The Majrovägen Project. Experimental building design for low energy use and good indoor climate

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SUMMARY

The Majrovägen project is the result of a design competition, held by the City of Stockholm and the Swedish Council for Building Research in 1990. The competition is a part of the efforts made by the City to promote efficient energy use and healthy buildings. Efficient energy use will help reduce disruption to the environment, the need for new, expensive energy plants, and, not least, the energy costs of the inhabitants of Stockholm.

Three different projects with multifamily houses of about 60 apartments each were chosen by a jury to be built in the same area during 1993. The paper presents the awarded building projects and discusses the expected performance from computer simulations.

1. BACKGROUND

The purpose of this paper is to present the winning entries in a site allocation competition sponsored by the City of Stockholm and the Swedish Council for Building Research. The purpose of the competition is, except for to promote development of energy efficient and healthy buildings, to evaluate the consequences of the City of Stockholm's Energy Programme for how new multifamily houses in Stockholm are to be built and operated in the future. The winning entries in the competition are described and their expected performance are reviewed. The winning entries were supposed to be built starting in the summer of 1992. However, the recession in the building industry and the low demand for new housing together with the rough financial climate have delayed the building starts at least one year from the original starting date.

The City of Stockholm promotes energy efficient and healthy buildings through its Energy Programme, which describes the functional requirements on new multifamily housing in order to meet the political goals for energy efficiency, good health, and reduced environmental impact. Houses can be designed with great freedom as long as the functional requirements are met. Energy use and indoor climate are monitored in the finished houses, which gives a great opportunity to see the performance of different technical solutions.

The functional requirement approach is discussed among Swedish authorities as to replace more detailed building regulations in the future. The starting point for these discussions is the City of Stockholm's Energy Programme.

The purpose of the competition was to see how the intentions in the Energy Programme could be realised through full-scale projects. The objectives of the programme and the site allocation competition were the same:

1. Healthy indoor climate and good thermal comfort
2. Low purchased energy requirement for heating and domestic hot water
3. Efficient electrical system solutions and efficient electrical apparatus
4. Problem-free operation.

The functional requirements of the four subsections are specified in the competition programme. These functional requirements are designed in such a way that it shall be possible to evaluate them in the completed buildings during the second stage of the competition. The purpose is to stimulate the development of methods for quality assurance and commissioning. Experiences from a previous experimental building project, the so called Stockholm project, had a great impact on the competition programme and were also used by the competitors.

Three winners of the 16 entries to the competition were awarded by the competition jury with a site allocation in a southern suburb of Stockholm. This means that they can build about 60 apartments each on adjacent lots. These entries were those which were judged to best fulfil the demands of the competition programme as a whole (1). Except for the winning entries, four honorary awards were also given.

Stage two of the competition is that two awards of 1.5 million SEK will be given to the houses that have lowest energy use and lowest electricity use, respectively, and one million SEK to the house with the best indoor climate. This competition takes place during the third year of operation. These houses are also planned to be extensively monitored and evaluated in the context of the four main objectives given above.

2. THE WINNING HOUSING CONCEPTS

The features of the three winning housing concepts are briefly described in the following. A more detailed description can be found in (1). All houses have concrete building carcass.

2.1 Svenska bostäder / BPA

The jury's motivation for choosing this concept was the best forced air heating system, the quality plan, low energy use and good solutions for efficient electricity use. The features of the concept are briefly described in the following:

External walls: Double wood-frame structure with mineral wool insulation 45+90 mm and 0.2 mm polyethylene air/vapour barrier between the frames. 100 mm mineral wool layer and a brick facade are added on the outside.
Heat supply: District heating for heating and domestic hot water, with additional solar energy for domestic hot water.
Heat distribution: Forced air heating system in two zones with individual post heaters for bedroom and living zones. The bedroom heater may be shut of for a reduction in

bedroom temperature. The supply air flow is used to distribute the heat (no recirculating air). The supply air temperature is designed to not exceed 50 °C. Ventilation system: Mechanical supply and exhaust ventilation with cross-flow heat exchanger. The supply air enters the room from the rear wall (i.e. not the window wall). The principle of the forced air heating and ventilation system is shown in Figure 1.

