‘The Open Air Office’
Climatic adaptation of the office building typology in the Mediterranean

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ABSTRACT
The paper reports on a dissertation project undertaken at the Architectural Association School of architecture towards a Master’s degree in Sustainable Environmental Design by the Author. The starting point for the research was the troubling common practice of office buildings in Israel - racing towards the tallest, highly mechanical and fully glazed buildings, scarcely applying any environmental considerations and occasionally using the local green point system code to render them as ‘green’. This research aims at contextualizing the office building typology to the local Mediterranean climatic conditions of Israel; based on a theoretical framework and a detailed study of local common practices and climate, followed by an analytic optimization study, the ‘Open Air Office’ concept is introduced: one which uses an integrated environmental design approach to rethink some of the core values that drive office building designs in Israel today.

INTRODUCTION
Adoption without adaptation

In contrast to a history of successful adaptations of international building styles in Israel which demonstrated high sensitivity towards the local climate, the adoption of the fully glazed office building typology in Israel- mostly throughout the late 80’s and 90’s- has been almost automatic (Figure 1), with very little awareness towards the environmental impacts of these buildings on all levels - from the cityscape to the occupant.

Figure 1 Gradual abandonment of climatic considerations throughout the history of Israeli Architecture. (Source, left to right: Le Corbusier, author’s sketch, Arieh Sharon, Emporis, and Telavivinf.com)

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Starting from evaluating the performance challenges of this common practice in Israel against the potentials of the local climate, this research began by questioning how to improve performance by taking simple considerations into account in the early stages of office buildings design in Israel; using the common practice as a base case this study gradually explored the possibilities of optimizing both comfort and efficiency by applying preliminary, good and further on best practice environmental strategies that fit Israel’s climatic conditions. In conclusion, this research aimed at offering a platform for architectural design that will give a new angle to the correlation between the contemporary indoor office space and the local climate.

Methodology

Firstly, a study was conducted on new global workplace trends and explored the potential of new occupancy patterns to affect both comfort and performance levels of office buildings in the near future. Secondly, the local climate of Israel was studied, followed by relevant basic and advanced environmental strategies evaluation. In order to study the existing context, combined literature and analytic work were used to help gather insights regarding the current performance, layout and materiality of the local common practice office building. These insights helped highlight specific challenges and potentials, so as to define the base cases towards further studies. The analytic work, which was focused on thermal, daylight and Solar geometry aspects, moved through different levels - from the simplest preliminary environmental concepts to more advanced ones, evaluating their potential to improve both efficiency and comfort levels within the typical office space; Simulations were conducted by using Tas (thermal, by EDSL), Ambiens (CFD, by EDSL), Radiance (Daylight, by Berkley lab) and Ecotect (solar geometry, by Autodesk) software. The last part of this research explored and analyzed the unique opportunity of the Mediterranean climate to open up the building’s envelope towards the outdoors throughout different seasons of the year with correlation to the changing internal office layouts. The performance analysis for this ‘Open Air’ concept, was followed by an applicability study of one possible office building configuration, which proved its potential to work very well with the local climate and office culture while providing high performance and comfort levels within the office space.

THE FUTURE WORKSPACE

Nowadays, in contrast to the prescribed tasks of the traditional “office factory” through single fixed workstations, the economic shift towards the “knowledge” society has created a need for variety of alternative spaces, with higher levels of interaction and autonomy (Harrison et al. 2004); As new technologies enable people to work virtually anywhere and new interaction between users within the office space through virtual computing (Johnson et al. 2011), a new office layout terminology has been evolved which encourage higher levels of flexibility, collaboration and autonomy (Duffy, 1997);

The Israeli work culture, characterized by a vivid, creative informal atmosphere, with strong communal routs is highly exposed to global trends, which are commonly taken into account during the design process. Therefore, the future trends which shape workspaces globally served as an important anchor for this research.

ISRAEL’S OFFICE BUILDING DESIGN CULTURE

Common practice design

The research has focused on the climatic and urban context of the Tel Aviv metropolitan area, the economical center of Israel, due to its large conglomeration of office buildings.

