Proposing Prototypes for Integration of Vernacular Windcatchers with Lightweight Tensile Structures in Contemporary Hot-Arid Urban Context

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1 INTORDUCTION

Windcatchers are part of the buildings in the hot-arid climates and they are classified as a human comfort cooling system for moderating the indoor temperature of the buildings. Windcatchers are usually found in the Middle Eastern countries. They use wind, as a renewable energy source and utilize thermal mass, stack effect and evaporation techniques to provide human comfort by natural ventilation. In recent decades they are rarely used in the contemporary buildings due to the disadvantages such as maintenance difficulties, lack of appropriate filtration, modifications in the habitable space utilization, and dependencies on mechanical air cooling systems.

The concept of using windcatchers as a passive cooling technology could be revived if only their functions are integrated with the contemporary urban context of hot-arid regions. Lightweight tensile structures could be possibly used as a method to integrate the functionalities of windcatchers with the modern urban utilization of hot-arid regions. With the recent advancements in the related technologies, tensile structures have the potential to be lightweight, transparent, self-cleaning, translucent, movable and deployable. These beneficial aspects could be used in proposing innovative natural ventilation prototypes to be considered in the modern hot-arid urban context.

2 BACKGROUND

Membranes are thin skins, which can be made of fabric, foil or any other suitable materials. Tensile structures are light in weight because their structural stability results from their prestressed shape rather than the mass of the materials used. Consequently, they are much lighter than conventional building structures yet offer high stability. The combination of low mass and wide span provides the architect with opportunities of expressing lightness and stability in a coherent and unified way through the organization and shaping of each detail.

The lightness of tensile structures gives them clear preferences over other constructions like mobility, adaptability and being convertible. In fact, convertible structures can be seen as the most adaptive systems; these features make tensile structures to be flexible in their spatial arrangement and response to climatic variations. The resistance of membranes to soiling is considered as an outstanding criteria for their appearance and maintenance cost; nanotechnology can provide high durability for fabrics in order to be self-cleaning.

Benefits of Tensile Structures

Short Construction & Quick Erection	Reducing Carbon Dioxide Emission	Reparable
Permanent/ Temporary	Absorb UV	Easy Cleaning/ Self-cleaning
Natural Light and Reducing Lighting Requirements	Non-flammable	Reflection of Heat

Figure 1. Benefits of lightweight tensile structures

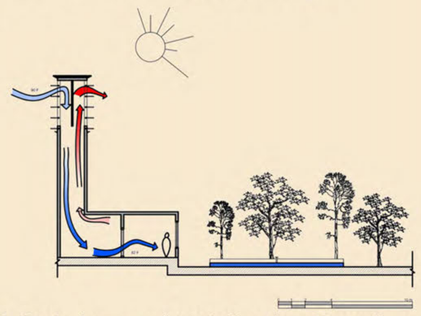

Figure 2. Typical vernacular windcatcher: Natural ventilation caused by stack effect

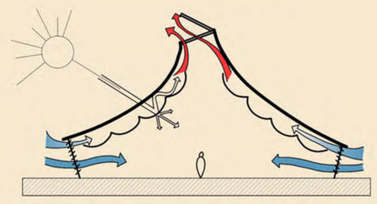

Figure 3. Use of movable sunshade and the thermal stack effect in order to prevent overheating and ventilation.

3 INTEGRATION CONCEPTS

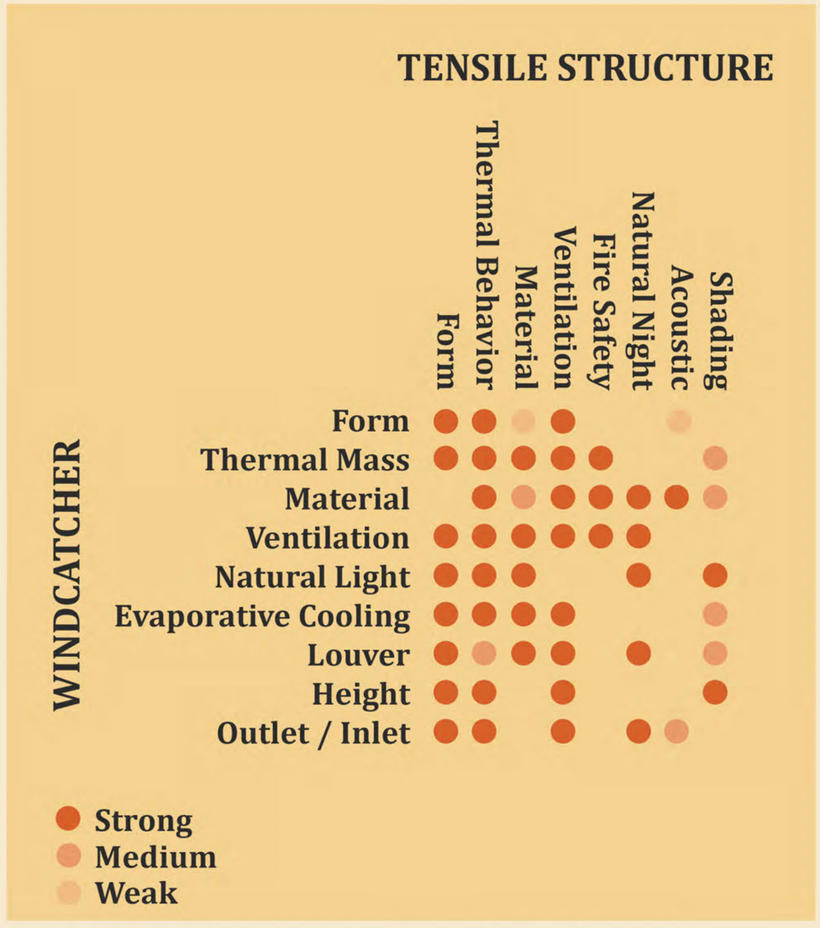

Figure 4. Potential areas for integration of tensile structures and windcatchers

In this integration of windcatcher with tensile structures, windcatchers would act as chimney, because of the stack effect. There is a big difference between the temperauture during the day and at night in hot and arid regions. At night, the thermal mass emits the heat that has absorbed during the day and becomes cool. The tensile structure in this proposal can be used as a shading which provides an environment for the social interactions of the dwellers. Also, using PCM material (Figure 5, b) helps to bring the natural daylight inside the building.

