Daylighting system based on single-axis polar heliostat

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INTRODUCTION

The growing need to increase energy sustainability in buildings requires the use of solar radiation as a renewable source of energy. Heliostats consist of a mirror that follows the path of the sun and aims to maintain the reflection of the solar rays into a fixed direction or point [1]. Therefore, they can play an important role in sustainable technological applications in urban environments [2], such as natural illuminators in buildings [3-6]. This paper presents an analysis of the performance of a heliostatic illuminator, based on the single-axis polar heliostat prototype developed by Torres-Roldan et al. [7] (Fig. 1), to improve illumination in a classroom at the Campus of Rabanales of the University of Cordoba (Spain).

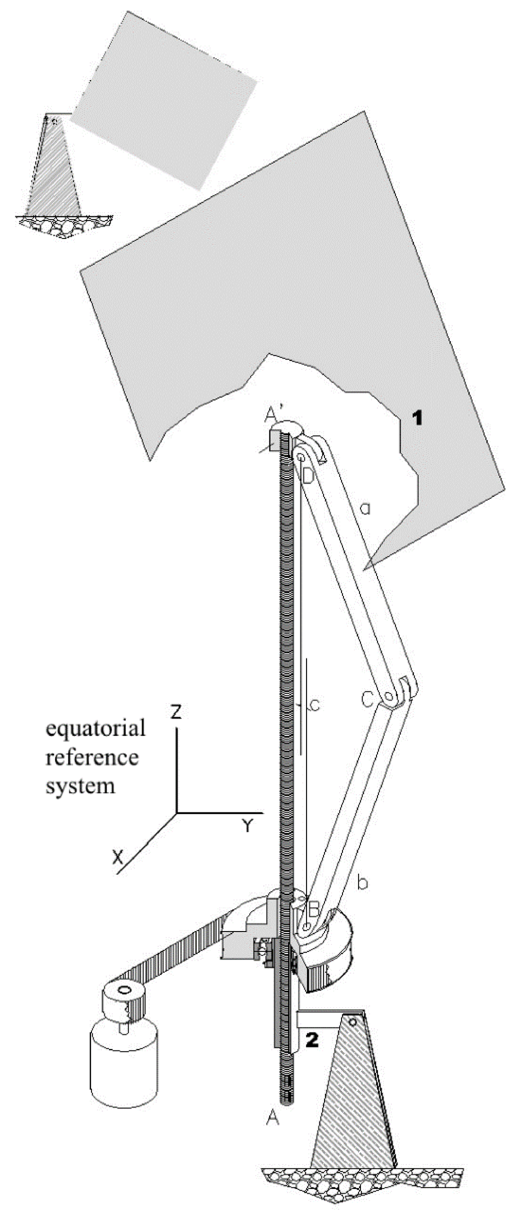

Fig.1 Mechanic scheme of the polar heliostat proposed by Torres et al. [7]

(a) (b)

Fig. 2 External (a) and Internal (b) appearance of the scale model of the chosen classroom

