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Futuristic Transparent Media Façade For Self-Ventilated Parking Podium: A Feasibility Study

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***Abstract*:** *History of architecture is perpetually on the path of self-renewal with new guises and use of new materials. Media surfaces are the new dimensions looking ahead of the postmodern architectural trends that mellow down the long standing conflict between "less is more" and "less is a bore" debate. With a click of a button the building façade could be a minimalist design for the "less is more" diehards, and the next moment it could be ornamented with a lot "more" for the proponents of "less is bore" maxim.*

Designing with media surfaces is an aesthetical, technological, environmental and social challenge that an architect is going to face. Here's one challenge that we undertook, and solved the question of spatial illusion, environmental impact and human safety, presented by a transparent media façade (TMF) designed to clad a self-ventilated seven-story parking podium of an under-construction corporate headquarter building in an upscale neighborhood.

Keywords: *transparent media facade, LED, parking podium, self-ventilated, advertising, signage, digital display, billboard,*

1. Introduction

Future of urban architecture wrests in the fact that every single part of a future building will be digitally connected. Buildings themselves will become novel media for communication particularly of visual content turning them into giant displays. Media façades comprise a category of urban computing concerned with the integration of digital displays into the built environment, including buildings, monuments, and street structures. "**Media Façade,**" in general, is a term for incorporating digital displays as an integrated part of a building's façade. Architects should be able to deal with this novel 'material,' as the appearance of their architecture significantly changes in a way that could not have been imagined before [1]. Examples of media façade include buildings surrounding Times Square in New York.

With the advent of SMD (surface mounted device) technology, high efficiency LEDs and powerful processors, digital displays are ushering a new era of transparent media surfaces that can skin buildings of the future. The possibilities and challenges of building urban structures that function as multidimensional graphical output devices are immense. While there's little doubt that integration of media surfaces into architecture is inevitable, these new possibilities aren't without its quota of criticism. Old school critics believe, media façade being a mixture between an enlarged computer screen and part of the building's face, the architectural quality of the building may suffer as a result of the flatness and rectangularity of the image. But, that argument may not be entirely tenable as today's media surfaces can be molded to any form or shape based on the need.

Media facades do take the building proportions into consideration if planned as 'display-integrated architectural design'. Additional new parameters that become part of media façade planning include viewing distances, eyeball densities, daytime / nighttime luminance, transparency of the façade, heat dissipation, ventilation needs, environmental impacts, human safety, so on and so forth. The field of media facade is interdisciplinary - not only does it involve research within architecture and urbanism, but also within some border areas of technology, urban design, art, culture, media and marketing. Media facade design process involves analyses of some specific design aspects that impact operational and functional objectives of the façade.

Unfortunately, media façades are usually an afterthought, and never a part of architectural planning. This is because they are still considered as “digital displays” or “signages” for displaying advertisements, which has never before been associated with architectural aesthetics. Our present transparent media façade (TMF) feasibility study, although a precedence for future media facade designs, was also an afterthought, undertaken only when the conventional signage solutions appeared to pose operational and functional snags.

2. Transparent Media Façade

This paper presents a feasibility study undertaken to design a transparent media façade to skin seven stories of naturally ventilated space that serves as a parking podium to a 27 story corporate headquarter building. With a total estimated deployment of 2640 square meters of transparent LED display material, we believe this is the biggest self-ventilated transparent media façade anywhere in the world.

In architecture, the facade of a building is often the most important aspect from a design standpoint, as it sets the tone for the rest of the building. A façade can be engaging & awe-inspiring if its form follows functions. Modern architecture is on the inevitable path of evolution of forms that merge real world functions with visually stunning digital world.

Fig. 1: A close up front view of a typical transparent media façade panel

Transparent Media Façade (TMF) is defined as a building façade cladding made up of surface mounted LEDs configured as RGB pixel dots in a curtain form, such that the spacing between each pixel allows light and air to pass through it, giving it a level of transparency that permits indoor ventilation and allows visibility of the outdoor views from inside the building, while visual media is displayed on the façade itself. The slim designs of such transparent LED displays may permit up to 80% transparency. Fig. 1 & 2.

