GENIUS, a methodology to integer building scale data into urban microclimate and energy consumption modelling

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1. Context

Accurate simulation of the city energy balance requires studying the thermal behaviour of buildings and therefore requires knowing many details: at least the buildings geometries, their envelope materials and surroundings ground covering. For instance, information on shape and location of a building are useful to assess the performance of solar panels; information on the materiality of the facades, make it possible to estimate solar gains through the windows and therefore to perform building energy balance simulations (Masson, 2000); etc.

Consequently, several recent research works have been aiming to integer building scale data into urban scale simulations (microclimate, energy consumption of buildings at the city scale, energy production, etc.). Among those researches, we can quote the WUDAPT project (Ching, 2012) aiming to define a worldwide building database based on the LCZ classification of urban forms (Stewart & Oke, 2009).

2. Problematics

The main issue in integrating this type of information to urban scale simulations is the lack of precision of the available data for buildings (Ching et al., 2009). If a limited number of buildings can be very precisely described (through existing Building Information Model (BIM) for instance (Ferries et al., 2014), but also through historical studies or architectural inventories), the data at the city scale remains broadly heterogeneous.

In this paper, we will present how we used those localized descriptions of buildings to enrich existing urban database existing at national scale in the context of the MApUCE project (a French research program that aims to integrate quantitative data from urban microclimate, climate and energy in urban policies).

3. Method

Our working method, called GENIUS (GENerator of Interactive Urban blockS), was to perform a literature review combined with interviews of urban planners to characterize a typology of urban forms in the whole French territory, and to associate it with a wide database. The key theme of our work concerns the integration of building scale data into urban microclimate and energy consumption modelling. It leads us to formulate the question “how can we characterize the building scale in oder to update, and to make full use of urban simulation tools ?” To answer this question, we have broken down our work into three consecutive sections:

- The first section interview urban planners about the differents urban typologies in France. Our aim is to take in account the vision of designers operating processes, in order to identify a system of ranking of urban typology .
- The second section covers existing buildings database for identify, characterize intangible datas, such as buildings use, date of construction and buildings location. The aim of this analysis is to create the conditions for identify representative buildings in France.
- The third section defines the building scale data. It is supported by a bibliographical study of building materials and systems, architecture and building cultures, conservation, etc. and is aimed at reaching an understanding of how information on building scale can be used for urban simulation tools.

To conclude, we define different paths to be developed with the aim of improving the link between scale building data and urban microclimate and energy consumption modelling.

4. typology of urban

The choice of urban typologies is based on parts of Marion Bonhomme thesis (Bonhomme, 2013) which proposes the setting up of seven urban typologies: detached house, continue house, detached building, continu building, high rise building, old center, industrial building. In order to focus and refine this choice, four "middle" urban typologies are added : semi-detached house, typical intermediary housing, semi-detached building, semi-detached industial building. At the beginning, GENIUS creates maps composed of "typical blocks" coming as shape-files of polygons with additional information (height, age, use, insulation...). The "typical blocks" come to seven archetypes of urban blocks that can be found in most European cities (Bonhomme, 2012).

The survey was forwarded by the **Fédération Nationale des Agences d'Urbanisme** (FNAU) to 52 public organizations specialists in development, management of urban agglomerations in France. The urban typologies survey has received 18 answers of the whole territory of France : Midi-Pyrénées, Alsace, PACA, Nord pas de calais, Lorraine, Aquitaine, Rhône-Alpes, Agglomération de Tours, Ile-de-France, Franche-Comté, Martinique, Bretagne, Haute-Normandie, Picardie.

The result of the survey has suggested an expansion to 10 urban typologies :

4.1 Detached house

The urban typology called "detached house" concerns urban island with houses of at least four facades, in ground floor or R+1, often implanted in the center of plot of land.

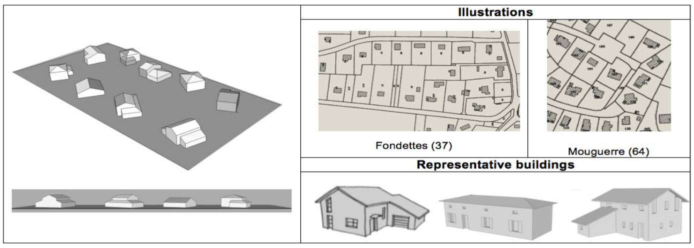

Fig. 1 detached house

4.2 Semi-detached house

The urban typology called "semi-detached house" correponds with the town house, terraced house or house detached on one side, with street related facades, wich combine to form the spatial walls of the streets.

