Better room climate thanks to façades made of stainless steel wire mesh

Energy- and cost-efficient, and comfortable

Textile-like woven metallic fabric made of stainless steel established itself at the beginning of the '90s under the brand name CREATIVE WEAVE™ as a visionary building material in terms of both aesthetics and technical functionality. Made of monofilament wires and flexible cables, stainless steel wire mesh opened up a whole new world of design potential as building façades, claddings for ceilings, walls or columns, floor coverings, partition walls or sunscreens. The puristic material reveals its special effect in its interplay with light. Depending on the angle from which it is lit, its surface becomes transparent or opaque, acting as a projection screen in decorative contexts; additionally it can be used to enhance architectural forms with veritable three-dimensional rhythm and tension. Over and above these aesthetic arguments, GKD's woven metallic fabric – originally a purely industrial material – also offers a wide range of functional advantages. It is fire-resistant, has a practically unlimited service life, is maintenance-free, robust and weatherproof, and the dimensions in which it can be produced allow it to follow the lines of every architecture like an apparently seamless outer skin. All this provides endless scope for application and gives planners – metal workers and architects alike – a totally free hand in exercising their creativity. In the meantime, countless office and administrative buildings, museums, hotels, airports and railway stations, cinemas, car parks, bars, restaurants and boutiques, and even sports stadiums and bridges – all created by the most renowned architects of our times – have been added to the list of reference projects of the company GKD – Gebr. Kufferath AG, which is based in Düren, Germany.

Study of thermic effects

In addition to the known functional properties of stainless steel wire mesh, GKD also wanted to reach the thermic effects of a stainless steel façade scientifically examined and so, in 2006, the company commissioned the Aachen-based consulting engineers heliograph with a corresponding research study. This team of consulting engineers operates independently of GKD and has been specialising, since 1993, in simulation-based optimization of buildings with respect to energy efficiency and room climate. The task assigned to heliograph was to assess the energetic, climatic and economic effects of a façade with GKD's stainless steel wire mesh and to compare these with the analogous values of alternative, conventional sun protection installations.

The result of the study left no doubt: due to the specific building-physical properties of the woven metallic mantle, the GKD façade led to a significantly improved performance by the building. The study has now verified this influence scientifically for the first time and has quantified it in terms of examples.

Comparison of Saarbrücken and Dubai

The reference object for the study was the ExpoMedia LightCube in Saarbrücken, a project accomplished in 1998 by the Darmstadt-based architects Kramm + Strigl which reflects the state of the art through modern architectural and formal expression. For the comparison, the same object was investigated in the climatically more extreme location of Dubai using numeric simulation tools.

Like a giant monolith, the cube towers over the embankments of the river Saar in the west of Saarbrücken. As the sun moves across the sky, the façade of stainless steel wire mesh changes from a monochrome grey in the early morning light to a glisteningly bright, cool silver at noon. In the evening light, it glows with a warm, shiny gold-orange color, and then, at night, it is transformed into a screen for extraordinary lightshows with computer-generated colors and shapes.

This cube-shaped building has 1,880 square meters of floor space over 8 floors in all (including basement) and is tailored to the needs of the multimedia branch. The entrance area is located on the first floor at the south side of the building and provides access to the upper floors via staircases. Exhibition spaces are located on the east and west sides, their functions complemented by flanking kitchenettes and sanitary facilities. A centrally located atrium facing the north side of the building connects all the floors. On each of the six upper floors, conference rooms are located on the south side of the building, while offices and facility rooms are located on the east and west sides. A gallery running round the atrium connects all the rooms on each floor with the functional zones located in the corners of the building, like staircases and sanitary facilities.

For the simulation, the real building was represented as a simplified numeric computer model with identical office utilization on all seven floors above ground level and with building-physical properties like type of material, thermal conductivity and heat storage capacity, vapor transmissibility, density and radiation characteristics. The orientation of the building was also taken into consideration, as were the special climatic conditions of the location – Saarbrücken or Dubai – on the basis of real weather datasets.

Using this information, the thermic-energetic behaviour of the building was defined. This involved examination of the ground against soil, exterior walls, load-bearing and non-load-bearing inner walls, the inner doors, the ceilings, the roof and the roof-glazing as well as the windows including frames and glazing.

The simulation model and its boundary conditions

For a better survey and to simplify the calculations, individual areas and rooms in the virtual model of the building were zoned. Rooms were grouped into zones according to type of use, working times and external and internal loads. In the simulation, each zone was subjected to specific investigation. In this way, precise data per hour for each zone were calculated for room air temperature and humidity, wall, ceiling and floor temperature, in- and outflow of air, heat transfer through opaque and transparent surfaces, solar radiation as well as the heating and cooling loads required to maintain stipulated room conditions. Moreover, the integration of data on materials used in construction allowed a detailed examination of the solar radiation, the heat storage capacity and its effect on the room climate. While solar radiation in cooler latitudes is a welcome supplement to the heating of a building, in the summer months and in southern regions it leads to undesired overheating of the structure. A fact also reflected in significant differences in the simulated comparison of the buildings in Saarbrücken and in Dubai. Temperature levels (on average 6.7°C in Saabrücken and 28.6°C in Dubai), radiation values (in Saarbrücken frequently under 200 W/m², in Dubai up to a maximum of 1,100 W/m²), and typical local wind speeds (in Saarbrücken between 3 and

12 m/s, in Dubai between 1 and 15 m/s) all illustrate the contrast between the two locations.

