

*Proceedings of the TensiNet Symposium 2019*

Softening the habitats | 3-5 June 2019, Politecnico di Milano, Milan, Italy

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## Textile architecture: "dressing the Aurelian walls"

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### Abstract

Rome has been exponentially increasing its lands use till 2030, with a rate of 3sm/minute. In the near future developers and authorities will have to face not only the restorations of existing building stocks, but also the environmental and social sustainable regeneration of wider open-air zones and still empty urban spaces (Ottone, Cocci Grifoni, 2018; Gehle, 2017). The study focuses on a representative cultural heritage built system in Rome - the Aurelian walls - which is listed as outstanding part of a new green infrastructure by the city regulatory plan. This ancient wall-ring surrounding the historical centre of Rome has seen as a potential area where to apply novel strategies of urban regeneration, due to the presence of several neglected urban zones and uncomfortable public spaces. Taking inspiration from Christo and Jean-Claude's artistic avant-gardes interventions, the authors are envisioning the temporary application of lightweight composite meshes as a sun-shading protective path, able to interact with the thermal mass of the ancient walls, in order to increase the level of thermal comfort of the open-air urban spaces. The final goal is, on one hand, to simulate the performances of the developed textile shells' building system and to assessment its potential of heatwaves mitigation, and, on the other hand, to investigate the replicability rules of temporary textile-based architecture as a mean for re-activating - in a sustainable and reversible manner - the urban live and the care of ancient and delicate, cultural heritage contexts.

**Keywords:** outdoor comfort, fiber design, parametric design, composite meshes, urban heatwaves mitigation.

DOI: 10.30448/ts2019.3245.19

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Peer-review under responsibility of the TensiNet Association

## **1. Introduction**

Starting from the visionary experiences of technological and constructive avant-gardes and taking inspiration from Christo and Jean-Claude's specific artistic intervention, that covered 259 meters of urban walls with polypropylene and rope for 40 days, this essay investigates how to improve climatic conditions through the use of technological textile shells matched to the thermal mass of the walls. The study aims to verify - through a performative design process and comparative analysis of simulated constructive alternatives - the hypothesis that, thanks to the application of light and breathable materials connected to a massive long-line construction system as the Aurelian Walls in Rome, a comfortable open-air zone can be created, offering a new quality to the urban areas adjacent to ancient wall ring.

The material taken into consideration, a key factor and the power supply of new locations, is based on an innovative technology, composed of multi-axial natural fibers, with high solar reflectance and high thermal emissivity (Cocci Grifoni, Tascini, Cesario, 2017).

The thermal characteristics of textile depend on the fiber type and the density of the "weaving" technique, for instance the specific pattern created by the overlapping of several fibers before the finishing lamination process. Through a parametric design, it is possible to modify not only the aesthetic yield of the material but, after a survey of the stress agent on the surface, it is possible to make the texture itself structural, optimizing the use of the installation systems.

This fiber-designing methodology can shape a novel kind of soft, sinuous, light, non-invasive and reversible architecture. Through the Aurelian Walls' case study we are willing to validate this design methodology, which allows:

- the definition of innovative technological systems that use external thermal comfort as one of the main requirements to consider in the design phase.
- the integration of the parametric climatic simulations already carried out (Ottone-Cocci Grifoni, 2017) with further data deriving from the material and its structure.

The optimization of the life span of textiles materials in relation to the desired structural form and functional needs; the replicability of the technological solution to be applied in historical urban contexts.

The dissemination of these reproducible, temporary and transformable systems could contribute to the environmental regeneration of parts of untapped urban fabric, using the thermal mass already present and expanding its effectiveness as a climate mitigation mean.

## **2. The Aurelian walls: an urban resource**

The Aurelian Walls were built in only 5 years in 270-275 a.C. by the Emperor Aureliano and elevated by Onorio start of 4<sup>th</sup> Century a.C. were developed for about 19 km. The Walls have been restructured and reinforced along the centuries, depending on the functional and military requirements, and saved almost the total integrity until the modern age.

