JAMES DYSON FOUNDATION UNDERGRADUATE BURSARY
Project report
Title: Plastic-sand bricks
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Introduction

According to the International Union for Conservation of Nature (IUCN) [1], 14 million tons of plastic end up in the sea every year, and 80% of all marine litter is plastic waste. This has fatal effects on marine life, is harmful to human health, exacerbates climate change, and worsens food quality [1. A sizeable amount of this plastic pollution washes up on the shores of many coastal countries in Africa, where some of the villages lack adequate waste management facilities.


Moreover, many of these areas lack sustainable and affordable construction materials. For example, in Kenya some buildings are built using coral bricks, mining of which reduces the coral variety and coral reef fishes. Plastic bonded sand bricks can provide a solution to both problems: plastic waste left to degrade in the environment and unsustainably sourced construction material. The bricks can be made from waste plastic and may provide sustainable and reasonably priced building materials. The project focuses on finding a safe plastic-sand bricks' manufacturing process and optimising materials to achieve optimal mechanical strength (maximum compressive stress) of sand bonded by HDPE and LDPE plastic blocks.

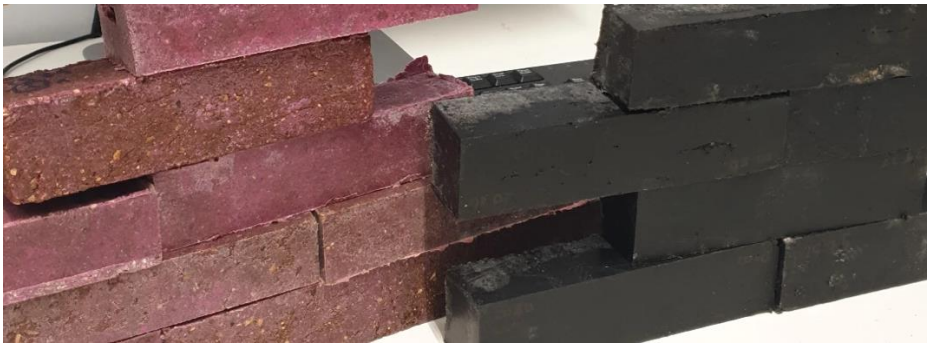
Safe manufacturing process

This project aims to develop a safe manufacturing process that could be performed by the average skilled person in a remote village. Many existing manufacturing methods use firewood to make their blocks. Firewood burns at a much higher temperature than the melting temperature of most plastics, which can cause parts of the plastic to degrade and release large amounts of toxins. Thus, this manufacturing process should be avoided as it is challenging to regulate the temperatures and keep it below polymer melting temperature when using firewood. Therefore, controllable heat sources were picked: the first method involves melting plastic sand in a saucepan on a hotplate and forming it in moulds, and the second method considers melting plastic in an oven and using a compression machine to form it into shape. LDPE and HDPE plastics were selected for this investigation as they give a wide range of temperatures to safely operate at without burning plastic (between 130◦C and 300◦C), and they are miscible plastics. The first method was not practical due to poor heat exchange and the need for constant observation to avoid plastic burning. The second method was therefore used to manufacture samples. The method involved melting the plastic-sand

mixture in the oven, kneading, and folding it to provide a more mixed mixture and compressing the blocks in a closed die forging rig as shown in the following figure. The toxic fumes were investigated and found safe for the plastic samples.

Testing mechanical properties

Three-point bending and compression tests were performed using an Instron machine to determine the structural strength of the bricks and if they would be suitable for 1-2 storey buildings. Tests were performed for HDPE plastic for 20%, 25%, 30%, 35%, 40% plastic content and LDPE samples of 20%, 25%, 30%, 35% plastic content. For HDPE plastic, the optimal ratio, where compressive strength is highest, was 30:70 with an average compression strength of 37.3MPa. For LDPE plastic, 20:80 was optimal plastic content with an average compression strength of 25.2MPa. The optimal ratio happens because, with sand proportion above optimal, there is not enough plastic to cover all sand particles, which lumps plastic together, causing brittle failure. With sand proportion below optimal, there is plastic excess; this means that compressive strength depends more on the plastic than the sand, hence is lower. Therefore, at optimal, there is enough to cover all sand particles and not have excess to achieve maximum strength. For plastic bricks to be used in 1-2 storey buildings compressive strength had to be above the 9 MPa requirement (according to BS EN 771 for clay bricks). Therefore, results show a great possibility to be used in low-rise buildings as all the results were significantly higher than 9MPa. Bricks are shown in the following figure: pink bricks are made using pink HDPE plastic and black bricks using black LDPE plastic.



Conclusion

In conclusion, plastic bricks were chosen as they create value (construction material) out of waste. LDPE and HDPE plastics were investigated in this project because they both melt above 130◦C and start burning at around 300 ◦C, leaving a wide gap to operate safely without releasing many toxins. The manufacturing method was developed, where plastic was melted in an oven, kneaded with sand, and then compressed into blocks using a compression rig. For HDPE samples, the optimal ratio was found to be 30:70, giving average compressive strength of 37.3MPa. For LDPE blocks, the 20wt% plastic addition was optimal, giving 25.2MPa. All results indicate that samples tested are more than two times stronger than the 9MPa requirement for a 1-2 storey building.