
CARDENAS

Thermal comfort in housing under solar obstruction derived from high building in urban renewal areas.

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Abstract

The built environment within cities generates urban microclimate that affects thermal comfort in residential buildings. One of the factor influence microclimate is shadows at neighbourhood scale. Urban planning instruments can induce new spatial arrangements through Real Estate in urban renewal areas. Pressure on site to achieve high densities produces skyscraper along with shadows on urban spaces and neighbour buildings. The objective of the paper is to analyse thermal comfort in housing under solar obstruction derived from tall building. A comparison is done between two urban scenarios such as with and without solar obstructions in order to compare its effects on thermal comfort indoor spaces. Solar energy simulations were the instruments for comparison shadows, irradiance and temperature values to design better cities. Results exhibit interesting differences in direct and diffuse radiation values on two scenarios. Consequently it affects differently on heating or luminance needs in housing.

Keywords: Thermal comfort, solar obstruction, urban renewal

1. Introduction

A world trend towards urbanization explains growing attention to the climate change linked to high densities in urban areas. Phenomenon such as temperature increase, change in wind patterns, moisture decrease, reduced solar radiation and luminance are some of consequences of high densities (Oke, 1978; Olgyay,1963; Santamouris, 2001; Ratti, 2005; Ng, 2010;). As a result, various microclimates are generated within cities that might be unfavourable for outdoor and indoor spaces because of discomfort issue for human being (Givoni, 1976; Szokolay, 2008; Moonen, 2012).

One way to analyse thermal comfort within cities is to understand solar benefits on buildings. So hypothesis is shadow falling from tall buildings on low houses surrounding impact on thermal comfort and luminance conditions at the indoor spaces of housing. Current Chilean urban normative and architectural code for buildings enhances singular plot constructability and it commands shadow analysis which only focuses on isolated buildings (OGUC, 2015). Many authors have already stated by that solar envelope on blocks should be considered in urban planning (Knowles,2003; Yezioro et al.,2006).

To convince local authorities of the benefit of solar energy in urban planning it is necessary previously to evaluate benefits on thermal comfort and luminance conditions on surrounding houses (Beckers, 2009). Hence, one of the main objectives is to demonstrate how much it reduces incident solar irradiance flux on facades of housing and consequently on thermal comfort values. To achieve that Ñuñoa district in Santiago of Chile city was selected because of its meaningful changes under urban renewal plans, particularly Irarrazabal Avenue. Fig.1. Ñuñoa district is located in a metropolitan region with 6.000.000 inhabitants approximately and its UTM coordinates are 33°27´Long 70°35´ Elevation 588 m.

Climate is template with four seasons and, on average, 8 dry months with annual rainfall of about 300 mm. Annual thermal amplitude is about 15°C and particularly wet on winter months (Jun-July-August). Mean temperature fluctuates between 9°C and 22°C.

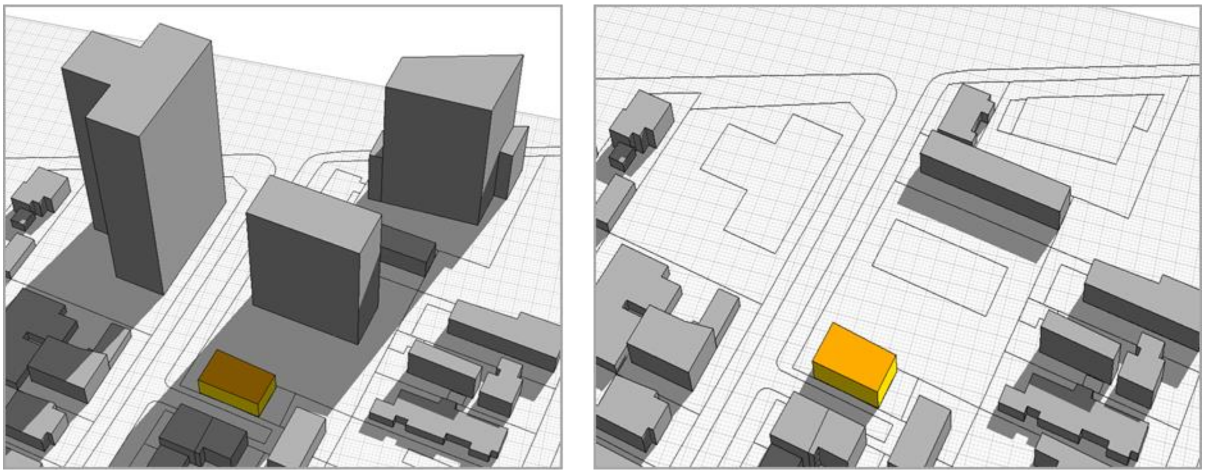
The winter season was analysed taking into account two clear days for solar radiation purposes. (10th-21th June). Shadow might be a benefit in summer because of hot climates (Dec-Jan-Feb), however, it might not be a benefit in winter because of the cold. As a result, sunlight is quite appreciated.