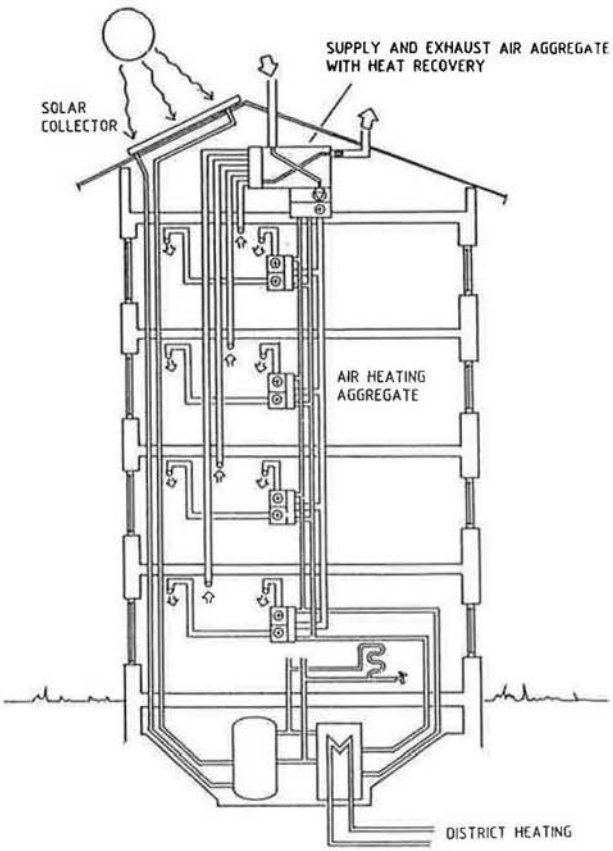

Figure 1. Principle of the awarded forced air heating and ventilation system in the Svenska bostäder/BPA concept. The system design has been made using laboratory measurements in a full-scale apartment.

2.2 HSB / Ohlsson & Skarne

This concept was chosen because of its own production of electricity and user-friendly building services together with low energy use and efficient electricity use. The features of the concept are briefly described in the following:

External walls: Concrete sandwich elements with an outer layer of 70 mm and an inner layer of 120 mm concrete with 150 mm of intermediary extruded polystyrene plastic insulation. A section of the building construction is shown in Figure 2.
Heat supply: Heating and domestic hot water for these houses are produced in a centrally located gas fired power and heating plant with a conventional gas boiler as

back-up for demand peaks. An exhaust air heat pump is driven by electricity generated in the plant.
Heat distribution: Twin-pipe hydronic system.
Ventilation system: Mechanical exhaust ventilation with fluid-connected recovery batteries to the heat pump. The supply air enters the apartments behind the radiators in the bedrooms and living-rooms via a newly-developed outdoor air vent which gives widespread distribution at low velocity for the incoming air. The constant exhaust air flow is complemented with carbon filter fans in the kitchens.

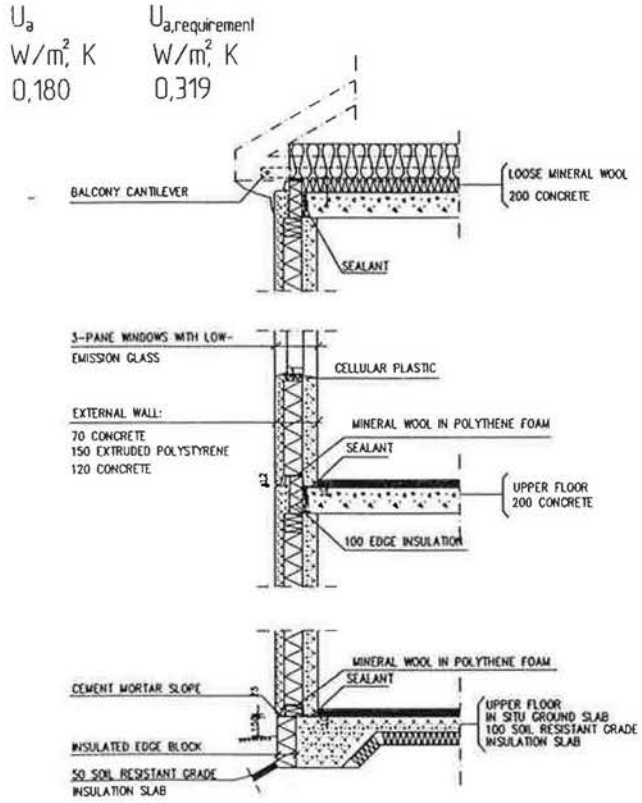

Figure 2. Section of the building construction for the awarded HSB/Ohlsson & Skarne entry. Note the balcony cantilever, which eliminates thermal bridging at balcony floor connections.

2.3 NCC-Stockholm

The third winner was selected for its high quality in construction and problem-free operation and fine-tuning of existing technology. It also has low energy use. The features of the concept are briefly described in the following:

External walls: The load-bearing concrete walls are insulated with 170+50 mm mineral wool. The outer layer consists of 120 mm of facing brick.
Heat supply: A gas boiler is used for heating and domestic hot water production. Solar panels and locating the incoming domestic water next to the waste water pipe contributes to the preheating of the domestic hot water.

Heat distribution: Twin-pipe hydronic radiator system and a floor heating loop along external walls.
Ventilation system: Mechanical supply and exhaust ventilation with double cross-flow heat exchangers. The kitchen cooker hoods are not connected to the heat exchangers. The principle of the heating and ventilation systems are shown in Figure 3.