In the simulation, four different sun protection variants were then compared at the two locations. Weather-dependent use of the sun protection facility was assumed within working hours from mondays to fridays from 8am to 6pm. A non-shaded building with simple thermal insulating glazing (oSS) as “worst-case“ scenario was compared to a building with internal sun protection (Ssi) and a building with external sun protection (Ssa). The fourth variant was the real Light Cube in Saarbrücken with a permanently installed GKD façade made of stainless steel wire mesh of type OMEGA 1520.

Consequences for technical equipment

The strongly differing solar yield of the four variants of the building leads to great differences in the demands on technical equipment. For the Saarbrücken location, for example, the variants without sun protection or with internal sun protection showed a high level of solar radiation and correspondingly high cooling loads. This implies the need for large air quantities which can only be provided by centralized air-conditioning systems. The variant with external sun protection shows such low cooling loads that these could also be provided draft-free with the required air quantities via decentralized units without a ramified ventilation system. In contrast, when the GKD façade is used, additional cooling via a ventilation system is only required in the conference rooms and for the atrium. In the offices, the cooling ceilings provided in all four variants are sufficient to meet the cooling requirements. To exploit heat recovery for the air conditioning in winter, decentralized air-conditioning units with heat-recovery facilities are installed here. Although the required thermal heating energy varies in all four variants due to the difference in solar yield, the peak heating load for the system design varies only very slightly. The heating systems are thus identical for all variants.

Analogous to the Saarbrücken location, the simulation also compared the different technical systems required for Dubai. The cooling load of the building is so high for all variants that it can only be managed through a combination of cooling ceilings and ventilation systems. In addition, the variants with no sun protection and with internal sun protection place extremely high demands on the ventilation system. The high air exchange rates called for can hardly be achieved draft-free via conventional outlets. For a better comparison, however, the additional costs for equipment with standard swirl diffusers were calculated in.

Operating costs

The costs for power consumption for lighting and equipment vary because of the different lighting times. The more the building is shaded, the greater the power consumption. Furthermore, power consumption for the ventilation and control systems depends not only on the volumes of air that need to be circulated but also on the complexity and dimensions of the system to be controlled. On the other hand, power consumption for cooling is linearly dependent on the refrigeration load of the building. This decreases, for the same inner loads, as the shading of the building increases, but causes energy consumption for thermal heating to rise because the fall in solar radiation means that the building is heated less by the sun.

In Dubai, power consumption for lighting and equipment is about the same for all the variants with sun protection due to the consistently high level of solar radiation throughout the year. Regarding ventilation and control systems, the contribution of ventilation systems to energy costs increases due to the high volumes of air that need to be circulated. The demands on the control systems are practically identical for all four variants. Because of the climatic conditions, energy consumption for cooling accounts for the greatest portion of the costs. For this reason, the sun protection of the building in this location is of greater relevance for total energy consumption. On the other hand, thermal heating is not required here due to the high outside temperatures throughout the year and to the fact that dehumidification is not needed. For the sake of comparability, calculations for this location were based on the same electricity rates as in Saarbrücken.

Longer life cycle compensates for higher basic investments

When the average service life expectancy of components for the technical equipment and the costs for their replacement are related, it is clear that the higher basic investment pays off over the life cycle of the building. Admittedly, the costs for the sun protection push up the primary investment costs for building and structural design (cost type 300), but on the other hand the improved sun protection leads to a reduction of the costs for technical equipment (cost type 400). Since technical equipment in, particular, usually has a shorter life cycle than the building components for basic structure and interior finish, the maintenance costs – calculated for the life cycle of a building – are higher for a technically more complex building, i.e. one without or with less efficient sun protection. On top of this there are the costs for service, inspection and consumption. Assuming a typical life cycle for a stainless steel wire mesh building façade in Central Europe of 100 years, the GKD façade thus offers an obvious cost advantage. For the location Dubai, calculations of investment costs were based on German prices, and on German quality regarding life expectancy. Due to the warmer climate there, the technical systems for cooling are more expensive so that, in spite of there being no need for heating installations, the total investment costs are higher than those Saarbrücken. The study thus proves even more clearly for Dubai that the higher basic investment for a GKD façade is balanced out by the lower costs for technical equipment, maintenance, inspection and service and by the reduced energy consumption.