Fig. 1 Tall buildings erected by urban renewal plan in Irarrazabal Avenue, Ñuñoa district. Santiago of Chile.

2. Materials and method

This study was carried out through computer simulations making use of ECOTECT 2011 software. Cadastral maps provided by Ñuñoa municipality was the cartography base to start modeling. Three task were undertaken for spatial and energy simulations: (i) to study shadows falling from tall buildings; (ii) to obtain solar radiation incidence on low houses (global, direct and diffuse) and (iii) to analyse indoor temperatures on housing affected by solar obstructions.

Two scenarios were set to evaluate the effects of shadows on housing. Scenario 1: real settings with solar obstruction on a neighbourhood site, and scenario 2: unreal setting - which means no obstruction at all. (Fig.2).



(a) (b)

Fig. 2 (a) solar obstructions and (b) unobstructed setting. Source: Vilches, 2014

3. Solar radiation on housing

3.1 Solar incident radiation on north facades

Solar incident radiation on low housing under shadow show decreased values as a result of solar obstructions. Particularly, direct radiation reaches 0 W/m2 throughout the day between 12.00hrs and 16.00hrs. The more representative case was an 80-meter long building with 11 floors situated on north site of affected houses, so it works as a great “wall” in the neighbourhood (NG, 2010). Then it transforms into the impediment of solar access to houses. Fig. 3

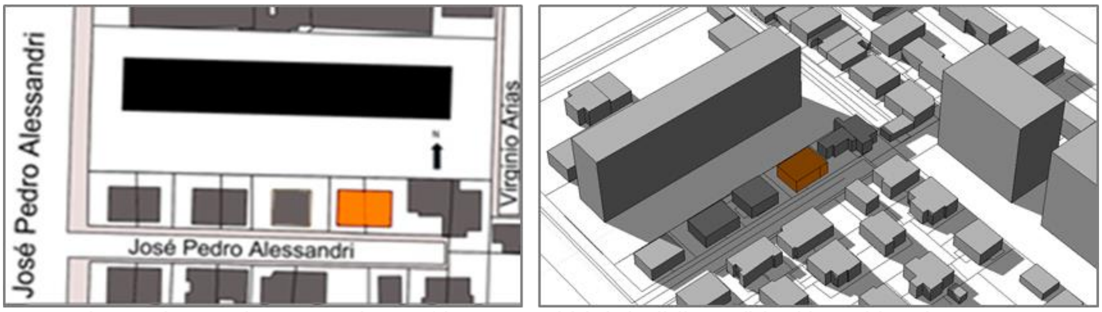


Fig. 3 Plan and perspectives of larger and high buildings (black) and low houses. (yellow: isolated, two floor; red and grey: semidetached, two floors). Source: Vilches, 2014

Figure 4 shows solar irradiance curves (global, direct and diffuse) incident on the north facades of a semidetached house, (red in figure 3). It points out a sharp fall of irradiance between 110hrs and 1700hrs reaching 0 W/m2 value in obstruction setting (10th June). In terms of energy, it falls dramatically from 700 W/m2 to 0 W/m2. By contrast, diffuse radiation gets a similar curve in both scenarios. Moreover, it tends a similar trend although the unobstructed setting is somewhat higher than the obstructed setting. It varies from 60W/m2 to 40W/m2. The first conclusion is that effects on luminance conditions are not quite as meaningful compared with thermal radiation on north facades.

