Passive solar design: a promising direction

Passive Solar Design — A Promising Direction

Conception de projets avec l'énergie solaire passive

Entwurf mit passiver Solarenergie

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SUMMARY

Since the energy crisis in 1973, much effort has been made world-wide for the utilization of solar energy. In Central Europe, at first active solar systems (collectors, absorbers, etc.) were developed in constructional engineering. These however, proved to be ineffective in Central European climatic conditions. At present — almost euphorically — passive solar architecture (giving preference to south orientation of glass areas in buildings etc.) is being dealt with. The Central European climate, however, also set narrow limits on passive solar measures: The criteria of compactness of buildings and of structural heat insulation are more important. The heat storage capacity of building components is negligible under Central European (and comparable) climatic conditions.

RESUME

Depuis la crise d'énergie en 1973, beaucoup d'efforts ont été entrepris, dans le monde entier, pour utiliser l'énergie solaire. En Europe centrale, l'industrie du bâtiment a d'abord développé des systèmes solaires actifs (collecteurs, dispositifs absorbants etc.) qui, cependant, se sont montrés inefficaces dans les conditions climatiques d'Europe centrale. A présent, d'une manière assez euphorique, c'est l'architecture solaire passive qui a la préférence (par exemple orientation vers le sud des surfaces vitrées dans les bâtiments). Dans les conditions climatiques d'Europe centrale, il y a des limites étroites également aux mesures solaires passives: les critères de la compacité des bâtiments et de la protection thermique de construction sont plus importants. La capacité d'accumulation de chaleur des éléments de construction est insignifiante dans les conditions climatiques d'Europe centrale et d'autres pays comparables.

ZUSAMMENFASSUNG

Seit der Energiekrise 1973 sind weltweit viele Anstrengungen zur Nutzung der Sonnenenergie unternommen worden. Im Bauwesen hat man in Mitteleuropa zunächst aktive Solarsysteme (Kollektoren, Absorber etc.) entwickelt, die sich im hiesigen Klima als uneffektiv erwiesen haben. Jetzt wird — geradezu euphorisch — passive Solararchitektur betrieben (Südpräferenz von Glasflächen in Gebäuden etc.). Auch passiven Solarmassnahmen sind im mitteleuropäischen Klima enge Grenzen gesetzt: Kriterien der Gebäudekompaktheit und des baulichen Wärmeschutzes sind wichtiger. Die Wärmespeicherfähigkeit der Bauteile erweist sich dabei unter mitteleuropäischen (und vergleichbaren) Klimabedingungen als unerheblich.

Passive solar energy utilization is only a newly coined word to those who have always been standing up for climate-adjusted building design. The sun as an energy source which is practically inexhaustible has always been an eloquent sign of successful building design in many regions of the world. In particular, the vernacular architecture in the developing countries is remarkable. People who often cannot read and write and do not know anything about microelectronics turn out to be really good master builders.

Since the energy crisis, the utilization of solar energy has also been dealt with thoroughly in Germany. However, it has not at all been understandable that in Central European climate solar energy collectors or other "collectors" were first of all used which are equipments to be put on buildings, in the surroundings of buildings or connected to buildings. Real experts have been knowing from the beginning that this so-called active solar technology cannot be that "active" in Central European climate. In contrast to this, the passive solar technology with structural means consisting of climate-adjusted building design and consideration of building physics principles according to the respective climate was neglected at that time. Within the last few years, however, there has been a change: The possibilities of passive solar energy utilization in Central European climate have been thoroughly investigated; important results are already available, some investigations are still going on. Architects have taken up the passive solar energy utilization intensely, almost euphorically. The users of dwellings and buildings have also become sensitive in this respect. Manufacturers develop products for the market to be used for passive solar energy utilization. On account of recent reports [1] to [6], the scientific findings have come to a certain close so that they can be put into practice as far as building design is concerned.

Except special problems, there are sufficient scientific findings available for practical design work in Central European climate conditions. This design help cannot be translated into other climatic zones. Vice-versa, design guide-lines cannot be "imported" from countries with different climatic conditions. For non-airconditioned buildings in Central European climate, the following general indications can be given:

1. Passive solar architecture understood so far by large glass areas and preference of south orientation is only of use for structural heat insulation with U-values of more than 0.8 to 1.0 W/m²K, as far as the energetical aspect is concerned. In all other cases, increased glazings with preference of south orientation are not necessary or even disadvantageous inasmuch as the free choice of ground plans is thus restricted. However, there should not be drawn the conclusion that an improvement of thermal insulation is of no use because passive solar energy utilization through windows would then become unsuccessful; absolutely speaking, an increased thermal insulation helps more to save energy than passive architecture alone.

