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# Comparison of Buildings' Thermal Loads against Building Orientations for Sustainable Housing in Pakistan

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RECEIVED ON 30.11.2011 ACCEPTED ON 15.03.2012

## ABSTRACT

As the sustainable settlements have been included as a vital end product of all planning exercises, the architectural layouts should be well integrated with the sun path charts and the orientations of windows. Appropriate orientations can offer thermally indoor conditions besides physical and psychological comfort in any settlement at lesser energy demand. This investigation uses a vast number of computer simulations to visualize and make better decisions about heating and cooling requirements of a building and facades as a function of window orientation in composite climatic condition of Lahore. This study in particular evaluates the solar load in residential buildings responsive to the objective of sustainable new housing leading to thoughtful integration of architecture. The orientation of the buildings could then be essentially integrated to the current architectural and urban design practices in order to optimize the relationship between the given site and the orientations for sustainable developments.

**Key Words:** Sustainable Housing, Orientation, Lahore, Simulation.

## 1. INTRODUCTION

Sustainable developments need building orientation as a vital feature of passive solar design of all planning exercises. Its main goal is to achieve an energy conscious residential building design. As the buildings are the major consumer of energy around the world [1], the architects and planners are required therefore to incorporate local climatic conditions which are the leading factor of the heating and cooling demand of a house for thermal control [2]. Newer housing settlements lack the sensitivity to orientation which needs to be determined for the building professionals for less energy demand [3]. The lot of the houses integrated with other passive design strategies can respond to the sustainability in new housing developments leading to

thoughtful integration of architecture with energy conservation [4]. Passively designed houses can use the heat of the sun during the heating season, and can protect the buildings from summer sun. But, the architectural design comprising more than one window towards different orientations can be easily evaluated with the in any climate context and control for comfort at minimized energy demand [5] in planned/ designed housing. The housing consumes the maximum energy among all the building sectors in Pakistan [6] and maximum heating load in buildings is from the roof [7]. The electrical energy use in domestic buildings increased to many hundreds percent and the energy used to condition them about more than 40%.

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Building energy simulation technique employing AutoDesk Ecotect 2011 to determine the cooling requirement as a response of different orientations in particular typology of housing settlements, built in different periods, was studied because Pakistan is striving for adopting energy saving strategies and renewable energy technologies. Hence there should be investigations on solar passive design strategies as a primary step. Among the guidelines for the solar passive control through the solar orientations [8-9] with respect to summer and winter seasons' cooling and heating with respect to the climate of Pakistan about which the practical information should also be provided to the professionals in building industry. The objective of this study is to investigate the effect of sun orientation upon solar loads of a house in an existing typology of houses so that its role on energy saving could be evaluated in any type of housing with different cases of orientations. Furthermore, the building could synchronize individual occupant data with more general building information, transient performance of facade materials, interactive building elements. For the present purpose a typical house plan is selected for the particular study and simulated with the building envelope detail for the key information for the sustainability in residential sector in Pakistan.

Each block is consisted of four houses with the similar architectural floor plans. Energy simulation is useful technique which can be adopted in existing conditions with the users' defined occupancy with one and two windows cases. 2-Lot layout and urban planning Solar access depends on site layout and the urban planning of the buildings blocks. Optimum lot orientation is the most important solar passive strategy for siting the house.

The micro climate strongly affects the urban climate [10]. Although a North-South lot in urban planning is recommended by many researchers [11] but a local climatic impact cannot be ignored [12] which further has effects due to two windows cases in any zone of a house. There are so many constraints on today's housing that it is very difficult to change unshakable urban and architectural planning practices in favour of passive solar orientation layouts. However, a study carried out by the CARB (Consortium for Advanced Residential Buildings) near Phoenix, the Del Webb Prototype, showed that in early design phase, the orientation specific strategy and its wide-spread use might stimulate developing and planning practices. Winter performance was strongly influenced by orientation up to 15% and it was agreed that the orientation-specific architectural-design or planning is responsible for solar heating [13]. In the present study, the opportunity at four main cardinal orientations and their results can be verified with the users and energy load comparisons.