Building design. High rise office buildings are becoming common within the Central Business District of Tel Aviv. The Israeli market is highly speculative, predominated by “Shell & Core” buildings, being designed within a central core rectangular layout due to costs and internal space considerations.

Materiality. Reinforced concrete frame & floor slabs is the prevailing framing method, cladding is usually done with different variations of curtain wall systems which combine glazing and opaque
cladding materials; Fully glazed buildings are very common and solar control is usually applied by reflective or tinted glazing systems combined with internal venetian or roller blinds.

**Office space layouts.** The demand for enclosed private offices is still relatively high; the common practice consists of 4.5 deep office spaces with changing widths. Double-sided or single-sided open space offices are becoming more and more common, with depths ranging from 9m (single-sided) to as much as 30m (double sided); These observations helped generate the base case as shown in Figure 2.

**Performance criteria and benchmarks**

Although it is widely acknowledged (McKinsey and Co. 2009) that most buildings in Israel are big energy consumers, official energy consumption database or performance criteria for office buildings are currently unavailable. In order to establish a reliable reference point for the performance studies throughout the research, data was gathered from HVAC experts in Israel and was correlated with published cooling energy consumption data from similar climatic zones within the US. For this comparison, Tel Aviv climate had been considered as part of the A2 category (using ASHRAE international climatic zone definition) and energy consumption data of office buildings in Houston Texas was selected as a general reference.

Based on findings from the common practice design studies, three layout configurations have been modeled, as shown in Figure 2. The boundary conditions\(^1\) for all the three base cases have been closely considered in regard to typical glazing, solar control, occupancy and materiality properties which have been identified as prevailing during the common practice studies.

As a starting point, in order to establish a reference for further parametric optimization studies, a thermal simulation was conducted using TAS for the three different base cases facing West (or East West) orientation (a very common orientation for office buildings with proximity to the Israeli coastline). The combination of high exposure, together with their West-facing orientation, resulted in very high cooling energy demands across all three office layouts, mostly in cellular office layouts due to

\(^1\) Boundary condition in all cases included fully glazed 75% WWR designs, oriented West (or West-East orientation in double sided configuration), no external shading, w. internal semi opaque blinds.
their high window to floor ratio (Figure 3). These results were found to correlate well with the data gathered from the actual practice in Israel, in which HVAC systems are being designed to supply cooling energy of approximately 200 kWh/m² annually.

ANALYTIC WORK - OPTIMIZATION PROCESS

Preliminary optimization

The first level of optimization was set up to explore the hypothesis that a high level of efficiency and comfort could be gained by applying very basic environmental design strategies at the very early design stages of office buildings. The parametric approach included four different strategies which were assessed separately (Figure 4), and were conclusively merged into different typical combinations according to the common office building design scenarios in Israel (Figure 5).

Set point temperature. When considering the adaptive comfort model, the common fixation of the temperature set point on 23°C or even lower during cooling period seems inappropriate. In order to test the implication of set point changes on performance, the three base case models were thermally simulated for three different set point temperatures (23, 25, 28°C); Simulations showed how this simple operational change could substantially improve the annual cooling loads in all office layouts by 20-30%.

Orientation. Thermal simulations for the three different layouts revealed large amplitudes in annual cooling energy demand between different orientations. In contrast to the Cellular base case which is more thermally fragile, open space layouts reacted more mildly, with the double sided model showing very limited performance effect by orientation.

Shading. Different external shading geometries were simulated and studied in Ecotect for all four major orientations. After daylight levels had been verified through simulations (Radiance), selected optimized shading configuration were modeled thermally TAS.

Window to wall ratio (WWR). This study explored the balance between minimizing exposure for thermal considerations while insuring adequate daylight levels for the 3 base case layouts through different orientations.

Figure 4  Parametric optimization study of annual cooling energy demand for 3 typical office layouts (in kWh/m², Source: TAS).

Figure 5  Annual cooling energy demand for different preliminary optimization scenarios (in kWh/m², Source: TAS).