The modifications realized on the original structure in course of the ages, such as the modernization of the original doors and the introduction of new passages, have been necessary for the development of the road networks. Only 13 km are currently left of the ancient walls: it is an open-air monument, at the same time an urban infrastructure symbol of the identity of Rome.

Though the Aurelian Walls are a unique patrimony of their kind, being an inestimable source of historical/cultural- and social value, continuous changes happened over the years, the rapid changes of the city, as well as several social and historical changes, made this monument loose identity and value. A program strategy for the realization of a linear park along its perimeter has been introduced the last **General town development plan**, with the aim of "recovering all the open spaces that can be redeveloped or restructured to enhance this exceptional building". (Municipality of Rome, PRG, 2008).

In particular, the case-study project of "**Dressing the Aurelian walls**" focuses on just a part of the Aurelian' Walls, exactly between Porta San Giovanni and Porta Maggiore, which identify the limit of the historical centre of Rome. This is a problematic area because of the concentration of car traffic and the lack of green areas able to regenerate air quality. Currently, a small linear garden runs along the stretch of walls without giving a significant contribution to this area's microclimate.

## **3. The problem of heatwaves mitigation in Rome**

In just one year, the City of Rome has transformed 54 hectares of soil, the highest value in front of the Italian big cities - Turin 22 hectares, Bologna 17 hectares. In numbers, land use passed from 31.064 to 31.594 hectares (24,58 %) between the 2012 and the 2016. If this current trend continue, we can foresee up until 2030 an increase of 2.895 hectares , 161 hectares per year, it means 3 square meters per minute, so + 9,32% (source ISPRA).

One of the easily predictable effect of this soil loss is, for sure, the rise in temperature.

According to the report “Future heat-waves, drought and floods in 571 European cities”, drawn up by a team of the Newcastle University and the Willis Research Network (Guerreiro, Dawson, Kilsby, Lewis, Ford, 2018), which has analyzed the climate changes in European cities, noting an aggravation of the heatwaves in all of these 571 examined cities (Rome is in the high eight of this ranking).

The United Nations’ International Panel on Climate Change (IPCC) recognized the key role of the cities to deal with climate change, and it highlights «Micro-climates at urban/city scales and their associated risks for natural and human systems, within cities and in interaction with surrounding areas. For example, current projections do not integrate adaptation to projected warming by considering cooling that could be achieved through a combination of revised building codes, zoning and land use to build more reflective roofs and urban surfaces that reduce urban heat island effects (Hoegh-Guldberg, Jacob, Taylor, 2018).

Starting from these considerations, we can state that, in the near future, professionals, construction companies and city administrators will have to identify new possibilities of under-exploited urban spaces transformation, without further soil consumption, with the goal to turn them into new urban resources, improving climate, social and economical conditions.

We therefore imagine an architecture for the open space, which can modify the framework of the city, enhancing environmental quality and connecting with the city from a physical-perceptive point of view.

Furthermore, ephemeral installations can be seen as a valid alternative to create contemporary architecture within the city of Rome, due to the very restrictive limitation of the authority dedicated to the protection of historical and architectural heritage.

#### **4. The need and the opportunity of temporary and soft architecture in cultural heritage contexts**

*“To design sustainable buildings means to get in touch directly with the weather and the core concept of place. This process seems a step towards the complexity of the nature rather than the man-made mechanicals. We need buildings with a high degree of empathy, a creative empathy” (Mario Cucinella, 2016).*

Through the design of a big, ephemeral, light and soft architecture, we imagine a different use of an almost forgotten portion of the city, even if it is placed in the central urban fabric and near to the public transport infrastructures.

The design simulation process here presented has to be seen as a programmatic research exercise, which is motivated by the need to carry out a verification of the effects that the project can achieve on the microclimate, acting on a grand scale (almost hyperbolic), in order to stress the result and make it more meaningful.

