

Design optimization of a suspended glazed corridor in Milan

Gian Luca Brunetti

Researcher, ABITAlab. Department of Building, Environment, Sciences and Technology (B.E.S.T.), Polytechnic University of Milan, via Durando 10, 20158 Milano, Italy, tel./fax +39 02 23995750, email gianluca.brunetti@polimi.it, www.abita.polimi.it.

ABITAlab, Department of Building, Environment, Sciences and Technology (B.E.S.T.), Polytechnic University of Milan

ABSTRACT: The study in question, commissioned by the public Administration of the Province of Milan, has taken place in the context of the refurbishment of the Feltrinelli Technical Industrial Institute in Milan, following a first design hypothesis by the Province's technical offices. The original retrofit proposal aimed to connect three buildings of the complex by the means of a glazed, walkable, suspended corridor, similar to those typical of airports. The author evaluated the thermal behaviour of the suspended corridor both as defined in the original design hypothesis and as modified according to alternative design hypotheses based on variation of solar shadings and envelope operability and composition. The suspended corridor had to be connected with a sunspace that the author suggested to be built on the south facade of a building nearby, and therefore had to be compatible with it at aesthetic and construction level. The thermal effects of the considered design hypotheses have been evaluated using the ESP-r software tool, and the conclusions deriving from the simulations results have been crossed with architectural and construction considerations.

Keywords: Passive cooling, solar shadings, energy simulation, schools.

1. INTRODUCTION

The case study in question is that of the design of a glazed suspended corridor connecting the main buildings forming the Feltrinelli school complex in Milan. The design solution to be defined had to be fit, at aesthetic and construction level, to a sunspace that the author suggested to be built on the south facade of one of the buildings, at the second floor level. The architectural solution proposed by the author

was chosen among several retrofit hypotheses, evaluated by the means of the ESP-r software tool, and constituted a slight compromise between energy performance and architectural constraints.

The consultancy work for the analysis of the environmental performance of an existing design hypothesis had been commissioned to ABITAlab by the Province of Milan, who managed and now also owns the school buildings.

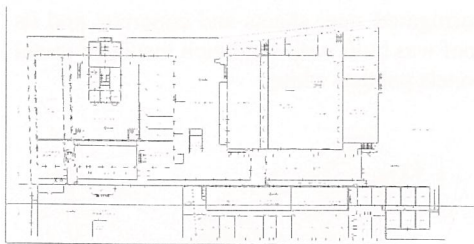


Figure 1: Plan of the Feltrinelli school building complex. The corridor in question would connect the southern, long building with the building in the east-northern part of the lot. (The building between the two, here present, is no more existing.)

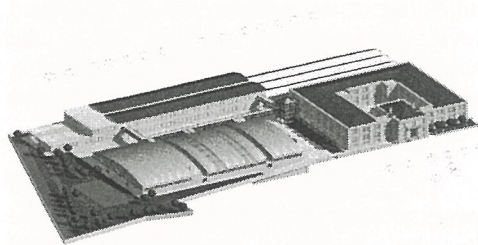


Figure 2: View of the first version of the project by the Province's technical office, from north-east.

This first design hypothesis implied a substantial morphological change of a building constituted by four pavilions in the north-eastern side of the complex. The vaulted roofs of the pavilions were indeed planned to be substituted with roofs vaulted in the direction transversal to the original ones; the volume of each pavilion would rather substantially be increased, to exploit it in the upper level with a new floor; and a glazed suspended corridor was planned to be built to connect the main buildings, running south-north and east-west (see fig. 1). And in a second version of the project, the part of the corridor running in front of the south facade of the pavilion-building was planned to be “embodied” in it.

2. THE ALTERNATIVE DESIGN PROPOSAL

ABITAlab advised the Province to keep the built volumes of the pavilions in the original configuration. And in the framework of this proposal, the author suggested to transform the “embodied” part of the corridor in a sunspace apt to increase the winter solar gains of the pavilion building and constitute a lively, regenerating greenhouse space for the students, usable for a long part of the year.

The part of the suspended corridor connecting the building in the southern part of the lot and the pavilions buildings was proposed to be kept in the project, while the part of it connecting the pavilion building with the building in the eastern part of the lot was proposed to be dropped.

In this context, the image and construction of the suspended corridor had probably to be changed from the original one. Its original was indeed a high-tech one, looking like one of those transition spaces used in airports.

