EVALUATING THE EVOLUTION OF GARDEN OFFICE TYPOLOGY AND DETERMINING ITS PERFORMANCE

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ABSTRACT

The paper presents documentation on “Garden Offices” a building typology found in the metropolitan area of Phoenix, Arizona and evaluates their performance using CFD simulation software (Flovent).

This building typology was identified, documented and evaluated using the capability of Flovent, a CFD program to model outdoor thermal comfort. DOE 2 interface eQUEST was also used to explore the feasibility of this typology while comparing it to a conventional office building. The analysis focuses on qualitative and quantitative aspects of Garden Offices. This would include tracing back their conceptual evolution and typifying the climatic control features for use in any hot arid conditions like Phoenix, Arizona. The quantitative objective would be to do a comprehensive analysis using simulation software (DOE-2, Flovent a CFD program); of their performance and to highlight the relationship between this building typology and the urban microclimate they create within the architectural design.

INTRODUCTION

A preliminary documentation and site visit to these offices displayed a definite architectural expression for the need to control and to adapt the harsh climatic conditions. Despite of them being well adapted to Phoenix and having a unique architectural expression coupled with some historical aspect, they are no longer being built and there is also a lack of documentation on them and of their actual or intended performance.

Literature from the field was studied to understand how atriums and courtyards work in general. The paper explores the capabilities of DOE 2 (eQUEST) and CFD (Flovent) as simulation software to model these features; specifically in hot arid climatic conditions. This developed a knowledgebase and understanding of software available for the study of urban microclimates and for evaluating their bioclimatic performance. The paper also contributes to the field by being able to revive an important building typology by discussing its design opportunities coupled with its technical merits and by being able to explore software for evaluating an important feature to enhance energy performance- contribution by improved outdoor thermal comfort.

METHODOLOGY

The evolution of Garden Office typology and assess its feasibility.

Qualitative analysis
-Photo documentation of the buildings - atrium space and from one of the offices
-Interview the architects on their concepts for these buildings Interview people for their experience of the use of the space Study the building drawings to understand the design principles
An analysis to investigate, why developers don’t build them anymore and prefer the conventional office structures. A technical assessment of the garden offices vs. conventional offices would be required. By means of interviews of real estate developers, utility bill analysis and calculations of;

  For e.g.-high amount of perimeter office space to high rental values
  -can the utility penalty in perimeter zones be reduced via garden offices

Quantitative analysis
To study building plans and sections for recognizing features that was used for adapting to the climatic conditions.
By using experimental evaluation establish some performance data like temperature differential, illumination levels, radiant temperatures of materials

<u>To do an in-depth study of these buildings for driving principles of climatic control derived from documentation</u>

Take buildings out of the pool of case studies documented and study the driving principle in detail. To use simulation tool appropriate to model that particular principle. The aspect studied would be a derivative of the documentation and interest developed after observation. The possible list of example performance characteristics, are daylighting, solar shading, MRT, thermal comfort, ventilation, etc.

<u>To optimize the performance of the building modeled by suggesting changes to the building space studied.</u>

The simulation model would indicate changes that could be implemented to improve the performance of the building studied. These would then be modeled to develop an optimized model for that principle in concurrence with the technologies available today.

<u>CASE STUDY SELECTION</u>

Fig 1: 4450 N 12 Street, 1980 Architect: Alfred Newman Beadle

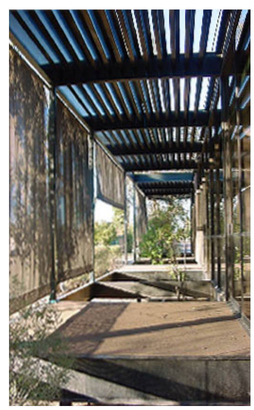
The courtyard of this building is enclosed; it is characterized by parking below the second floor for half the floor area. The depth is one office deep; an introverted space with less percentage of glazing on the outside and large openings towards the courtyard.

Fig 2: 2525 E. Arizona Biltmore Circle; 1980- Edward B. Sawyer. Jr.

