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EUROPEAN COOPERATION
IN SCIENCE & TECHNOLOGY

SHORT TERM SCIENTIFIC MISSION (STSM) SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

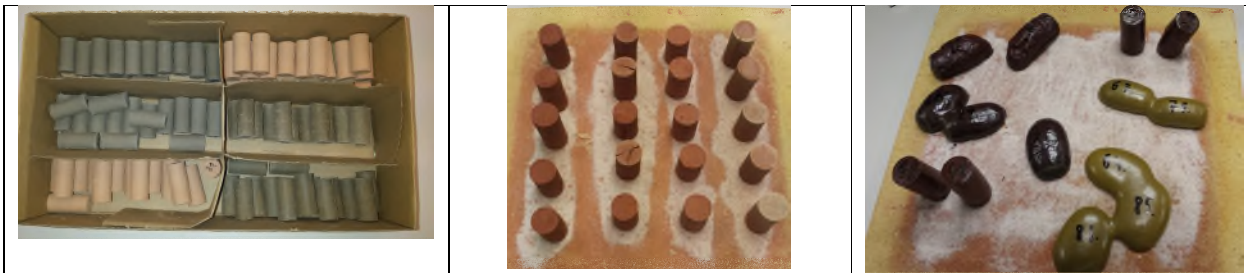
Action number: CA17133
STSM title: Development of new construction material utilising Air Pollution Control Residue (APCr)
STSM start and end date: 01/03/2020 to 13/03/2020
Grantee name: Dr Gaurav Goel

PURPOSE OF THE STSM

The aim of this STSM was to explore utilisation of Air Pollution Control Residue (APCr) in development of new construction material thus moving towards circular economy. The expected impact of sustainable production of such novel construction material is threefold: (i) reduced exploitation of natural resources (in this case clay), (ii) avoiding the problem APCr disposal and (iii) recycling of APCr as a secondary source for an environmentally-friendly material production. By joining active networks of Rudolfs Cimdins Riga Biomaterials Innovations and Development Centre (http://rbiac.rtu.lv/), I gained an insight into the current developments in Latvia towards circular economy. Colleagues at Riga Technical University have been working to create value added products from waste without substantially compromising engineering properties. For this purpose, excellent milling and grinding facilities have been developed, capable to grind in micrometer size. By participating in development of these brick/ceramic materials I could contribute my knowledge on recycling of waste materials. The developed bricks offer a solution on APCr disposal problems and reduce the consumption of clay thus offering a promising solution towards sustainable production of these bricks.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSM

In the first part of the STSM I characterized the clay and APCr sample. The homogenised clay from Liepa deposition , Lode Ltd brick factory (Latvia) was used for brick preparation. The clay lumps were dried at 105°C for 24 h, followed by refining in a jaw crusher to yield particle sizes in the range of 10-20 mm. Then they were milled using the laboratory disintegrator DSL-175 (Mironov et al., 2014; Shishkin et al., 2012; Zimakov et al., 2007), in selective mode for particle sizes < 50 μm.



(a) Green specimens | *(b) Sintered specimens* | *(c) Overburnt specimens*

Fig. 1: Prepared specimens

Clay mixtures with APCr content of 13 wt% and APCr and Glass 22 wt% were prepared by mixing-milling.The preparation of specimens comprised of the following steps. Samples of clay - APCr and glass 15 wt% were prepared by adding 14 wt% distilled water to the dry clay - glass mixtures, which were subsequently mixed to obtain a homogeneous plastic mass, which was inserted in the extruder. Cylindrical samples, with a diameter and height of 14 ± 1 and 18 ± 1 mm, respectively, were extruded. These were air-dried for 72 h, then in ovendired (MEMMERT ULE 400 (Memmert GmbH + Co. Schwabach, Germany)), for 24 h, and subsequently sintered in a furnace (Nabertherm LHT 08/17 equipped with controller P330 (Nabertherm GmbH, Lilienthal, Germany)), at temperatures of 700, 800, 900, 1000, 1050, and 1100 °C in an air atmosphere, at a heating rate of 5 °K/min and a dwell time of 30 min at the highest temperature. The height of the obtained samples was sawn down to 14 ± 0.5 mm with help of the Buehler IsoMet Low Speed Saw (Illinois Tool Works, Glenview, IL, USA). Seven samples were prepared (Fig. 1.).

During the second part Physical and Mechanical Properties were determined. I am thankful to Dr Andrei Shiskin for completing this part as activites of the STSM were affected due to COVID-19 situtation. Firing shrinkage was determined by direct measurement of the sample's linear dimensions before and after firing. The liquid (distilled water) absorption, bulk density, apparent density and apparent porosity were determined by the Archimedes method (*Annual book of ASTM standards, ASTM Standards C20*, 2015). The apparent porosity was calculated as the sum of open and closed porosity. Compressive strength of the sintered cilynder samples were assessed using a Universal Testing Machine (UTM) (Instron: 8801) at room temperature and a strain rate 0.01/s. The reported results of all tests are based on a set of five samples in each category, and the average value and standard deviation have been calculated.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

Water absorption and compression strength of APCr mix samples with different loadings are shown in Fig. 2 and Fig, 3, respectively. Water absorption values increases for APCr mix samples and it decreasres with a firing temperature increase beyond 1000°C.