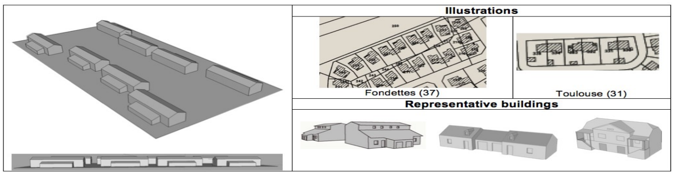

Fig. 2 semi-detached house

4.3 Row house on open island

The urban typology called "row house open island" corresponds with the type of the building "terraced house" along a street, and a garden beyond.

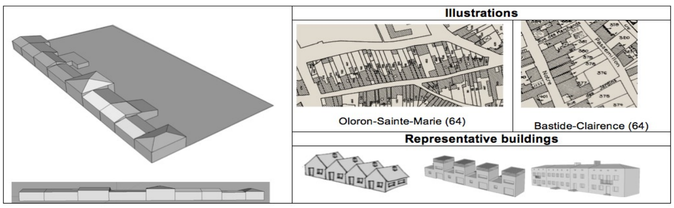

Fig. 3 row house on open island

4.4 Row house on closed island

The urban typology called "row house open island" corresponds with the typical intermediary housing, terraced house with patio or in old center the construction in "chartreuse".

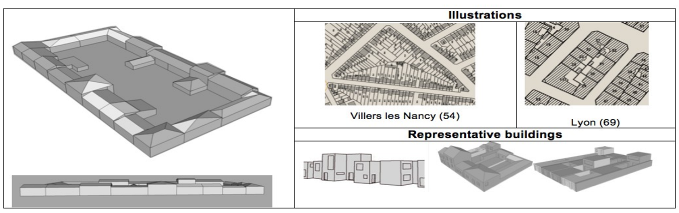

Fig. 4 row house on closed island

4.5 Detached building

The urban typology called "detached building" corresponds with building in the center of the urban island with four facades.

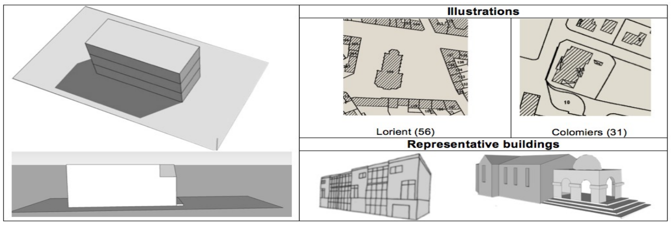

Fig. 5 detached building

4.6 Linear building on open urban island

The urban typology called "linear building on open urban island" corresponds with a building complex in the center of the urban island.

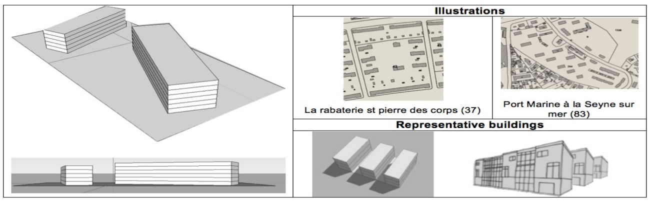

Fig. 6 linear building on open urban island

4.7 Linear building on closed urban island

The urban typology called "linear building on closed urban island" corresponds with building along the streets.It could be old center, or urban fabric of the industrial revolution (Hausmanian buildings)

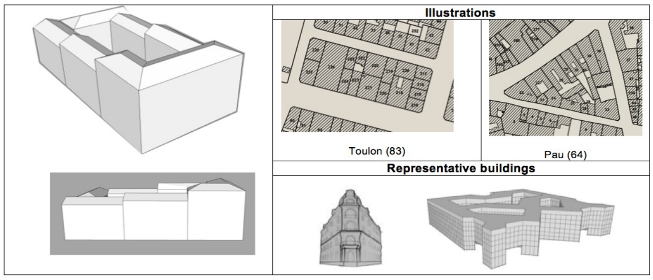

Fig. 7 linear building on closed urban island

4.8 High rise building

The urban typology called "high rise building" is a tall building of unknown height from 12 floors, such as tower block, apartment tower, office tower, etc.

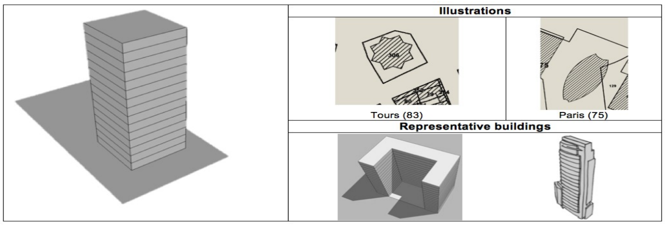

Fig. 8 high rise building

4.9 Industrial building

The urban typology called " industrial building" is represented by industrial, commercial or agricultural buildings even the sports building. They are characterized by their morphology and their size.

