IEA ECBCS Annex 36: Retrofitting in Educational Buildings –
Energy Concept Adviser for Technical Retrofit Measures

SUBTASK A

Overview of Retrofitting Measures

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Chapter 5

Solar control and cooling systems

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5.5. Solar control systems

5.5.1. Glazing with solar optical control

Today, a large variety of glazing or selective coatings is proposed by the manufacturers, some of them devoted to protect internal spaces from excessive light, reducing the brightness glare of the glazing and heat with respect of luminous performance. Three innovative trends are particularly attractive [3]:

- An active control of transmittance, eg. thanks to a varying dc voltage/current which may be controlled manually or automatically (electrochromic glazing) or thanks to a temperature dependent properties layer or deposit (thermotropic or thermochromic glazing) in order to switch from a transparent state to a lower transmitting state when indoor temperature is likely to exceed overheating limit.
- An angular selective coating, obtained thanks to anisotropic coatings. Previous work in this field has considered metallic or cermet films obliquely deposited by thermal or filtered cathodic arc evaporation.
- A light scattering or deviation surface eg. prismatic surfaces which displace the incident light sideways, arrays of microlens which act as controlled diffusers, etc

Among these innovative trends, switchable glazing technology can be used to control the amount of solar energy passing through windows. The use of switchable glazings should reduce the peak electricity demand and the cooling, lighting, and total electricity consumption associated with windows, compared with all other window technologies currently available. The maximum benefits can be obtained when the glazings are used in conjunction with dimmable electric lighting controls. These technologies are still in the field of research at this date and consequently they may be difficult to find, to implement and to justify economically.

Other less advanced technologies proposed in most manufacturers catalogues are:

- the coloured panes, that lower the daylight and solar transmittance
- the reflective coatings, that increase the reflected part of sun radiation
- the sealed blinds between panes, whose blades tilt is calculated depending on the orientation and the shading requirement of the window, in order to reflect incoming sun light
- the transparent insulation

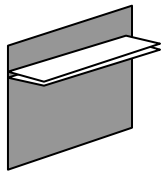
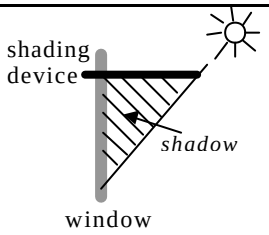
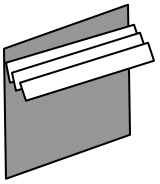
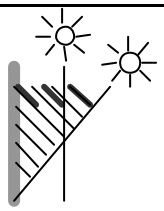
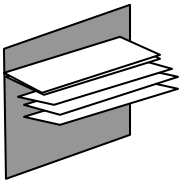
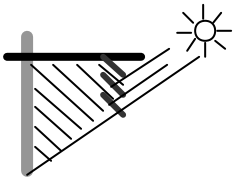
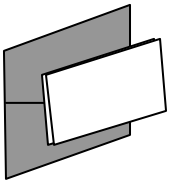
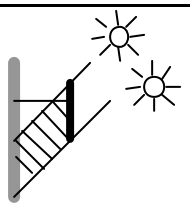
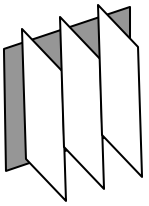
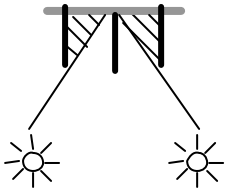
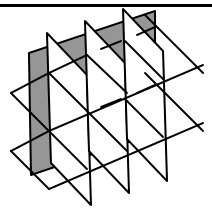
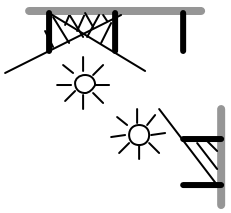
First two types of glazings should be used with caution: the associated reduction in daylighting is quite important for a solar gains reduction that varies a lot depending on the type of device. Furthermore, they are not adapted to variability of the solar gains depending on the season. Documentation must be found directly at the manufacturers' to use such king of glazing or coatings.

5.5.2. Fixed shading control systems

An important advantage of fixed shading devices is that they are passive or self operating. However they have an impact on the aesthetic of the facades and must be robust enough to resist snow loading. Large horizontal overhang can also reduce in a significant way the

availability of daylighting in deep plan school resulting in a need for permanent artificial lighting.
Design of fixed shading device depend on the seasonal angle of incidence of the direct solar radiation to permit some selective control to be achieved. Orientation, inclination and geometry of fixed overhangs and fins must be carefully analysed [4].