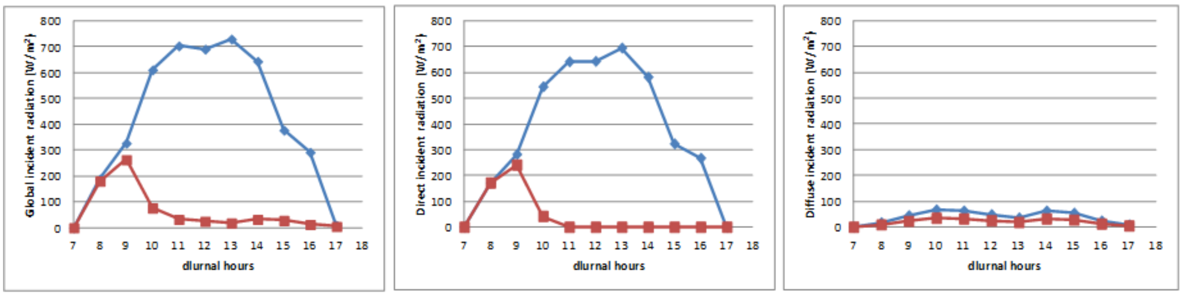


Fig. 4 Global incident radiation, direct and diffuse falling on north facades the 10th June, winter month. (Colour blue: unobstructed; colour red: solar obstruction) Source: Vilches, 2014

3.2 Solar radiation on housing facades

Figure 5 shows the mean of solar irradiance curves for the whole housing facades: roofs, north, south, east and west. Total energy is less as (than) expected, values reaches only the half between 250W/m2 y 350W/m2 compared to a peak of 700W/m2 in north facades. It is important to considers all facades because they are potential surfaces to settle whether passive o active devices for solar energy. Particularly, the winter period decreases capacity to capture and accumulate solar energy which may influence thermal comfort.

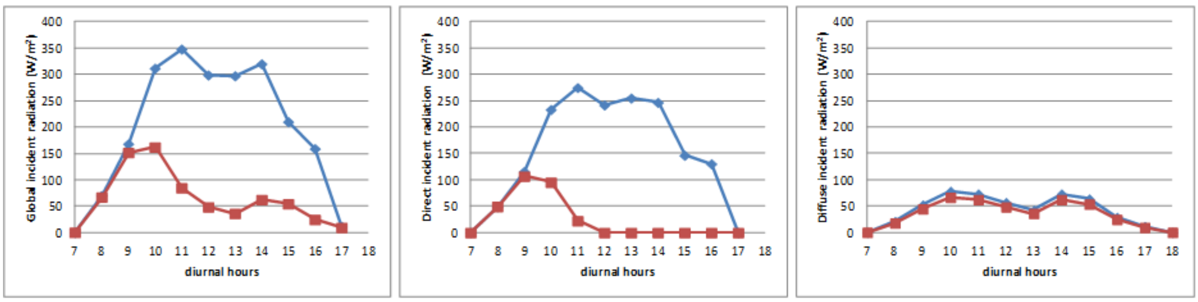


Fig. 5 Mean radiation on all facades of semidetached house: global, direct and diffuse (10th June). Colour blue: unobstructed; colour red: solar obstruction) Source: Vilches, 2014

4. Thermal performance of housing.

Shadow above low houses produces a decrease of indoor temperature on a winter day. A comparison of temperatures in two scenarios as mentioned above it is showed in table 1 for semidetached house. Rooms oriented to north, south and west register a decrease of between 1°C and 3°C. If the comfort zone is equivalent to a range of temperatures between 18°C and 23°C, according to ASHRAE 55, then none of rooms belong to that zone.

Table 1 shows the biggest differences in each room at 1400hrs. South rooms reach 1,7 °C, North rooms reach 3,7°C and West rooms reach 3,1°C. North and west facades receive sun in winter prior to the urban renewal process. The construction of tall buildings in the northern block leads to worse thermal conditions in precinct behind it. Differences greater than 3°C are really a problem for microclimate adaptation.