The project idea starts from the utopian thoughts, looking on the one hand at Buckminster Fuller's utopias (Emili, 2003), like the geodesic climatic dome above the center of Manhattan in 1960, but on the other hand at the radical architecture of the 60s and 70s (Archigram, Superstudio, Cedric Price), that aimed at the creation of a functional urban superstructure for the city. These theories however were at the time impossible to carry out in the practice, due to technological lacks. «But we're at time when Bucky said that there would be ample resources to support all life at a higher standard of living than anyone has ever known. All we need to do is shift our focus and resources from weaponry to "livingry" as Bucky championed for most of his life» (Sieden, 2013).

Approaching Rome's specific case, the limitations for the protection of ancient monuments have generated, since the 1980s, a reflection on temporary and ephemeral architecture as an opportunity to intervene in historic cities with events capable of re-activating neglected sites that would suddenly come alive. The artwork "The Wall - Wrapped Roman Wall" (1974) by Christo and Jean-Claude, who wrapped part of the Aurelian wall with 259 meters of polypropylene fabric and ropes for 40 days, is the main example of the creative possibilities of this area. Other crucial references are the experimentations conducted by Renato Nicolini, Petroselli and Costantino Dardi's art exhibition "Transavanguardia, Mura Aureliane".

The goal is therefore to transform these conceptual and visionary experiences into a methodology of intervention within historical contexts, using the same communicative and symbolic force to obtain an environmental result that would transform some areas of the city, making them less exposed to the effects of climate change.

Through this study, we want to put forward the use of a light material, an innovative fabric, reusable and able to not only to regenerate an urban context left unused, in totally abandoned, but also to generate a system able to improve the urban comfort from several points of view, architectural, climatic / environmental and perceptual.

In addition to the survey methodology based on the CFD simulation system (Computational Fluid Dynamics), we thought it would be appropriate to stress dimensional data using the concept of paradox, to bring the project in an ideal scenario with extreme dimensions to obtain convincing and significative responses.

## 5. The concept of “dressing walls”: a weather-adaptive sun-shading path for the city of Rome

This project’s conceptual idea was developed during the teaching experience of the Environmental Design Laboratory at the University of Camerino, School of Architecture and Design. A long-line of wooden portals climb over the existing walls, without interfering with the ancient structures. The preliminary study of the shadows and the measurement of the thermal mass of the walls determined the distribution of the ribs according to a rhythm able to maintain a stable shade, with the aim of contributing to the summer cooling of the intervention area. The study was then extended with the definition of the material, a completely reversible structure.

The final aims of this conceptual design proposal of a novel wood and fabric-based promenade to the ancient walls of Rome, is the simulation of the comfort benefits, and the decrease of the urban heat island effect, by the integration of massive and light materials.

Eventually two technological options for the new shading portals are here simulated and comparatively investigated. In the first scenario, the portals are designed as opaque and rigid frames, while the latter scenario redefines the portal as an ultra-lightweight screen made of I-MESH, an innovative fabric composed of interwoven mineral fibers in a multiaxial mesh, supported by a wooden structure designed according to the Segal construction method (Fabris, 2002) and based on a modular wooden grid similar to the balloon frame. (*figure 1*).

