DEFEAT

Development of an Innovative Insulation **F**ire Resistant Facade from the Contruction and D**e**molition W**a**s**t**e.

Newsletter

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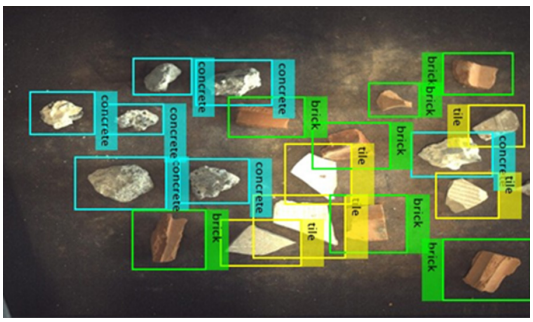
DEFEAT Highlights

Robotic Separation of Construction and Demolition Wastes (CDW)

Hardware System of CDW Separation

The separation of CDW in the 3 main types of interest, i.e. concrete, bricks and tiles was achieved through a prototype system. The hardware configuration of separation has been assembled and consists of a conveyor belt that carries the mixed rubbles, an industrial 3D camera overlooking the conveyor workspace and two robotic manipulators, one on each side of the conveyor.

The brain of the process utilizes a supervised deep learning image processing approach that identifies the type and the location coordinates of each rubble. This information is then fed to the robotic arm manipulators to perform a pick and place action and separate the different types of rubbles deposited on the conveyor belt. The camera is setup in a supervising position of the conveyor workspace at a height of one meter. It is interfaced through a graphics processing unit (GPU) and allows snapshots to be taken either by external or software triggering.



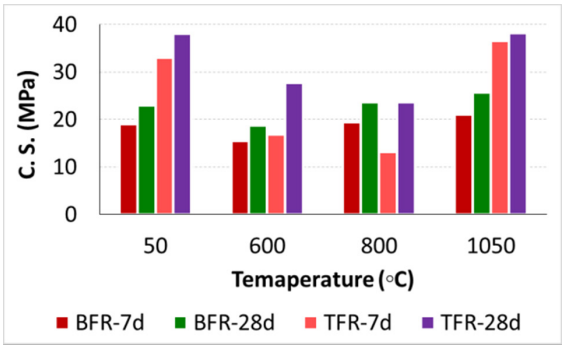
Realisation of the YOLO detection and classification process

The snapshots taken are input to a combination of supervised deep learning architectures for the detection and classification method of CDW. So far, 100 images and a total of 400 samples of each type of CDW were recorded. The images were pre-processed to a format compatible with the training of the YOLO object detection network. In the YOLO detection and classification method each rubble is framed, its type is identified and a confidence score is given. Current work on the CDW Separation system focuses on the optimisation of the deep learning algorithm, the integration of the image processing and the robot programming.

Raw Materials Characterization

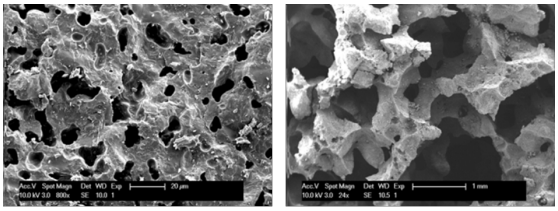
The three specific streams of CDW used as raw materials in the research activities of DEFEAT project, i.e. bricks, concrete and ceramic tiles, are fully characterized in terms of chemical and mineralogical analysis, particle size distribution, density and Si and Al dissolution in Na- and K- based alkaline solutions. The high Si and Al content and the easily dissolved Al-Si mineralogical phases of bricks and tiles made these streams suitable precursors for the development of geopolymeric materials.

Design and Development of a composite fireproof and heat-insulating geopolymeric material



Residual Compressive Strength of optimized geopolymers based on bricks (BFR) and tiles (TFR) in 7 and 28 days after curing (50 °C) and exposure at 600, 800 and 1050 °C

Based on waste bricks and waste ceramic tiles, fire resistant and thermal insulation geopolymeric materials were developed and optimized to be combined together in one composite building façade. The optimized fire-resistant geopolymers kept their shape unchanged, without presenting any apparent surface defects or spalling and damage phenomena, after their exposure at temperatures up to 1050 oC. Their residual compressive strength was high, ranging from 15 to 40 MPa. To confirm the applicability of these materials for the passive fire protection of buildings, their testing according to the standard ISO 834 time-temperature curve is planned in the coming months. The optimized heat-insulating geopolymers reached densities ranging between 400 and 550 kg/m3, with extensive porosity developed through foaming with hydrogen peroxide or aluminum powder. Their compressive strength varied from 1 to 5 MPa, which was considered as satisfactory for materials focused on thermal insulation of buildings. From now on, the Consortium's efforts will be concentrated on the assembling of the innovative façade that will combine both of the optimised geopolymeric materials. The final product will consist of a core from the optimum porous heat-insulating geopolymer, covered by the optimum fire-resistant one.