## **2. SELECTED CASE STUDIES**

The study of orientation faces difficulty in occupied residences due to the inability of control over the indoor environment. Therefore, the thermal analysis in buildings with occupancy can be assisted with simulation technique. The selected types of houses are comprised of same house plan configurations but their layout is at different orientations. After conducting a survey of UET (University of Engineering & Technology), Lahore, Staff Colony, the L and R-Type houses were selected for undertaking the measurements. The results were compared to assess the lowest cooling and heating requirements for the typology of the houses.

The models were erected in Ecotect 2011, then the thermal and non-thermal zones were defined to run the analysis.

### 2.1 L and R-Type Houses

These types of residential buildings are studied with the local weather file of Lahore. This case study on L-Type houses was also presented in the ICAE (International Conference on Applied Energy), Singapore. The buildings are present in the residential colony in UET, Lahore, Pakistan. Each block comprised of four residences with typical planning and with different four orientations. The architectural language of this typology of houses is quite different from other building tradition in planning.

The conductivity of the windows used for simulation was  $15.91 \text{ W/m}^2 \text{ }^\circ\text{C}$  with each window size as  $25 \text{ ft}^2$ , for 13 inches brick Wall is  $1.76 \text{ W/m}^2 \text{ }^\circ\text{C}$ , and for the roof is  $0.971 \text{ W/m}^2 \text{ }^\circ\text{C}$ . The master bed room with two windows at different orientations and living with three windows oriented towards each direction in different residences were simulated for the comparison of the on the cooling or heating requirements as a response of building orientation.

The windows of master bed-room have different orientations in EW (East West) axis in layout-1 and the opposite orientations towards NS (North South) axis of layout-2. Similarly, the drawing room faces south exposure in one block, layout-1 and in opposite layout-2, North orientation in other block while the living faces either east or west orientation in both the cases of same axis of block orientation. The dining room and the master-bed have two windows case in which each window faces two orientations. One block faces S-orientation while Living room faces E and bed' windows face S and E. For cold season in December, heating loads are shown in Figs. 1-3. Then selected four R-Type houses and simulated with the same methodology.

A comparison between the cooling loads of adjacent oriented houses, R-49 and R-50 are made according to their plan configurations.

### 3. RESULTS AND DISCUSSION

The above results (Figs. 4-7) showed a considerable difference in thermal loads for the real case of L-Type .

The orientation of SW windows in Bed-1 a maximum cooling was required, where as, it was minimum for the same room with the north and eastern oriented windows. It is implied that in case of South and West windows in bed-1, the block was facing north or windows in these