Scenario A - Optimized configuration (A+B+C+D).
Scenario B - Fully glazed configuration, all parameters applied besides the reduction in WWR (A+B+C).
Scenario C - Sea View/Western configuration, all parameters applied besides optimized orientation (A+C+D).
**Preliminary optimization.** Figure 4 shows the effect of each of the parameters on the base case cooling energy demand; the chart demonstrates how orientation is critical for cellular offices (A); when oriented North, cellular offices will perform better than the double sided open space (C) due to reduction of solar gains being replaced by the effect of other internal gains. The chart also shows the changing trends between single (B) and double sided (C) open spaces, the latter being less effected by orientation due to its double orientation exposure. The combination of different strategies (Figure 5) indicates similar trends in cooling energy demands between the three layouts, in which differences observed between the three base cases dissolved in different scenarios when solar gains were being effectively modulated by applying external shading.

**Good practice optimization**

Aiming at higher performance and comfort levels, the following studies evaluated the potential of more advanced strategies to further reduce the resultant temperature and cooling loads accordingly;

**Glazing properties.** The thermal balance of glazing, being a dominant component, was studied; for each base case, five envelope properties were considered, each offering a different balance between heat gains vs. losses as well as different daylight intensity (Figure 6).

**Thermal mass and night ventilation.** The possibility of applying high thermal capacity materials within the common office space layout was narrowed down to the 3 scenarios; (a) Exposed concrete floor, (b) a + concrete partitions, (c) b + exposed ceiling. Thermal simulations for the three scenarios revealed considerably lower days within comfort for scenario (c) during cold periods, indicating that heating might have to be introduced, and that the ‘cold’ outcome might work better in cases of high internal gains due to occupancy patterns or equipment usage.

**Natural ventilation.** These studies evaluated the balance between space cooling and physiological cooling considerations; after determining the required air flow rates needed to optimize performance, CFD simulations had been used in order to evaluate resultant temperatures and air flow rates throughout the office space for a typical mid-season week. Natural ventilation studies proved that in periods when external temperature reaches above certain limits, the space cooling effect achieved by natural ventilation was often very limited; however, under the same conditions, physiological cooling effect by air movement throughout the space could effectively lower the resultant temperature towards comfort.

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**Figure 6** Annual cooling energy demand of five different glazing properties scenarios for Cellular base case (in kWh/m², Source: TAS).

**Figure 7** Cooling energy demand for different good practice optimization parameters (in kWh/m², Source: TAS).

**Good practice optimization.** The study showed how further efficiency improvements could be achieved by applying advanced strategies (Figure 7); however, high internal gains will still generate an inevitable need for cooling (mostly during hot period), and by cutting off solar gains during cold period,
heating demand will increase. Nevertheless, during the process of their evaluation, strategies such as natural ventilation or thermal mass should also be measured against their added values for the quality of the space; i.e. by creating desirable air flow and stabilizing internal temperatures.

Towards best practice

Aiming towards the ‘zero carbon’ office space, this part of the research, within the recognition of air conditioning as the main energy consumer, focused on the passive cooling solutions that might reduce or eliminate its use. After four selected passive cooling strategies had been evaluated (based on data from contemporary research, literature and precedents), this section highlighted radiant and ground cooling as the most effective passive cooling strategies for Israel’s climate. However, considering the highly speculative Israeli market, the applicability of these strategies in Israel is expected to face strong market barriers, and most probably would be considered only for a ‘use value building’ (Harrison et al. 2004), custom designed for specific end user organization. The limiting potential of the Israeli air to effectively absorb excess heat indicates the need for hybrid or mixed mode systems in which low energy mechanical systems are coupled with natural forces; e.g. hybrid evaporation systems could be very efficient, as well as heat recovery mechanisms which could be coupled with the ground cooling system. These should be integrated aside renewable systems (which were not addressed in this research), mostly solar systems, in the light of Israel’s high solar radiation availability.

