Reducing overheating in buildings with passive solar systems made from textile wastes

Michael M. Santos [1], Madalena Sena [2], João C. G. Lanzinha [3]

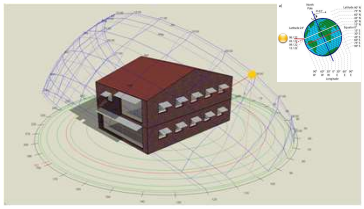
1: Centre of Materials and Building Technologies (C–MADE/UBI), Department of Civil Engineering and Architecture, University of Beira Interior (UBI), 6201-001 Covilhã, Portugal. E-mail: michael.santos@ubi.pt

2: Center For Research in Communication, Information and Digital Culture (CIC·DIGITAL), Nova University of Lisbon, Portugal. E-mail: emmesenn@gmail.com

3: Centre of Materials and Building Technologies (C–MADE/UBI), Department of Civil Engineering and Architecture, University of Beira Interior (UBI), 6201-001 Covilhã, Portugal. E-mail: jcgl@ubi.pt

Context

Before discussing shading elements, it is important to have an understanding of the different types of solar radiation that affect the glazed openings of buildings. Solar radiation consists of three types of electromagnetic waves: infrared (IR), visible (VIS), and ultraviolet (UV). The spectrum of solar radiation varies based on the position of the sun in the sky and the absorption and reflection of the surrounding environment.



Visible radiation is responsible for natural lighting of the environment and is perceived by the human eye. It is crucial for the health and well-being of occupants in the space. Infrared radiation is responsible for heating the environment, while ultraviolet radiation is the main cause of damage to skin and materials.

Glazed openings are a critical component of modern architectural design of building. They allow natural light to enter inside, provide panoramic views, and create a sense of open space. However, the extensive use of glass can lead to problems such as excessive heat, glare, privacy risks, and general discomfort for building occupants. To address these issues, shading is an essential element of facade design.

The use of awnings to shade glazed openings has a long history dating back to ancient Egypt, where awnings made of cloth or papyrus were used to protect construction windows from adverse weather conditions. Awnings were also popular in ancient Greece and the Roman Empire. Over time, awning technology has evolved, and they are now made from various materials such as canvas, vinyl, plastic, wood, or aluminum. Awnings are commonly used worldwide to protect glazed openings from adverse weather conditions and to control the amount of sunlight entering a building, particularly in warm, sunny climates where excessive heat can be a problem.

In non-industrial buildings, the space heating and cooling process to maintain thermal comfort can represent up to 60-70% of total energy consumption. Shading devices can reduce incident solar radiation and improve thermal and visual comfort in indoor environments. External shading is most effective in reducing interior overheating since most of the solar radiation is blocked out of the building and reflected. If comfort is improved by passive measures such as awnings, the energy demand for cooling will be much lower.

According to the European Environment Agency (EEA), the European Union produced approximately 16.7 million tons of textile waste in 2017. The total amount of textile waste produced worldwide is challenging to quantify, but estimates suggest it is around 92 million tons per year, according to a report by the United Nations Children's Fund (UNICEF) and the Ellen MacArthur Foundation. However, the numbers may vary significantly depending on the methodology used to define and measure textile waste.

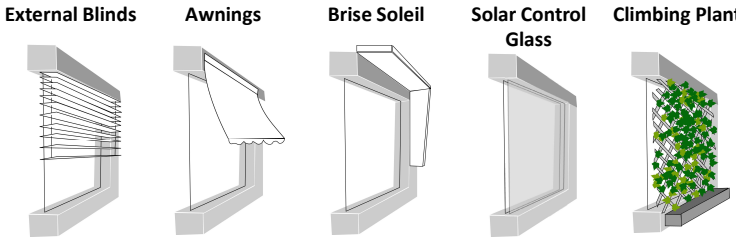
This proposal aims to achieve the following objectives:

1. To promote the reuse of textile waste in the production of awnings
2. To design innovative awnings that decrease surface temperature and increase convection
3. To promote a circular economy and extended circularity across different industries
4. To increase awareness and encourage sustainable textile practices.

Results

Starting point

There are several types of shading that can be used in buildings, such as:



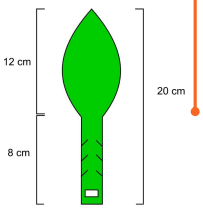
Problem / opportunity

Combining the circular economy's goal of maximizing the value of existing resources while minimizing waste and pollution with the opportunity of using efficient shading techniques in glazed openings, which reduces electricity consumption by using recycled or reused textile fabrics, makes it possible to create innovative and sustainable solutions to the problem of textile waste. This approach also helps promote a healthier and more comfortable environment.

Shading system proposal

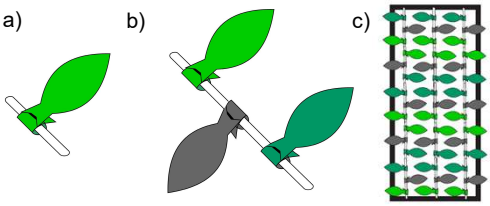
Discarded textiles

Sorting, cleaning, and treatment



Cut according to the proposed design

The individual elements (leaves) can be combined in various configurations to provide shading, like a traditional awning. The density of the elements can be increased to achieve a higher percentage of shading, as desired. Besides circularity concerns, the suggested design aims to minimize the visual impact of the awnings. Below are some configurations:



a) Flange sheets are used for fastening to a tubular system.
b) Combination sheets in the tubular system.
c) Combination of sheets in a tubular shutter-type structure.

d)

d) Example of an application in a traditional building, aiming to reduce the visual impact of conventional shading.

Conclusions

To improve textile sustainability throughout its life cycle, from design to end-users, this work proposes an alternative and innovative awnings design to promote surface temperature reduction, increased convection, and the untapped economic potential of reusing textile waste or recycling into canopies, thus promoting circular economy and extended circularity across different industries.

- Reduction of solar heat gain
- Light control
- Improved privacy
- Enhanced aesthetics
- Reduced environmental impact

ECOCITY World Summit London 2023

Funding: This work is supported with Portuguese national funds by FCT - Foundation for Science and Technology, I.P., within the C-MADE- UIDB/04082/2020.

UNIVERSIDADE BEIRA INTERIOR

C MADE CENTRE OF MATERIALS & BUILDING TECHNOLOGIES