Table 5.2: Examples of fixed shading devices and their protection against direct sunlight [5]

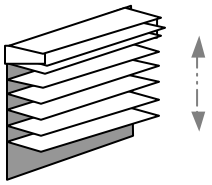
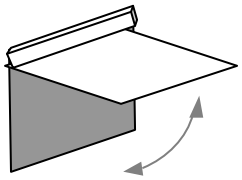
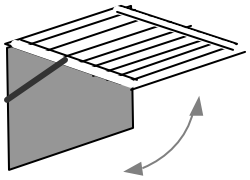
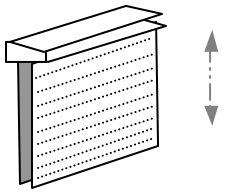
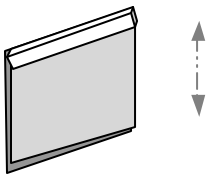
		Horizontal overhang is more efficient around southern orientation.
		Louvers parallel to the wall allow air to circulate. Slanted louvers offer better protection.
		Where protection is needed for low sun angles, louvers hung from horizontal overhang are more efficient.
		A solid or perforated screen parallel to the wall can block lower rays of the sun.
		Vertical fins serve well towards east and west and near these orientations. They may be oblique for more efficiency and detached from the wall to avoid heat conduction.
		"Eggcrates" or any combinations of horizontal and vertical fins are also possible to benefit of previous advantages.

Landscaping is also a natural means to protect facades against direct sunlight. Vegetation needs no specific device and is naturally adapted to the season climate (the choice of a vegetal specie with deciduous leaves is of main importance). It is however uncontrollable upon time and can reduce daylighting more than expected.

5.5.3. Movable shading control systems

They are more responsive than the fixed shading devices, but their movement mechanisms can present installation and maintenance problems. For external ones, weather implies some robustness constraints and sometimes some control implications (eg. awnings might be withdrawn if the wind is too strong).
Combination of a movable outdoor shading device and an indoor light blind offers best opportunities to control solar gains all year long.
A wide range of blinds is available at the manufacturers' documentation. Robustness is an important factor to take into account in addition to the daylighting and energy performance.

Table 5.3. Examples of outdoor movable shading devices

	Movable horizontal louvers can change their mask characteristics according to their position. Ventilation through the blades avoids overheating. Low security protection, bad night insulation (same idea with movable vertical louvers).
	Canvas canopies have the same characteristics as solid slanted overhangs but may be retractable and not completely opaque to light.
	Bahamas shutters offer a sun obstruction whatever is their position. With disjointed slats, they can be not completely opaque to light. Manual control only.
	Roller blinds offer good protection against night heat losses and sometimes allow infiltration through it in a specific position. However possibilities to control simultaneously solar gains and daylight are very limited.
	Screens can be used indoor and outdoor, but will be more efficient outdoor. Usually made of PVC covered material with a wide range of solar factors. Not completely opaque to light. Air infiltration somehow allowed to pass through it.

Indoor shading devices includes: screens, horizontal or vertical venetian blinds, and curtains. Usually they are not as efficient as outdoor shading devices unless they have a high reflective property.

Most of the shading devices presented in this paper could be motorized and automatically controlled. Combined with a control system for electric light, the energy consumption could significantly be reduced.
The shading devices can be classified on the basis of their adaptation to the seasonal requirements and to the climate conditions as fixed/movable, or on the basis of their position as internal / external / interpanes. External shading devices provide more effective shading because the solar energy is rejected before it can enter the building. However, they tend to be expensive due to the need for weather resistance and maintenance. Shading devices can also be classified on the basis of their construction features: horizontal axis slat/fin, vertical axis slat/fin, blind, awning, screen, curtain, shutter, coatings, tints, film, opaque pattern, integrated louvers.
Venetian blinds, vertical fins, screens and slatting shutters permit simultaneous shading and ventilation on the contrary of roller blinds and curtains that can be an obstacle if maintained in operation.
Finally, they can be classified on the basis of the material, as metallic/plastic/wooden/glazed.

The shading devices options can be classified following a more architectural point of view:

- Special solar optical properties of the glazing : reflective, selective, thermochromic, etc Architects often appreciate the potential of aesthetics offered by the large choice of glazing and films manufacturers. Spectrally-selective tints and spectrally-selective low-E coatings have entered the market more recently. Solar control retrofit film is widely available.
- Fixed external solar obstruction: overhang, vertical fin, eggcrate, etc They can also be integrated to the facade as part of its aesthetic by the architect.
- Movable external or internal shading devices: screen, blind, louver, awning, etc They are only considered as necessary appendices by most architects. Integrated louvres and silk-screened glazing are available from specialised window manufacturers.

References:

[1]. PASCOOL Final report: Model development subgroup – Volume 2: Solar control. Editor S.Sciuto. Project coordinators: M. Santamouris and A. Argiriou. 1993.
[2]. Daylight Performance of Buildings. Edited by Fontoynont M. Published by James & James. 1999.
[3]. Properties of glazings for daylighting applications-Final report EEC-JOULE Sept. 1995.
[4]. Passive Solar Schools – A design Guide. Building Bulletin 79. Architects and Building Division. UK Department of Education. Published by HMSO London. 1994.
[5]. Horizontal study on passive cooling for buildings. EEC Building 2000. Final report. 1989.