North bedroom second floor			
10-jun	Unobstructed	Obstructed	Diff Temp
Hour	T. Inner(°C)	T. Inner(°C)	(°C)
8	7,2	6	1,2
9	8	6,9	1,1
10	9,5	8,2	1,3
11	11,5	9,3	2,2
12	12,7	9,7	3
13	13,6	10	3,6
14	14,2	10,5	3,7
15	14	10,7	3,3
16	12,8	10,2	2,6
17	11,4	9,5	1,9
18	10,5	8,9	1,6
19	10	8,6	1,4
20	9,6	8,3	1,3

South bedroom second floor			
10-jun	Unobstructed	Obstructed	Diff Temp
Hour	T. Inner(°C)	T. Inner(°C)	(°C)
8	6,4	5,8	0,6
9	7,1	6,4	0,7
10	8,1	7,5	0,6
11	9,6	8,8	0,8
12	10,8	9,5	1,3
13	11,4	9,7	1,7
14	12	10,3	1,7
15	12,2	10,5	1,7
16	11,2	10,1	1,1
17	10,3	9,4	0,9
18	9,6	8,8	0,8
19	9,3	8,5	0,8
20	8,9	8,2	0,7

West lounge second floor			
10-jun	Unobstructed	Obstructed	Diff Temp
Hour	T. Inner(°C)	T. Inner(°C)	(°C)
8	5,9	5,2	0,7
9	6,8	6	0,8
10	8,2	7,4	0,8
11	10,3	8,8	1,5
12	11,7	9,4	2,3
13	12,6	9,8	2,8
14	13,6	10,5	3,1
15	13,7	10,8	2,9
16	12,4	10,4	2
17	10,9	9,6	1,3
18	10,2	9	1,2
19	9,7	8,6	1,1
20	9,3	8,1	1,2

Table 1 A comparison of indoor temperatures according to orientation of rooms in two scenarios. Source: Vilches, 2014

To sum up, figure 6 shows thermal performance of each room of the semidetached house under the two scenarios considering how close or far they are with respect to the comfort zone. The chart shows the temperature at 1400hrs when maximum differences between the unobstructed and obstructed situation have occurred.

Figure 6 shows maximum temperature differences in rooms of the semidetached house for the 10th June in the two scenarios. The second floor has a greater difference compared to first floor because heat transfer through roofs in an unobstructed scenario.

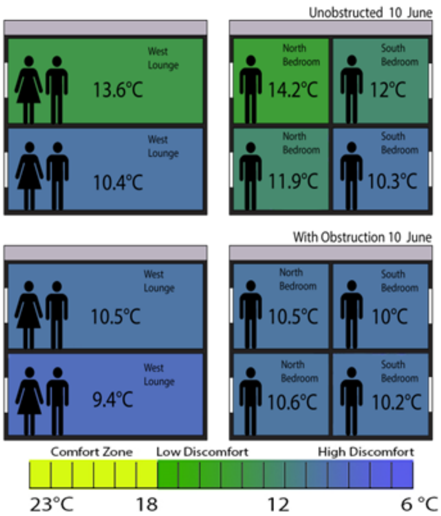


Fig. 6 Thermal performance of rooms of semidetached house at 1400hrs on the 10th June. Source: Vilches, 2014

5. Conclusions

The initial hypothesis was verified given that the thermal performance of the semidetached house on one day in winter month worsened. Tall buildings cast a shadow on southerly houses producing negative effects by reducing direct solar radiation. Diffuse radiation does not change too much and, consequently, daylight is not really affected by the shadow of nearby buildings. The temperature of rooms is reduced dramatically - on average 3°C on the second floor. The comfort zone is further to reach in obstructed scenarios unless counteracted by using more energy consumption for heating. That might have consequences in the domestic economy and the healthy environment.

Current urban normatives command distance and shadow according to unique profit land but it does not yet consider solar access for nearby housing. Looking for alternative design plans considering orientation and shadow on blocks and neighbouring sites is suggested. Solar access is not a legal concept embodied in the Chilean urban normative.

The spatial configuration of buildings in a block considering solar access is a matter of discussion. It is necessary to expand traditional emphasis towards energy issues and urban microclimates in planning instruments and architectural codes. Other authors have already started a discussion in Chile in which they have stated that solar access is a missing link in urban normative for designing architectural projects. (Cárdenas & Uribe, 2012)

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