Utilization of Clay-Containing Aggregate Sludge Waste as Structural Concrete and Asphalt Aggregate

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In the aggregate quarries in Çiftalan and Ağaçlı (Eyüpsultan, Turkey) regions, greywacke-shale type rocks belonging to the Thracian Formation are used as concrete and asphalt aggregates (Fig. 1). After crushing, these rocks are classified into 0-5 mm, 5-12 mm and 12-24 mm sizes and marketed as concrete and asphalt aggregates. Aggregates with sizes larger than 5 mm can be used directly in concrete and asphalt applications without any washing process, while aggregates with sizes smaller than 5 mm are called fine aggregates and are marketed after the washing process since the methylene blue value is too high for concrete and aggregate (Fig. 2a). After the washing process, grains smaller than approximately 100 µ in size (especially clay minerals) are stockpiled in waste sites (Fig. 2b).

Figure 1: Top view of the quaaries

Figure 2: a-Fine aggregate containing clay with grain diameter less than 5 mm, b-100 µ sieved waste sample

The main oxide compositions of these wastes were analyzed, revealing 54.51% SiO_2, 18.1% Al_2O_3, 19.66% combined fluxes (CaO, Na_2O, Fe_2O_3, K_2O, MgO) and 5.8% loss on ignition (Table 1). The waste materials with a grain diameter of less than 100 µ consisted of 28.6% quartz, 21.9% albite, 17% muscovite, 24.9% chlorite and 3.6% calcite minerals (Fig. 3). Additionally, 3.4% organic matter was detected (Table 2).

Table 1: Major oxide composition of waste (wt.%)

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI*	Total
54.51	1.11	18.10	7.74	0.13	3.74	3.64	2.01	2.53	0.23	5.80	99.54

*Loss on Ignition

Table 2: Mineral composition of waste (wt.%)

Mineral	Quartz	Albite	Muscovite	Chlorite	Calcite	Ornagic matter content
(wt. %)	28.6	21.9	17	24.9	3.6	3.4