But in the alternative proposal here described, the suspended corridor aimed to have an architectural impact compatible with that of the suggested sunspace. Therefore, it had to be built with the same materials of the sunspace: which was planned to be built in wood, with closures constituted by double, clear glazings panels, fixed wooden overhangs at the height of the eaves and with a textile, seasonally removable canopy working as a solar shading near the glazed roof.

In the thermal simulations, the sunspace had proved to be capable to reducing the winter heating requirements of the adjoining pavilions of about 10%, and the solar shading of the sunspace roof proved to be essential to avoid mid-season overheating.

The simulations regarding the glazed corridor had now to clarify whether its thermal behaviour was compatible with the thermal comfort of the inhabitants in summer.

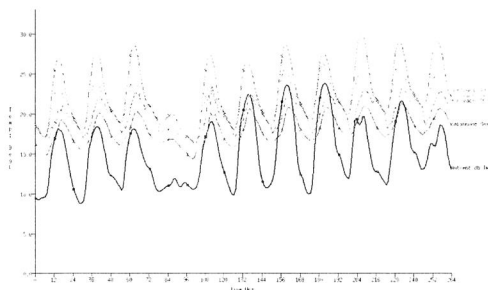


Figure 3: Temperatures in the sunspace, in the corridor below it and in the adjoining pavilions, April 15-25th.

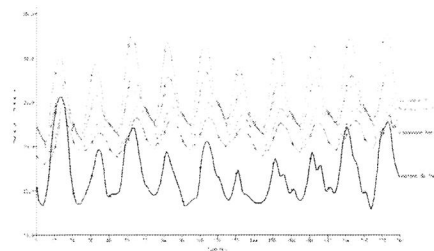


Figure 4: Temperatures in the sunspace, in the corridor below it and in the adjoining pavilions, June 1st-10th.

2.1 The principal design parameters

In the suggested configuration, the suspended glazed corridor was separated from the sunspace and from the southern building by glass doors. These were necessary to avoid excessive heat losses from the suspended corridor, which would be a net energy loser in winter, due to its exposure, orientation and construction type.

The suspended corridor was planned to be 2 m high, 2 m wide and 12,5 m long, and was closed with double glazing, wooden framed, and supported by two steel beams. Its floor was of the type built with

corrugated steel sheets and concrete, and its roof was built with sandwich insulated metal panels painted white.

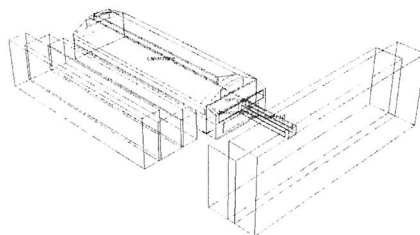


Figure 5: The volume of the glazed corridor as modelled in ESP-r. The scene is made by one of the pavilions, a corridor adjoining to its southern facade at ground level, the sunspace on top of it, the suspended corridor, and the shading obstructions, constituted by the nearest buildings.

The glazings were composed by double panes of clear glass, identical to those used in the sunspace, for aesthetic and construction coherence. (Anyway, the effect of mirror glasses was tested for reference.)

Two situations, constituted by two combinations of glazing quantities within frames, were tested in the simulations: one entirely glazed and transparent and the other half glazed (in the higher half of the corridor) and half opaque. The opaque parts were supposed to be formed by sandwich metal insulated panels.

3. SIMULATION RESULTS

The simulation results showed that both the substitution of the transparent closures with opaque, insulated panels (8 cm glass fibre) and the substitution of the outer clear glass panes with anti-sun ones are effective means of reduction of summer overheating in the given situation, with the former solution consistently better performing than the latter.

The operability of the corridor had also to be conceived to make possible natural ventilation to a degree sufficient to avoid summer overheating. With this purpose, three operable windows configurations were tested: (a) one, already described, with 50% of the upper transparent closures operable; (b) one with 50% of both the upper and lower transparent closures operable; (c) one with with 25% of both the upper and lower transparent closures operable. The discharge factor of the openings was supposed to be 0,7 and the opaque lower panels, when present, were supposed to be non-operable.

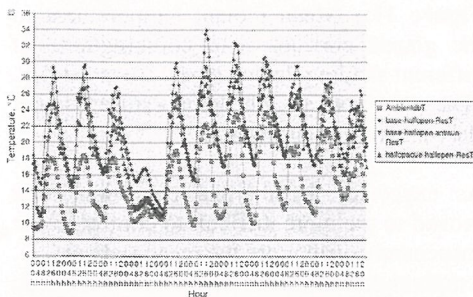


Figure 6: Resultant temperatures in the glazed corridor with just the upper glass panes (50% of them) opened for ventilation: in the base case, in the case of the lower panes opaque and in the case of antisun glass panes. April 15-25th.

