

The problems of a shade-shadow and light in a design of open-air market stall

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ABSTRACT

This paper presents an analysis of some overlooked aspects in an environmental agenda for retail design. The work outline the analysis of the possibilities of maintaining low temperatures in an open-air market's stall space by using an appropriate shed and shading techniques and therefore avoiding direct solar radiation. Temperature difference of up to 10⁰K was realised between shaded and un-shaded surfaces when some spot measurements were taken in the summer month of July (Ernest, 2004). Lower temperatures are imperative to halt the deterioration process of fruits and vegetables (Flores and Karen, 1997). At room temperature half of stored vitamins would be lost in three days (British Nutrition Foundation, 1999). Lower temperature would also enhance human comfort in the summer season. Shading and shadow study were done with digital models built in Square One - Ecotect software with consideration of London as a location. The analysis for optimum orientation and shading at different periods of a day have been presented and discussed, and also the discussion on the separation of heat from sunlight is highlighted. The information is based on the work done during the Environment and Energy Programme at the Architectural Association Graduate School in London.

1. INTRODUCTION

Open-air market uses the stall as the fundamental equipment for display and sale of goods. In Britain, the design of a 'stall' as a basic erection for open market retail trading has remained the

same for almost a century now (Ernest, 2004). We have a stall as almost a zero energy structure being used for open-air trading since the ancient Greek times and in the same context we have some energy intensively driven retail stores (Ernest, 2004). This paper investigates the role of a stall as equipment for open air retail trading. A stall is a minimalist and functional equipment. It could be movable, adjustable and temporary. The design features that are mainly analysed include; the shed, shade, shadow and light. Shade and shadow positions are monitored for comfort and welfare of the trader and customer; and protection of the quality of the merchandise against severe site conditions (Flores and Karen, 1997).

Typical practice

Traditional design of a stall structure does potentially give access for a huge amount of solar radiation from it's sides. Figure 1 presents some approaches extracted from case studies.

- *Approach 1:* The trader allows the products to be in open sky. It is argued that the products will have attractive glow, less-glare, clearly observed and their properties being easily recognized and accentuated in this approach. Items do quickly perish under such circumstance.
- *Approach 2:* A stall has a flat roof over the display table and around the perimeter of the stall space. This is most common practice protects the trader from overhead sun and rain.
- *Approach 3:* The set-up of its staged platform is more dictated by the view from a customer than climatic forces.

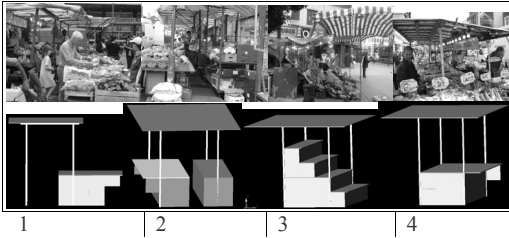


Figure 1: Typical stall design approaches.



Figure 2: Typical covered stall



Figure 3: Typical unprotected merchandise

- *Approach 4:* It is a basic approach with problems similar to approach no.2. Protection of the customer & trader relies on size of awning and position of shadow.

All surveyed stalls do generally lack flexibility and adaptability to varying circumstances. They are different versions with potentials that do not complement one another.

2. STALL ILLUMINATION

As merchandising strategy, light is needed to sell not only in big stores where it sharply does pinpoint a product (Din, 2000), but there is the same battle with stall traders whom effort to improve light levels has proven to count in business (Ernest, 2004). Light uphold the merchandise relative to their context (Din, 2000). However, merchandise such as fruits and vegetables require as low temperature as possible to halt the deterioration process (Flores and Karen, 1997) and the challenge is to isolate heat from sunlight.

With an exception of a short period within winter season, it is possible to naturally lit a stall space by using daylight. The study found some stalls being operated with electric light installation, turned on in the middle of bright sunny days in summer season as shown in Figure 2. Several case studies measured light on the stall table varying between 5,000 and 1,000 lux

while the outside overcast sky measured 15,000-50,000lux on 24th July (Ernest, 2004).

The problem of immediate stall space being highly lit by open sky seems to take the glory off the stall table. The struggle for adequate light within stall space cause most traders to opt for direct solar radiation while disregarding the consequence on the products. The provision of diffused light doesn't seem successful to most traders who then choose to install the incandescent light. The principle of retail design suggests that the merchandise should be in the more lit point than the immediate surrounding for effective attraction of the customer. This has made some traders to avoid having a roof on their stalls as shown in Figure 3.