This office complex surrounds a lush courtyard containing fountains and an observation tower. Exposed metal studs form a sunscreen high above the courtyard. Pedestrian bridges extend from the courtyard out over the parking area to stair towers.

Fig 3: 2234 N 7St; 1975 Orcutt-Winslow

Exposed wooden columns and beams support shade screens and a walkway overlooking a small garden. The garden area surrounded by eucalyptus trees; buffers the offices from the vehicular traffic of 7 street.



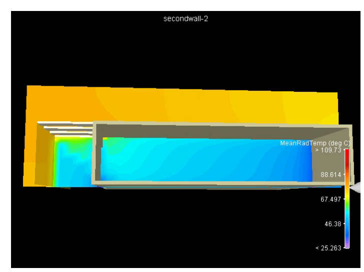


Fig 4a

Fig 4b

Fig 4a: 1545 W. Thomas Road; 1977 James Flynn and Associates

Exposed steel columns and beams support shade screens and a steel deck around the office. This one storey building sits right on the main street but because of the vegetation around is almost camouflaged. The most noticeable feature though; is the Fabric screens hanging around the building perimeter at one end of the deck.

Fig 4b: CFD run : showing the temperature difference due to the combined effect of the louvers and the screen on a test cell.

<u>EXPERIMENTAL EVALUATION</u>

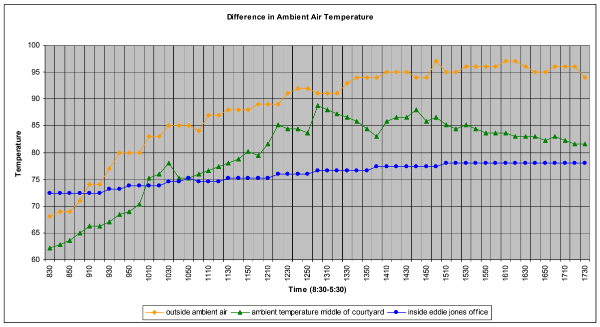


Fig3: Graph showing the difference in dry bulb temperature of Ambient Air : _On the outside, within the courtyard and the inside of the case study building using measured data.

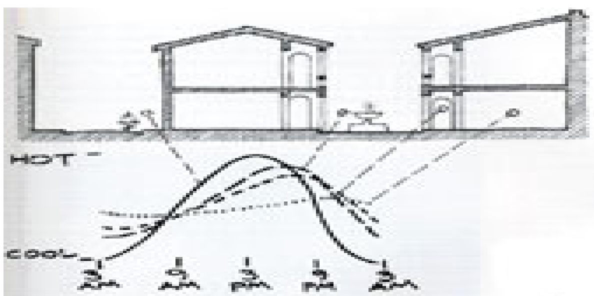


Fig 4: Graph showing the Ambient Air difference in outside, courtyard and the inside. (source: Reynolds, John. Courtyards)

Measured data was collected from the site using HOBOS for a typical work day from 8:30am to 5:30pm. The most dramatic thermal contrast was noticed between the street and the courtyard

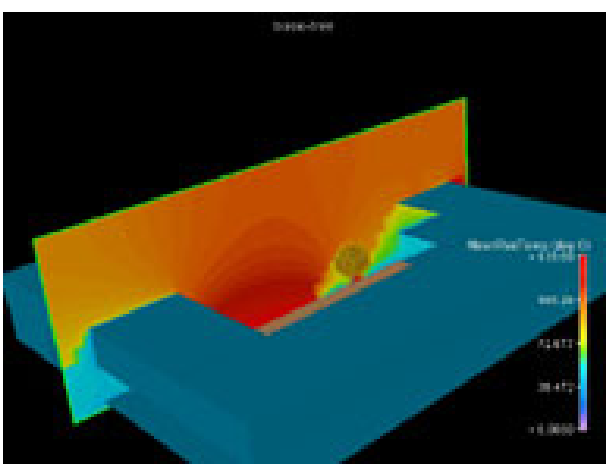


Fig 5: CFD run expressing the difference in mean radiant temperature.

