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Use of local raw materials for construction purposes

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Abstract. A geopolymer produced from Jordanian kaolinite is described in this work. The aim is to produce low environmental impact materials from local raw materials. In this paper the emphasis is on the general characteristics of the material and on its durability. With the used kaolinite, specimens with compressive strength of 41 MPa under dry conditions and 23 MPa under immersed water conditions were obtained. The durability under environmental conditions was good.

Introduction

Since some years research is going on in Jordan to produce construction materials, starting from local raw materials [1,2]. Geopolymers have the benefit that they have a smaller environmental impact than concrete, but also the main raw material, for instance kaolinite, is often locally available. To minimize the production cost, the kaolinite will be used as such and thus not be dehydroxylated.

The aim of this research is to
-find out which local raw materials can be used (reactive and filler)
-optimize the production (composition, curing) of bricks, tiles,.
-find out how to do the production in the field
-make a water reservoir for water harvesting

The proposed raw materials are kaolinite, smectite rich clay, tripoli, calcareous porcelanite, diatomaceous clay, silica sand, granite, zeolitic tuff, scoria (tuff) and basalt. The reactivity of these materials was tested in the framework of the PhD of Islam Aldabsheh and Muayad Esaifan. No further details will be given in this text.

As kaolinite, a Hiswa clay, rich in kaolinite was chosen [3-5]. With the Hiswa kaolinite (JHK), specimens with compressive strength of 41 MPa under dry conditions and 23 MPa under immersed water conditions were obtained. Since the materials will be used for the construction of water ponds, the durability of these specimens was tested. These materials also exhibit good mechanical performance upon heating to 600 °C, opening a possibility for use under elevated temperatures. The work presented in this paper is part of the PhD of Faten Slaty [6].

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Results and discussion

Optimization of the geopolymer preparation. First an optimization of the composition and reaction conditions was performed. The NaOH and sand (JSS) amount were varied with respect to the amount of kaolinite (JHK). In Table 1 the compressive strength as a function of the amount of NaOH is presented. The optimal amount is about 16wt% of NaOH compared to the raw kaolinite.

Table 1: The optimization for NaOH ratio in the JHK geopolymer mixture

JHK: JSS: NaOH: H_2O	Compressive strength [MPa]	Avg. strength [MPa]
100: 50 : 8: 22	13.2	13.0
	13.1	
	12.6	
100: 50: 12: 22	26.66	23.5
	20.7	
	23.1	
100: 50 : 14: 22	29.2	29.4
	30.4	
	28.6	
100: 50 : 16: 22	32.1	33.1
	34.2	
	32.9	
100: 50 : 18: 22	31.2	30.3
	31.0	
	28.6	
100: 50 : 20: 22	27.7	28.0
	27.3	
	28.8	

For sand an optimized ratio of about 0.5 to 1 sand/kaolinite was obtained.

The reaction product of the final geopolymer was studied with XRD (Fig 1). Na-zeolitic phases namely: phillipsite ($(Na,K,Ca)_{1-2}(Si,Al)_8O_{16}.6(H_2O)$) and natrolite ($Na_{16}Al_{16}Si_{24}O_{80}.16(H_2O)$) were identified. Hydroxysodalite ($Na_2Si_2Al_2O_5(H_2O)_6$) is also observed. Quartz occurs as a major phase in the specimen along with the remainings of kaolinite, muscovite/illite and hematite.