Another aspect that should not be forgotten is comfort. In order to sustainably guarantee a room temperature of 26°C in countries with similar climatic conditions to those in Dubai, air has to be supplied in rooms without a GKD façade at speeds so high that the rooms feel uncomfortably drafty. Only in rooms with a GKD woven metallic façade is it possible to provide comfortable, draft-free air conditioning.

Conclusion

The study conducted by the consulting engineers at heliograph in Aachen confirms a new dimension in the functionality of GKD stainless steel wire mesh façades. When taken into account in the planning process as an integral part of the structure, as a technical product they minimize the operational and maintenance costs in the long term. As a permanently installed, robust sun protection, they allow long-term reduction of requirements for air conditioning and ventilation systems, making it possible to save on the procurement and operational costs for such systems, and on the space required for them. Furthermore, in locations with very high levels of solar radiation, GKD façades also ensure a level of comfort in terms of room climate that would not otherwise be possible. Future buildings will be increasingly judged on their ability to meet the needs of their users in an elegant and cost-efficient way, and also on the way they make aesthetic and functional use of renewable energies. In this respect, too, façades made of stainless steel wire mesh by GKD set global standards.

15.256 characters incl. spaces

GKD – WORLD WIDE WEAVE

As a privately owned technical weaver, GKD - Gebr. Kufferath AG is the world market leader in metal, synthetic and spiral mesh solutions. Four independent business divisions bundle their expertise under one roof: Industrial Mesh (woven metal mesh and filter solutions), Process Belts (belts made of mesh and spirals), Architectural meshes (façades, safety and interior design made of metal fabrics) and Mediamesh® (Transparent media façades). With its headquarter in Germany and five other facilities in the US, South Africa, China, India and Chile – as well as its branches in France, Spain, Dubai and worldwide representatives, GKD is close to markets anywhere in the world.

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GKD
WORLD WIDE WEAVE

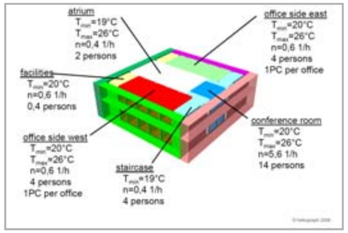

Fig. 1: Simulation: Edge condition utilization

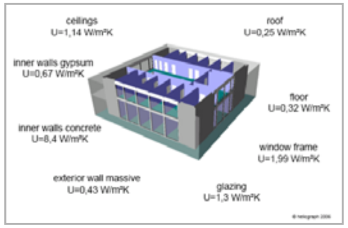

Fig. 2: Simulation: Edge condition material

Fig. 3: Specification of technical systems Saarbrücken

Fig. 4: Specification of technical Systems Dubai

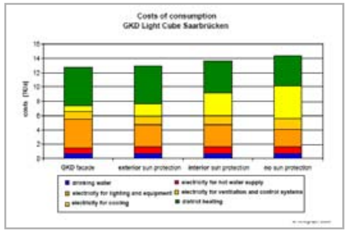

Fig. 5: Costs of consumption Saarbrücken

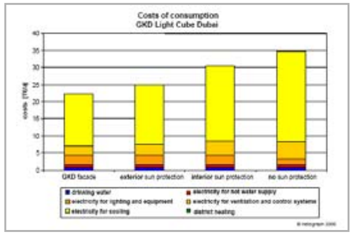

Fig. 6: Costs of consumption Dubai

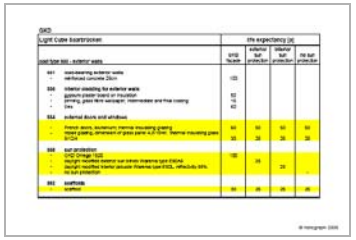

Fig. 7: Life expectancy of constructive components Saarbrücken

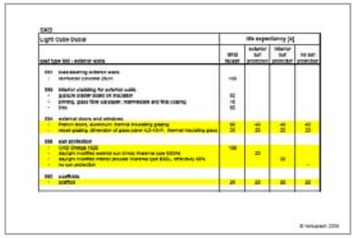

Fig. 8: Life expectancy of constructive components Dubai

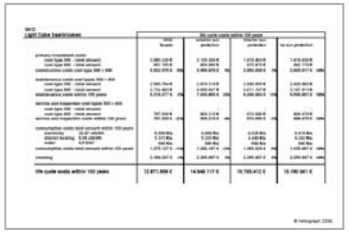

Fig. 9: Life cycle costs Saarbrücken

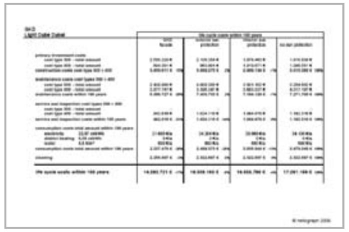

Fig. 10: Life cycle costs Dubai

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