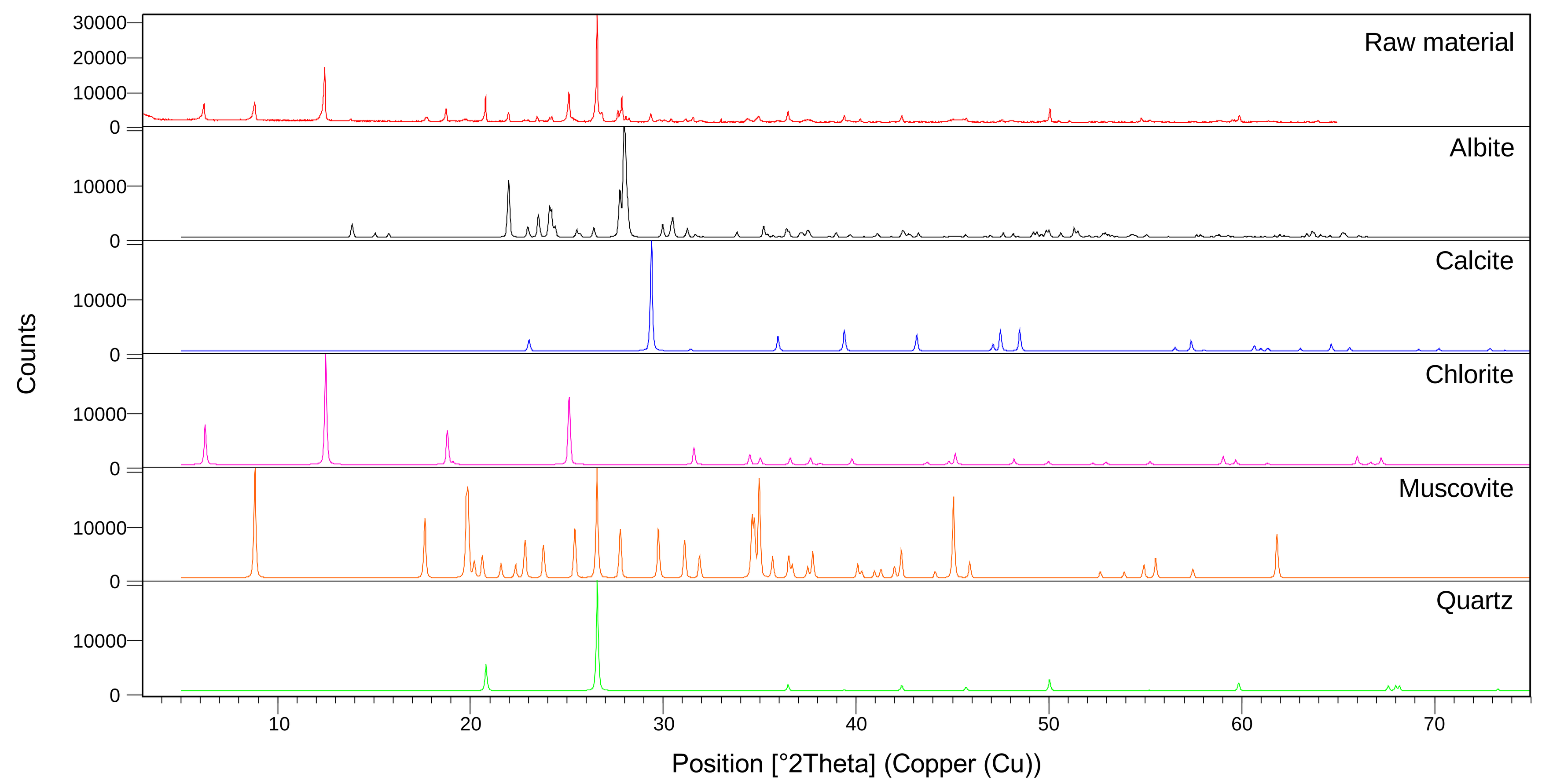

Figure 3: XRD pattern of waste

DTA (Differential Thermal Analysis) analyses revealed the occurrence of two distinct endothermic reactions within the temperature range of 500-600 °C and 700-800 °C, indicating dehydroxylation reactions (Fig. 4). Additionally, within the range of 1000-1100 °C, an exothermic reaction occurred, suggesting the formation of new phases or several phases (Fig 4.). Taking into account these thermal properties of the wastes, a sintering temperature of 1100 °C was established.