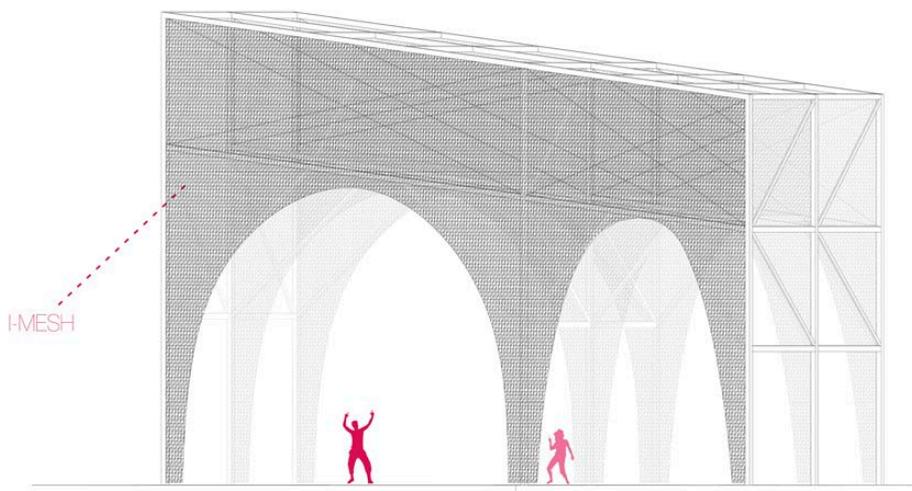


Figure 1: I-MESH with installation system\_Axonometric

In both cases, the join between the structure and the ground is done through the support on plinths foundation, hidden inside a platform that divide the structure from the flooring that will host the installation. The installation is supposed to be modular and fully removable, without affecting the existing supporting surfaces.

### 5.1 The mesh fabric

I-MESH is an innovative fabric composed of mineral fibres coated with a polymer resin. The fibres may be fibreglass, carbon, basalt, technora, or zylon. The unique nature of the material makes I-MESH an exceptionally good outdoor performer. The energy studies conducted on I-MESH concern the effect of the material when it is used as a outdoor shading device.

The shape of I-MESH can be customized and parameterized; the characteristics of I-MESH obviously depend on the different fibres used. In this case, the fibreglass fibre was chosen for the research. (*figure 2*)

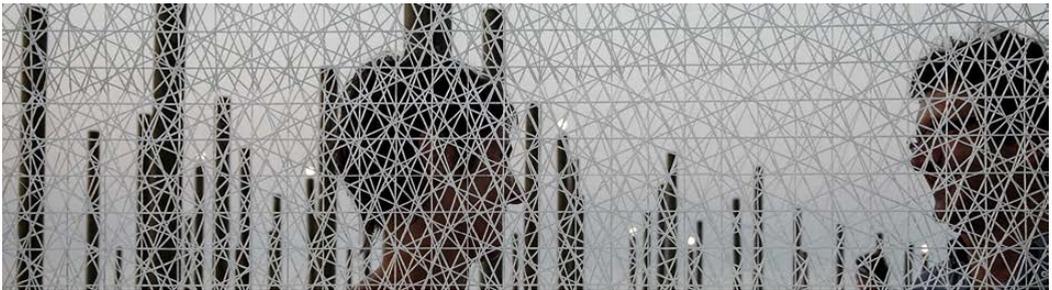


Figure 2: I-MESH fibreglass weaving with 60% opening. The extreme characterization of the material

The main physical characteristics of the fibreglass I-MESH are the following (Cocci Grifoni, Ottone, Cesario, Marchesani, 2017):

- thickness 2.5 mm;
- reflectance 0.60;
- emissivity 0.9;
- thermal conductivity 0.18 W/m\*K at 20°C;
- heat capacity at constant pressure 1200 J/Kg\*K at 20°C;

- specific heats  $1200/1175 = 1.02$ .

The pattern of the material is engineered to give the fabric an adequate stiffness, in according to a parametric design methodology, developed by the company in collaboration with the Politecnico di Milano.

The rovings that composes the material is placed freely in 2D space to create a soft mesh where both structure and decorative motives are blended. The positioning and composition of the rovings are custom. The fiber layout can be designed to absorb and distribute the loads generated by the weight of the material and wind load, in relation to the specific constraints dictated by the construction technology adopted.

## 5.2 The urban-scale simulation: objectives

To monitor the interaction of human-environmental phenomena, preliminary multi-level analysis were made. Each of them produced multiple information, deriving from the different sources, measured with the help of the current urban monitoring devices (mobility, climate, etc.) and, in some cases, with empirical measurements carried out on the site. To conduct the comfort estimation, a CFD (envimet) tool has been used. Such tool is able to work on an urban scale returning a map where is possible to read the values of PMV (Predicted Mean Vote), defined by the classic chromatic scale, that indicates wealth as much as they tend to zero.

