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Design of buildings shape and energetic consumption

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Abstract

This work aims at relating the heating consumption of the buildings with their shape. This information is dedicated to the architects and engineers. At the beginning of the project, they need global information enabling them to find economical solutions as for energy consumption. First of all, a parameter that has been chosen to characterize the shape of the buildings is introduced. The selection of this coefficient is grounded on the necessary simplicity of its use by conceivers. Thus, the shape coefficient is defined as the ratio between the external skin surfaces and the inner volume of the building. Then, the sample of the studied buildings is described. Fourteen buildings have been chosen according to their varieties in shapes and their representativeness in current constructions. The calculation code used to evaluate the heating consumption is briefly described. This code operates the method of weighting factors. The method is quick and well adapted to the study as the 14 buildings are conceived from the same basic cell. The results show that the energetic consumption is inversely proportional to the compactness (weak shape coefficient) in case of cold severe and scarcely sunny winters. However, it can't be applied in case of mild climates, which leads to no recommendation of compactness.

Keywords: Design tools; Morphology; Expert rules; Energy consumption; Heating in building

1. Introduction: description of the matter, aims

At the begin of the conception project of a building, architects and engineers are facing many social, economic, environmental, technical and aesthetic constraints. Indeed, a building is a very complex object and almost always unique. Moreover, the concern for energy savings and pollution reduction must remain one of the principles of high environmental quality building conception. When they prepare the sketch of their project in the very first stage of conception, these architects need *global* and *operative knowledge*. The tools they use have to be easy and enable them to direct their work to good energetic solutions. Thus, scientists have to provide them tools that enable to evolve quickly and efficiently towards appropriate energetic solutions. This has nothing to do with computing tools of performance *checking*. Indeed, when the conceiver has to use them, the project doesn't exist yet. That concerns *expert knowledge*, elaborated by scientists with the help of numerical simulation and formulated as general rules or trends tested on several theoretical buildings. They become concrete with conception rules or trends diagrams. The theoretical sample will have to be representative of buildings currently met in reality although each building has its own singularity.

It may be conceivable to build these rules by operating results on energy consumption of actual buildings. Assuming that these results are available, their practical treatment still remains complex. Indeed, actual building consumption depends on inhabitants' behaviour. It seems so to be more relevant to transmit information which specifically characterise the building in order to allow comparisons between architectural solutions. Then, facing inhabitants in the conceived building, energy consumption levels will be different and will mainly depend on their awareness of the energy saving topic.

This expert knowledge may concern information about:

- the setting up on the site (concerning the climate analysis of the site),
- the shape of the works (concerning morphology),

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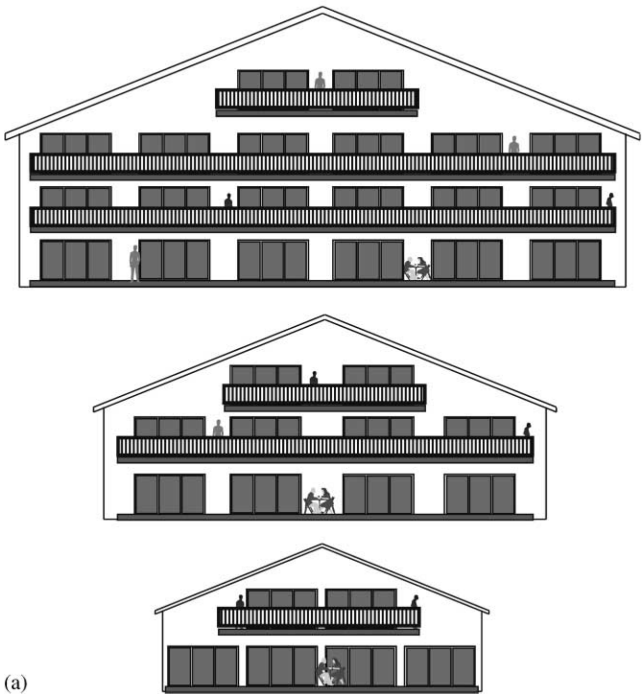
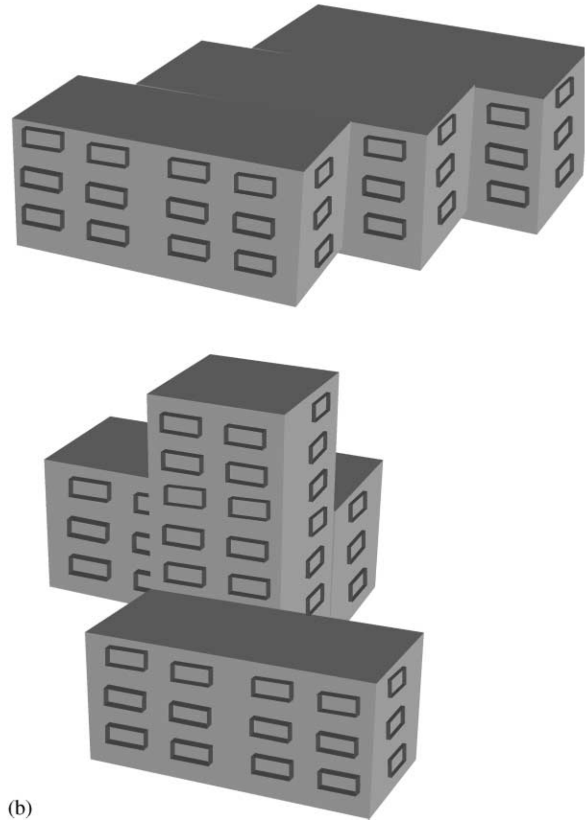


(a)



(b)

Fig. 1. (a) The two possible situations for the study of building shape. Case n° 1: The shape of the building is constant, their size differs; (b) The two possible situations for the study of building shape. Case n° 2: The shape of the buildings change, their size remains the same.

- the performance of the walls (concerning materials),
- the performance of basic thermal systems (concerning the heating, ventilating and cooling systems),
- the performance of complementary systems (concerning energy savings).

This article sets out a study on the link between the building shape and their energy consumption.

2. Definition of the shape parameter

The information about the relation between the shape and the energy consumption is presented on trend diagrams that show the consumption variation according to shape parameter. The selection of this shape parameter must be relevant. Conceivers must be able to handle it easily when they imagine their project. It is thus important that its geometrical and mathematical definition should be simple and easy to use in the development of the project [1–3]. In order to qualify the shape, a “shape coefficient” C_f is defined as follows:

$$C_f = \frac{S_e}{V} \quad (m^2/m^3), \tag{1}$$

where S_e is the envelope surface of the building, i.e. the external skin surfaces, and V is the inner volume of the building.

Once the coefficient has been chosen, the study of the buildings can be treated in two different ways:

- considering a given shape of the buildings and making its dimensions vary in the same proportions (see Fig. 1a),
- comparing the shapes between them, for a same volume (see Fig. 1b).

For the second case, building comparison means to study volumes with different shapes but however presenting the same floor areas and the same high between two levels, that is to say the same internal volume.

The study of the shape coefficient C_f then comes to the study of the envelope surface S_e. This case will be treated in this work because it corresponds to the project situations that conceivers have to deal with. Indeed, when a building is set into project, its size (floor areas and volume) is known, based on the needs of the operation: blocks of multi-storey flats, office blocks, hotels, hospitals, factory blocks, etc. Thus this shape coefficient is quite easy to be understood and used by conceivers.