Parametric simulations to evaluate the necessary thickness of the massive layer in the soil of building

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Abstract. In Algeria, the buildings are responsible for over 40% of the total energy consumption. Following the current global warming impacts and economic crisis, Algeria has adopted an ambitious program to promote the renewable energy applications, including the integration of energy consumption optimal methods, in the buildings. This paper investigates the impact of the thickness of the massive layer of the soil in building, since, the thermal conductivity of the soil has a significant impact on the heating requirements of buildings. The increase in thermal through the ground is proportional to the thermal conductivity. The heat absorbed in the soil will be returned to the atmosphere when its temperature is lower than the ground temperature. The magnitude of this passive refreshment is dependent on thermal properties of the soil. The obtained results improved improves the modeling of the heat transfer between the building and the ground. Ideally, 3D-modeling through the Type 49 (a TRNSYS subroutine) was used to model the vertical and horizontal distribution of the earth's temperature.

1. Introduction
The recent assessment on the Algerian building energy consumption showed that the total energy consumed has reached about 40% of the total consumed amount. This is why research will deploy a more coherent strategic approach in this area. The passive use of solar energy is the cheapest way to use the sun's energy. Our project team is currently focusing on studying different scenarios to obtain a house with low energy consumption. Passive architectural of solar house, building positive energy, high environmental quality, energy-efficient ... constitute the main research issues. Balance between the buildings; the surrounding environment and the comfort of the inhabitant shave to be taken into consideration. The main goal is to ensure the sustainability and the optimal comfort while reducing energy through passive and active architectural energy consumption techniques. In this view, reducing the energy consumption leads in improving the building performances. Although most buildings have some form of thermal coupling to the ground, there is normally very little thought put into the consequences of this thermal connection. nowadays, the well-built house has not energy efficient above the coupled-ground, whereas, heat losses can be reached from 30% until 50% of the total heat loss. Thus it showsthe importance of a detailed analysis of ground coupled heat transfer. The soil surface temperature can also influence the mean radiant temperature of the considered space. The ground is based on a finite element model. It has different horizontal layers, each of which is
characterized by its thermal capacity, density and conductivity. The soil is also characterized by its surface by considering its absorption and solar reflection coefficients, as well as its emissivity. Furthermore, the convection coefficient at the soil surface depends on the wind speed. The soil temperature at 2 m depth is calculated according to the Kasuda equation. It depends on the time of year, the assessment depth and the ground properties.

As significant impact on soil heat transfer that is often over looked, the effect of moisture can vary the effective thermal conductivity by a factor of ten. The objective of this attempt aims to investigate the ground-coupled heat and moisture transfer from buildings, then to improve energy simulation of ground-coupled heat.

Many studies have been conducted to describe soil temperature profiles by depth and surface stresses. The distribution of the subsoil temperature is affected by several factors: the outside climate, the vegetation covers and the properties thermophysical soil. According to the method developed by Hellström (1989) and the ground temperature profile following the model based on a study by Kusuda and Achenbach (1965).

T Kusuda and Achenbach (1965) and Kusuda and Bean (1984) were able to verify from the results of measurements (Figure I-12) that the simplified approach of considering the soil as a semi-infinite medium subject to a harmonic solicitation was legitimate to determine the temporal variation of the temperature of a soil as a function of the variation of the temperature of the outside air. Baggs (Baggs, 1983) complements the previous expression by taking into account the effect of vegetation in area from measurements located in 20 different regions, for depths ranging from 1 cm to 500 cm. Bareither et al (1948) have conducted experimental studies to evaluate these losses for different types of floors.

The three-dimensional ground-based heat transfer model developed by Thornton et al. (2012) aims to enable the dynamic thermal simulation of a building coupled with its subsoil. The model relies on a 3-dimensional finite difference model of the soil and solves the resulting inter-dependent differential equations using a simple iterative method. The model takes the heat transfer into/out of the building at the outside. Calculates the fully 3-D soil temperature profile, and then outputs the average underfloor surface temperature for each zone. Also provided, the Ground Temperature Viewer can display the soil node temperatures of the output file. The near-field soil temperatures are affected by the heat transfer from the slab. The far-field soil temperatures are only affected by the surface conditions (time of year) and depth. The model in return calculates the slab/ground interface temperature, which is passed back to the building model as an input. This slab model is intended to be used in conjunction with Type56.