First of all, the calculation was made on a larger scale considering the geometries of the actual state (*figure 3*). A subsequent enlargement of the same area, allows a better evaluation of the effects that the design project produces on the urban system of the Aurelian Walls.

The simulation has been carried on in two-steps:

- analysis of the project “Urban Portal” (figures 4.a and 4.b), that uses opaque and rigid material. The material utilized, although shading, did not offer acceptable results from the PMV's point of view, as it was designed as impermeable full screens.
- analysis of the project, that has the same spatial composition and morphology of “*Urban Portal*”, by replacing the opaque and rigid material with I-MESH.

This investigation was simulated on August 19th. This day is considered as representative day in comparison to temperature data in the summer period (Ottone, Cocci Grifoni, 2017). The pictures show the comfort scenery at 12 o'clock, obtained by cutting the geometries at eye level,

with an air temperature of 30° and a humidity of 45%. The mean radiant temperature and the wind speeds data are obtained thanks to the software.

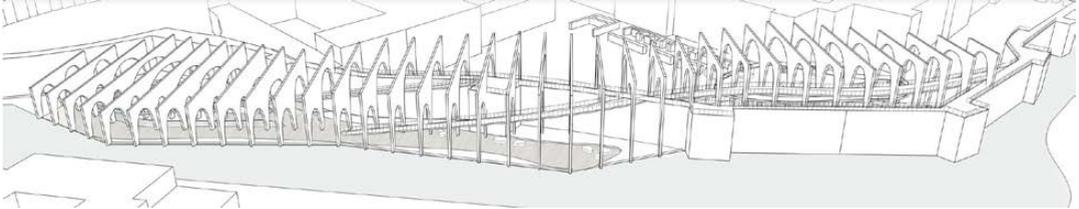


Figure 4.a: “Urban Portal” (S. Castellani e C. Vagnozzi Environmental Design Laboratory at the University of Camerino, School of Architecture and Design,, Prof. Federica Ottone)

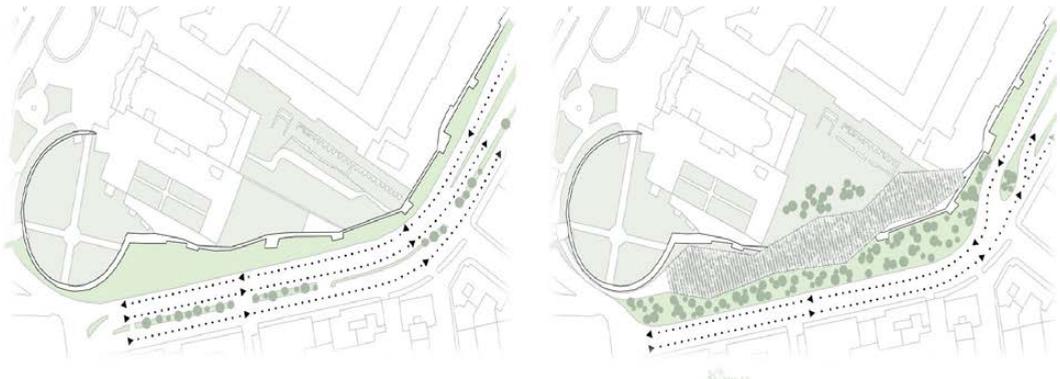


Figure 4b: plan before and after the integration of the new “urban portal” lightweight system

### 5.3 Results

Considering the existent scenario before the project (fig. 5) and then comparing the two alternative materials applied to the project proposal (fig. 6 and fig.7), it can be argued that the non-conventional use of vertical textile screen, instead a normal horizontally oriented shading system, may create a valid shading and filtering system, better allowing the circulation of air flows, avoiding overheated zones and creating a qualitative effect of textile promenade beside the ancient massive walls.