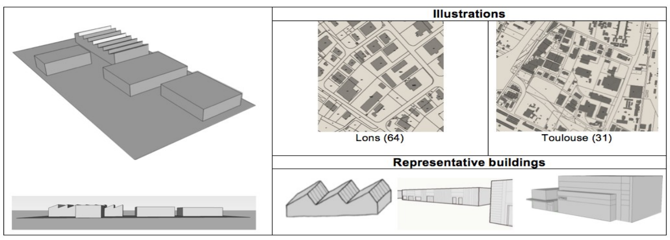

Fig. 9 industrial building

4.10 Informal urban island

The urban typology «informal urban island» corresponds with ephemeral constructions, non-traced on registers.

In the framework of research project "MApUCE", the urban typologies will be defined by morphological indicators (coded on the OrbisGIS/H2GIS GIS by IRSTV) at urban island scale. This morphological indicators will be used as input to an automatic classification (unsupervised statistical analysis). The method of the classification is a work in progress.

5. Three input datas : use building, date of construction and location building

To meet the aim of our project, we need to combine “intangible” input data such as use building, construction's date and building's location to identify “reference building”. We can examine how these datas are used in the database existing.

5.1 Use building

To be able to define the materiality of the “reference building” in the territory of the France, it is necessary to know what the building is used for. The building's use has an impact on the morphology of the built according to the sizing of rooms (natural lighting), their height (industrial building), etc.

The definition of the uses result from the analysis of databases such as IGN (Institut Géographique National). The most common uses were as housing, office, religious building, castle, school, hospital, and unheated areas such as garages, cellars.

5.2 date of construction

The period of construction influences the choice of the materiality of the built according to the evolution in science and technology, the fashions, the doctrines and the regulatory requirements. To take into account the impact of various periods of constructive in France, these research work anchors itself on the rhythm of the application of the thermal regulations which is one of main levers of the evolution of the materiality (choice of the insulation, the bioclimatic design, etc.). Consequently, seven periods are retained given by the rhythm of the thermal regulations after the 1st oil crisis in 1973.

- before 1948 : build heritage
- 1948/1973 : reconstruction period
- 1974/1981 : application of th 1st thermal regulations : energy saving
- 1982/1989 : application of th 2nd thermal regulations : energy saving
- 1989/2000 : application of th 3th thermal regulations : control of energy
- 2001/2012 : application of th 4rd thermal regulations : reduction in greenhouse gas emissions.
- from 2013 : The aim is to cut energy consumption by a quarter between now and 2040.

5.3 location building

Finally, the local materials are taken into account to characterize “reference building”. The definition of territories ensues directly from the location of an urban island in a department. A cross-reference table will allow to make the link between this information, the period of construction and the territories of the local materials. For a department and a period given, several territories can be defined. Maps list the local materials before 1948, then a second map collects the location of the typical materials of territory (brick, wood, stone, etc.).

6. Characterize reference buildings in France

From input data listed in this article (urban typology, use building, periods of construction and location), it is possible to predict typical or representative buildings on the territory of the France (Electricité de France, 1981).

This work was the object of a bibliographical study which associates the works which collect the data (Rapport «RAGE 2012») on “reference buildings” in France and the more technical works on the choice of materials (Hegger M. et Al. 2007) (Deplazes A., 2008) (Vittone R., 2010), and works specific in uses (Brigode G, 1966) (Maillard C., 2007) (Morancé A. 1930) (Pelegrin Genel E., 2006) (Pelegrin Genel E., 2007).

6.1 Morphologic and facade characteristics

Every “reference building” is described in index cards. According to the urban typology, the use building, the date of construction and the location (local materials) one “reference building” is analysed. On the one hand, it allows to integrate morphologic data, such as the compactness of the built, the relationship between the street and the building, the number of floor, the basement (cellar, garage, or on earth plateform), etc.
On the other hand, facades are analyzed with the percentage of glazed surface, and the facade character with slats arranged horizontally or vertically, according to the date of construction.

6.2 Constructive system of walls, floors and roofs.

To define the constructives systems, five scales are established : unheated areas (without insulation), house, building, high rise building and industrial building. Every scale corresponds to the size of a building and consequently to a particular sizing. For each constructive system, four layers are noted : Internal cover / carrier / insulation / cover outside. Firstly, these informations give the thermal performance of every constructive system. Secondly, they allow to know the albedo of the outside cover, and more particularly the roof surfaces which influence the urban microclimate.

For one urban typology, one use building, one date of construction and one location, there isn't one constructive system wall and roof. So, actually, this work is based on three options for the wall constructive system and two options for the roof constructive system.

