

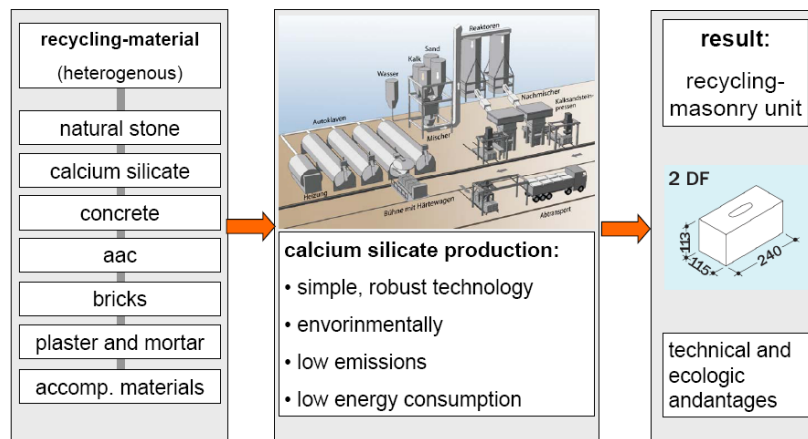
FORSCHUNGSVEREINIGUNG KALK-SAND EV

Short Description

Development of a Recycled Masonry Unit using Masonry Waste Material Manufactured and using Normal Calcium Silicate Production Technologies

Project number: Az: Z6-10.08.18.7-6.30 II2-F2006-26

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Summary

A new masonry unit has been developed that uses recycled building materials and which can be manufactured using normal industrial practices for the manufacture of calcium-silicate masonry units. The main project results are listed below:

- The production of recycled masonry units by application of existing manufacturing technology is possible.
- The choice of the recycled masonry material to use has a specific effect on the production process and the specific engineering properties of resulting masonry units. The main influencing properties of the recycled sands are: grain size distribution, water absorption, as well as chemical and mineralogical properties.
- In most cases the addition of recycled sands from masonry-construction waste decreases the quality of the masonry units, especially with respect to dry density and compressive strength.
- Before using recycled material, organic impurities such as wood, old wallpaper, etc. have to be fully removed from the recycled material.
- Quality decreases with an increasing amount of recycled material in the raw mixture. Therefore, the addition of recycled material has to be limited.
- The grain size of the recycled aggregate should be limited to the finer fractions. The use of a coarser aggregate fraction of the recycled material (2/4 mm) resulted in lower quality than when a fine fraction (0/2 mm) of material was used.
- For the production of recycled masonry units the addition of masonry recycled material from calcium silicate brick, concrete and natural stone is possible. The use of waste material from autoclaved aerated concrete is not possible.
- In most cases the quality of the recycled masonry units can be improved by changing some of the production technology parameters, such as increasing the pressing strength, the lime content and the autoclaving time.
- The analysed masonry recycled units were produced from conventional masonry recycled material. Just like calcium silicate units, the recycled units are harmless with regard to health and environment effects. Therefore, further environmental analyses/investigations are not necessary.

The application of the results of this research project to the full-scale production within calcium silicate plants requires, in every case, specific preliminary investigations relevant to the specific plant under consideration.

Aims of this Research Project

The objective of this project was to develop a masonry unit using masonry recycled material and the application of traditional calcium silicate production technology. The main aims were:

1. to develop ways to re-use building waste material at a higher recycling level
2. to contribute to the reduction of landfilling with building materials
3. the material circuit is a closed loop
4. to increase sustainability through the increased use of recycled materials

The following specific topics of investigation within the research project were:

- a. investigations and development of materials classes for the production of recycled masonry units
- b. manufacture of recycled units using regular calcium-silicate manufacturing technology
- c. use of a high content of secondary raw materials
- d. application of a simple production technology and a low energy consumption
- e. use of masonry recycled units in the do-it-yourself-sector

The test results deliver basic approaches for optimized production parameters for manufacturing masonry recycled units. The results can be used directly in the production.

Investigations

Sequences of the investigations:

The development of the masonry recycled units is based on a step-by-step procedure that searched for the optimized mixes.

1. the different masonry recycled materials were used in different proportions as raw materials for calcium silicate brick production
2. the units, produced by using the calcium silicate technology, were analyzed in the laboratory
3. after units were developed with acceptable properties, the production parameters were changed step-by step to examine the sensitivity of the parameters in the production of higher quality units .

The following production parameters have a strong influence in determining the properties of the units. Below the values of the parameters that were used in this investigation are listed:

- | | |
|--|---|
| a. amount of lime | CaO = 5 / 7 / 9 wt.-% |
| b. amount of the crushed recycling material: | 25 / 50 / 75 wt.-% |
| c. grain fraction of the recycling material: | 0/2 mm and 2/4 mm |
| d. pressing force: | $\sigma_p = 10 / 15 \text{ N/mm}^2$ |
| e. duration of the autoclaving process: | $t_h = 1-4-1 \text{ h}$ and $1-6-1 \text{ h}$ |
| f. temperature of the autoclaving process: | $T_h = 194/203 \text{ }^\circ\text{C}$ |

Investigations of the units:

The masonry recycled units were produced in the laboratory as well as in a calcium silicate production plant. The following properties were measured:

- compressive strength
- bending tensile strength
- tensile strength
- shear strength
- texture properties (dry density, porosity, water absorption)
- deformation properties (modulus of elasticity, thermal expansion)
- chemical and mineralogical properties