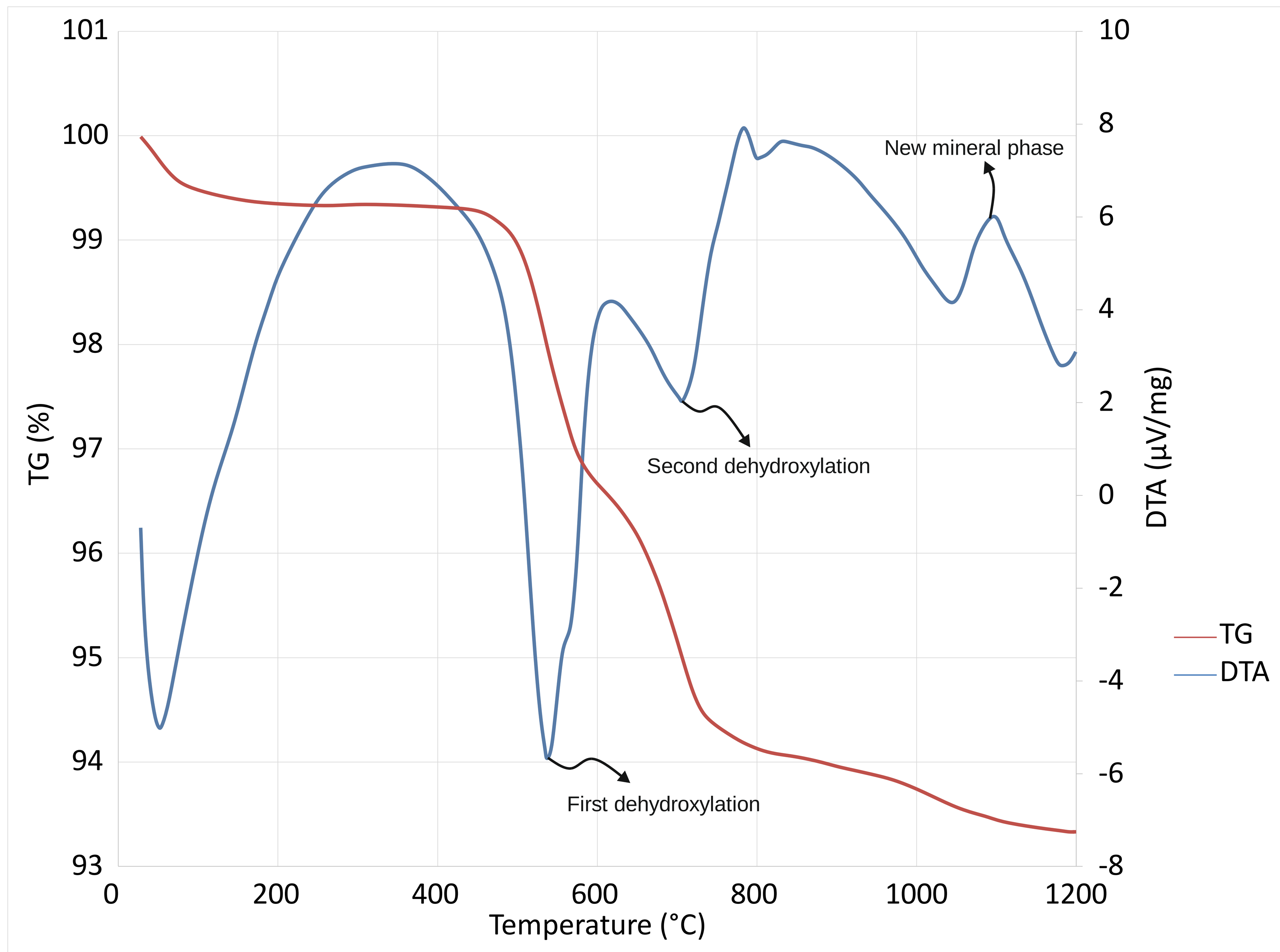

Figure 4: DTA and TG patterns of waste

In preparation for the sintering process, the samples underwent initial drying at 105°C, followed by milling and subsequent powdering. The powdered samples were then packed into a metal cell measuring 5 cm in diameter and 10 cm in height and compressed with a load of 200 kg per cm^2 (Fig. 5a and 5b). Due to the resulting height of the sintered cylindrical specimens being less than 10 cm, the Indirect Tensile Strength test method was employed to assess their strength (Fig 5c).

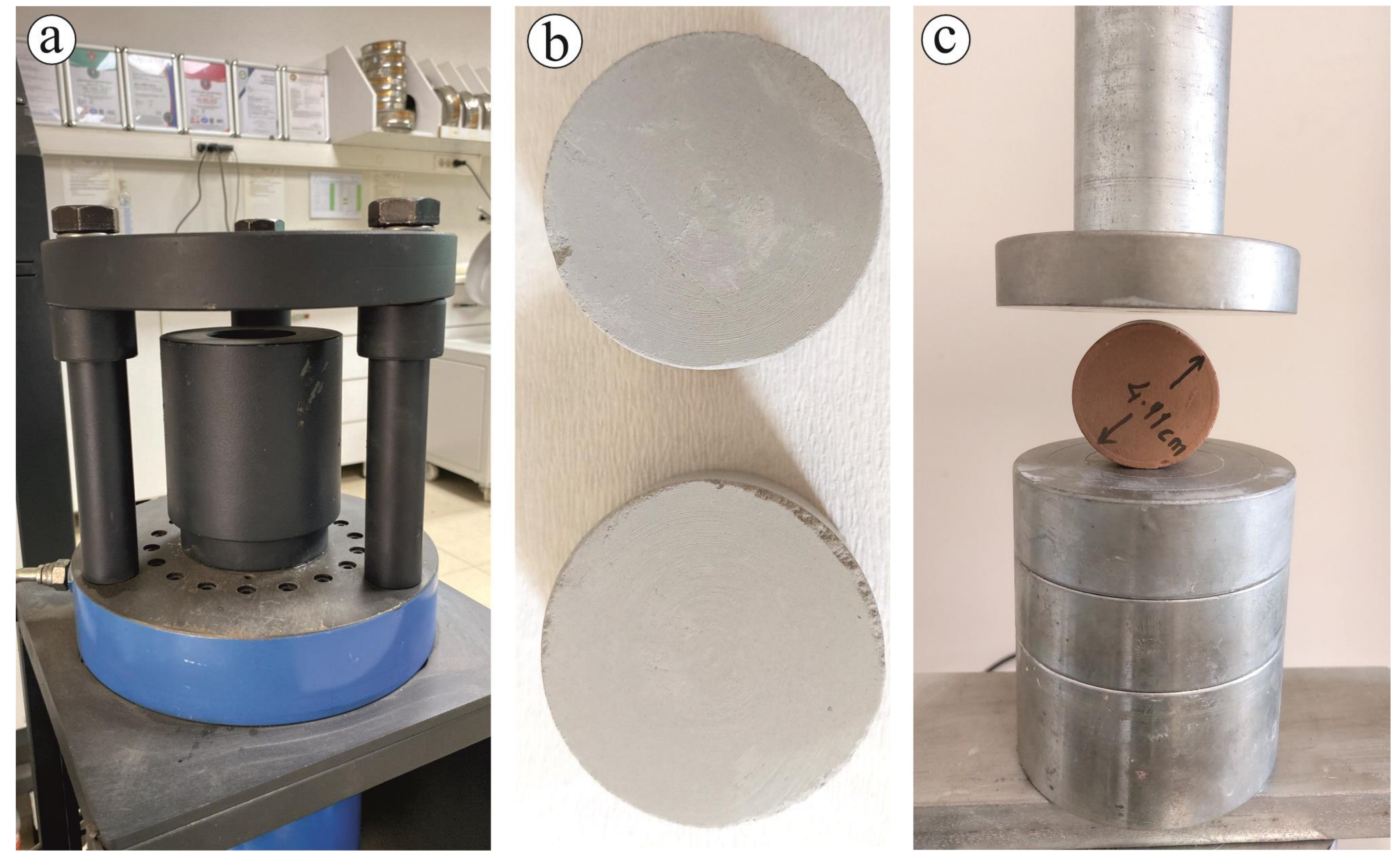

Figure 5: a-Compress machine, b-Compressed waste samples, c-Loading the sintered samples