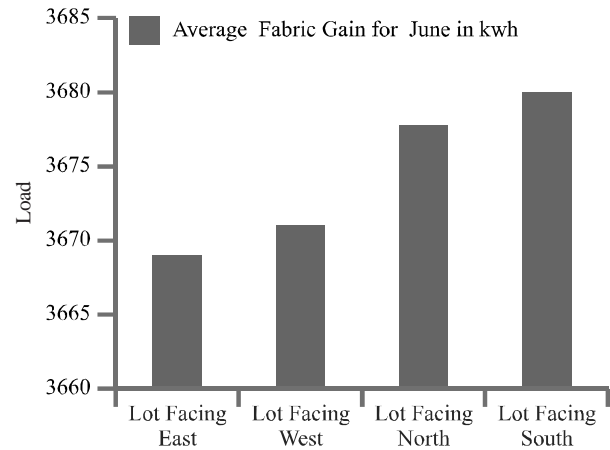


FIG. 1. BUILDING LOT ORIENTATIONS: FOR JUNE

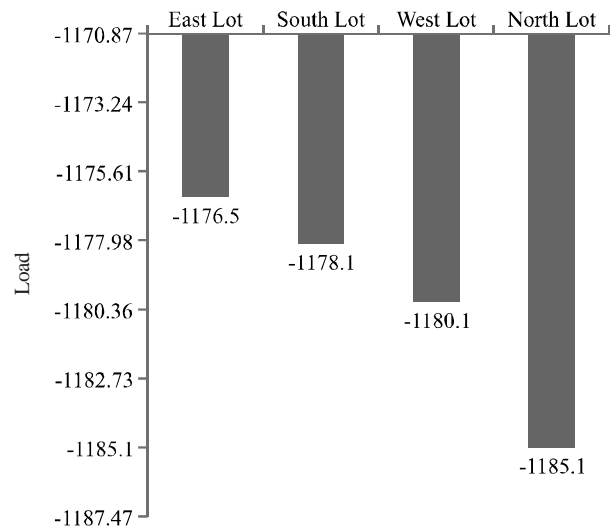


FIG. 2. AVERAGE LOAD FOR DECEMBER IN kWh

walls receive maximum solar radiations as it was more exposed to the sun on 21st June.

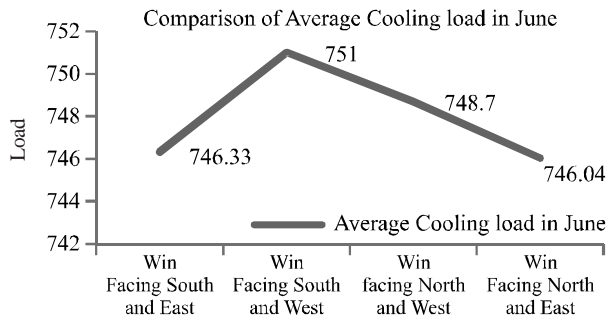


FIG. 3. COOLING LOADS IN kWh, DECEMBER (BED ROOM)

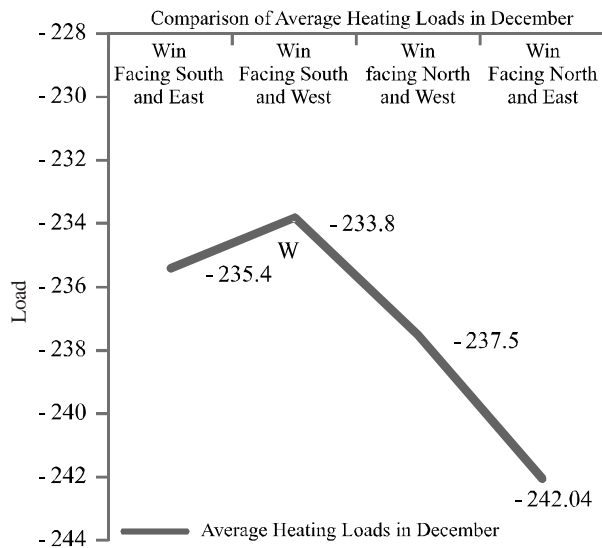


FIG. 4. COOLING LOADS (kWh), DECEMBER, (IVING ROOM)