3. SIMULATION OF SOLAR ACCESS

The simulation of solar access is based on the fact that exposure to solar radiation increases the temperature of a space and the hotter part will be a radiator into the cool part (Givoni, 1998). The measurements taken during physical experiment revealed a difference of up to 10^0K (Table 1) between surfaces under shade from solar radiation and those which were not. It therefore became factual that the design of a shade would make a significant difference.

Manipulation of the stall awning would keep the heating loop (Figure 4) between shaded and non-shaded parts at a distance away from stall space and therefore delaying heat transfer into the stall space (Yannas, 2003).

The created digital experimental models consider a British model of a stall with approximately 3000mm wide and 3300mm deep roof area to protect the stall table and the storage space underneath from the exposure to solar radiation. Two orientations as shown in Figure 5 were considered for analysis to create series of hourly simulations.

The model scenarios shown in Figure 6, aim

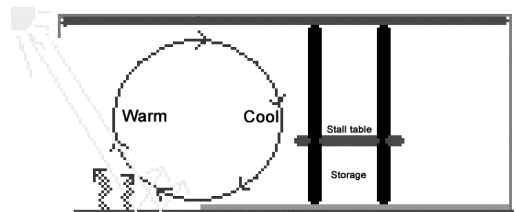


Figure 4: Heating loop.

Table 1: Surface temperatures from spot measurements at 12:30 on 25th July.

Time hrs	Air temp (°C)	Concrete pavement (°C)		MDF stall table (°C)		Fruit surface (Banana) (°C)	
		Shaded.	Exposed.	Shaded.	Exposed.	Shaded.	Exposed.
1230	22.3	27.0	37.0	25.8	35.1	25.5	30.8
1238	21.8	30.5	40.5	28.9	33.6		

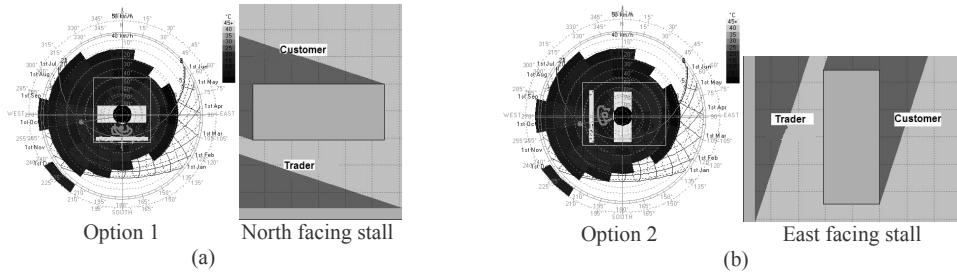


Figure 5: Orientations options within a sun-path diagram and wind rose.

at minimizing the impact of solar radiation by avoiding non-shaded sun-facing spaces.

It is the choice of this study to consider a closed façade behind the trader. The facade behind the north facing stall as shown in Figure 5(a) is exposed to the extremes of southern sun. Second option shown in Figure 5b presents a stall facing east to avoid the western sun in the afternoon. The simulations were run for London (51.4°, 0) on 25th July, in order to compare and contrast the two selected orientations with other experiments that were done in the same period.

The Table 2 shows simulation results comparison of the effect of orientation on the percentage solar exposure of the stall space for North and East facing stalls in London where the spaces facing east are more shaded during the potentially critical period between April and

August when compared to north facing stall.

3.1 Option 1: North facing stall

Discussion of the results

The sun is very low in early morning when vertical shading will be more effective to cut off the sun. Shading from early morning solar radiation is not essentially for human comfort but for the merchandise that needs protection from any source of heat as shown in Figure 6(a).

Figure 6 shows the shading exercise with roll up & down curtains as shading devices against direct solar radiation. The wall behind the trader is facing South direction when the stall is facing North. The trader area will need screening as shown in Figure 6(b) but ultimately after 12:00noon (Figure 6(e)) the model will need right hand panels as shown in Figure 6(f) and