Environmental properties:

- VOC-emissions according to the German AgBB-Protocol, Eurofins A/S, Hamburg
- Leaching test according to the German DEV-S4-test, Chemical Laboratory Dr. E. Wessling, Hannover

Recycling Material:

Recycled masonry materials were obtained from the following sources and integrated into this investigation:

- calcium silicate units
- bricks
- autoclaved aerated concrete (aac)
- concrete
- natural stone



fig. 1 to 3: Basic material: pure masonry material (example)
Brockmann Recycling GmbH, Nützen, picture: TerraTextura GmbH, Soest



fig. 4 to 6: Crushed recycling material, fraction 0/5 mm calcium silicate material, brick material and concrete material
Brockmann Recycling GmbH, Nützen, picture: TerraTextura GmbH, Soest



fig. 7 to 8: Crushed calcium silicate recycled material (example)

Figures 9 and 10 give an example on the effect of a calcium silicate recycled material on the properties of the masonry units. In most cases the quality of the masonry units can be improved by changing different parameters of the production technology, for example: increasing of the pressing strength, amount of lime and the autoclaving time.

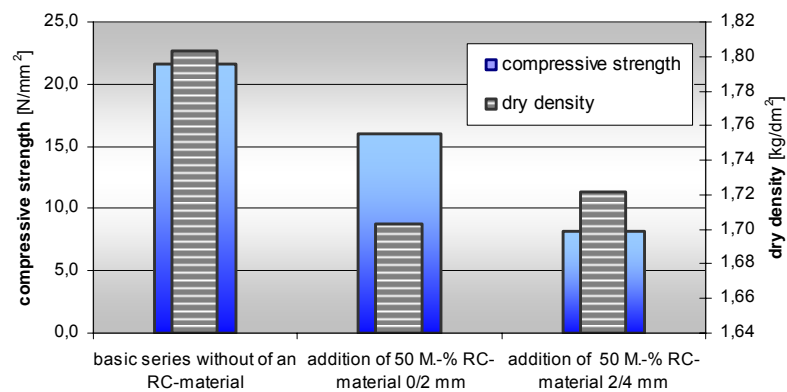


fig. 9: Influence of the masonry recycled material on compressive strength and dry density masonry units

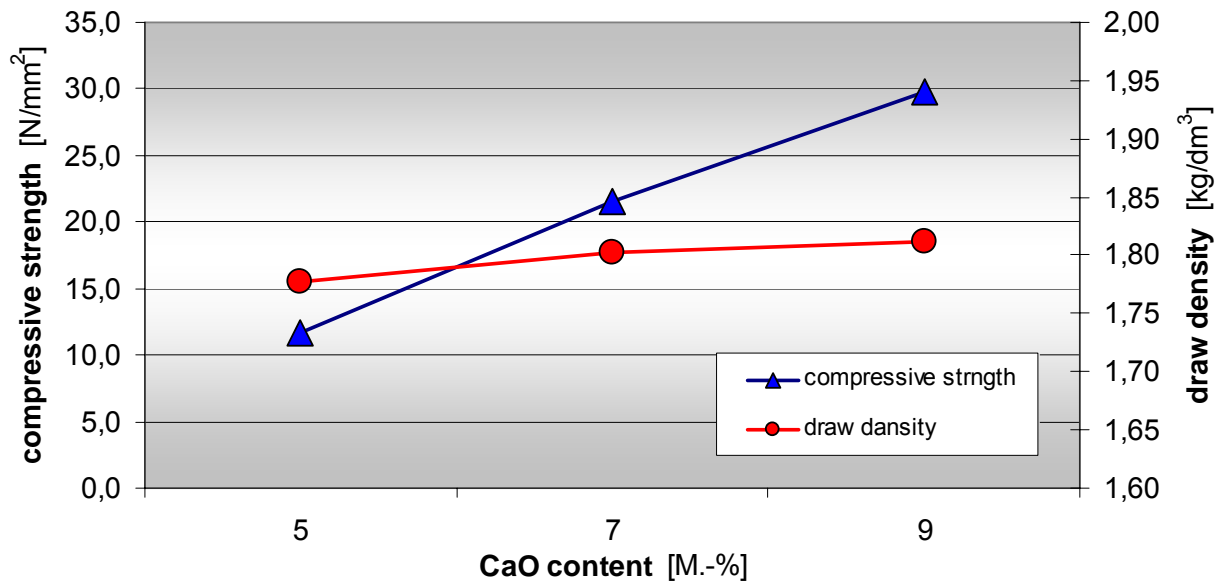


fig. 10: Compressive strength vs. CaO content in the raw mix. The higher the amount of lime the higher are compressive strengths and dry densities of the recycled masonry units



fig. 11: Specimen of the series 9 with 50 wt.-% of calcium silicate of the fraction 0/2 mm (example)

Environmental analyses of the recycling masonry units

The results of the environmental analyses show that all concentrations stay below the present environmental threshold values. Thus, a risk for customers using these recycled masonry is no different than with normal calcium-silicate units, and thus can be excluded. There neither are any pollutants (VOC or SVOC) detected nor is it expected to find any pollutants. The different specimens that were analyzed qualify for use in interior rooms. As expected, these products are quite safe. Since no harm with respect to environmental and health issues exists from the use of these products, further environmental investigations are not necessary.