The results showed that a rather intense ventilation was an important condition for the reduction of resultant temperatures in the suspended corridor, and that the solution (c) was more effective than the solution (a).

The results also showed that the adoption of efficient solar shading devices was absolutely crucial to keep the radiant and resultant temperatures down in the given situation.

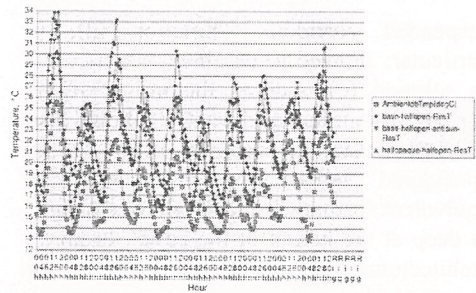


Figure 7: Resultant temperatures in the glazed corridor with just the upper glass panes (50% of them) opened for ventilation: in the base case, in the case of the lower panes opaque and in the case of antisun glass panes. June 1st-10th.

The solar shading of the vertical closures of the corridor was planned to be done with wooden fins, in five possible, alternative shading configurations: (a) horizontal externals fins, 25 cm deep, spaced 50 cm; (b) vertical external fins, 50 cm deep, 100 cm spaced; (c) a combination of horizontal and vertical fins; (d) a combination of horizontal fins plus a shading canopy on top of the roof; (e) a combination of horizontal and vertical fins plus a shading canopy on top of the roof.

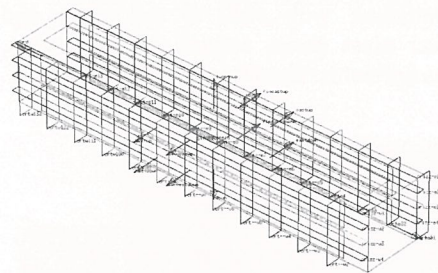


Figure 8: The combination of horizontal and vertical shading devices in the model.

The thermal results showed that the horizontal fins are more effective than the vertical ones in the described situation and that the top canopy is particularly important to lower the summer temperatures inside the

suspended corridor. Solution (d), in particular, showed to be almost as effective as solution (e), making the utility of the vertical fins almost irrelevant. It should also be noted that the shading effect of the considered horizontal fins would be equivalent to that of one single overhang 1 m deep at the height of the eave. From an architectural point of view, therefore, since the overhang of the planned sunspace was already composed by a single overhang 1 m deep at the height of the eave, the overhang solution may be the most appropriate in this case.

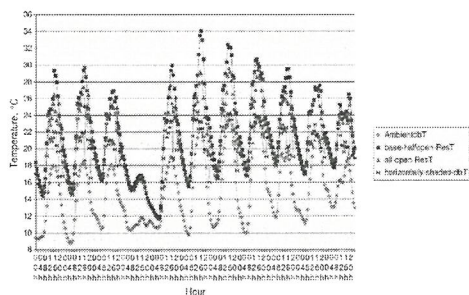


Figure 9: Resultant temperatures in the glazed corridor: with 50% of the upper glass panes opened for ventilation; with 50% of the upper and lower glass panes opened for ventilation; with 50% of the upper and lower glass panes opened for ventilation, plus horizontal shadings. April 15-25th.

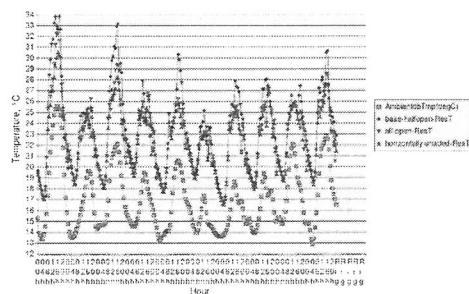


Figure 10: Resultant temperatures in the glazed corridor: with 50% of the upper glass panes opened for ventilation; with 50% of the upper and lower glass panes opened for

ventilation; with 50% of the upper and lower glass panes opened for ventilation, plus horizontal shadings. June 1st-10th.

