Available online at www.sciencedirect.com

ScienceDirect

Procedia Environmental Sciences 38 (2017) 178 – 186

Procedia Environmental Sciences

International Conference on Sustainable Synergies from Buildings to the Urban Scale, SBE16

Cool Roof Impacts on a School-Building Thermal and Energy Performance in Athens, Greece

A.V. Androutsopoulos[a,*], G.M. Stavrakakis[b], M. Damasiotis[b]

[a] *Energy Measurements Laboratory, Centre for Renewable Energy Sources and Saving, 19th km Marathonos Av., GR-19009 Pikermi, Greece*
[b] *Division of Development Programmes, Centre for Renewable Energy Sources and Saving, 19th km Marathonos Av., GR-19009 Pikermi, Greece*

Abstract

This study presents the results of a thorough investigation of a cool-roof application on a public school building (pilot building) located in Athens, Greece. An impact assessment was conducted by means of both energy monitoring and numerical analysis of whole-building's thermal behavior. A twin nearby school building (reference building) was used for comparison purposes. The measuring process in both buildings included the recording of thermal performance indicators (TPIs), i.e. roof internal and external surface temperature, indoor air temperature and relative humidity. The ambient air temperature and incident solar irradiance were also recorded at the roof of the reference building. The duration of the monitoring period was approx. one month, two weeks before and two weeks after the application of the cool roof material. TPIs' differences before and after the application were based on comparisons to the reference building recordings to ensure the same outdoor climatic conditions. The impact of the cool roof in the building's energy performance was based on hourly dynamic energy simulations (in annual basis). The model developed uses as input conditions: a modified weather file based on the onsite weather measurements, the thermo-physical properties of the building materials taken from the available insulation study, and the optical properties measured from surface samples. Inspection surveys' with interviews, which provided building's systems operation and occupancy schedules, were also used as input schedule files. The model was validated with comparisons of calculated and measured indoor air temperatures. The results showed that, ten days after the application, the reduction of the daily mean indoor air temperature below the cool roof ranged in 1.3-2.3^{0}C and 1.6-1.9^{0}C as provided by measurements and simulations, respectively. In terms of annual energy consumption, a reduction of up to 30% in cooling demand was estimated in summer, while the heating penalty for winter period reached 12%.

Peer-review under responsibility of the organizing committee of SBE16.

Keywords: Cool Roof; School building; Thermal performance measurements; Dynamic energy simulations

* Corresponding author. Tel.: +30 210 6603379; fax: +30 210 6603305.
E-mail address: aandr@cres.gr

Peer-review under responsibility of the organizing committee of SBE16.
doi:10.1016/j.proenv.2017.03.103

1. Introduction

Reflective coatings are considered to help the energy needs of a building by decreasing the incoming solar irradiation to the building shell. Various studies have been carried out to quantify the decrease in cooling energy needs in a variety of building types[1,2,3,4]. Research work has also focused on the impact of such materials on the mitigation of the Urban Heat Island effect[5,6].

The contribution of such a coating to the thermal behavior of a school building was investigated in the present study. In order to achieve this, a roof component with and without the presence of a coating layer was monitored during summer conditions in Egaleo area, Athens, Greece. The purpose of the study was to record the behavior of two rooms the roof of which was equipped with a coating layer, and compare the thermal measurements with the rooms of an identical building without the application of the coating. A dynamic simulation followed in order: 1) to validate the model from the measurements procedure, 2) to calculate energy savings for cooling purposes and associated heating penalties, and 3) to test an alternative ventilation scenario in order to determine under which operation and systems' conditions is the most beneficial.

2. Pilot building and cool-roof

2.1. Building location and construction characteristics

The selected Pilot Building, on which the cool roof reflective coating is applied, is the 7th elementary school situated in Egaleo Municipality (longitude: 23.40E, Latitude: 38.00N), which corresponds to climate zone "Csa-Hot Summer Mediterranean Climate" according to the Koppen-Geiger climate classification[7]. The building comprises a ground-floor and some building blocks (Classrooms) on the 1st floor. Exposed horizontal surfaces of the ground-floor are mosaic roofs, while the ones of the 1st-floor building blocks are asphalt-membrane roofs. The associated impacts of the cool-roof are accomplished through comparisons between the measured indicators in the ex-ante (before cool roof) and the ex-post (after cool roof) condition. To ensure comparisons under the same climatic conditions before and after the application of cool-roof a twin School nearby with very similar surroundings is used as the Reference Building, the 15th elementary school of Egaleo, representing the ex-ante condition throughout the project (i.e. no intervention is applied on the reference building). The testing site with the pilot and reference buildings is presented in Fig. 1.

The building envelope materials and thermophysical properties were found in the formal technical insulation study of the building. According to the insulation study the building is thermally insulated with glass wool. The layers of each opaque construction (roofs and walls) are presented in Fig. 2. As far as transparent surfaces and openings are concerned most rooms have regular and skylight windows. The former are double-glazed, 9mm gap, with typical aluminum frame dividers of 0.06m width, while the latter are single-glazed with typical aluminum frame dividers of 0.06m width. Classrooms' doors are mainly wooden, with few exceptions, i.e. metal doors appearing in the boiler room and the chemistry room.

Fig. 1. Bing-maps screenshot of the pilot (7th School) and the reference (15th School) building.