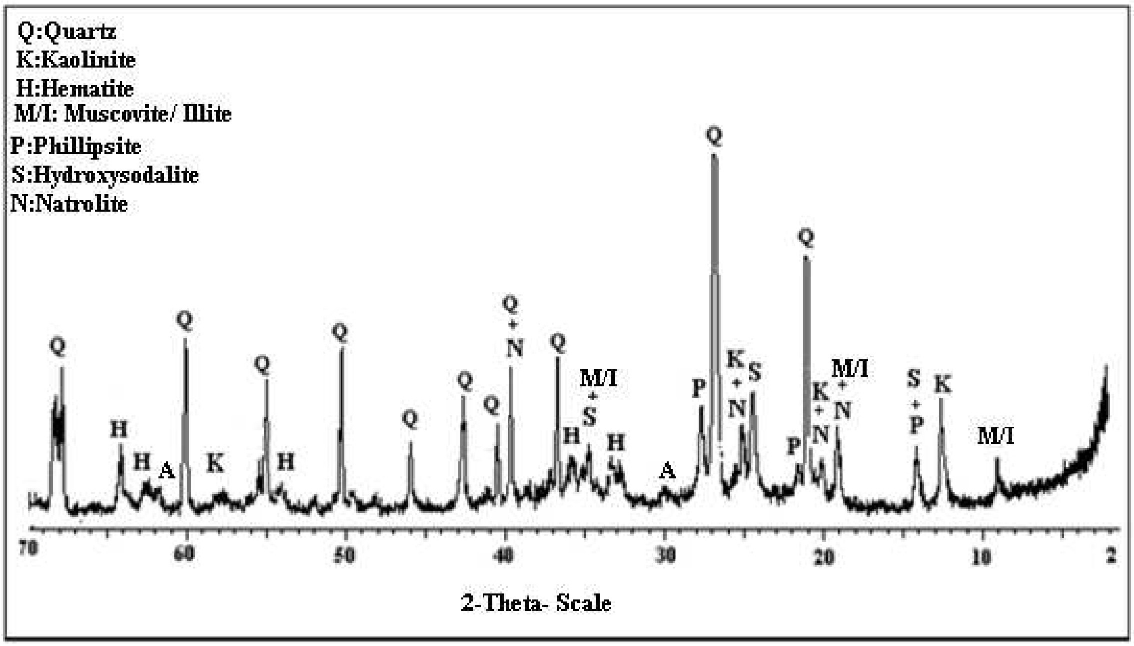

Figure 1: The XRD spectrum of the optimized geopolymer specimen

Durability. Geopolymer specimens were subjected to different types of durability tests namely: the drying shrinkage test, ambient conditions, de-ionized water conditions, wetting-drying cycles, and the aging tests under chemical conditions, which include the chemical attack, acid attack, and alkali-silica reaction. The samples proved to be stable under ambient and water conditions. Possibly a slow further hardening occurs improving the mechanical strength upon storage. The results for the wetting-drying cycles are shown in Table 2. The compressive strength varies between 18 and 30MPa without a trend. Even after 100 cycles no deterioration of the samples is observed.

Table 2: Mechanical strength for the geopolymers of JHK with sand (JHKS) under wetting-drying conditions

Cycles No.	5	10	25	50	100
Avg. Strength for mix. JHKS	21.7	25.5	25.3	21.5	24.6
JHKS 1	28.8	18.3	26.4	16.5	27.2
JHKS 2	18.3	31.4	19.1	26.0	21.4
JHKS 3	18.0	26.9	30.5	22.1	25.4

The specimens were also subjected to immersion in sea water and sodium sulfate solution. Again no negative impact on the samples was observed. The obtained compressive strength results during the acid attack (HCl, 0.1N) test are given in Table 3. According to these results, the compressive strength values decrease as a function of time. The average compressive strength has decreased already after 7 days to about 15MPa (starting from about 23) and decrease even further to 9 MPa after 90 days. The specimens are visually being attacked (weight loss) by the acid. The samples also do not withstand the alkali-silica reaction.

Table 3: Mechanical strength for the geopolymer specimens immersed in hydrochloric acid

Time	7	30	60	90
Avg. Strength mix JHKS	15.0	12.5	11.7	9.0
JHKS1	14.5	12.6	10.7	9.2
JHKS2	16.0	11.3	11.7	9.4
JHKS3	14.6	13.5	12.6	8.4

Conclusion

Geopolymer specimens were prepared from a local Jordanian Kaolinite (Hiswa Clay) and NaOH solution. An optimized composition of 100:100:16:22 kaolinite:sand:NaOH:water was obtained. The samples were shown to be stable under environmental conditions and to wet/dry cycles. Only acid and alkaline attack breaks down the material.

The Hiswa clay is thus suited to be used as a raw material for the production of bricks and tiles for the construction of water reservoirs.

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