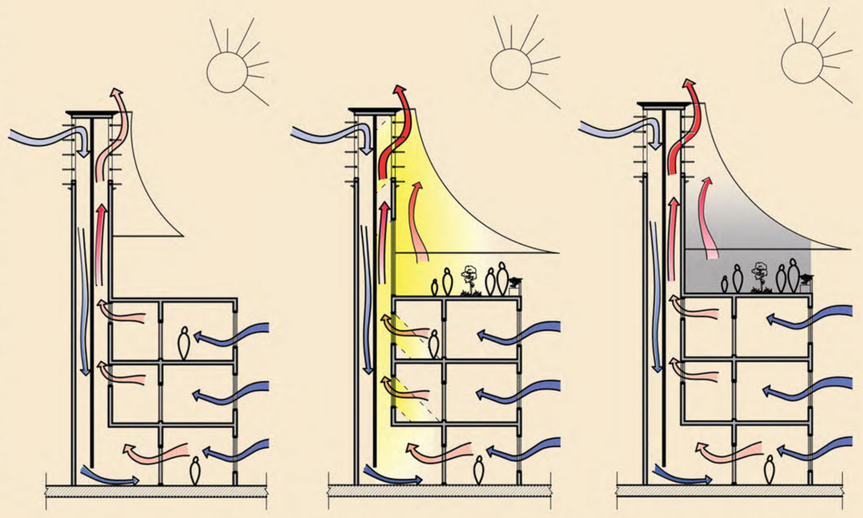

Figure 5. Integration of traditional windcatchers with tensile structures for new multi-story apartment buildings: a) natural ventilation cooling, b) adaptation with PCM thermal mass for natural daylighting, and c) adaptation for shading on habitable roof.

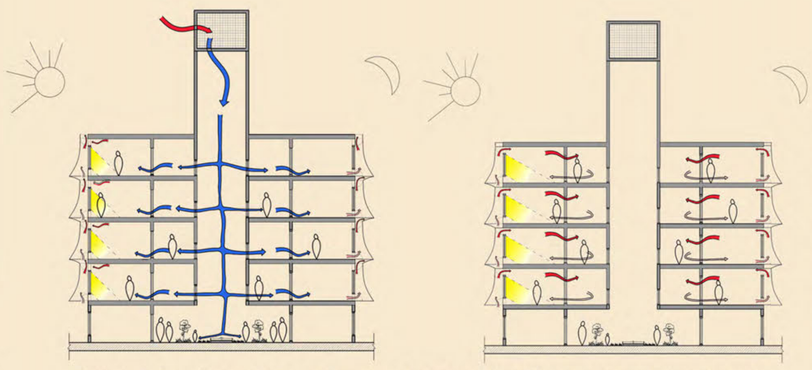

Figure 6. Function of thermal mass integrated tensile structures by using cool tower: a) in summer b) in winter

This concept uses cool tower for bring the air into the buidling. Tower produces fresh cool air which sinks through the tower and then enter the openings of each floor in order to provide required fresh cool air for natural ventilation in each story of buildings. Also, in this proposal PCM materials are used as a thermal mass in glazing windows. The purpose of using PCM materials is to have natural light and thermal mass at the same time.

In this concept, the material of blades and the rings is thermal mass. This windcatcher has the ability to turn towards the prevailing wind and capture the wind. The biggest advantage of this concept is that the dwellers in each story of the building can control their own tensile windcatcher and the windcatchers could be used individually.

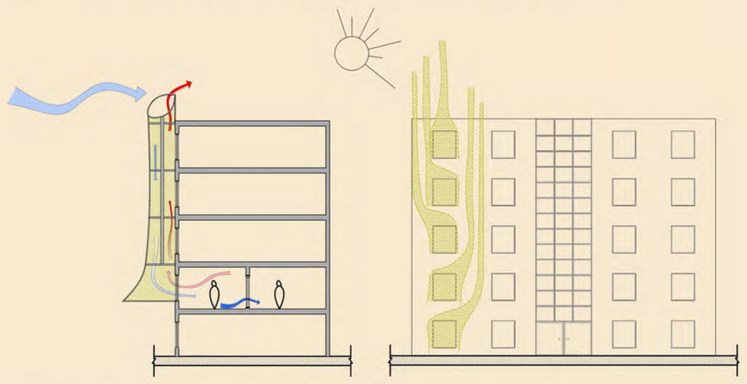

Figure 7. Section and elevation of fully conceptual tensile structure windcatcher

Figure 8. Illustration of windcatcher integrated with rotatable panels

In this concept, each story of the building has one module that will be attached to the existing building. In each module, stack effect, air bouyancy and cross ventilation help to speed up the exhasution of the used air to the outside. The panels can open or closed based on the direcion of prevailing wind to expedite the air movement in the building.

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