The Building modelled in CFD is a protype building which has no windows on the interior facades. The run shows us that due to the presence of the tree there is a shift in the mean radiant temperature of the courtyard. Which is expected as a correlation from the experimental evaluation. This same courtyard was tried to model in eQUEST but due to its lack in modelling Urban Microclimates;one could not predict the real effect of the courtyard on the Building Energy use according to end uses.

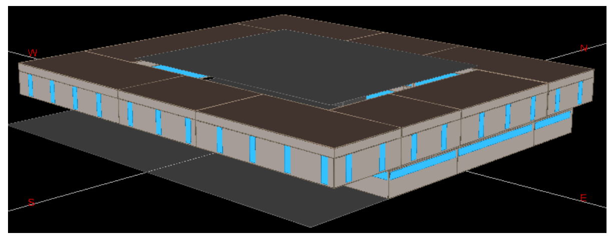


Fig 6 : eQUEST model for the existing case study Garden Office.

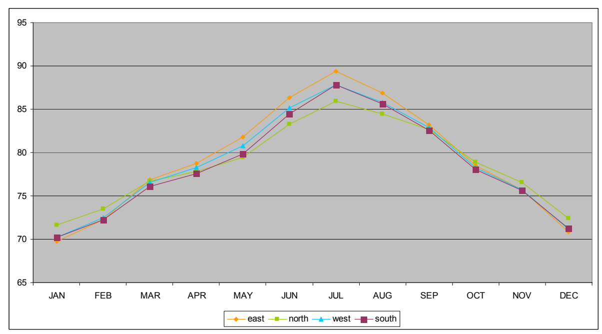


Fig 7 : Varying temperatures in a Garden office building for the various zones.

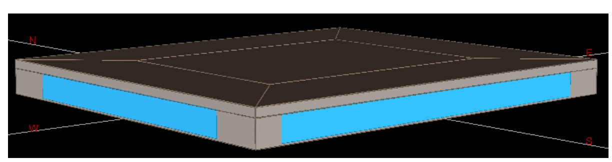


Fig 8 : eQUEST model for a comparative square footage in a conventional office building.

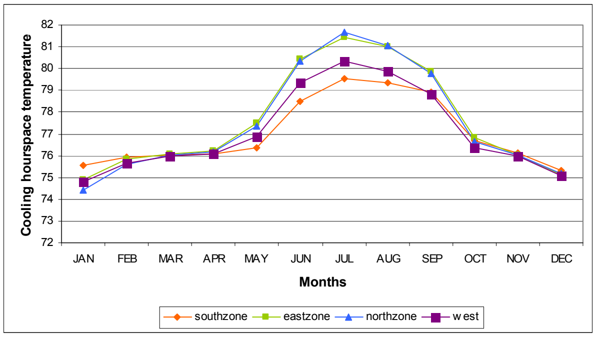


Fig 9 : Varying temperatures in a conventional office building for the various zones.

GARDEN OFFICES

Architecture is generally conceived, designed, realized and built in response to an existing set of conditions. These conditions may be purely functional in nature, or they may reflect in varying degrees the social, political and economic climate. The initial phase of any design process is the recognition of a problematic condition and the decision to find a solution to it.

This paper focuses on broadening and enriching our vocabulary of office design in Phoenix through the study of a building typology recognized as the "Garden Offices". This would be accomplished by the study of essential elements of this office type and exploration of wide array of solutions these provide to the architectural problems developed because of the climatic conditions in Phoenix.
Fundamentally the physical manifestations of architecture accommodate human activity; however by the arrangement of form and spaces it can bring forth responses and communicate meaning. It might be appropriate to be able to recognize basic elements of form and space and understand how they can be manipulated and organized in the development of a design concept, while addressing important issues of thermal comfort; a more vital meaning in the issue of architecture. In the hot dry climate of Phoenix, Where the temperatures result in dry climatic conditions, these buildings stand out and it is therefore imperative to understand why and where they evolved from.