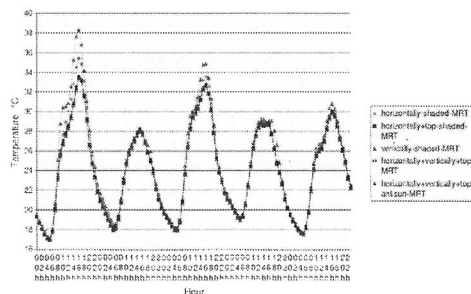


Figure 11: Mean radiant temperatures in the glazed corridor with combinations of different shading device types. June 1st-5th. (The ambient air db temperature is not shown here, for clarity.)

As expected, the thermal conditions that proved to me more difficult to control in the suspended corridor are the mean radiant temperatures. In the given situations, mean radiant temperatures always resulted much higher than air db temperatures.

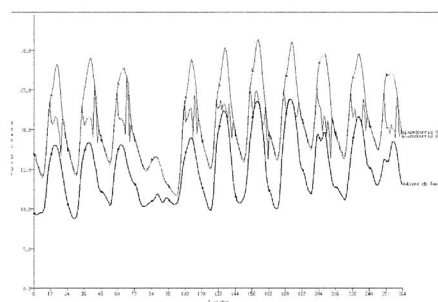


Figure 12: Air db temperature and mean radiant temperature in the glazed corridor, in the case of combined horizontal and vertical shading plus a shading canopy on top of the roof. April 15-25th.

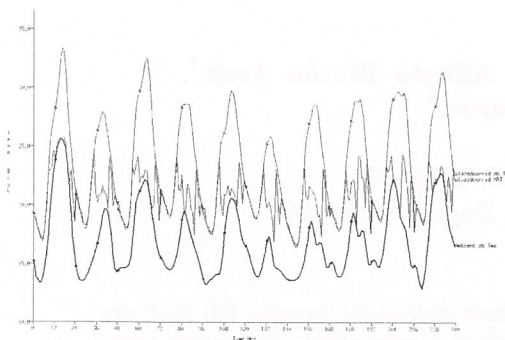


Figure 13: Air db temperature and mean radiant temperature in the glazed corridor, in the case of combined horizontal and vertical shading plus a shading a canopy on top of the roof. June 1-10th.

4. CONCLUSIONS

The thermal condition that proved to be the most difficult to control in the situation in question is the mean radiant temperatures inside the suspended glazed corridor in summer.

But even the mean radiant temperatures resulted to be sufficiently controllable by passive means without breaking the architectural constraints governing the project and without the use of expensive construction components.

REFERENCES

- ABITALab. 2007. *L'innovazione tecnologica per un'architettura sostenibile*. Liguori. Napoli.
- Bottero, B. 2004. Continuità e mutamento. *ANANKE*, Alinea. Firenze. n. 41 (March).
- Brunetti, G.L. 2007. *Architettura Pratica*, vol. II. Sistemi Editoriali. Napoli.
- Butala, V. Novak, P. 1999. Energy consumption and potential energy savings in old school buildings. *Energy and Buildings*. Elsevier. Vol. 29, n. 3 (January).

Corgnati, S.P., Filippi, M., Viazzo, S. 2007. Perception of the thermal environment in high school and university classrooms: Subjective preferences and thermal comfort. *Building and Environment*. Elsevier. Vol. 42, n. 2 (February).

Da Graça, V.A.C., Kowaltowski, D.C.C.K. 2007. An evaluation method for school building design at the preliminary phase with optimisation of aspects of environmental comfort for the school system of the State São Paulo in Brazil. *Building and Environment*. Elsevier. Vol. 42, n. 2 (February).

Drkal, F., Dunovka, T., Neuzil, M., Skrlant, V. 1997. Recent Czech building energy simulation case studies. *Proc. of Building Simulation '97 in Prague*. 5th International IBPSA Conference. International Building Performance Simulation Association.

Desideri, U.; Proietti, S. 2002. Analysis of energy consumption in the high schools of a province in central Italy. *Energy and Buildings*. Elsevier. Vol. 34, n. 10 (November).

Khedari, J., Boonsri, B., Hirunlabh, J. 2000. Ventilation impact of a solar chimney on indoor temperature fluctuation and air change in a school building. *Energy and Buildings*. Elsevier. Vol. 32, n. 1 (June).

Meda, A. 2005. *The environmentally sustainable renovation of school buildings: the Milan setting*. PhD thesis. Politecnico di Milano.

Virgilio, P., Gerosa, M. 2004. Non solo una scuola, ma anche un pezzo di storia e di città: l'Istituto Tecnico Industriale G. Feltrinelli. *ANANKE*. Alinea. Firenze. n. 41 (March).