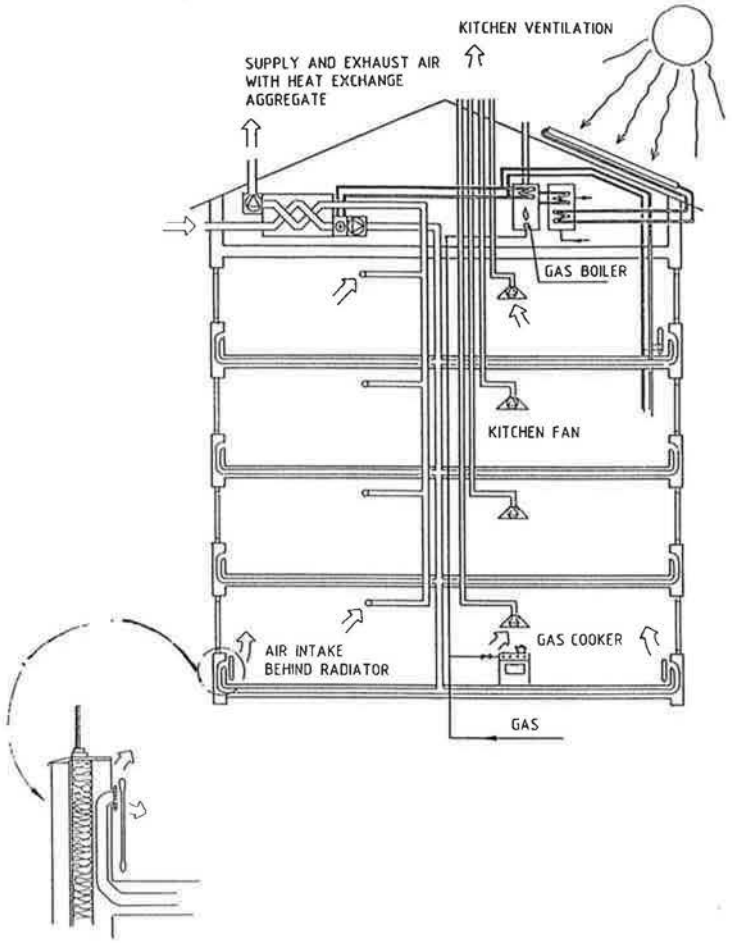

Figure 3. Principle of heating and ventilation systems for the awarded NCC-Stockholm concept.

3. COMPARISON WITH SWEDISH STANDARD HOUSING.

According to the result from computer calculations, the average expected total energy use for the houses in the competition are about 90 kWh/m^2 or about 30 % less than for the houses in the Stockholm project built in the mid-1980-ies, see figure 4. The Stockholm project houses were, however predicted to have a total energy use lower than the obtained. The lower energy use for the competition houses is achieved by improving the thermal performance in reducing the effect of thermal bridging. Also, electricity use for building services and domestic electricity use are much lower than for the older houses.

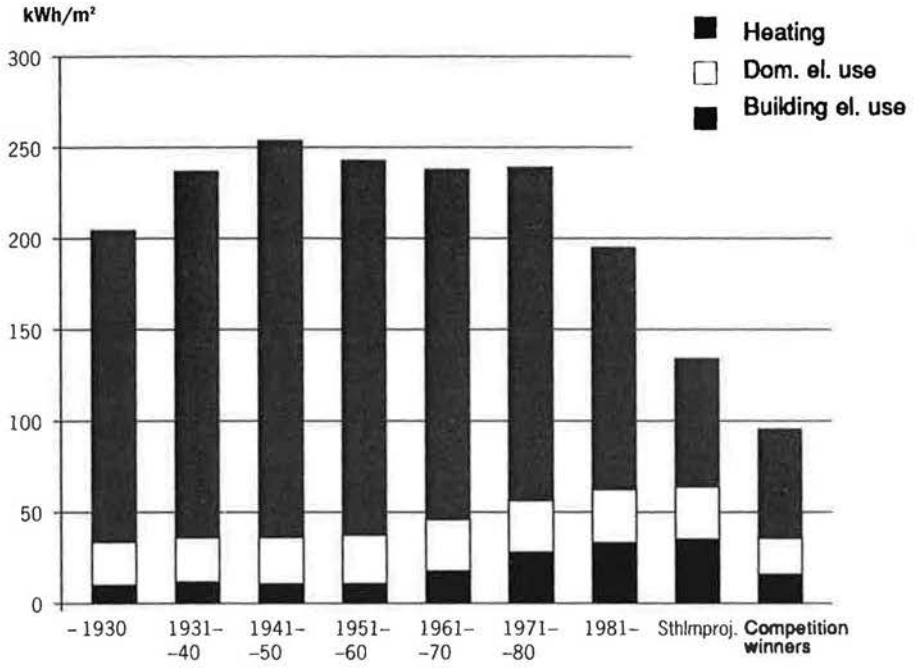

Figure 4. Total energy use for multi-family buildings in Stockholm (recalculated to standard year) separated by year of construction (2). The two bars on the right are from the experimental building projects: Measured results from the Stockholm project and averagepredicted results for the competition winners.

4. CONCLUSIONS

Many interesting solutions for construction details and HVAC systems to achieve the goals of the competition were presented by the competitors. The reviewed entries show that, with good incentives, builders and consultants can go one step further towards more energy efficient and healthy buildings. Results from measurements when the houses are built will show if the predicted performance will be obtained and hopefully also answer many of the questions we have today regarding efficient energy use and indoor climate.

5. REFERENCES

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2. Fyrhake, L., 1992. Nya friskare hus med lägre elbehov (in Swedish). Byggforskning 92.6. Stockholm 1992.