(a) (b)

Porosity of geopolymers based on (a) waste bricks and (b) waste tiles

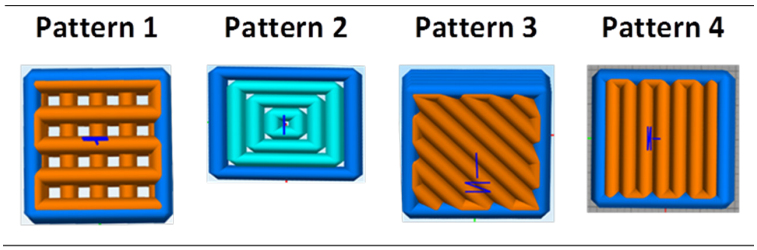
Besides, the Katholieke Universiteit Leuven (KUL) in Belgium (i.e. the Foreign Organization of the DEFEAT consortium) developed innovative geopolymers based on CDW bricks and tiles that achieve thermal insulation and passive fire protection of a building, at the same time. These materials show extensive porosity, relatively high compressive strength (20 to 40 MPa) and high residual compressive strength (35 to 70 MPa) and structural stability, after their exposure at temperatures up to 1100 oC. Their testing according to the standard ISO 834 will also take place in the coming months.

Materials and Properties Engineering

Test trials on 3D printing process with the new equipment installed at Frederick Research Center (FRC)

The feasibility of 3D printing process to manufacture fire-resistant and heat-insulating CDW-based geopolymeric materials with sufficient mechanical properties was evaluated through a series of well-designed experiments and tests. After several test runs performed with the new 3D printer installed in the laboratory of Frederick Research Center (FRC), the involved research team concluded for the deposition strategy and operation parameters that have to be followed during the build-up process. Studied parameters included feeding speed, extrusion rate, layer height, printing speed and deposition pattern (geometry, internal infill type and infill percentage). Moreover, the rheological properties of different geopolymeric pastes were assessed and their viscosity was measured, as a function of time. To select the appropriate process parameters for 3D printing of geopolymeric materials, different compositions of feeding material, deposition patterns and infill percentages were evaluated.

Tested patterns include the rectilinear ones (0o/90o) with infill percentages 60% and 100% (Patterns 1 and 4, respectively), the ones with perimetric lines outside-in and infill percentage 100% (Pattern 2) and the triangular ones (45o/-45o) with infill percentage 100% (Patterns 3). The 3D-printed geopolymeric materials developed similar compressive strength to the relevant casted ones, when infill percentage was 100%, regardless the pattern and the raw material used. Actually, pattern seems not to affect the mechanical strength as much as the infill percentage. The compressive strength of the rectilinear pattern 3D printing geopolymers with infill percentages 60% and 100% was 3.6 MPa and 14.1 MPa, respectively for the tile-based materials and 3.2 MPa and 12.6 MPa, respectively for the tile-based ones. Based on the experimental results so far, the 3D printing will be optimized in the coming months and boards of semi-industrial dimensions will be produced for demonstrating purposes in the frame of DEFEAT project.



Optimum patterns for the 3D printing of geopolymers

Strategic Action Plan for the CDW Recycling and Reuse

In order to better record and understand practices and perceptions of Cypriot stakeholders involved and interested in the reuse of recycled CDW, a survey was conducted between the months of September 2021 and December 2021.

The survey questionnaire comprised of 20 questions (plus demographic items) and data collection was based on (i) face-to-face interviews and (ii) electronic responses via electronic mail. The population of stakeholders (obtained from sources such as the Chamber of Engineers in Cyprus and the Federation of the Building Contractors Associations of Cyprus) is estimated at 2675 civil

engineers, 2135 architects and 2300 building contractors and materials suppliers. 187 individuals were also participated in the survey, hence producing a statistical sample that allows for a Confidence Level of 99% with a Confidence Interval of 9%. Stakeholders from all areas of Cyprus were sampled, according to census population data and the response rate to the survey was approximately 40%. The data obtained were statistically analyzed and are being further studied so that they can form one of the bases for the development of an Action Plan for the successful reuse of CDW in Cyprus.

1st Progress Evaluation Meeting of DEFEAT Project

The 1st Progress Evaluation Meeting of the DEFEAT Project (INTERGRATED/0918/0052) was held remotely on the 7th of June 2022.

The work elaborated during the first 18 months of the Project and the further planned actions for its successful implementation were presented from the Consortium Partners to an external Evaluator and the Project Scientific Officer. During the meeting, productive discussions took place between the Evaluator and the project Partners. The Evaluator pointed out the important scientific work performed by the Consortium and the compliance with the contractual obligations, while he also provided scientific advice on several issues.

After the successful evaluation of the project progress so far and the positive comments received, Partners will continue their research and scientific efforts, in order to achieve the timely implementation of the DEFEAT Project, and succeed in reaching its objectives.

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