The experiment demonstrated that three distinct specimens displayed Indirect Tensile Strength values of 8.8 MPa, 9.6 MPa, and 15.7 MPa, respectively (Fig. 6). Drawing from these strength measurements, it was inferred that the dust wastes originating from these aggregate quarries could be effectively employed to manufacture optimal products for concrete and asphalt aggregates.

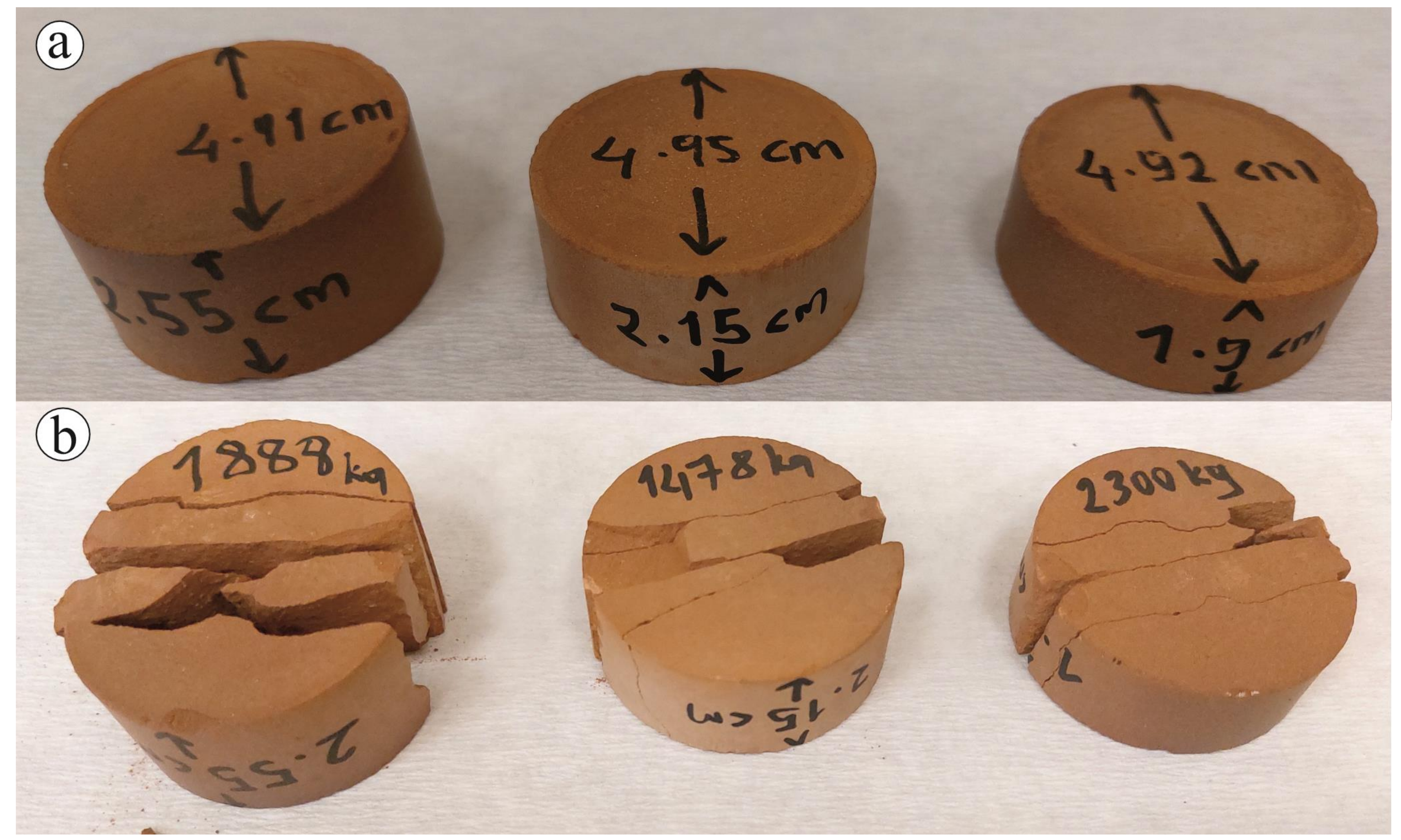

Figure 6: a-Sintered cylindrical samples, b-Samples after the Indirect Tensile Strength