Low-Energy Social Housings
Marchin (BE) : A Case Study Revisited

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Abstract

In 1997, LEMA research team revisited 20 housings of Marchin. It was to assess the houses performances 15 years after their construction, and check the possible interactions between "energy-conscious design" and social factors. This paper briefly exposes the results of this recent experiment, in the light of the project requirements, design options and design methodology. It indicates that carefull design may guarantee, for quite long periods of time, both robustness and affordability of "energy-conscious" housings.

INTRODUCTION

In 1982, the LEMA realized a real-size "energy-conscious design" experiment in Marchin (BE). It followed a preliminary research work [1] carried out in the framework of the first call for tenders coming from the European Commission (DG XII). During this first research, the LEMA had developed a manual design methodology mainly oriented to the conception of low-cost houses which integrated some fundamental energy concepts into the design process.

The 1982 experimental research [2] took place in the framework of the second EC-DGXII call for tenders. It had for target to apply its design method to an actual case, in order to test the practicability of the method, to bring its lacunas to the light and to confront its theoretical estimations with actual measurements. In agreement with the designers and client, the research team deliberately selected cumbersome conditions as well as low budget housing and important north oriented site slope. All common design constraints (social houses rules, urban regulations, etc.) had to be strictly respected. The challenge was to demonstrate the feasibilty of major energy savings even under poor design conditions and in most buildings contexts.

The recommanded design process was followed along the design of 20 houses. These 20 houses were built by the Belgian National social Housing Society (S.N.L.). Five of them were monitored during the research. The experiment led to very impressive energy savings with standard construction techniques (no high-tech solar devices) and no extra costs.

The design guide was then revised by a re-writing of the manual version, and was computerized on a micro-computer. This gave birth to new energy calculation methods "Strategy 0" and "Strategy I". The Wallonian Region authorities understood the opportunity of such a design guide software. In 1989, the LEMA was asked to create Strategy II, a deliverable educational version of the previous prototypes. Strategy II [3] has been used with great success for several projects.

In 1997, LEMA research team revisited the housings of Marchin. It was to i) assess the houses performances 15 years after their construction and ii) check the possible interactions between "energy-conscious design" and social factors. Our analysis was therefore based on a technical inspection of the houses and a questionnaire submitted to 15 of the 20 occupiers. This paper briefly exposes the results of this recent experiment, in the light of the project requirements, design options and design methodology.

THE PROJECT REQUIREMENTS

Marchin's project has been chosen to study the feasability of energy savings in the building sector in general, and more precisely in the social housing sector. The scientific challenge was thereby quite unusual : it consisted in defining i) affordable and ii) robust low-energy building solutions.

1. Affordable because the house programme and the construction costs were strictly definited by the client (Société Nationale du Logement) :
   - the programme consisted in building a group of 20 subsidized houses. Each house has a habitable area of approximatively 120 m2. Their main functions are a living, a dining room, a kitchen, three bedrooms and two sanitaries; this program was higher than existing Belgian social housing standards;
   - the mean budget per house, inclusive of tax and consultant fees for the project author, is 75 kECU, (actualized cost for 1997 according formula used in the Belgian building sector), while the usual building cost of a 120 m2 house in 1997 is approximatively 100 kECU.
2. Robust because social housings drastically lack of basic inhabitants' care : these buildings are usually loaned for short periods to underprivileged people that cannot spend much time nor money to the building they live in.

These two basic requirements must be considered as key features of the experiment since they automatically enforced both scope and attractivity of its results.

The research team deliberately adopted a "smooth constructive approach" : use of traditional techniques, complete respect of all common requirements,...

Sophisticated devices, like solar panels or optimized heating systems, were at once rejected. Construction costs and maintenance demands made them inappropriate in an affordability and robustness perspective. Most research innovations were thus focused to the architectural design methods which had to integrate easy to disseminate energy concepts.

Location, climate, and site.

Marchin is located in Belgium, on a low plateau between the Meuse and the Hoyoux rivers. At an altitude of 115 m above the sea level, and 51° north latitude, the site is characterized by a temperate climate.