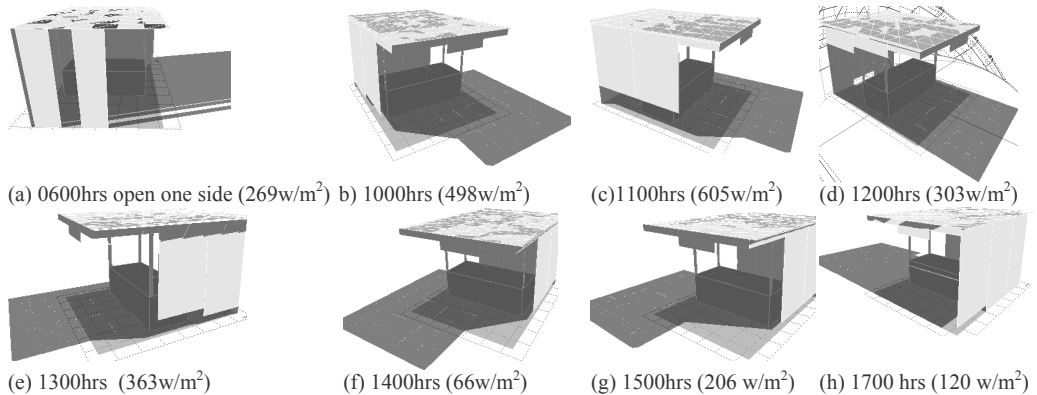


Figure 6: Simulation results for a stall facing north (Square One).

Table 2: Percentage solar exposure of the stall space (Average Shade) July 25th Tool: Square-One Ecotect Software.

North facing stall (Option 1)						East facing stall (Option 2)					
MONTH	GLOBAL kWh/m ²	AVG SHADE	REFLECT kWh/m ²	COLLECTED kWh/m ²	Total (kWh)	MONTH	GLOBAL kWh/m ²	AVG SHADE	REFLECT kWh/m ²	COLLECTED kWh/m ²	Total (kWh)
Jan:	19.0	100%	0.0	0.0	0.00	Jan:	19.0	80%	0.0	0.5	1.28
Feb:	26.2	99%	0.0	0.0	0.00	Feb:	26.2	79%	0.0	0.9	2.34
Mar:	62.8	85%	0.0	0.4	0.99	Mar:	62.8	73%	0.0	4.8	12.17
Apr:	102.2	68%	0.0	3.4	8.72	Apr:	102.2	80%	0.0	6.9	17.50
May:	98.1	61%	0.0	7.8	19.95	May:	98.1	89%	0.0	4.6	11.81
Jun:	134.0	49%	0.0	16.2	41.26	Jun:	134.0	89%	0.0	7.2	18.47
Jul:	145.9	51%	0.0	15.6	39.71	Jul:	145.9	88%	0.0	8.8	22.44
Aug:	97.7	63%	0.0	4.5	11.52	Aug:	97.7	83%	0.0	6.6	16.71
Sep:	62.0	81%	0.0	1.0	2.62	Sep:	62.0	81%	0.0	3.4	8.62
Oct:	52.8	94%	0.0	0.0	0.09	Oct:	52.8	77%	0.0	3.2	8.25
Nov:	16.2	100%	0.0	0.0	0.00	Nov:	16.2	90%	0.0	0.5	1.17
Dec:	15.6	100%	0.0	0.0	0.00	Dec:	15.6	86%	0.0	0.3	0.87
TOTALS	832.4		0.0	49.0	124.85	TOTALS	832.4		0.0	47.7	121.62

after 13:00 as shown in Figure 6(f) and 6(h) the sun will be on the western façade and later in the evening, it will move towards north before complete sun set. Front screening will be needed in the late evening. We can learn in this strategy that the panels in all three stall facades will have to be dynamic in order to practically isolate direct solar radiation from the stall space. This orientation option will work best with stall lined in a way that the side elevations are shaded by the next stall as shown in Figure 7.

3.2 Option 2: east facing stall

Discussion of the results

The east facing stall is also analyzed by using a series of vertical panels. Figure 8(a) and Figure 8(b) presents the early morning solar radiation when customers are not yet in the market.



Figure 7: Stall boundary sharing.

Figure 10(c) shows an adjustment to solar radiation at 1000 when the market is picking-up and Figure 8(d) presents the situation at 1100 which could form the last control/adjustment in a day.

The east-facing stall seems to be an optimum strategy due to less panel manipulation during market hours. As shown in Figure 8 after 1100 the trader can decide to halt the controls. The orientation is useful in a way it involves curtain movement in only one side of the stall and only in the morning before 1100hrs. There could be less or no movement at all during peak trading hours, between 1100hrs and 1600hrs. The constantly closed façade behind the trader is more useful with this orientation.

3.3 Experiment conclusion

Although a common practice is to use horizontal shading as opposed to vertical panels, good/easy shading has been achieved through vertical panels, the simpler and more effective scroll-up & down solution.