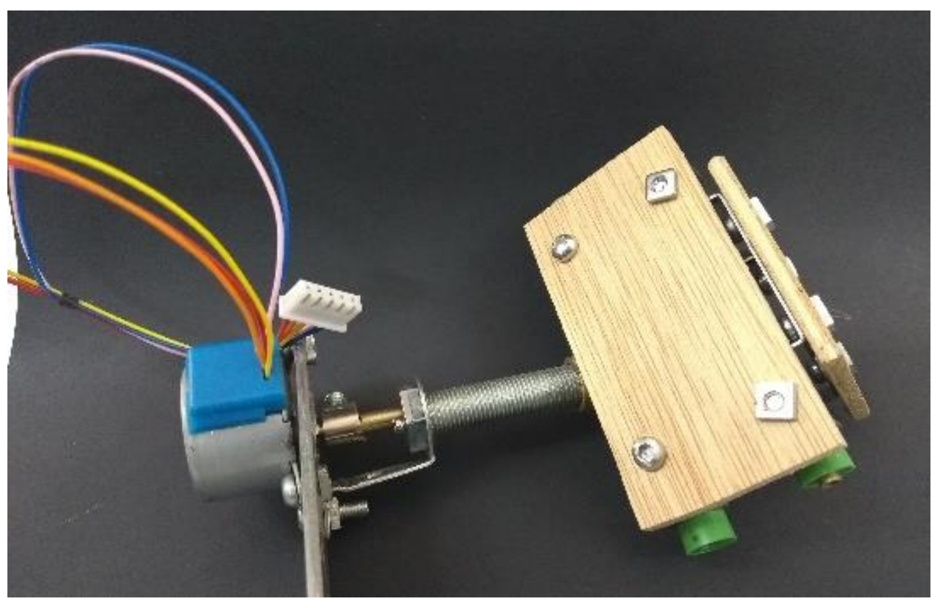

Fig.3 Scale model of the proposed heliostatic illuminator

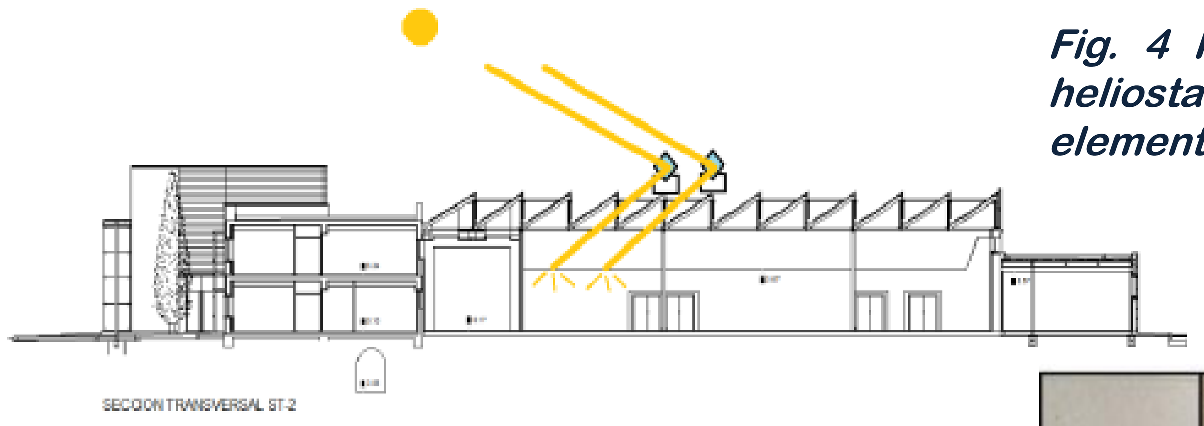

Fig. 4 Installation scheme of heliostats as a daylighting element

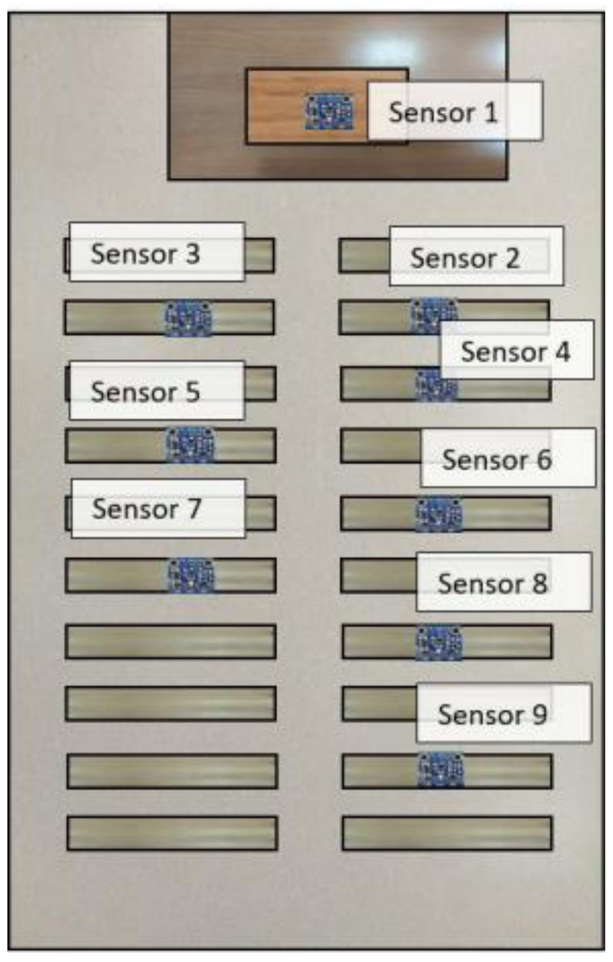

Fig. 5. Layout of the TSL2561 sensors inside the scale models

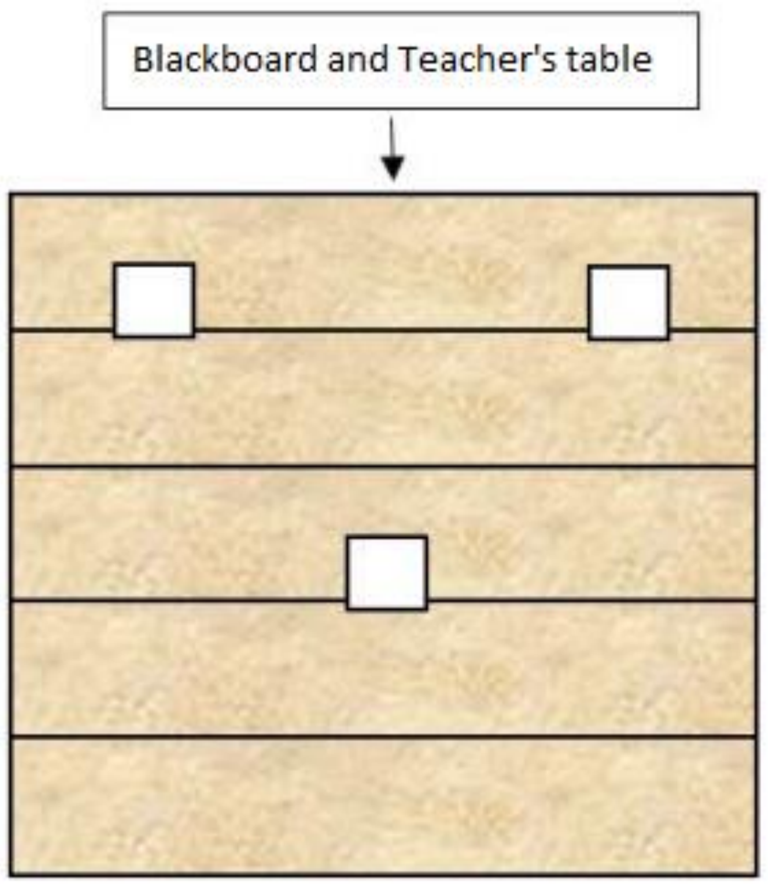

Fig. 6. Layout of the heliostatic illuminators on the plan view of the chosen classroom

Fig. 7. Measurement campaign

METHODOLOGY

Two 1:15 scale models of the chosen classroom have been developed (Fig. 2). A 1:15 scale model of the proposed system of heliostatic illuminators have been developed (Fig. 3) and installed in one of the scale models according to the schemes in Fig. 4 and 5.

Additionally, an illuminance monitoring system, with Arduino MEGA 2560 and TSL 2561 illuminance sensors, has been developed and installed in both scale models according to the layout in Fig. 6. With these sensors the increases in the levels of natural lighting thanks to heliostats have been analysed. For that purpose, both scale models have been placed outdoors with the same orientation as the replicated classroom (Fig. 7) and experimental data have been registered.

RESULTS

Fig. 8 shows the image of the interior of each of the scale models, captured by two webcams, at the same instant of time and under the same conditions of solar incidence on the outside.

Table I shows the average illuminance levels registered by the sensors in each scale model, as well as the increment registered in the case with heliostatic illuminators.

Qualitative and quantitative comparative analysis demonstrates that the heliostatic illuminators favours a higher level of light inside the classroom.

Fig.8. Qualitative comparative analysis of daylighting levels inside the scale model without heliostat illuminators (a) and the one with heliostat illuminators (b).

(a) (b)

Sensor	Average Illuminance (lx) Without heliostats	With heliostats	Increase (%)
1	68,9	178,4	158,73
2	70,3	197,3	180,79
3	71,3	213,6	199,71
4	73,9	253,1	242,58
5	76,0	164,5	116,50
6	80,3	181,8	126,22
7	86,2	157,4	82,63
8	87,2	151,5	73,82
9	93,5	159,2	70,40

Table I. – Quantitative comparative analysis of daylight levels inside the scale models with and without heliostat illuminators

CONCLUSSIONS

The levels of illuminance are considerably higher in the case of the scale model with heliostatic illuminators, with increases ranging from 70.40% to 242.58% compared to the situation without heliostatic illuminators. **Heliostat illuminators can therefore improve daylighting conditions inside buildings, reducing artificial lighting requirements and improving energy efficiency.**

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