Then, each “reference building” been the object of an estimation of air permeability, from a campaign of measure realized in France (A. Litvak, 2001).

7. conclusion and development

This work involves the laborious work of project analysis, which can be very time-consuming. Indeed, to optimize the enhance its data, it will be necessary to increase the number of building analyses. Moreover, this study is about a simplified vision of the energetic behaviour of the reference building. Afterward, data will be added as the consideration of renovated building, or still the impact of the occupants, etc.

For the moment, these “reference building” analysis give trends which establish a first urban mutli-scale database.

This typology structures the information according to four main themes: (4) type of urban form (house, towers, etc.), (5.1) buildings use (housing, office building, etc.), (5.2) date of construction (5.3) buildings location. For each combination, our database provides information regarding: building materiality (envelope materials for walls, roofs, floor and windows), buildings morphology (compactness, number of floors, etc.), integration to the urban fabric (contiguity, alignment, size of plots, etc.).

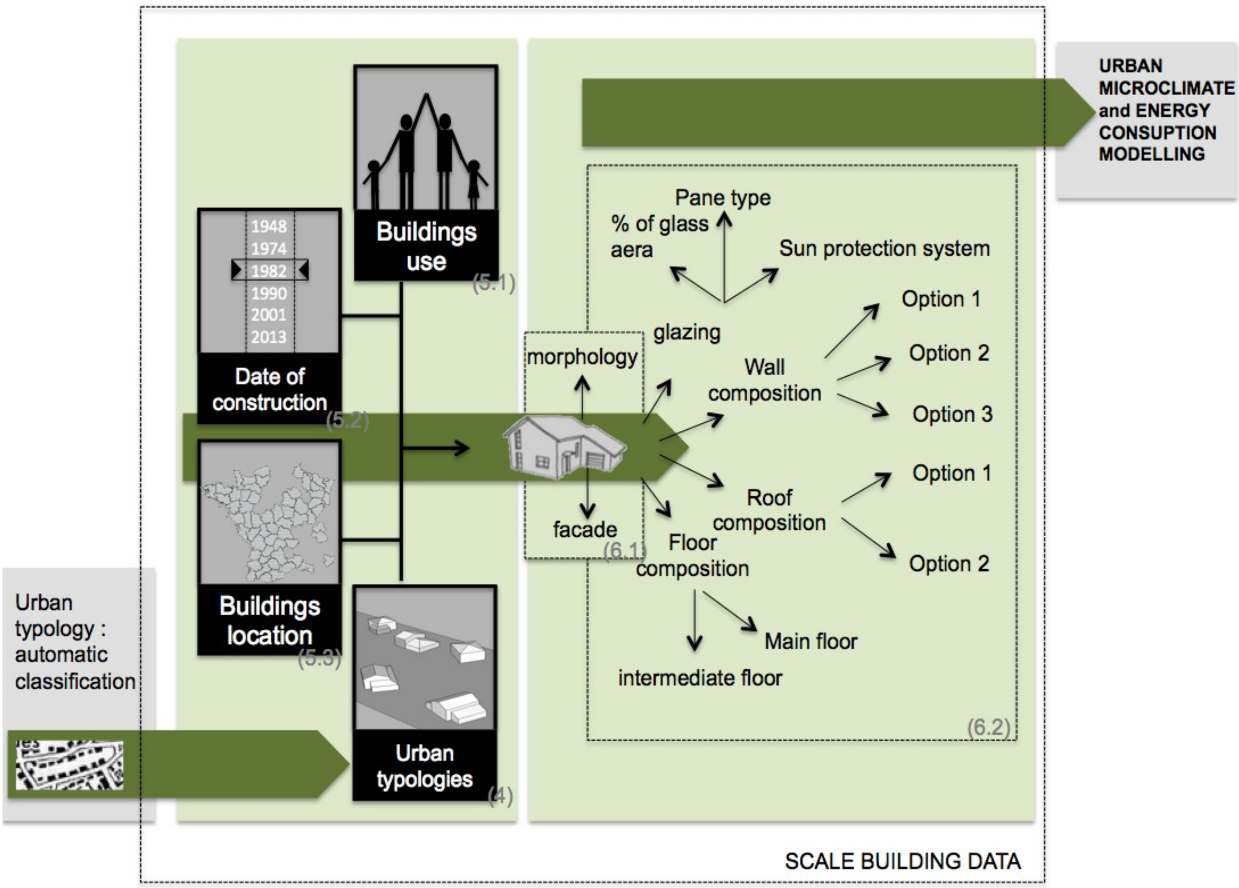

Fig. 10 Integration of scale building data into urban microclimate and energy consumption modelling

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