The site, distribued among 3 parts, is bordered by a small valley and a road. The part of the site nearest to the small valley rises rapidly and is timbered; it rises afterwards with a mean slope of 16 %. The slope is oriented North-North-West.

The site conditions were deliberately cumbersome : bad orientation and important slope. This reduced the land prices, but enhanced the construction costs (bigger excavation costs for instance).

THE MARCHIN PROJECT (1982)

Settlement and housing layout

A basic design option of the settlement layout was to dispose the houses in a direction as parallel as possible with the contour lines in order to reduce the excavation works for the setting of the houses clinging to the ground (see figure 1). Besides, this layout provided a good bipolar north-south orientation to the houses which, in northern latitudes, maximizes solar recuperation in winter and reduces overheating risks in summer.

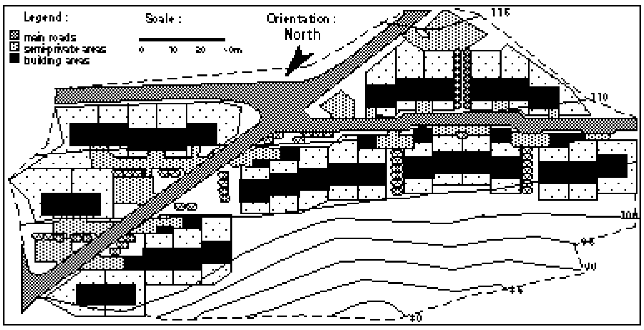

Figure 1. Settlement layout

The plots, usually 8 m wide in social housing standards, have been broadened to 10 m in order to increase south and north facade areas. The whole housing layout has been organized according to this basic orientation. All "technical spaces" (sanitaries, kitchen) were located on the north part of the house. They act as thermal buffers for day-time spaces (living, dining-room, ...) which are concentrated on south part.

Some garages have been located between the public road and the second row of houses. These low volumes act as screens which, being usual, increase the front-yard gardens privacy. Treated as relatively low volumes, they don't give large masks for the solar recuperation in the house.

Finally, the settlement layout maximizes wind protection for most houses. On site meteorological measurements confirmed that west winds were the most unfavourable in this area. In such conditions, east-west oriented terraces reduce the exposition of the houses to one gable by row.

Fenestration

A special effort has been devoted to the fenestration of each room. The final solution results from a lot of 'divergent' constraints which had to be respected : daylighting, visual comfort, overheating risks, building standards and of course energy consumption both for heating and artificial lighting.

North windows, for instance, have a heat balance always negative from the heating energy point of view. Nevertheless, Belgian buiding standards impose a minimal fenestration ratios per room. Indeed the indoor visual comfort requires some visual contact with exterior spaces, especially in the kitchen. Not to speak about daylighting, hygienic and natural ventilation needs. In the case of north windows, a satisfycing compromize has been searched which minimizes the total energy consumed for heating and artificial lighting (electricity) of the room itself.

External walls

The external walls are composed of (from inside to outside):

1. a wall made with heavy concrete blocks (providing the structural support and the thermal inertia)
2. insulating panels placed directly against the interior wall and interlaced with a lattice of wood;
3. an outer "skin" to protect the insulation from wind and water. Between the weather-tight skin and the insulation, a small air space is left by using an additional wood strip to assure for easy circulation of air, which keeps dry both the skin and the insulation behind it.

This type of external wall is relying on usual construction techniques and materials and so remains cheap. But its setting method presents the interest of a continuous control during the construction and gives so the guarantee that the expected properties of the materials could actually be realized (for energy saving reasons).

Window Frames

The connection of window frames with external walls received a special attention. The design team objective was to put the window as far as possible from inside, in order i) to minimize thermal bridges, ii) to approach the element recuperating the solar radiations (the glazing) near outside and iii) to give a better visual comfort.

An original, cheap and simple solution has been proposed. The window frame problem has been split in two parts : the frame supporting the glazing material in the sash and its connection with the surrounding wall. By this way, sills and jambs were replaced with an intermediate peripheral frame between the window and the wall.

