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Optimizing insulation thickness of external walls in cold region of Morocco based on life cycle cost analysis

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Abstract

One of the effective ways to reduce energy consumption of buildings is the use of thermal insulation. This study focuses on the optimization of thermal insulation thickness of typical building's wall in the cold regions of Morocco based on life cycle cost analysis and national technical and economic data. It demonstrates the profitability of the thermal insulation of building's wall in these regions for expanded polystyrene, polyurethane and cork using degree-days method. The optimum insulation thickness varies significantly as a function of the selected insulation material, the source of energy and its pricing. The maximum recorded optimum thickness is 16.8 cm and the minimum is 3.4 cm.

Peer-review under responsibility of the scientific committee of ICOME 2015 and ICOME 2016.

Keywords: Heating, Insulation materials, Optimum thickness, Cold regions of Morocco;

1. Introduction

Morocco relies on more than 95% of foreign energy supply, and its energy consumption increased rapidly due to demographic growth and economic development. To remedy this situation, the authorities launched an energy strategy with two main axes: renewable energy development and energy efficiency. The goal is to take advantage, at a larger-scale, of the important renewable energy resources, mainly solar and wind energies, and to promote energy efficiency as a better way to use and save energy.

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Building is one of the concerned sectors by this strategy, since its energy consumption accounts for 36% of the country's final energy bill [1]. Its consumption is expected to increase rapidly in the upcoming years, with the emergence of new towns and large construction projects, currently underway or planned in Morocco.

One of the most effective ways to reduce energy consumption of building is the use of thermal insulation. In Morocco, the insulation of buildings is not of a common occurrence, although there are regions with severe climate conditions. Recently, on November 2015, the implementation of the first national thermal regulation was launched. It's a starting point for the integration of energy efficiency in building sector.

In many countries, particular interest has been given to building's thermal insulation systems. Yu and al. [2] studied four typical zones in China using five different insulation materials. Maximum savings achieved over a period of 20 years, were 54.4 $/m^2 in Shanghai, 54.8 $/m^2 in Changsha, 41.5$/m^2 in Shaoguan and 39.0$/m^2 in Chengdu. Ucar and Balo [3] showed that optimal insulation of exterior walls can achieve energy savings over a period of 10 years, ranging from 4.2$/m^2 to 9.5 $/m^2, considering the city and the insulation material used. Shekarchian and al. [4] found that 2.2cm glass wool, applied to a typical wall in Malaysia, can lead to 1.86 $/m^2 saving and a reduction of CO_2 emission of about 16.4kg/m^2 per year. Ozel [5] showed that if an optimal thermal insulation thickness is applied, emission of CO_2 can decrease by 19.55 to 6.37kg/m^2 per year and SO_2 emission between 0.013 and 0.040kg/m^2 per year, depending on the type of used insulation.

In Morocco, the energy efficiency of buildings has recently got interest with the establishment of the first building thermal regulation. A major effort should be made to raise awareness about thermal insulation and its economic viability. This study evaluates the optimum insulation thickness of a typical external wall in the coldest region of Morocco, which is Ifrane city, located in the Atlas Mountains.

2. Heating degree-days calculation

Degree-days are a summation of the differences between the outdoor temperature and the base temperature over a specified time period. The formula (1) is the basis of the heating degree-days (HDD) calculations in this study.

$$\begin{cases} HDD = \sum_j^{N_h}(T_b - T_{m,j}) & if\ T_b > T_{m,j} \\ HDD = 0 & if\ T_b \le T_{m,j} \end{cases} \tag{1}$$

Where N_h is the number of days in the specified time period of heating, T_b is the base temperature and $T_{m,j}$ is daily mean outdoor temperatures in day j.

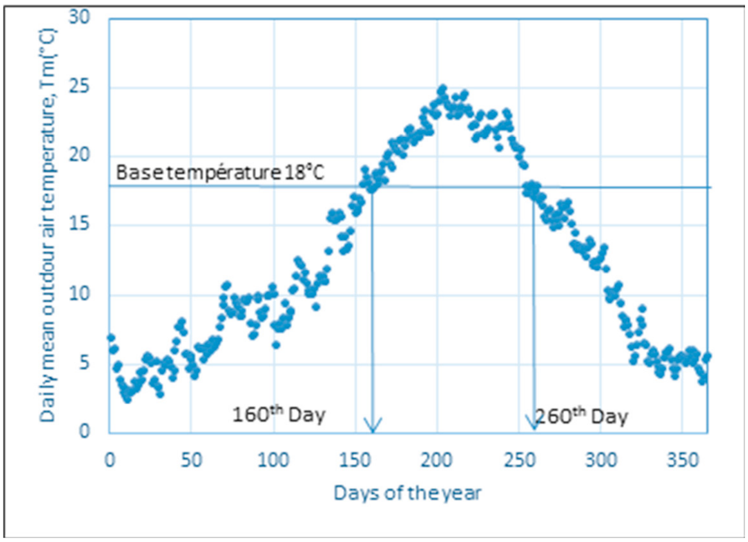

Fig. 1. Mean daily outdoor air temperature variation for the city of Ifrane (2000-2009).