Fig. 2: Actual view of the outdoors from inside a TMF cladded building.

2.1. The Challenges

Before initiating the study we were aware of the following challenges for urban media façade design identified by Dalsgaard and Halskov [2]:

1. New interfaces
2. Integration into physical structures and surroundings.
3. Increased demands for robustness and stability
4. Developing content to suit the medium
5. Aligning stakeholders and balancing interests
6. Diversity of situations
7. Transforming social relations
8. Emerging and unforeseen use of places and systems.

2.2. Purpose, Scope & Methodology

The purpose of this feasibility study was to develop and design a media façade for an under-construction skyscraper building in an upscale high visibility neighbourhood of Dubai using state-of-the-art digital

technology for showcasing sponsor messages and brands in the most architecturally aesthetic, environmentally friendly and cost-effective way. The study commenced with the following understanding:

- Lower 7 floors constitute the podium of the building that houses car parking
- The GRC-cladded podium will be naturally ventilated through 25% openings in the GRC
- A Jet Fan based mechanical ventilation system will supplement in case of emergencies
- Three sides of the façade face high visibility and therefore suitable for cladding it with digital displays
- The media façade should minimize structural and environmental impact, and ensure human safety
- The layout, sizes, dimensions and type of digital displays should have high viewer impact
- The signs if monetized should yield a high ROI
- Transparent Media Façade (TMF) could be the display technology of choice to meet the goals

Undertaken to review technical, design, commercial and deployment aspects of media façade technology the scope of the project included the following:

- 3D Mapping & Interactive 360° Virtualization of building outdoors.
- CFD (Computational Fluid Dynamics) 3D simulation for TMF impact on indoor parking environment.
- Eyeball density analysis for TMF display sizes, optimum pixel pitch, types & timing of ads, TMF rest cycles, so on and so forth.
- MEP Analysis for TMF structural / electrical installation planning, TMF maintenance approach, total TMF power consumption, and TMF impact on indoor environment.
- Final TMF design & specifications.

This was a multi-prong feasibility study that included a combination of diverse approaches that included eyeball density surveys, geo-mapping, site surveys, 3D computer graphics, computational flow dynamics (CFD), environmental research, advertising market research, transparent LED research, regulatory research, augmented reality techniques, financial analysis, so on and so forth. Because architecture is a visual art and a media façade further emphasizes that notion, we used Augmented Reality concepts for architectural virtualization and showcasing the simulated visual effects of the TMF (www.archar.in/LMG).

Fig. 3: The architectural visualization of the building and its façade design at www.archar.in/LMG

The complete expanse of the original feasibility study was extensively broad, hence impossible to cover within the confines of a single article. Presented herein the environmental implications of TMF as relevant to a self-ventilated parking podium.

2.3. Environmental Factors

As any electrical appliance, LED displays also impact the environment and vice versa. The conventional LED displays, particularly in big sizes, have huge environmental consequences that prevent them from being deployed as building facades. They generate significant amount of heat that cannot be dissipated without the use of dedicated air conditioning, and do not allow free flow of air and light between outdoors and indoors adversely impacting the indoor environment and the aesthetics of the building itself. However, transparent LEDs are lighter, use less energy, and allow some level of transparency for connecting the outdoors with indoors. As

found in this study they have minimal or zero adverse impact on the outdoor and indoor environments or vice versa as found in this study.

2.3.1. Outdoor Factors

A building façade protects the building from heat, dust, rain and wind. A TMF cladding should be able to withstand all of those adversities and still be aesthetically functional. IEC (International Electrotechnical Commission) has published standard 60529, International Protection Marking, IP Code, also termed as Ingress Protection Marking, which classifies and rates the degree of protection provided against intrusion, dust, accidental contact, and water by mechanical casings and electrical enclosures. For adequate protection against all outdoor adversities we recommended a minimum of IP65 protection on both sides of the TMF LED panels.