THE DESIGN METHOD

The existing manual design method was mainly suited for one single-house and barely outlined the site analysis of a group of houses. This research work offered a major opportunity to enlarge the scope of these methods and to validate their ground hypotheses through on site measurements.

1) The first stage of the design methodology consisted in a feasibility study of the project. The whole architect's attention was focused on the research of "satisfycing

criterions" for global parameters : shape factor, heated floor area, volume, global heat loss coefficient. These criterions integrated different requirements : technics, energy, costs, main objectives defined by the client. They would guide both layout, building and detailed design.
For example, stereographical sun-path diagrams were used for the determination of acceptable solar radiation losses. Overshadowing periods were weighted by the corresponding solar radiation intensities. The overshadowing risk criterion resulting from these calculations determined that the maximal solar energy lost on the lowest point of the South facade would be of 5 %, where 3 % are already caused by the site itself. It did affect the general layout (east-west orientation), building and technical design (acceptable self-obstructions).

2) On the basis of the conclusions of the feasibility study, the architectural team roughly sketched several plans of dwellings. Three different types of houses were designed. They respected the same general space allocation : the South portion incorporates both the general entrance and the living-room, with a window area as large as possible, in order to give the house a good solar recuperation.
3) The three designs were then compared from the energy point of view : one of them had a larger volume but needed annually 76 % heating energy more than the others and has so been eliminated. The others had estimated energy needs nearly similar (1,9 % difference). The preference has been given to the design having a larger aperture to the South, giving so the hope of a better daylight comfort, while remaining reasonable in order to avoid glare risks.
4) The last stage of the design was the detailled technical design. The whole architect's attention was then focused on the respect of all the contraints defined at the previous stages.
For example, the type of external walls was chosen according to the energy consumption, the cost of the insulation, the investment and maintenance costs, the respect of the Belgian regulations related to thermal losses of the envelope and other particularities, e.g. related to the risk of thermal bridges.

MONITORING - RESULTS

A detailed monitoring of 5 houses was achieved just after their construction. The interest of this monitoring standed in the evaluation of the significancy of the design parameters. It involved the experimental measurement of their sensitivity and the statistical interpretation of them. Consequently, the highest number of data on space and time were recorded, as possible.

Measurements were made simultaneously in five attached houses and in the weather station (a critical measurement). Three of the five houses were occupied ; the two unoccupied houses were used as references for the analysis of well defined effects. More than 200 points were recorded.

Measurements confirmed the good quality of the thermal resistance of the houses. The continuous insulation placed outside and coupled with a thermal mass easily accessible from inside gives a negligeable daily oscillation of the temperature without heating (tWH). Its measured amplitude of oscillation indeed is varying from 1°C to 2°C maximum in the most sensitive rooms. This thermal behaviour is the guarantee against overheating during the day or against night discomfort. No overheating has been measured during the dog-days of July 1983 : under clear sky conditions and with a peak outdoor air temperature close to 35°C, the peak indoor globe temperatures were recorded only around 28°C.

THE MACHIN PROJECT REVISITED (1997)

During the summer 1997, the LEMA research team, accompanied by experts, have done a survey and a technical inspection on Marchin site. On the 20 houses, 15 have been revisited and 15 occupiers have filled a detailed questionaire about their energy consumption, their "thermal habits" and their satisfaction level of the social house. The householder (S.N.L.) satisfaction was also assessed through an open interview with one of its managers. This analysis has allowed to answer two important questions :

1. is the inhabitants' behaviour compromissing the efforts made by the designers to obtain a good performance ?
2. how are these low-energy housings considered by the inhabitants and the experts, 15 years after their construction ?

Energy performances

The mean fuel energy consumption is bounded by 125 (for 1 or 2 occupants par house) and 166 (for 3 or 4 occupants par house) kWh/m2 per year. In 1997, the Belgian federal Minister of Energy [4] still considers such consumptions as very low for attached houses for this climate (see figure 2). We can insist here that much of the energy savings were due to the south window apartures. All the houses benefit from plenty of daylight.

