Development of autoclaved aerated concrete production with silica raw material having a higher solubility than quartz

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Motivation
The time and energy consumption during the production of AAC is strongly determined by the steam curing process [1], which is firstly necessary to dissolve the silica raw material and secondly to establish the conditions for C-S-H formation. A reduction in processing time and temperature would provide relevant advantages. Currently, it is well established to use quartz as SiO$_2$ source for AAC production. Quartz has a relatively low solubility in water and the rate of dissolution is also relatively slow [2, 3]. Therefore, in the case of using quartz as a silica source in AAC, steam curing with a quite high temperature i.e. more than $T > 180 \, ^\circ C$ is required [4]. However, with silica sources which have a higher solubility in water, there is a possibility to have lower steam curing temperature which would provide advantages in energy consumption (lower curing temperature, shorter curing times, less binder usage, lower CO2 emissions) and use of a wider range of raw materials. This study focuses on developing AAC mixtures with optimized curing conditions and binder requirements by substitution of quartz with silica materials having a higher solubility than quartz.

Materials and Methods
In this study, two types of silica sources, Dorsilit as quartz and Calcined Diatomaceous Earth (C-DE) as silica with higher solubility than quartz was used. The first part of the study deals with the possibility of using C-DE as the substituent for quartz in the AAC mixture. Moreover, the influences of C-DE substitution on properties of AAC produced at a typical autoclaving temperature of 192 $^\circ C$ for 6 hours are studied. The second part is about developing DE-substituted AAC, produced in the first part, in which less extreme curing temperature and also less binder is required.
Different measurements including compressive strength, XRD analyses, SEM, and thermal analyses are performed. Phase contents determined by Rietveld method and ZnO as the internal standard.

**Results and Discussion**

Results have shown that applying a steam curing temperature of 192 °C, which is a typical figure in industrial AAC production, inhibits the tobermorite formation in the more soluble silica-system while promotes that in a quartz-system. This could be because of the different dissolution behavior of silica raw materials. Quartz has relatively low solubility in water and the rate of dissolution is also relatively slow. Therefore, in the case of using quartz as a silica source in AAC, steam curing with a quite high temperature, i.e. more than 180 °C, is required. However, silica sources, that have a higher solubility in water, dissolve faster so at the same steam curing temperature i.e. of 192 °C the C/S ratio of initially formed C-S-H in a more soluble silica-system is lower (higher Si content) compared to that of a quartz-system. Moreover, it has been reported that the C-S-H with a low C/S ratio tends to have long and cross-linked chains of silica tetrahedrons [5]. So it is more difficult to be transformed into tobermorite while C-S-H with high C/S contains short and dimer silicate chains so it crystallizes readily to tobermorite [6] (Fig. 1). It seems that in the case of using more soluble silica than quartz, lower steam curing temperature might be needed to obtain optimum tobermorite formation. Therefore, there is a possibility to control the dissolution of C-DE by applying a lower curing temperature in a way to promote tobermorite formation. This will be the topic of part II of this study where C-DE-substituted AAC mixtures with optimized curing conditions and binder requirements are developed.

![Fig. 1: Schematic structures of silicate chains represent short chain in quartz-system (right), long chain in amorphous silica-system (left) at the autoclaving temperature of 180 °C [6].](image)

**References**