2. Building structure:

Obtaining an optimal construction, under arid climates methodology consist our main target. Within this frame, this work has been undertaken on local building in desert area of Ghardaia region, southern part of Algeria. The exterior envelope, apart from contributing to the energy savings during the building cycle life by controlling the energy exchange between indoor space and environment developed a comfortable indoor environment [5] - [7]. Figure 1 shows a dynamic 3D-building simulation will carry out by TRNSYS using the 3D drawing capabilities of Trnsys3d for Google Sketch-up, then importing the geometrical information into the TYPE 56 (Multi-zone building model). The house has a net area of 71.3 m², and wall heights are equal to 2.8 m while the other dimensions are shown in detail in Figure 1.
3. Thermo aeraulic modelling

3.1. Coupling of models

CONTAM is a numerical simulation software that calculates air flows (by the mechanical system, wind effect and thermal draft) between zones in a building (Dols and Polidoro, 2015). Figure 2 shows the thermo aeraulic coupling of these softwares. The thermal behavior of the building is modeled (TRNSYS) as a building monozone that interacts with the following elements: an "aeraulic" model (CONTAM) which allows to calculate the ventilation rate and the air permeability through the envelope, a roof model to take account of the radiative properties of the cool roof coating and a soil model to evaluate the transfer of heat from the ground [2].

The thermal simulation of the building was carried out by cutting a thermal model developed under TRNSYS and an aeraulic model via the CONTAM software. TRNSYS is dynamic thermal simulation software applied to the building. This program allows integrating the completely building characteristics (structures, materials, technical equipment, operation ...) as well as climatic parameters (Klein et al., 2004).

3.2. CONTAM & Type 97

Concerning the ventilation, it has only been applied natural (window or door opening). Air exchanges between the different zones and the outside temperature. It is enough to fit the dimensions of the doors and windows to model these openings and return the ventilation rate and the air blowing temperature for one double flux ventilation. It is more difficult to make modelling an air inlet module and Infiltrations Figure 3.
 Figure 3. Airflow and pressure distribution in the six zones, calculated by CONTAM.

4. Modeling under TRNSYS & Type 49 & Soil Temperatures:
For define the boundary for Trnys3D zone we have opening Google SketchUp, we start to create a new Trnys3d zone by choosing Plug-in > Trnys3d > New Zone Tool from the main menu. We are interested in the method of calculating the heat transfer coefficient of walls in thermal contact with the ground. This method takes account of the three-dimensional thermal flux in the soil below the building. In general, we have three levels of the interior floor surface, when it comes to floor over-ground, floors on crawlspace and unheated basements, and at ground level.

Outside, for heated basements, we have used the first case since, it suits our project. The soil temperature Type 49 is a TRNSYS subroutine to model the vertical and horizontal distribution of the earth's temperature. The subprogram "As inputs" requires an effective interaction of the average temperature Figure 4. The surface area of the mass, the temperature amplitude for the surface of the year, the difference in time between the beginning of the year and the time of the minimum surface temperature, and soil thermal diffusivity. These parameters were calculated under the considered weather file and they were manually supplied as input to the subroutine. Temperature distributions were used to predict the temperature of the air.

The ground (slab on earth) was modeled under TRNSYS version 17-00-0019 (TR-GCT) using the multi zone building model type 49. The prediction of heat transfers. In the soil and the estimation of its temperatures, several hypotheses and models were selected.

 Figure 4. Multizone slab in TRNSYS (type 49).
5. The evolution of the temperature of the surface indoor of the floor as a function of the thickness of the layer with thermal inertia.

![Figure 5. Temperature of the interior surface of the floor as a function of the depth of the floor in Ghardaïa.](image)

Heat transfer has been calculated, through the ground three dimensional 3D this model coupling with Type 56 by the Type 49, in this anatomy case, House shows how the interior temperatures in a building can be affected by the ground temperatures. Figure 5 shows the evolution of the temperature of the interior surface of the floor at Ghardaïa as a function of the thickness of the layer with thermal inertia. The thickness considered here varies up to 45 cm.

The results averred that the temperature of the floor no longer varies significantly for a thickness of the first layer above 40 cm. In the following, the total thickness of the ground of 10 m will be constituted by a 45 cm mass layer and a layer of resistance equivalent to 9.55 m, for the one-dimensional model with thermal inertia.

6. Conclusion
This model investigates the heat transfers in the ground along the three directions the heat transfer was assumed to be conductive only. The role of the soil should not be neglected. The floor surface and soil characteristics play an important role in the energy balance. Heat degradation through a floor showed that if the building is not insulated, the losses represent 10% of the total losses and 30% to 50% for the well-insulated envelopes. In addition, soil is a key factor to consider due to its thermal inertia for low-rise buildings. As consequence, the buildings of large volumes at low height, soil is an important factor should be considered. On the other hand, the insulation of the soil may have a negative effect during the summer period.
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