An architecturally optimized mono-nitrogen oxide reducing modular photo-catalytic concrete skin

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ABSTRACT: Mono-nitrogen oxides (NOx) are common urban outdoor air pollutants that result in acid rain, atmospheric ozone depletion, and severe health issues including chronic asthma, learning disabilities in children, and mortality. This research leverages the large surface areas of southern facing building facades to chemically neutralize NOx via a modular photo-catalytic concrete brise-soleil/ rainscreen system. By utilizing a combination of ultraviolet radiation and titanium dioxide (TiO2) further activated with the performance enhancer strontium aluminate (SrAl2O4) not only is air pollution reduced during the day, phosphorescent illumination is also provided at night with luminance levels comparable to electric street lighting. The system provides multiple environmental services without the use of carbon-based fuels, is non-toxic, and produces only inert nitrates as a byproduct of the NOx neutralizing reaction.

Modular panel designs were tested via both physical and digital models in order to optimize the performance of four criteria: 1. ultraviolet radiation (solar) collection, 2. NOx neutralization through windspeed reduction and particle trapping, 3. phospholuminescent potential, and 4. additional micro-climactic mitigating properties such as shading, precipitation disbursement, and thermal storage. Ultimately two versions of the modular panel forms were developed, one for climates with large diurnal temperature shifts that leverage the benefits of concrete's thermal mass to create microclimate, and one for small diurnal swing climates which minimizes the thermal mass performance.

The minimized thermal mass system was developed for the predominantly hot/ humid city of Baton Rouge, Louisiana which experiences high levels of NOx air pollution from both oil refineries and automobile traffic. This system utilizes a thin, flat panel tilted 15 - 30 degrees off vertical to not only maximize ultraviolet collection, but also to deflect precipitation. The maximized thermal mass system was developed for the seasonally variable city of Philadelphia, Pennsylvania which also experiences high levels of NOx air pollution from both oil refineries and automobile traffic. This system's form is based on a curve that optimizes solar tracking throughout the day. It consists of four modular components that can be configured in multiple forms to produce a filigree skin. These skin systems can be sited adjacent to NOx sources, significantly reducing the dispersion of NOx air pollution in dense urban areas, while simultaneously providing additional environmental services.