THE OPEN AIR OFFICE CONCEPT

The inspiration for an ‘open’ approach for office buildings in Israel was drawn from the local building tradition; one in which the potential of outdoor and semi-outdoor activities to take place throughout a considerable time of the year had been widely recognized, mostly throughout the pre-AC era. The ‘Open Air’ concept aimed at reintroducing that potential to the contemporary office building typology (Figure 8). The need for diversity and informal reflection and meeting areas as part of the new office space, generated an excellent opportunity to reinvent these spaces in the Israeli office building typology through transitional or outdoor spaces. A dynamic semi-outdoor space, which could be opened or closed according to the user demand and the outdoor conditions, could serve as an extension to the internal office space and activity.

Analysis methodology

For the thermal and daylight analysis, a double sided section had been chosen with similar proportions as the previous 15m base case used throughout this research. The layout of 15m X 12m which included the fully optimized configuration (as previously studied) was coupled with a 3m transitional space projected towards to South, with openable full height glass partitions between them calculated to be opened when the adjacent semi outdoor space temperature was within the boundaries of comfort (Figure 9).
Thermal simulations for the internal office space in a free running mode (Figure 10), revealed resultant temperature fluctuating very closely to the external ones and relatively high levels of comfort hours yearly; strong potential was evident for opening the office space to the outdoors in sunny days during cold-periods, as well as through most of the mid-period. Daylight simulations for the same boundary conditions showed the potential of the adjacent space to serve as an effective buffer from direct sunlight without compromising the required daylight levels in the office space.

**Figure 9** Case study model for the Open Air Concept analysis.

**Figure 10** Annual resultant temperature simulation (Source: TAS).

**Thermal vs. visual comfort**

By applying adaptive opportunities and space diversity, the occupants interact both with building elements and with the building space. In addition to the basic environmental strategies applied (orientation, exposure, ventilation etc.), the application of the adjacent semi-outdoor space towards the South is taking performance further - by serving as a mediator between internal and external conditions, and by offering a good balance between thermal and visual issues. Figure 11 shows how the deep projection addresses glare and excess heat issues effectively while the adjustable louver-shelf serves as solar protection for the semi-outdoor space and redistributes light towards the depth of the office space.

**Figure 11** Adaptable envelope design.

**Figure 12** Exterior view of the open air case study showing the design expression of the environmental concepts.
Activities

The diversity of space which is required to address new patterns of office activities have been addressed and distributed according to visual and thermal considerations; e.g. presentation areas in less exposed spaces, informal areas in semi outdoor spaces with higher tolerance levels to the outdoor climatic conditions and fixed workstations, with higher control levels and stabilized thermal conditions.

Design expression

The external figure of the building (Figure 12), reflects the shift of mind from the sealed glass building, disconnected from its environment, to a new model in which different levels of exposure drive the building’s external image. The correlation between the external layout and the performance becomes complete and corresponds with the local architectural design language from earlier times in Israel’s history, in which climatic considerations helped contextualize the modern trends to the local climate.

CONCLUSION

This research showed that by adopting an environmentally responsive approach, the troubling performance of the Israeli common practice office could be dramatically enhanced - even up to a ‘zero energy’ balance. As overheating was identified as the main issue, optimization phases mostly focused on blocking solar heat gains while dissipating internal ones; while preliminary optimization studies showed how effective simple design decisions could be, In further optimization levels, when direct solar gains were effectively blocked, internal heat gains became predominant, and issues such as control, adaptability and thermal vs. visual comfort balance became critical to comfort and performance.

Aside the more ‘technical’ aspects which evaluate comfort and performance through numerical prediction, the architectural performance of the space must also be accounted for and correspond to the office concepts of tomorrow. In the new work environment where borders dissolve (e.g. ‘home’ and ‘work’ or ‘virtual’ and ‘real’), the same levels of flexibility and adaptability will have to be applied to the spatial differentiation between ‘in’ and ‘out’; The ability of the coastal Mediterranean climate to dissolve these boundaries within comfortable outdoor climatic conditions, offers the unique opportunity to open up the sealed office ‘glass box’ to the outdoors. The open air office approach had been incorporated into this concept, in which new office organizational trends and spatial design values reintroduce the potential for working with the Israeli outdoor climate.

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