Building-Integrated Salt Construction: 
Design Framework for Air Quality and Passive Cooling in Tehran, Iran

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ABSTRACT: The building envelope plays an integral role in its interactions with the outdoor climate because it is the most exposed to the outside environment. The role of the building envelope in achieving human thermal comfort and well-being is considerable. This research illustrates vital factors that are influential in adaptive architecture within a polluted region at the district 12 of Tehran, Iran. The adaptive architecture framework is implemented for an existing typical five-story multifamily residential unit. Environmental strategies are developed to obtain natural ventilation and air filtration in a dense urban environment. As a result, architecture is responsive to its environment in terms of enabling fresh air quality and thermal comfort for building occupants. Specifically, the outside layer of the adaptive building envelope serves to purify outdoor air through unique windcatchers formed with salt construction, while also providing a shade-screen effect for hot summer conditions. Select experiments are identified within this design framework to inform the effectiveness of the proposed salt fabricated windcatcher system.

KEYWORDS: Salt construction, Air purifier, Natural ventilation, Urban environment, Multifamily housing

1. INTRODUCTION

Tehran is selected as one of the examples of megacities in the world. It has many environmental issues that need attention and air pollution is one of them [1]. Iran is among the top ten countries in the world in energy consumption [2] and about forty percent of it is related to the building sector [3]. Tehran is denser in its central areas and the height of buildings in a dense urban environment causes an air pollution trap in the urban canyons. Therefore, the focus is on how building envelopes can mitigate air pollution problem as well as encourage natural ventilation and air circulation to reduce dependency on mechanical air conditioning to achieve energy conservation (Fig. 1).

Figure 1: Proposed environmental system: two components of windcatchers and stack effect that are made of salt and work simultaneously to create natural ventilation and clean the air.

2. SALT MATERIAL AS AIR PURIFIER THROUGH NATURAL VENTILATION TECHNIQUE

There are different materials such as titanium dioxide and salt that may be used for urban air quality remediation. However, TiO₂ is more expensive than salt and only serves as a coating material, whereas salt can emulate lightweight ceramic building materials. Salt is used in halo-therapy and healthcare to purify the air and as a result an improvement in patients’ health is obtained [4, 5]. A new restaurant in Iran provides a contemporary example of using salt as a construction material for air quality improvement [6]. Salt resources are vast and regionally available within 85 kilometers from Tehran’s urban boundary.

In this design, the windcatcher is introduced as a contemporary passive cooling system adapted from traditional Iranian architecture. Windcatchers have different shapes and blade mechanisms to effectively capture prevailing winds from various directions [7]. The structure and form of the windcatcher emulates the complex geometries found in traditional Iranian shade screens [8]. The resulting adaptive windcatcher façade provides a synthesis of cultural heritage, passive design technique, and regionally appropriate material technology.

3. EXPERIMENTAL TESTING AND DESIGN

The proposed environmental system is made from salt and is designed to be installed on the south elevation of the selected existing building (Fig. 2).

Figure 2: Salt flow screen on south elevation of a building.
The environmental system functions both as a windcatcher and with stack effect ventilation to create airflow circulation for the interior spaces of the building. To prevent negative effects of moisture on salt, the outside layer of the screen is coated with clear sealant while the interior cavity of the tubular elements maintains exposed salt conditions for air quality processing. Three empirical experiments were conducted to investigate the effect of humidity on salt (Fig. 3), light transmission through salt (Fig. 4), and airflow through the proposed windcatchers (Fig. 5). In the Humidity test, humid air is passed through the salt sample in a controlled cylinder chamber and lose of its weight was measured. The relative humidity and the dry bulb temperature is measured every 12 seconds for two hours. The amount of 0.075% of salt loses in this experiment that is not considerable.

In the second test, light transmission meter was used to measure three different values that are in the graph. There was a gradual decrease for transmission when the thickness increases.

In the third test, Part of the geometry was modelled and the smoke from incense is entered to the geometry from lower elevation to the higher elevation. smoke is entered to the interior spaces of the building through the openings on the walls.

4. CONCLUSION AND FUTURE WORK

According to the identified problems in the urban environment of Tehran, an adaptive building envelope should be responsive in terms of providing natural ventilation for passive cooling effects and air pollution remediation for human health benefits. Hence, an environmental system is proposed that contains three elements: geometric design referencing cultural heritage in Iranian architecture, windcatcher elements to provide air circulation, and using salt as a regional construction material to clean the air when natural ventilation is provided. Based on the initial physical experiments, the design shows promise for minimal impact of humidity interactions with the salt, daylighting and shading control at the façade, and effective airflow for ventilation functions. By providing natural ventilation as a primary passive cooling strategy in the hot climate conditions, the energy performance of the building improves considerably.

Future research includes: air quality remediation testing, salt fabrication studies, passive cooling thermal comfort analysis, building energy analysis with natural ventilation, and salt porosity optimization. The construction techniques and structural support conditions will require context specific considerations with local contractors and existing buildings.

REFERENCES