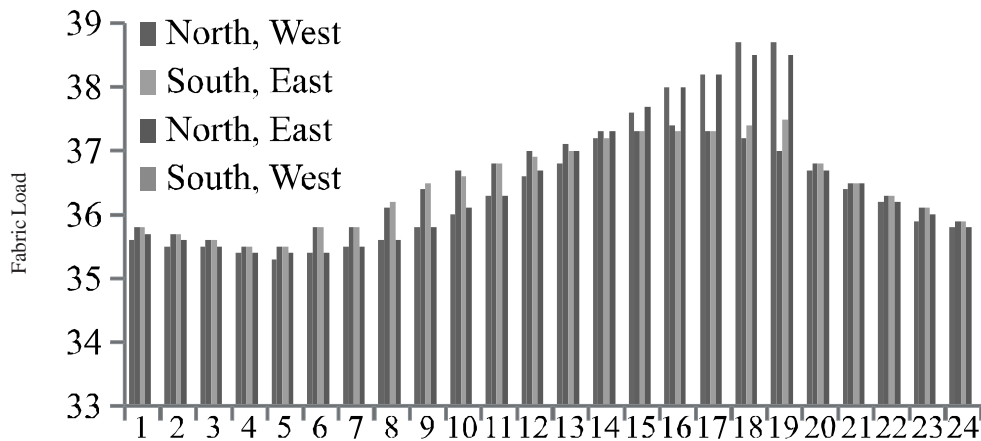


FIG. 5. FABRIC GAINS FOR 21ST JUNE FOR THE BED-1

In case of windows in the North and East orientations, the glazing on north did not receive direct radiations due to less exposure to the sun as indicated through the Sun Path chart for Lahore. In case of two windows, when one window faces North orientation and the other East orientation are not recommended for heating season as shown by the results.

North-West and South-West oriented windows are recommended for cooling season in N-S oriented lot.

Developers of new settlements can achieve the benefit of this study and can incorporate the zone planning in accordance with resulting effects. The houses can take advantage of good orientation which can further reduce operating costs and indoor thermal comfort. The residential block in which windows are facing east and west (shorter dimensions) of the block rectangle, with the longer axis facing Southern orientation have resulted in lowest cooling requirement and minimum heating requirements.

#### 4. CONCLUSIONS

The results showed that the north, east and west oriented living rooms are not feasible for the year round performance. It was also concluded that east and the north living required 31% more thermal load for cooling

than the southern oriented living rooms and the orientations require 34% more energy to heat when compared to south oriented living in winter season or in the month of December.

It was also concluded that after careful analysis of measured data of ground floors bedroom, drawing room and the first floor bedroom, the cooling load of R-49 increases to 21.90, 22.20, and 28.70% respectively while the cooling loads of bedroom of R-55 reduces to 28.88%, drawing room increases to 24.40% and first floor bedroom reduces to 26.80% depending upon varying orientations of their windows.

**ACKNOWLEDGEMENT**

The authors appreciate the support and encouragement provided by the Directorate of Research, University of Engineering & Technology, Lahore, Pakistan.

**REFERENCES**

[1] Ahmed, K.S., "Comfort in Urban Spaces: Defining the Boundaries of Outdoor Thermal Comfort for the Tropical Urban Environments", Energy and Buildings, No. 35, pp. 103-110, 2003.

[2] Andamon, M., "Thermal Comfort Study in Makati City", Ph.D. Thesis, University of Adelaide, Philippines, 2005.