2.3.2. Indoor Factors: Computational Fluid Dynamics (CFD)

Our targeted façade area was the seven-floor podium that would serve as enclosed parking for parking cars of the inhabitants and visitors of an under-construction building. The parking podium will have no air-conditioning and therefore for adequate fresh airflow and ventilation it will rely on natural outdoor/indoor air circulation, supplemented by jet fan ventilation system. It will also rely on daylight for its savings on indoor lighting costs. Any additional structure (advertisement signage in this case) on the façade that impacts the indoor environment will impact electrical installations and will bound to have consequent adverse implications.

The key elements that affect the indoor environment include wind (airflow), heat and light. We used each of these elements in modelling our computational fluid dynamics (CFD) study of the indoor environment. We created 3D models of the GRC wall panel and the TMF panel.

2.3.2.1. Air Flow

The most important environmental factor that impacts a self-ventilated TMF design is the natural airflow and mechanical ventilation of the indoor parking spaces. Natural airflow not only impacts indoor ventilation, but also plays important role in dissipating the heat generated from operation of transparent LEDs. This ventilation and heat dissipation takes place through the air gaps in the LED panels in addition to the built in heat sinks.

The ventilation of an indoor parking garage consists of introducing acceptable air from outside and to filter / dilute the polluted air caused by car emissions, especially carbon monoxide (CO), and maintaining levels of contaminants to reasonably healthy levels. The flow of outside air also dilutes and removes vapours escaping from automobiles and prevents potential fire hazards resulting from leaked gasoline. Ventilation is also important for customer acceptance based on smoke and odour generated by the automobiles driving through. The more dynamic airflow exchanges, the better indoor air quality and efficiency. While conventional displays do not allow any airflow, the airflow through TMF display can be up to 80% depending on its pixel pitch, panel design, air gap and anchor structure behind the TMF. Thus, it was necessary to estimate the volume of flow of the outside air needed to dilute the CO under the limits permitted by law.

Average wind speed in Dubai varies between 5 miles/hour to 15 miles/hour, and it is predominantly north-westerly. It plays an important role in allowing flow of outside air for maintaining indoor ventilation and keeping CO levels in check. The LEDs in the TMF do not contribute to any CO emission or accumulation per se. Therefore, the TMF installation in itself carries no risk of introducing any extra burden on the CO monitors already requisitioned in the original plan. Although the parking podium will be self-ventilated, 12 jet fans per floor automatically detect CO levels and augment the natural ventilation for diluting the CO levels in emergency.

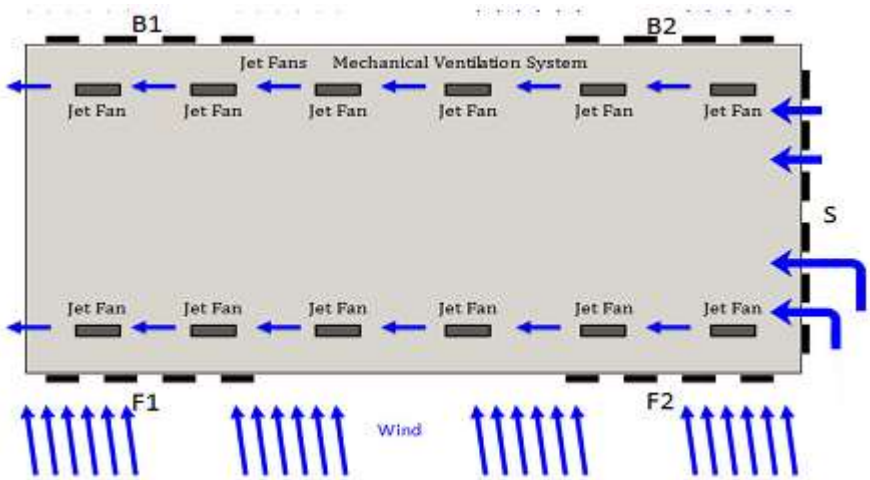

Fig. 4: Flow diagram showing the air exchange through the TMF screens F1, F2, B1, B2 and S

