Short Report
Krems, December 2010

LIGHT CONDITIONS

DAYLIGHT IN RESIDENTIAL BUILDINGS AFTER THERMAL REFURBISHMENT

On behalf of the City of Vienna, Municipal Department 50, Vienna Housing Research

Daylight Conditions Daylight in residential buildings after thermal refurbishment

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Scientific studies of rehabilitation-related quantitative changes of diffuse and direct daylight entries, passive solar gains and artificial light use in housing space based on the building's condition before the thermal remediation.
Survey on the general quality perception of light situations in interior rooms.

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Aims of the research project

In the course of thermal rehabilitations for existing residential buildings the building insulation is primarily targeted to minimize thermal losses.
The consequences are reductions of daylight quantity and quality in interior rooms.
The rehabilitation-related changes of diffuse and direct light entries, the usable solar gains and daylight autonomies are calculated, based on existing dwelling examples and a selected test appartment.
Strategies for daylight-optimizing remedial measures are derived from the results

In addition, frequently used types of thermal renovation of buildings and the meaning of direct light incidence for the general qualitative perception of living situations are rated and inquired by two online surveys conducted at the Department of Building and Environment

Practices of the thermal building renovation

The insulation of the building envelope, including window replacement is the most commonly used type of thermal renovations, according to a survey of architects, interior architects, housing developers and property managers.
Other restoration methods provide only the insulation of the building envelope, or be subjected to a complete refurbishment, including renovation of the building services plant.
Mainly, as an insulating material, thermal insulation systems are made of EPS or XPS boards. Inorganic or bio-sustainable building materials are used rarely.

In the course of the renovation, exchanged windows are generally made of wood and aluminum with 2-fold heat-resistant glazings. The ratio of glass and frame components is taken into account by about half of the respondents, mostly for aesthetic reasons but also for lighting design. Changes of window sizes and interventions in the appearance of the facade are hardly applied.

Quantitative light entries

Diffuse light input

Measurements and calculations of light situations show low light displays in all surveyed homes, with an average daylight factor of 1.21% before the renovation. Through the rehabilitation intervention, the average values of quantitative light displays are reduced by 22%.

The following factors are mainly responsible for the reductions of light of entries:

+ Increased frame portions by an average of about 11%
+ Increased wall thickness by additional layers of insulation applied on the outer wall (insulation thickness between 10cm and 18cm)
+ Rectangular, shaft-like window soffits
+ Inside and outside surfaces with low light reflection properties

Daylight-optimizing methods

The following options for light-optimizing remedial measures are recommended:

+ Use of windows with reduced frame portion
  (In the studies, the proportions of the window frame were reduced by about 10%, the frame face-width decreased from 14cm to 10cm)
+ Modeling of window soffits, bevels in fall and flank areas
  (To avoid thermal bridges and to simplify implementation without replacement of existing window-overlayings the bevels were introduced about 7cm to window frames)
+ Use of internal and external surfaces with high reflection properties (for soffits and - if possible – for outside grounds, fronts and on opposite walls)
+ For balconies: use of transparent parapets to increase light entry in the floor area of behind located common rooms.

The frequently adopted persumption, direct light entries could be increased by moving windows to the front edge of the external facades, can not be confirmed by additional studies. Rather, light losses can be expected by this measure.

By considering these recommendations, the quantitative diffuse light displays in the homes can be brought to comparable levels as before the reorganization and provide orientation-dependent increases in direct light.

Enlargements or increased numbers of window openings were not used in this study.

Direct light entries

Direct light entry is quantified by that time, a horizontal measurement surface is exposed to direct light in the course of one year.

By the described light-optimizing remedial measures, direct light entry can be increased compared to the conditions before the renovation. Depending on the orientation, the annual increase of direct light achives the following values:

+ East or West orientation: increases up to 17%
+ South orientation: increases up to 8%

Renovations without daylight-optimizing measures (shaft-like soffits, high rates of window frames), contributions have orientation dependent reductions in direct light entry:

+ East or West orientation: light losses up to 6%
+ South orientation: light losses up to 9%

Daylight autonomy

Daylight autonomy indicates the percentage of a rated time, when natural light in dwellings is sufficent to maintain an assumed minimum illumination and therefore no artificial light has to be switched on.

An experimental flat has an average daylight factor of 1.27% and therefore has a daylight autonomy of 23% (assuming minimum illumination of 300 lux and a usage period from 7:00am to 10:00 p.m.).

In months with short day length and low external light levels (about in December or January) artificial light has to be switched on nearly continously; during the summer period, natural light is 50% sufficient of the rated time to obtain the required minimum illumination upright.

The rehabilitation-related loss of light entries causes reductions of the daylight autonomy up to 35%.

Optimized light remedial measures will help to limit the additional energy consumption for artificial lighting. An increase of light displays (daylight factor assumption 3%), would allow an increased daylight autonomy of 23% to 57%.

Heating demand and solar gains

The rehabilitation-related reduction of heat consumption (HWB) through the application of a 10cm thick insulation ammounts between 19% and 23% (according to method of rehabilitation and orientation) compared to the condition of the building before rehabilitation (with a heating demand of 87kWh/m²a for north orientation, 83kWh/m²a for eastern and western orientation and 74kWh/m²a for south orientation).

The passive solar gains Qs show values on the following scales:

+ North orientation Qs = 7% of the HWB
+ East-West orientation Qs = 12% of the HWB
+ South orientation Qs = 24% of the HWB

In northern orientation the usable passive solar gains are reduced in all examined remediation alternatives in comparison with the state before the renovation.
Provide an east or west orientation, light-optimizing remedial measures allow maintainings of solar gain values, in south orientation solar gains can be increased by up to 11% compared with those before rehabilitation.

Qualitative light perception

Based on the results of an online survey, the importance of daylight on the appearance of residential areas was investigated. It turns out, that direct light entry shown in pictures achive more acceptance than diffuse light conditions for comparable spaces in more than 80% of the examples.
Against this background and because of the importance of light on health and welfare, changes in light conditions in dwellings that may arise in the course of building renovations are to be observed in the sense of positive perception of space.