Water uptake capacity decreases from 22% to 5% for APCr mix after temperature increase from 1000°C to 1100 °C, as shown in Fig. 2. Tested clay exhibits densification and formation of closed pores caused a reduction in water uptake capacity after sintering at temperatures above 800 °C. Sintering temperature increase above 850 °C resulted in deformed and overburnt samples for pure clay.

Addition of the tested glass feedstock up to glass content levels of 15 wt.% reduces water uptake and compressive strength at all sintering temperatures.

Compression strength decreases for all APCr mix series. With the firing temperature increase beyond 1050°C it increases. However, the intensity of increase is highly dependent on the APCr content. Many of the pure clay bricks were damaged due to melting and overburning and their values were not determined. In this case, the amount of APCr plays a more significant role, and the result of 13% APCr composition shows a higher value of compression strength than APCr and glass 15 wt%. Overall, the low mechanical properties of 22% mix could be explained by the lower mechanical properties of the glass phase.

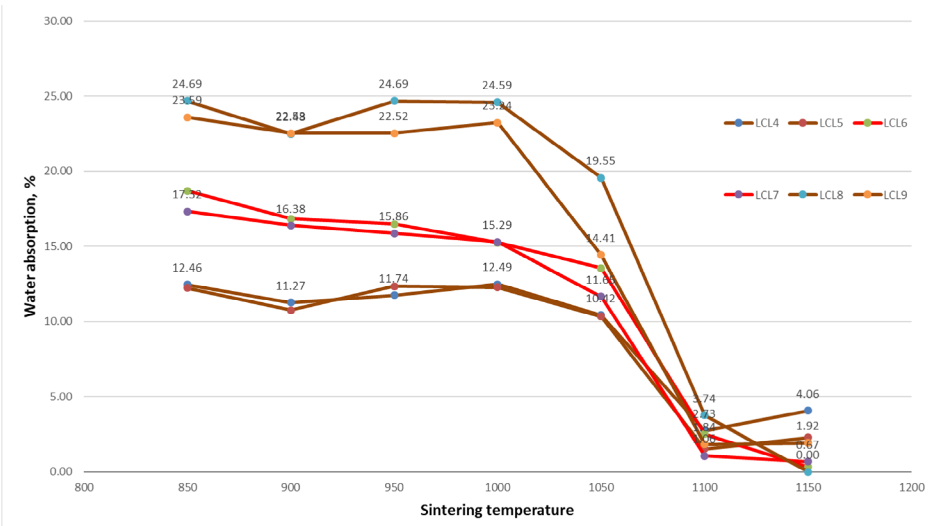


Fig. 2: Water absorption of brick samples

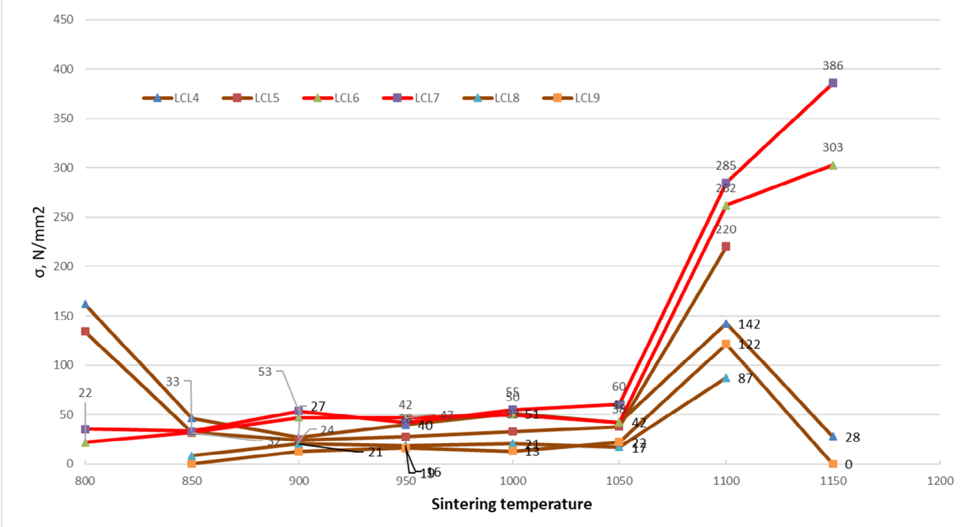


Fig. 3: Compressive strength of brick samples

FUTURE COLLABORATIONS

The cooperation with the Rudolfs Cimdins Riga Biomaterials Innovations and Development Centre at Riga Technical University, Latvia will continue. It is planned to write a joint paper entitled “Development of new construction material utilising Air Pollution Control Residue (APCr)” based on a results obtained during the STSM. Another paper titled “Recycling of cullet for energy efficient fabrication of porous ceramic to achieve sustainability in large scale industrial waste water filtration” has been submitted in Journal of Cleaner Production. Further collaboration will be developed based on our mutual interests.

References

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