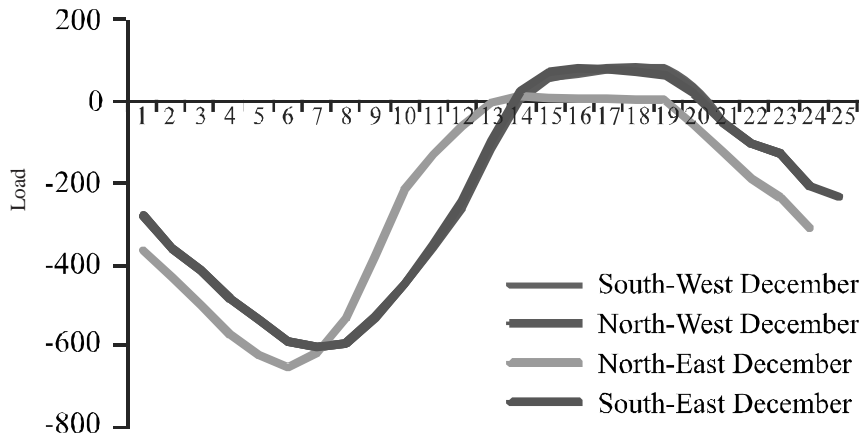


FIG. 6. SIMULATIONS ON 21 DECEMBER (kWh) WITH TWO WINDOWS

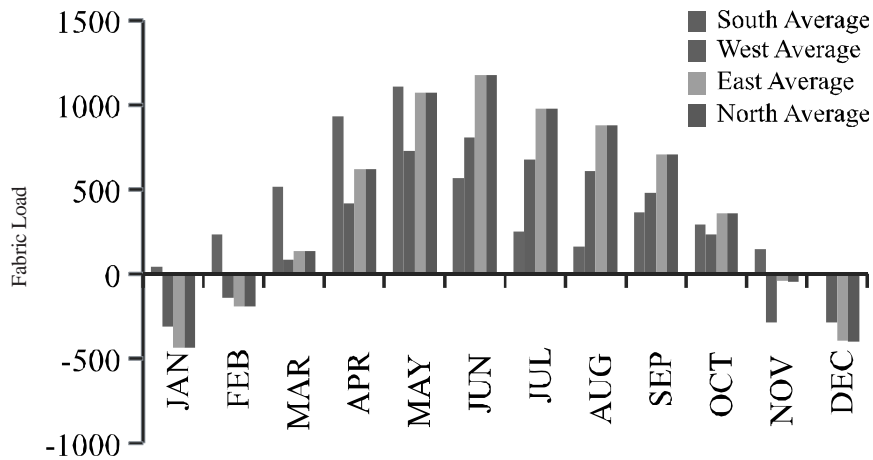


FIG. 7. AVERAGE FABRIC LOADS FOR LIVING ROOM

- [3] ASHRAE ANSI/ASHRAE Standard-55, "Thermal Environmental", 1992.
- [4] Wheeler, and Stephen, "Planning Sustainable and Livable Cities", Routledge; 3rd Edition, New York, 1998.
- [5] Roo, G.D., and Miller, D., "Compact Cities and Sustainable Urban Development: A Critical Assessment of Policies and Plans from an International Perspective, Ashgate Publishing Ltd., Hampshire, England, 2000.
- [6] Gupta, J.P., Nahar, N.M., Chaurasia, P.B.L., Sharma, P., "Design Consideration for Passive Cooling of Rural Houses in Arid Areas", Renewable Energy for Rural Development, McGraw Hill, pp. 249, New Delhi, 1989.
- [7] Alamgir, S., "A Quick Design Approach Towards the Energy Efficient Buildings in Pakistan", 25th Conference on Passive and Low Energy Architecture, Dublin, October 22-24, 2008.
- [8] Alamgir, S., and Tahir, M.A., "Study of Optimized Orientation of British Colonial Bungalows in Mayo Garden, Lahore", Mehran University Research Journal of Engineering & Technology, Volume 28, No. 4, pp. 555-564, Jamshoro, Pakistan, October, 2009.
- [9] Alamgir, S., and Khan, A., "Solaris, Solar Radiation and Day Lighting", Anmaya Publications, IIT, Volume 1, New Dehli, India, 2007.
- [10] Shashua, L., and Hoffman, M.E., "Quantitative Evaluation of Passive Cooling of the UCL Microclimate in Hot Regions in Summer, Case Study: Urban Streets and Courtyards with Trees", Building and Environment, Volume 39, pp. 1087-1099, 2004.
- [11] Ahuja, R., and Rao, V.M., "Natural Cooling of Residential Buildings in Hot-Dry Climate", Asian Journal of Civil Engineering, Building and Housing, Volume 6, Nos. 1-2, 2005.
- [12] Arif, S., "Energy Efficient House Design: Effect of Orientation on Indoor Temperature Profile", Ph.D. Dissertation, Department of Architecture Engineering & Design, University of Engineering & Technology, Lahore, Pakistan, 2011.
- [13] CARB (Consortium for Advanced Residential Buildings), "Building America Field Project: Orientation-Specific Design and Solar Potential at Two CARB Projects", Steven Winter Associates, Inc. Volume 6, No. 7, January, 2003.