The available open area for parking per relevant floor was approximately 42,000 square meters accommodating up to 128 parking spaces per floor. Ventilation rates for enclosed parking garages can be expressed in terms of either flow rate per unit floor area such as CFM / ft, or CFM / parking space, or air volume changes (ACH) per unit time. Since our focus was the impact of TMF on the parking space ventilation, and since each parking space itself was the source of smoke, CO and air pollution, resulting from cars using the parking, we chose to measure the impact in terms of CFM / parking space. CFM refers to the method of measuring the volume of air moving through a ventilation system or other space, also known as "Cubic Feet per Minute."

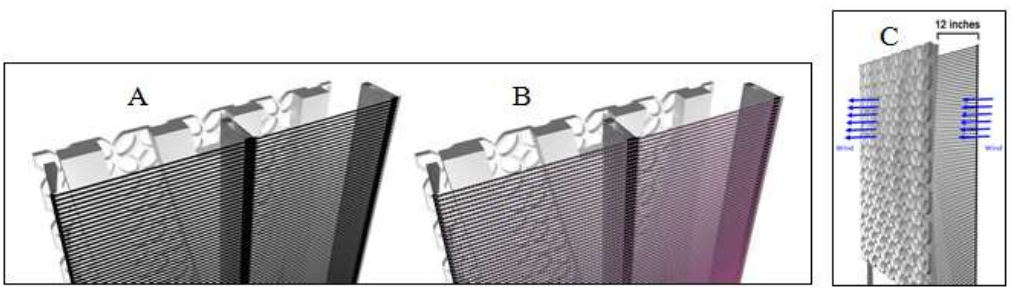

Fig. 5: Perspectives of GRC with TMF switched off (A), switched on (B) and wind flowing through (C).

Each GRC wall panel measured 3.3 meters x 2.7 meters constituting an area of 8.91 square meters. We used a single GRC panel fitted with TMF panel for the analysis because each panel is the smallest repetitive unit of the façade. Using this methodology and assuming any single direction of wind at 5 mph, the indoor air flowing through the transparent façade was estimated at 8,440 CFM / square meter. Additionally, in emergency situations, 12 fans per floor were also capable of circulating additional @ 3050 CFM / fan totaling 36600 CFM. Therefore the total CFM airflow through parking area could reach to as much as (36600 + 136,000) 172600 CFM / floor /128 parking spaces, which meant the net maximum CFM available for each parking space was as high as 1348 CFM. Since according to the international standards the minimum CFM recommended for indoor parking is 500 CFM under ambient conditions, the level achieved with the TMF installed were already more than twice the International standards.

In conclusion the natural air flow through TMF was sufficient to provide twice the levels of minimum ventilation prescribed by International standards for covered parking. 79% of the indoor ventilation capacity of the self-ventilated parking podium was found to be through the natural airflow through the transparent façade and 21% via the ventilation fans (when they are operating at full capacity, which they will only do when either CO levels rise or there was a fire emergency).

2.3.2.2. Heat Sinking Dynamics

In electronic systems, a *heat sink* is a passive heat exchanger that cools a device by dissipating heat into the surrounding medium. Although LEDs in themselves do not generate any heat, but the resistance at so called

temperature junctions does transform about 60% of the power supply to heat. It is for these reasons heat sinks are used in designing LED devices. Aluminum is widely used for heat sinking because it is a good conductor of heat. LED screens are designed with extruded Aluminum heat sink and pressed Aluminum panels. Transparent LED screens have additional built-in air gaps as very important heat sinking mechanisms. For these reasons big TMF screens do not need any additional cooling like their traditional predecessors.