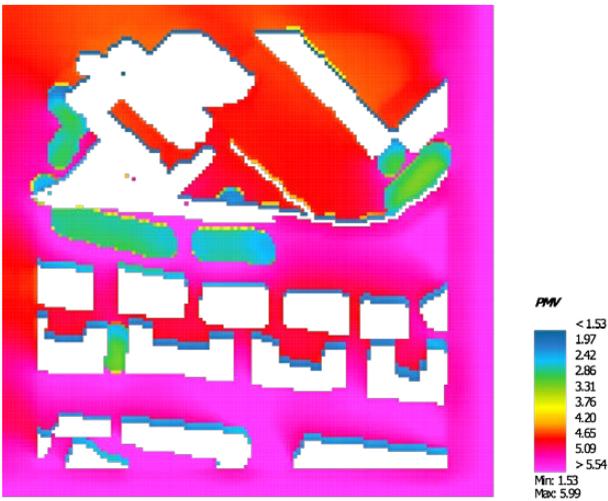


Figure 5: PMV before the project

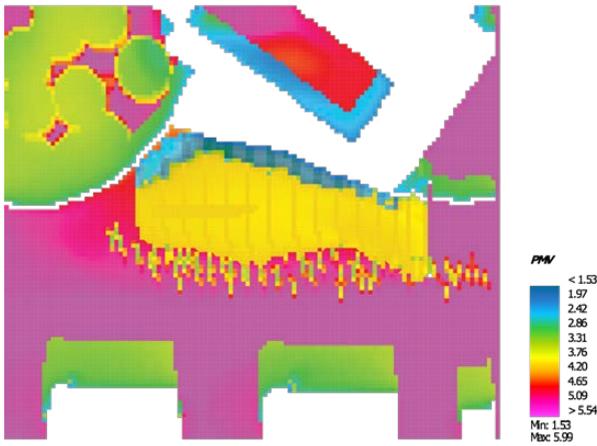


Figure 6: PMV with portals made of opaque material

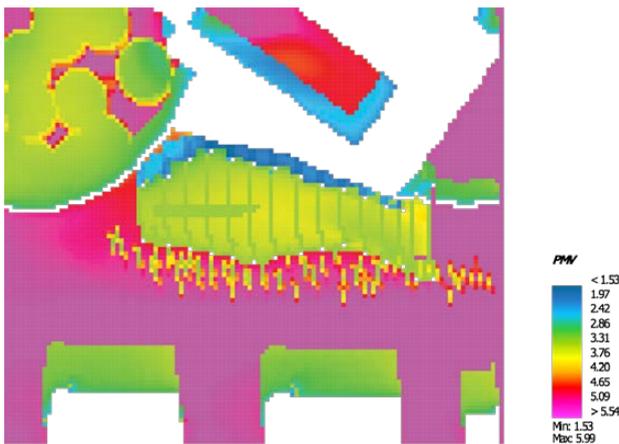


Figure 7: PMV with portals made of I-MESH composite fabrics

In particular, the characteristic of I-MESH may mean that even in a situation like the one designed, with big light portal, the installation system can become stable without the need for additional substructures, thanks to the composite nature of the material. Furthermore, it is well-known that the application of meshes in outdoor structures may improve the thermo-hygrometric comfort of a covered area. The innovative application of the I-MESH product in a large-span vertical panel opens a new way of designing shading systems, allowing the perceptive comfort of the fully open-air environment, compared to other traditional solutions. This is also possible due to the high strength performances of the I-MESH composite fabric.

Moreover, the developed portals long-line integrated to the urban existing building are though as a easily transformable, transportable ultra-lightweight structure; the mesh material has the qualities of transparency and lightness which allow to minimize the visual impact of the new structure, integrating it with the historical presence.

#### **4. Conclusion**

This experimentation wants to be an occasion to investigate on innovative practices of intervention on important historical urban contexts, preserving their memory, and applying on them reversible, lightweight artifacts able to generate places dedicated to the development of a new urban sociality.

At the same time, we are convinced that this opportunity gives the chance to restore, through temporary installations, a fruitful relationship between history and contemporaneity, giving continuity of life and meaning to the presences and triggering new scenarios of urban regeneration, through the reconfiguration of open spaces, increasingly protagonists of historic cities.

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