4. ROOF TO STALL CONCEPTS

Call for stall remodeling is the fundamental aspect of this work. Design concepts shown in Figure 9 propose a way towards a foldable, adjustable and adaptive structure. The concept considers a blob structure that would be formed under a system of ball joints that could easily be pressed/pulled/sucked. The proposal is used to present an alternative system that is made simple and could simply be manipulated to track

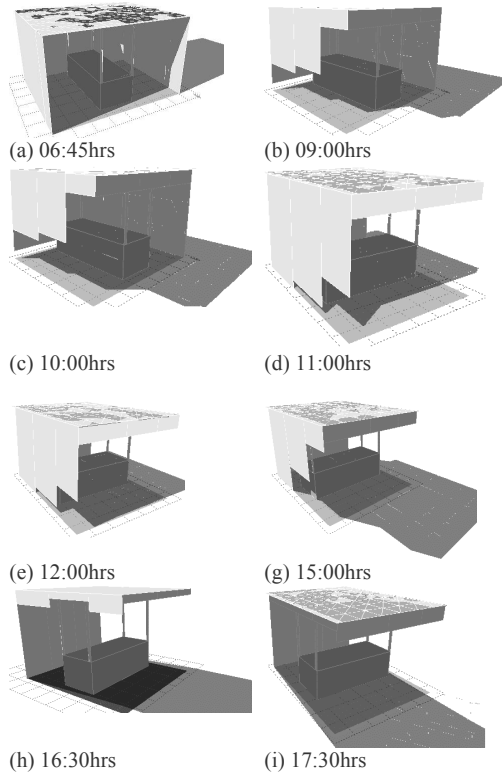


Figure 8: The simulation results for East facing stall (the wall behind the trader facing West direction).

Table 3: Hourly solar exposure of a shed in Figure 8(b).

HOUR	GLOBAL (W/m ²)	SUN ANGLE	SOLAR SHADE (%)	REFLECT (W/m ²)	COLLECTED (W/m ²)	(W)
04:	3	89.2	44%	0	0	1
05:	15	81.3	51%	0	1	11
06:	93	72.6	54%	0	5	64
07:	439	63.4	53%	0	78	972
08:	598	54.0	58%	0	123	1537
09:	674	45.0	68%	0	130	1632
10:	732	36.8	76%	0	117	1463
11:	730	30.7	87%	0	70	874
12:	543	28.2	80%	0	67	845
13:	674	30.2	96%	0	26	323
14:	403	36.0	83%	0	35	444
15:	592	44.0	89%	0	40	502
16:	466	53.0	86%	0	32	404
17:	305	62.3	87%	0	17	208
18:	155	71.5	73%	0	11	135
19:	18	80.3	62%	0	1	13
TOTALS	6440			0	752	9426

the shadow.

This adjustable structure is meant to look for new expressions of a stall that would allow pushing and pulling of some parts for different thermal stratification through provision of dif-

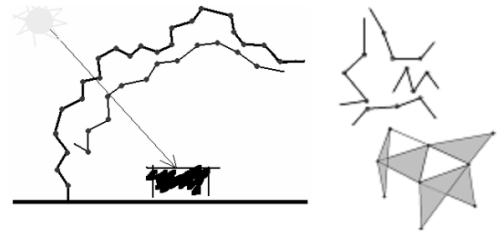


Figure 9: A structure through interconnectivity of nodes.

ferent depths. The aim is to provide a solution at some critical business hours between 1100 and 1500 as shown in Table 3.

Optimization of east facing stall

In previous simulation results indicated east facing stall as relatively the best choice available in this study. This concept has been capitalized in expressions presented in Figure 10.

Figure 11(b), presented above reveals better shade at the critical business hours 1100 to 1500. It is intended that the structure will have a non-uniform geometry, be easily collapsible, extensible, some triangular modules able to be opened by unpinning a joint to adjust to certain microclimate and access to daylight. Roof modules tonalities would also influence access to light.

5. DAYLIGHT FUNNELS DESIGN

Daylight provides five times more lighting lumens per watt of heat energy than a normal incandescent globe (Square One notes). To reduce the need for artificial light and to add visual quality to the space, the concept of daylight-funnels roof is proposed as a solution in this project. The idea is for a roof to have multiple funnel-like blobs that could either be a development of the canvas surface or as fixtures into it.