RECOGNIZABLE FEATURES OF GARDEN OFFICES

The Garden offices studied in the Metropolitan region of Phoenix had some recognizable features as a typology.

- Scale- Buildings were generally limited to a floor or two
- Shape- was mostly rectilinear
- Organization pattern – the offices were either with courtyards or had linear organization.

If they had courtyards they had mostly introverted exterior facades and a high percentage of openings on the inside. The courtyards had vegetation, water features and vertical circulation within them. Research has shown that evapotranspiration coupled with the effect of water being absorbed by the building material close to the plants while it is being watered is an important way of bringing down the mean radiant temperature.
Linear arrangements were generally buffered from the harsh temperature conditions by the use of horizontal louvers like shading elements that went around the whole building. These were further buffered by planting trees of the deciduous variety with large leaf areas.

- Colors- the colors of the building were generally of hues of brown and grey with a rough texture.
- Quality of Openings- Garden offices had less percentage of glazing on the outside compared to the facades overlooking the courtyard. This created benefit by daylighting.

The courtyard is at a lower temperature because of microclimatic effects and the higher external temperature creates a differential; heat flows from higher temperature to lower temperatures and thus the heat from the outside flows into the offices which then dissipates the heat into the courtyard.

- Sensory experience- The occupants of these offices have varied sensory experiences.

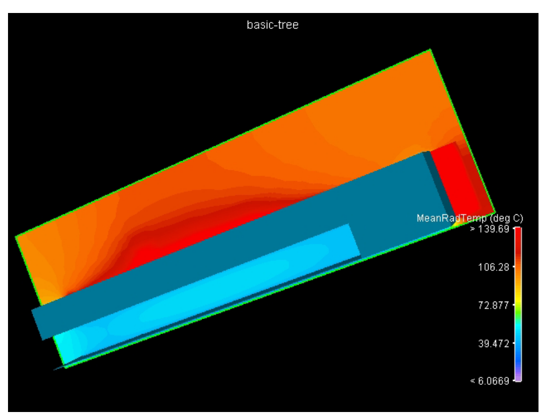


Fig 10 a.: Showing the MRT differential because of the raised floor

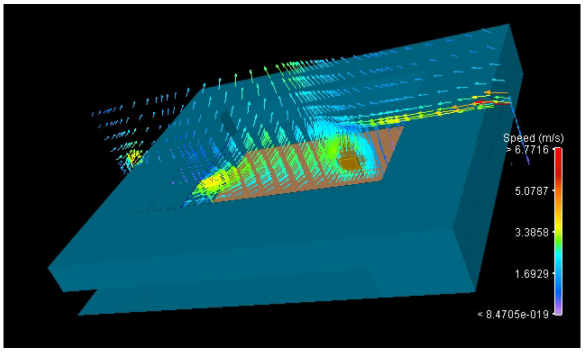


Fig 10 b.: The air movement caused due to the courtyard. (using Flovent, CFD)

COMPARISON BETWEEN A CONVENTIONAL OFFICE TO A GARDEN OFFICE

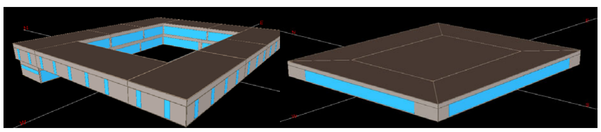


Fig 11 : Showing the models of Garden Office and Conventional Office building created using eQuest (DOE 2).

