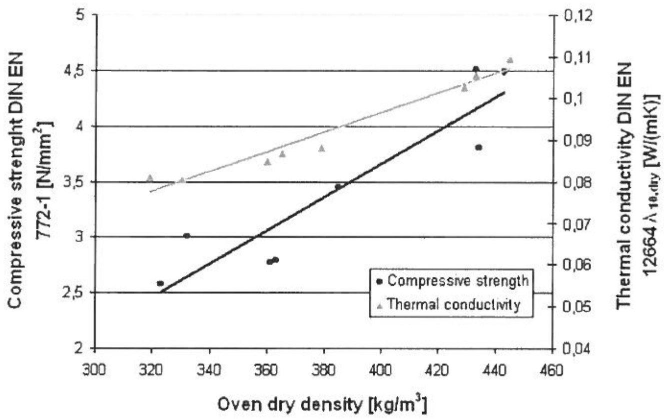

Fig. 3. Compressive strength and thermal conductivity

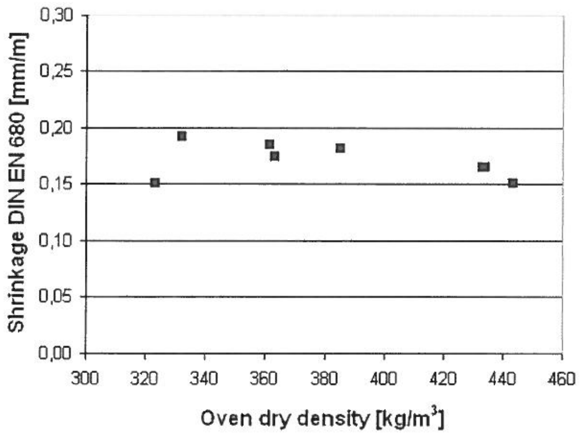

Fig. 4. Shrinkage values

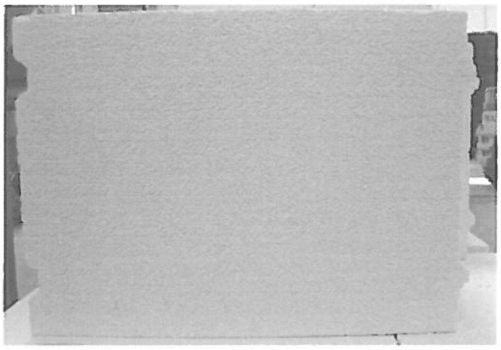

Fig. 5. Rough surface of cement and sulphate free AAC

4. CONCLUSIONS

Technological solutions and recipes were found to produce cement and sulphate free AAC with low bulk densities in moulds with the size of 5.4 m^3. The material meets the requirements for the German bulk density class PP2/0.35 with λ 0.09 W/(mK). The shrinkage tests show values under 0.20 mm/m according to DIN EN 680. Finally, it was shown that cement free recipes lead to fewer transportation damages due to less brittle surfaces.

Further research is currently in progress.

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