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In France, the building sector is considered as the first energy consumer with at least 40% of the total energy consumption. Many different parameters influence the building behavior as the climate, the envelope characteristics or else the occupancy. In metropolitan France, the heating load constitutes the main point of interest and many solutions have been proposed recently in order to reduce drastically the heating consumption. Inversely, the French tropical territories as the Reunion Island do not know such kinds of heating issues but are more constrained by their huge cooling loads. Indeed, the building sector in tropical environment is affected by energy waste due mainly to the importance of cooling systems consumption.

The sensitivity analysis is increasingly used in the building field since a few years. Initially, the main objectives were to explain better the building behavior and to understand the uncertainties of the numerical building models. In the last few years, the applications of the sensitivity analysis in the building field have been largely diversified. Among them, we will focus in this paper on two specific numerical applications. First, the sensitivity analysis is used as a multi-objective optimizer in order to improve the design of the building envelop considering several different criteria as the thermal comfort and the natural lighting. Secondly, the sensitivity analysis is used to set up efficient monitoring strategies with the aim to improve the thermal comfort during the building operation.

As part of this numerical study, a retrofitted office building will be our case of study. It is based in the coastal town of Saint-Pierre located in the South of the Reunion Island. As we mentioned above, the main issue in the tropical climate concerns the reduction of the cooling consumption. Moreover, this aspect is even more accentuated in office buildings where the internal loads due to computer hardware can become really important. Given that, cooling solutions must be expected to maintain the indoor thermal comfort. First of all, an important aspect occurring during the early design phase and conditioning the future operation phase is the building envelope design defined to anticipate the discomfort caused by the climate and environment local constraints. The Reunion Island knows important solar radiations that can degrade the indoor thermal comfort or increase the cooling consumption. A first step will then be to optimize the building envelope in order to reduce the solar internal loads. However, minimizing the solar gains can lead to deteriorate the visual comfort. Thus, the resulting building envelope must be able to reach the objectives of both thermal and visual comfort. Secondly, in anticipation of the future building operation, other transient cooling solutions able to evacuate instantaneously the exceeded internal loads must be added in order to maintain a suitable thermal comfort. Air conditioning has been largely used in the last few years resulting in the huge increase of energy consumption in the tropical climate. However, some passive cooling solutions have already shown their efficiency and particularly the natural ventilation. The Reunion Island is greatly swept by winds with the trade winds during the day and the thermal breezes during the night. Thus, combined with an efficient monitoring strategy, the potential of natural ventilation in the Reunion Island can be really effective. Though, implementing monitoring strategies of natural ventilation can be quite complicated by the fact that the natural ventilation depends on many different parameters whereas the monitoring is obviously constrained by the amount of available in-site sensors. Indeed, a real in-site instrumentation is largely restricted in order to remain as discrete as possible for the occupants. Thus, it is crucial to be able to propose an accurate association between efficient monitoring strategies and a low intrusive instrumentation. Then, the main work will be to assess a list of available sensors influencing the natural ventilation and absolutely required for the implementation of an efficient monitoring allowing to reach the thermal comfort.

The first step consists in optimizing numerically the building envelope in order to reach both a visual and a thermal comfort. For this first case, the natural ventilation contribution is not taken into account. The work focuses on the windows characteristics with notably the frame and glazing thermal coefficient and the solar factor. Thus, two aspects are taken into account with the thermal and the visual comfort. In order to reach those objectives, two successive sensitivity analysis methods will be employed. The qualitative Morris method is first used on an exhaustive list gathering all the input parameters to be optimized. This first method is chosen for its ability to restrain the amount of influent parameters. Output indicators for each objectives are defined with attention as scalar values in order to simplify the interpretation of the Morris method. Finally, it highlights the less influent parameters and lead to reduce the input parameters list. Thereafter, the more quantitative SRC (Standard Regression Method) is used on the restrained number of influent parameters. This method is quite restrictive given that it suggested that the building behavior can be described linearly according the variables parameters. Nevertheless, in a first approximation, many authors showed that this assumption is validated and especially in this specific case for which the natural ventilation is not considered. Finally, thanks to these sensitivity analysis methods combined with a building expertise, optimal characteristics for each window of the demonstration building are determined.

This second step gives the means to provide effective monitoring strategies of the natural ventilation in our demonstration building. More specifically, this study consists through numerical simulations to understand the influence of each measured parameters already in place on the natural ventilation and to deduce a restricted list of available sensors that would take part in the monitoring. Contrary to the previous linear case, the natural ventilation is a complex nonlinear phenomenon. As we mentioned previously, it is an aspect that requests a large attention for the choice of the sensitivity analysis methods. The Morris method allows precisely to isolate the linear from the nonlinear parameters. This technique is used on all already available measured parameters to keep only the most influent. For a better validation, the Morris method is associated with another more quantitative method. The SRC method gets less used to this application given the high non linearity of the natural ventilation. Nevertheless, many other sensitivity analysis methods could be used as the chaos polynomial or else the FAST method. Finally, a restricted list of the available sensors contained in the instrumentation already in place is retained for implementing efficient monitoring strategies of the natural ventilation in our demonstration building.

To conclude, this study applies sensitivity analysis methods to building applications. More precisely, the objective is to determine efficient passive cooling solutions allowing to reduce the solar gains and to evacuate the internal loads in an office building located in the urban tropical environment of the Reunion Island. In order to do that, two applications are specifically considered: the multi-criterion optimization of the building envelope allowing to minimize the solar gains with maintaining a suitable visual comfort and the assessment of a restrictive list of available in-site sensors that would take part in the monitoring strategies of the natural ventilation. Given the different degree of complexity, sensitivity analysis methods have to be well-chosen in order to be able to solve efficiently and accurately each problematics. In perspective, the sensitivity analysis methods could be coupled with uncertainties analysis in order to improve the robustness of the monitoring strategy. Moreover, our methodology could be completed by an additional step consisting to propose the addition of new required sensors serving the improvement of the monitoring strategies.