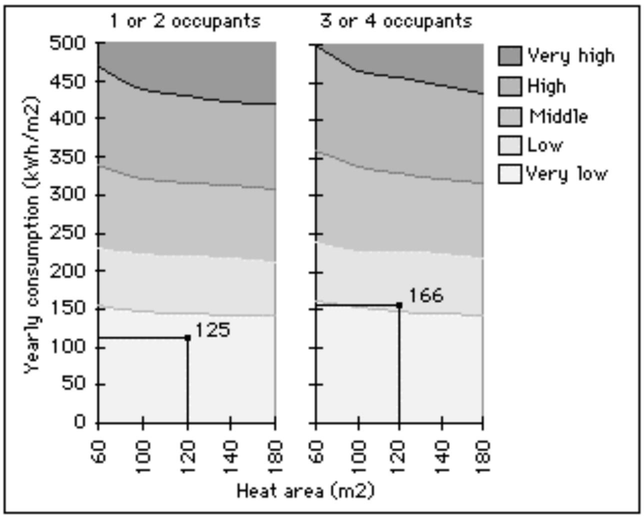

Figure 2. Yearly energy consumption level

Technical performances

The maintenance cost is very low in comparaison with other social houses built at the same period. On the other hand, the S.N.L. heard nothing about structural defect.

The technical inspection prooved the very good durability of the external walls. Nevertheless it should be noted that some inhabitants do not trust it as "good solid bricks walls". Some of them regard it as cheap, unfinished. They sometimes obturated with silicone the infiltration openings that were to dry the wall skin ... It demonstrates again the need for simple, robust solutions when devoted to unspecified inhabitants.

Privacy concerns

External shutters have been added on some windows which could point possible overheating problems. In 1982, external solar protections were scheduled by the architectural team, but they have not been constructed, because of a client's decision to make extra economy.

But another explanation of the shutters adding could be found in a possible lack of privacy inside several houses. Such a phenomenon has already been observed by Littlefair [5] in his analysis of Milton Keynes evolution. Similar interactions between daylight conscious design and social habits have been highlighted by Boudon [6] in his study of the evolution of Le Corbusier's Pessac project.

In Marchin case study, lack of privacy as a possible modifying factor would be confirmed by the fact that mostly unprotected windows, highly visible from the public domain, have received external shutters. Consistently with this presumption, one remarks that frontyard gardens protected by garages are much better appropriated than the unprotected ones, may they be backyard. These last had to be hidden from public view by vegetation that was never planted by authorities nor by inhabitants of course. This assumption could be confirmed by detailed enquiries, led by social scientists, but one can already keep for granted that frontyard gardens, if protected by efficient screens, is a very acceptable solution in cumbersome conditions.

Occupant reaction

The inhabitants' satisfaction regarding their houses can surely be considered as exceptional. Marchin social houses are very demanded by economically underprivileged people. The houses are characterized by an exceptionally long turn-over (6 to 10 years). This duration is considered as three times the mean one observed in social houses. Some of the first occupiers are still living there. Many of them spontaneously affirmed they would buy their house if such an arrangement would be proposed by the public householder.

CONCLUSIONS

Marchin low-cost social houses experiment demonstrated that major energy savings were possible even with standard construction techniques. It highlighted the seminal role that architectural and urban design should play in such an approach, especially when one tries to achieve a robust an affordable solution.

Our revisit of the project confirmed our initial assumption that social factors may interact with energy performances through the occupiers' habits. The fact that even some simple devices, like the wall design, are not necessarily well understood, and thereby accepted, by the inhabitants can proove to be an important source of misfunctionment. Not to speak of high-tech solar devices and heating system regulations...

In the same vein, some of the most basic passive solar recipes may come into conflict with social factors. For instance, large window opened to the south may be disregarded because of privacy concerns if poorly protected from public view. One thus has to carefully balance energetical and social issues if one tries to maximize the buildings general habitability, which is a very limited aspect of sustainability. This will often mean to accept some trade-offs between these somehow competing criterions.

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