2. Compactness of a building should be preferred to the utilization of solar gains by passive architecture and south orientation. Rooms and dwellings situated peripherally in a building have, as a rule, considerably higher energy consumption than those situated centrally. Unless aspects of use or daylight supply are opposed, lower-heated rooms should be situated at the periphery of a building. This requires careful consideration of ground plans according to energetical aspects.

3. In existing and new buildings, temporary thermal insulation measures at windows are the best means to utilize solar energy passively. Temporary thermal insulation is a measure of insulation and has nothing to do with solar architecture in the sense of solar energy utilization. Temporary thermal insulation is effective with all orientations of façades. The decision of where it

should be attached does not depend on solar points of view but on criteria of construction, investment and use. Thermal insulation glazings of novel type can achieve relatively low U_{eff}-values* even without temporary thermal insulation.

4. The heat storage capacity of external and internal building components has practically no influence on heating energy consumption of buildings; it is only favourable to summer heat protection. If there are sunshading equipments, the heat storage capacity of building materials need not be taken into consideration for passive solar measures. What matters is their thermal insulation capacity, i.e. the U-value resp. U_{eff}-value of the external building components.

5. The passive solar gains of external building components impermeable to radiation are negligible. Non-transparent external building components must be thermally insulated in order to keep the heat losses low; the gains are not important. Solar gains are achieved by window areas. Mixed forms between window areas and building envelopes impermeable to radiation are external building components with translucent covering and possibly with translucent insulating materials, which are to be considered positive.

6. In buildings with average insulation (with $U_{Wall} \approx 0.6$ W/m²K), passive solar energy utilization with increased window areas is not very effective - even with south orientation. Improvements can only be achieved by temporary thermal insulation or by increase of structural heat insulation, i.e. by decrease of the U-value to about 0.3 W/m²K, which corresponds to good thermal insulation of the façade.

7. If external non-translucent external building components have a good structural heat insulation with $U \approx 0.3$ W/m²K and if there is a temporary thermal insulation at the windows, further passive measures are superfluous. By means of carefully placed temporary covers with different insulating values, the differences between the various façade orientations can be compensated. Although in Central European climate preference of south orientation - of secondary importance in relation to the principle of compactness as mentioned in point 2 - is quite correct, the exclusiveness of this rule can be broken by means of temporary thermal insulation measures. In such case, the distribution of window areas to the different orientations and the size of window areas need not be chosen only according to aspects of passive solar architecture. There is free choice in façade design and the windows can be chosen as up to now according to the specific requirements of use. Accomplished solar architecture is shown by buildings with completely "normal" shape, which is not eccentric but simple. The buildings are compact and well insulated; the windows must have a temporary thermal insulation. An effective sommer sunshading equipment is necessary; it should not be forgotten. Apart from that, shape, façade design and choice of materials are free. Reversely, this high degree of liberty for the architectural design means that "non-normal" shapes are unnecessary but also possible, if there is good structural heat insulation and temporary thermal insulation. Such shapes are not typical of solar architecture in the sense of solar energy utilization. In Central European climate, there is no reason for typical solar architecture as created in the

*The U_{eff}-value implies not only the transmission heat losses but also the energy gains due to solar radiation, being an average value for the total heating season. It applies to a special climatic zone. In the English-speaking countries, it has come into use to specify the (normal) U-value as "black value" and the effective U-value as "white value".

past years with large glazed areas. Obviously, "architectural ideas" have been borrowed rather uncritically from abroad, especially from the USA. It would be interesting to check whether such new shapes of solar architecture are really appropriate over there from the point of view of energy saving.

8. The energetical effect of glazed front structures or superstructures is to be rated like a doubling of thermal insulation or like the effect of a good temporary thermal insulation at the windows. However, winter gardens cause problems of summer heat protection and involve relatively high investment costs. From the energetical point of view, they are unprofitable. Nevertheless they offer interesting possibilities of livening up the façade and of improving the dwelling quality.

The preceding general indications for practical design work in architectural projects can be completed, in individual cases, by concrete calculations of heat consumption or solar gain according to the U_{eff}-method. This method offers a simple and quick way to obtain data of sufficient accuracy enabling the architects to take immediate decisions in design. The method is most suitable for designing architects because there is not much calculation work required. If the solar energy amount - which may be different for each building - is utilized this way and if it is done by simple means, solar energy utilization will pay back in many cases. The design help is simple: Temporary thermal insulation at the window, solid structural heat insulation at the building envelope and, as far as possible, compact ground plans! Apart from special cases, all other structural measures are useless in Central European climate from the energetical point of view. This core result confirming the efforts from the building industry and from building authorities makes clear that in Central European climate structural heat insulation is of primary importance and not solar design. Further education on solar design or so-called "solar workshops" are, therefore, superfluous. On the contrary: There is danger that passive elements from other climatic zones slip into Central European architecture which do not belong here; this causes more confusion instead of making the matter clear.

LITERATURE

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