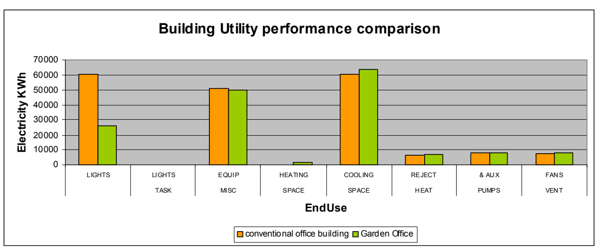


Fig 12 :Graph showing the difference in the performance of a Garden office to a conventional office building for different enduses. (using DOE 2 eQuest)

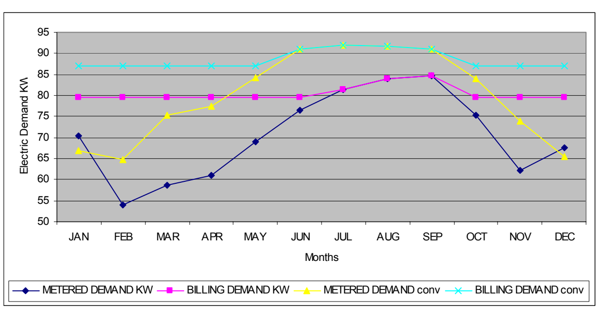


Fig 13: Graph demonstrating the difference in the Metered and Billing demand in KW for a Garden and a Conventional Office building.

There is a significant difference seen in the energy performance of the Garden office. The utility rate used was APS e-32 and the Garden office was performing better than a conventional office building of the same square footage. Eventhough there is larger surface area exposed; but the percentage of exposure is divided between to microclimatic and to external conditions. The mocirbclimatic exposure mitigates the temperature differential while giving benefit for the daylighting enduse.

It therefore becomes imperative for us to understand the percentage impact from the façade overlooking the courtyard and the exterior walls. This was calculated in DOE 2 using eQUEST by running the model of the Garden Office twice. Once the exterior walls were deleted and for the second run the courtyard walls.

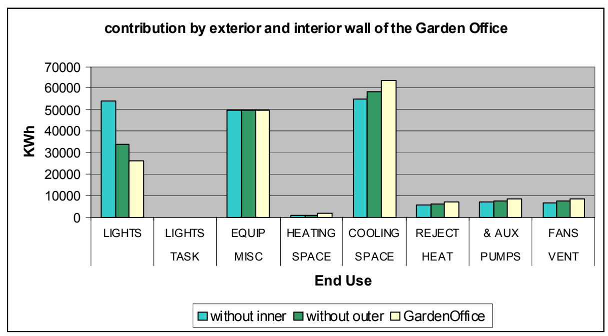


Fig 16: Contribution of the exterior and the interior walls against the total electric consumption. (using DOE 2 eQUEST)

The case with no courtyard walls uses maximum energy and the whole Garden office has smiliar energy use pattern as with interior walls. Garden Office shows higher metered energy than the case with just the inner walls in summers. That shows that the best imapct of Garden office with the courtyard is during the summer.

ECONOMIC POTENTIAL

Garden Offices have reduced in construction and it is perhaps the most important analysis to establish their economic viability. They cost more to build per squareft ,to maintain and to operate them because of the open spatial organization. The landscaping would also cost more. But investigations shows that the benefits of daylighting are far more than the load on cooling. This is when we are not accounting for the benefits of microclimate because of eQuest's incapability to predict those benefits. Even after assuming that the construction and maintenance cost is more; one can prove that utility cost would be less and also that there would be a higher chance of the the Garden Offices being occupied than the conventional office; which would compensate in the longer period as a payback on the higher cash invested for contructing a Garden Office.

CONCLUSION

Relationship between architectural form and energy was explored and how form is a manifestation of the energy flows that are always present in a building and a designer can with some experience, create form that guides and shapes those energy flows of sun, wind and light. Beyond just making buildings functional energy processors; these Garden Offices express those energy processes in their form; in a time where most buildings conceal their environmental control systems. Garden offices display a definite expression to achieve lower temperatures next to the building skin to reduce the balance point temperature; thereby reducing the heating cooling requirements. Conventional office buildings create static thermal environments which are universally applied. In contrast the adaptive models created by the Garden Office advocates variable indoor temperature standards that fully exercise the adaptive capabilities of building occupants. This approach leads to responsive environmental control algorithms, enhanced level of occupant comfort, reduced energy consumption and the encouragement of climatically responsive building design.

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