Our CFD analysis focused on the impact of heat generated by the TMF on the indoor environment. This is particularly important because Dubai's summer temperatures can reach as high as 50°C, and the indoor parking area was not air-conditioned. Heat generated from the LED panel was estimated based on the formula:

$$\text{Heat (Joules)} = \text{Power (Watt)} \times 60\% \times \text{Time (Seconds)}$$

A transparent LED panel with 25mm pitch in its routine operation consumes on an average 150 watts when it is displaying a normal colored image. In test conditions at 100% brightness it will consume about 400 watts. Therefore, heat generated from the routine operation of a TMF system with 25 mm pitch would be:

$$\text{Heat/second/square meter} = 150 \times 0.6 \text{ x } 1 = 90 \text{ Joules/second/square meter}$$

Out of the total heat generated about 45% is generated within the LED panel itself and rest 55% in the cables and computer terminal in the control room. Therefore the total average heat per square meter of the transparent LED panel was estimated to be:

$$90 \text{ x } 0.45 = 40.5 \text{ Joules/second/square meter.}$$

This 40.5 joules of heat generated per second per square meter is dissipated via the Aluminum panel assembly and the air gap between the LED strips and the additional air gap between the LED panel and the GRC wall. 40.5 Joules of heat is equal to 0.0213 Celsius. At 150 Watt power consumption and assuming an ambient temperature of 40 degrees Celsius and average wind speed of 5 miles / hour (wind speed in Dubai ranges between 5 miles/hour to 15 miles/hour), there was no trace of any additional temperature rise in CFD analysis when the air gap between the TMF panel and GRC panel was, zero, 6, 12 or 18 inch respectively. We therefore, changed the heat generation setting to a hypothetical 4X of average power consumption of 600 Watts, which is an extreme and unlikely situation. This was done to precipitate abnormally high heat at temperature junctions and find out if there was any un-dissipated heat effect on the indoor temperature. There was no increase in indoor temperature recorded at 12 inch and 18-inch gap between the TMF panel and the GRC wall.

Based on these findings, we conclude that a minimum air gap of 12 inches between the LEDs and the GRC wall was sufficient to annul any possible heat impact of the TMF on indoor temperatures.

2.3.2.3. Illumination

The indirect brightness on a reflective surface during average daytime conditions in Dubai measures around 2000 lux and around 1000 lux with clouds or post-sunrise and pre-sunset hours. According to the International standards, the indoor parking should have at least 50 lux of illumination. The computational analysis of illumination effect heavily depends on the colors and reflective surfaces that bounce the light. Assuming color of GRC wall was white, 12-inch air gap between the TMF and GRC, and ignoring the indoor wall colors that bounce light, the illumination indoor was estimated to be between 300-150 lux, which was more than sufficient for an indoor parking area.

2.4. Conclusion

Transparent Media Façade (TMF) is a major innovation that will significantly impact the future of urban architecture. As the market for different types of TMF applications evolves, designing self-ventilated parking podiums with TMF is a promising new possibility for urban high rises in high visibility neighborhoods. Skinning a parking podium is always a difficult question that most architects either like to avoid or neglect. It is because the façade designed for the rest of the air-conditioned floors of the building is neither suitable nor economic for parking podiums. As a result most buildings with self-ventilated parking podiums face aesthetics problems. TMF is environment friendly, promotes natural ventilation, saves energy on mechanical ventilation

and illumination, and aesthetically very flexible. Our CFD analysis established that a TMF with pixel pitch 25 mm provides sufficient transparency to allow air flow in much excess of the 500 CFM / parking space required under International standards without the assistance of any mechanical ventilation system. Continuous operation of TMF dissipates heat so efficiently that there's zero impact on the indoor temperatures. It can also provide enough indoor illumination during daylight hours. More importantly TMF can be monetized for generating recurring revenues from advertising.

3. Acknowledgements

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4. References

[1] M. H. Haeusler, Media Facades: history, technology, content. Avedition, Ludwigsburg, 2009.

[2] P. Dalsgaard and K. Halskov, "Designing Urban Media Façades: Cases and Challenges," CHI 2010: Public Displays, April 10–15, 2010, Atlanta, GA, USA. Pp 2277-2286. Available: www.peterdalsgaard.com/documents/publications/dalsgaard%20-%20designing%20urban%20media%20facades.pdf