

ASSESSMENT OF THERMAL REHABILITATED BUILDINGS, FROM AN ENERGETIC POINT OF VIEW AND OF THE INDOOR ENVIRONMENT QUALITY IN THE SPIRIT OF THE TOTAL PERFORMANCE CONCEPT

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Summary

The adoption of some rehabilitation measures concerning the improvement of the energetic performance of buildings directly influences also the indoor environment quality, such as: air composition, condense hazard, lighting and acoustic comfort. However there are many cases when in some rehabilitation designs have in view exclusively the reduction of the energy consumption necessary for operation, especially for heating and hot water, giving less attention to the above mentioned aspects. Unwanted consequences of this kind of approach come up especially in spaces with a higher degree of occupancy and on long periods of time, like schools, kindergartens, hospitals, hostels, etc., the results being an inadequate air composition (insufficient ventilation degree), condense phenomenon, insufficient acoustic protection. As a result, it appears the necessity of a global approach of buildings thermal rehabilitation, but also of an instrument for the assessment able to integrate the effects of all the energy efficiency measures on the quality of a building or of a space with a certain destination.

The present paper proposes a methodology by means of which the building quality, that is the subject of a thermal rehabilitation process, may be appreciated on the base of Total Building Performance, that is estimated not only by the energy performance certificate, but also by the performances related to the indoor environment quality.

A case study for a building that is the subject of a thermal rehabilitation process emphasizes not only the utility of such an assessment instrument, but also the difficulties that must be solved for this kind of generalization.

Keywords: thermal rehabilitation, indoor air quality, total performance, users' requirements, building performance

1 Introduction

The thermal rehabilitation of the housing facilities from Romania represents a national priority asked not only by the requirements derived from the European Directive, but also by the low degree of thermal insulation of buildings associated to the improper quality of the indoor environment. As a result, it was started an ample rehabilitation action.

In a first stage, the attention was given to the public buildings, with a high occupancy degree, characterized by a certain occupancies' sensibility given by the inside environment, like schools, hospitals, hostels, etc.

The methodology for the energetic audit that has in view the thermal rehabilitation means:

- the valuation of building before the rehabilitation from the point of view of the energy performance and CO₂ emissions;
- the proposal of some solutions for thermal rehabilitation of the envelope and building services for spaces heating and hot water;
- the valuation of building after the thermal rehabilitation.

In the estimation process there are taken into account the optimum values for the parameters of the indoor environment (regarding the ventilation rate), but further checking of the measure in which these values are achieved are not yet foreseen. There are noticed some cases of buildings with a high energy performance, where are not ensured the optimum parameters concerning the indoor environment quality. This is happening especially for naturally ventilated buildings, where it is absolutely necessary to respect a certain operation program.

The paper proposes an estimation way of buildings quality in general and especially of those rehabilitated, taken into account besides the energetic performance, the indicators that characterize the indoor environment quality, integrated in the global performance concept.

A case study for a real education building emphasizes the importance and necessity of this kind of approach.

2 The total performance concept

The total performance concept gives a coherent scientific frame for the estimation of a building quality, in all respects. It appeared during the second half of the past century in USA and it was defined for the first time by Hartkopf and all. Now, the Centre for Total Building Performance (CTBP) is functioning in Singapore, as a research centre.

The development of the valuation system, based on this concept is the subject of an important number of studies and researches that, although are based on different types of approaches, have in view a single objective: the estimation of the level in which the users' requirements are met.

Essentially the valuation system based on the TBP means:

- the existence of some valuation instruments for the level of users' satisfaction (subjective or objective);
- the possibility for a comparing process as against a reference system resulted from regulations.

The use of a global valuation indicator for the building total performance may be used as an optimization method of the building quality or of the site activity, but the comparison of the requirements satisfaction level with the characteristic values is compulsory in this case too.

3 Study case

The performance analysis was realised on an education building which was the subject for rehabilitation works.

The building has a big glazed area related to the opaque one; as a consequence the rehabilitation works consist in the replacement of the old wooden carpentry with one of PVC frame and thermal insulated glass.

For the valuation of performances concerning the inside environment quality it was used the combined method, respectively the occupants' perception and the objective investigations.

3.1 Results concerning the users' perception

A number of 108 occupants answered to a questionnaire concerning the satisfaction level, placed on a scale from 1 to 5, for the following requirements: functionality, thermal comfort during the winter and summer seasons, acoustic comfort and indoor air quality (odours, CO₂ content). The results, presented in table 1, emphasize the following aspects:

- the majority of the occupants declared that they are contented with the indoor air quality, in all respects, at levels "well" and "very well";
- the dissatisfaction percentage concerning the thermal comfort during the winter season is 12.2%, which is corresponding to a value of $-0.7 < PMV < +0.7$. According to EN ISO 7730, this value places the building in the 3rd category for comfort;
- the highest percentage of the subjects that are pleased at levels "exceptional" and "very well" is recorded for "functionality" and "visual comfort" requirements;
- the highest percentage of dissatisfaction is registered for requirements concerning the summer time comfort (14,53%) and indoor air quality (14,03%).

Tab. 1 Satisfaction levels for the asked requirements

Requirement	Satisfaction level (%)				
	Unsatisfactory	Satisfactory	Well	Very well	Excellent
Functionality	0,00	5,08	23,72	37,28	33,89
Winter thermal comfort	12,06	17,24	31,03	25,96	13,79
Summer thermal comfort	14,53	22,3	31,57	15,78	15,78
Visual comfort	8,62	6,89	41,37	22,41	20,68
Acoustic comfort	12,03	13,28	29,07	28,92	15,78
Indoor air quality	14,03	19,29	42,1	14,03	10,52

3.2 Objective investigations

In the analysed space, it was placed a device that registers the temperature and moisture variation of the interior air and also the CO₂ concentration. The decreasing of the CO₂ content during the period of time when the space was unoccupied allowed us to estimate the natural ventilation rate by means of the tracer gas method. The mean values of parameters of the indoor environment quality resulted on the base of measurements made during the cold season from 2009-2010 are presented in table 2.