A funnel concept has been resolved by contemporary selected set of materials from the market. It is proposed that the inner layer is coated with *Solar reflex* panels as demonstrated by Figure 12(a). The material is said to be 10-15% more reflective than normal glass mirrors, aluminium foil and Mylar reflector film. It is said to be 0.03 emissive and 96% reflective. Panels allow guided daylight that has been isolated from heat down to the stall table. The top cap is Micro grid, it offers diffuse solar rays. It's

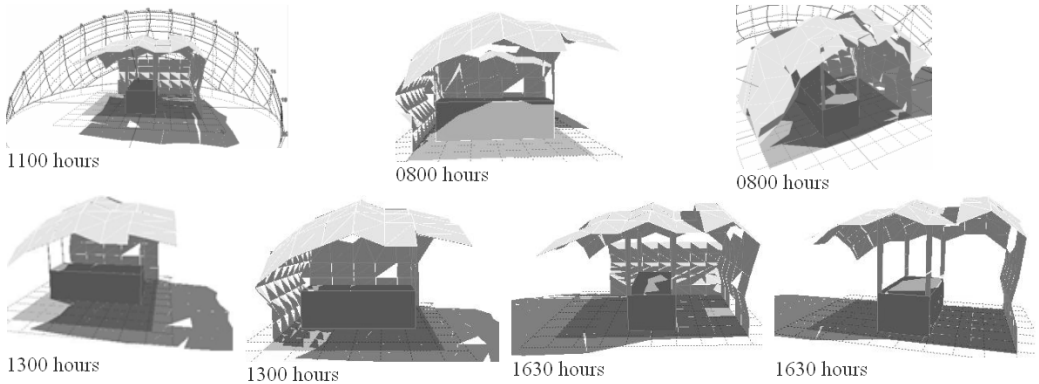


Figure 10: Simulation results for proposed diurnal adaptation.

material composition is aluminium-coated plastic that is micro louvers. An alternative to Micro grid is ETFE, manufactured by DuPont. This material is also introduced as a provision for corrosion resistance and mechanical strength over a wide temperature range.

Figure 4 1c presents the form that tracks sun path diagram. The proposed ideas make it easy to take advantage of lower sun in winter season and bring light into a space to warm for human comfort.

6. CONCLUSIONS

The proposed strategies will effectively achieve

lower temperatures than the current model, and be useful for fruits and vegetables that require cooler climate in all seasons and at all times. Stalls should be provided with slightly deeper floor to ceiling height in the summer season for thermal stratification that would isolate heat from the stall space. Since there are some open-air street markets that have different orientations based on street patterns, definite and permanent shading positions can fairly be applied into new schemes. Vertical scroll up & down panels will also be useful as a retrofit to existing markets stalls. However, the analysis and discussion on optimum orientation and shading and lighting through effective exposure of transparent and

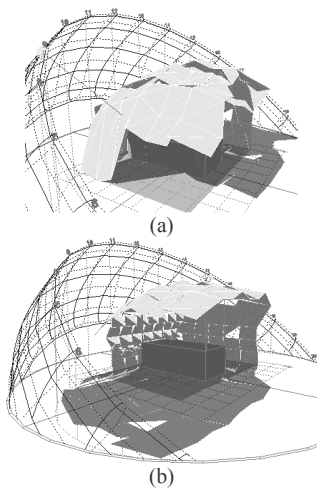


Figure 11: Simulation results for (a) The stall in the critical mornings at 09:00 hours and (b) Stall in the secure afternoon after 11:00.

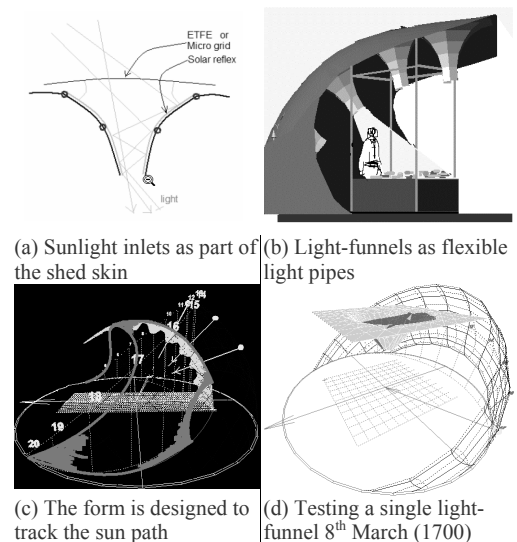


Figure 12

opaque elements of the structure at different periods of a day will be useful for cooling and evolution of a market stall.

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