Tab. 2 Recorded values of the indoor air quality

Parameter	Recorded values			
	Mean	Maximum	Minimum	Standard values
Temperature [°C]	23.45	25.8	18.9	20...26
Dew point [°C]	14.40	17.2	11.4	8...12
Relative moisture [%]	37.25	45.44	34.35	30...60
CO2 concentration [ppm]	2373	3669	774	1300
Ventilation rate [h ⁻¹]	0.16	-	-	0.9

Analysing these values, it can be noticed the following:

- the mean values for the characteristic parameters of the indoor air (temperature, moisture, dew point), correspond to the standard values, specific for the education buildings;
- the minimum temperature values are registered during short periods of time and are made during night, when the space is not occupied; the maximum registered values do not exceed the maximum limit values allowable for the 3rd comfort class.

If these values are compared with the results of the subjective analysis, it can be noticed:

- there is a concordance between the users' perception (fig.1) and the results of the objective measurements concerning the thermal comfort (fig.2);

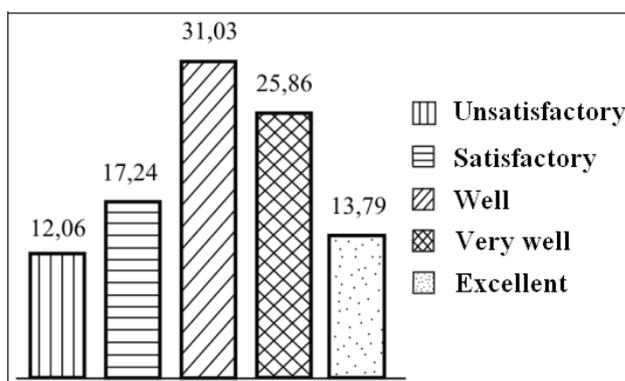


Fig. 1 Occupants' perception concerning the winter comfort

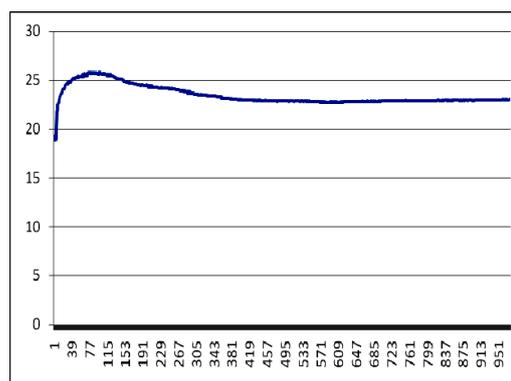


Fig. 2 Temperature variation during the occupancy time

- between the users' perception (fig.3) and the real quality of the inside air there is an important discordance (fig.4); the recordings show a considerable exceeding of the allowable level for the CO₂ content with 82% for the mean values and 282% for the maximum ones, registered during the occupancy duration;

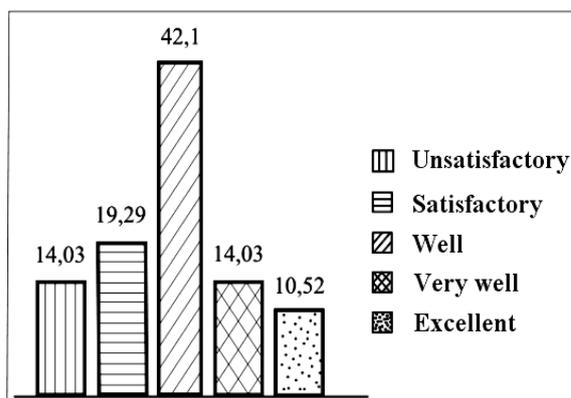


Fig. 3 Occupants' perception concerning the indoor environment quality

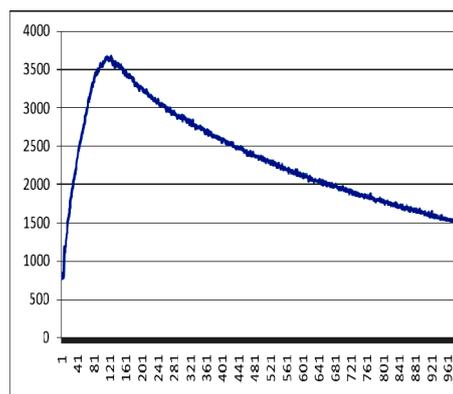


Fig. 4 Recorded CO₂ concentration

4 Conclusions

The measures that have in view the thermal rehabilitation of buildings must take into account the effects on the indoor environment quality, respectively the comfort and interior air parameters. With that end in view, a study in the respect of total performance concept is strongly imposed in the designing stage. The subjective and objective estimations concerning the satisfaction level of the above mentioned requirements for a building which was the subject for some thermal rehabilitation measures show a high satisfaction level for the comfort requirements, but an inadequate level for the air quality. This thing could be avoided if the windows framework would have devices for a continuous and moderate ventilation of the space. In these circumstances, it is absolutely necessary a ventilation program for the occupancy duration, correctly conceived and rigorously fulfilled.

The total performance concept gives a scientific instrument for the quality valuation of the built environment space, in all respects, from the strength to stability, from functionality to indoor environment quality.

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