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Air and well being—a way to more profitability

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ABSTRACT

Until recently, the air quality did not play a major role in the planning of buildings. Air quality was simply understood to be synonymous with pollution-free and safe air. This approach, however, omitted consideration of how to achieve the well-being of the occupants. As research has shown, elimination of pollutants is far from being sufficient and does not significantly reduce the dissatisfaction rate of building occupants. More recently, research has addressed the occupants' perception of indoor air with the goal of increasing their satisfaction rate. In this context, air quality, encompassing both olfactory and thermal comfort, plays an important role. In particular, the hedonic value of indoor air has to be taken into consideration when measuring the air quality. The economic consequences are still not fully apparent to investors and developers. Competition and market conditions in the commercial property market require that investors adopt new ways to attract tenants to buildings. One of the solutions are so-called performance-based buildings, which go well beyond traditional methods of addressing the well-being of building occupants, resulting in enhanced productivity, reduced absenteeism and reduced health risks. A case study will show that such high-performance buildings can create a sufficient return on investment for investors, even if the initial investment costs are higher than for conventional buildings. Addressing the well-being of the building users can realize a significant increase in a building's value.

INDEX TERMS

Indoor environment; Perceived air quality; Performance-based buildings; Profitability; Olfactory comfort

INTRODUCTION

Until recently, cost has been the primary consideration in the targeting of building efficiency. Nowadays, the requirements for buildings are changing since investors, developers and tenants are increasingly requesting performance-based buildings. In mergers and acquisitions, corporate real estate values are being tied more closely to the performance of the individual buildings. The differentiation between 'normal' and higher quality buildings is becoming more important. However, for these companies, a primary concern remains whether there is a sufficient return on investment for developing a performance-based building. The necessary air quality can only be justified, if the higher initial investment costs result in a market advantage in comparison with competing buildings. A performance-based building goes well beyond traditional methods of addressing the well-being of building occupants, resulting in enhanced productivity, reduced absenteeism and health risks. Physiological and neurophysiological research shows that air quality and the perception of air, encompassing both olfactory and thermal comfort, play an important role. One of the targets of the European Audit Project (Finke and Fitzner, 1996) was the subjective perception and evaluation of the air based on the factors of freshness, odour and acceptance of the air quality. The Building Owners and Managers Association (BOMA, 1988) conducted a survey that indicates that, in the US, the indoor environment is regarded as being a major problem in building design, maintenance and management. Laurence E. Sheehan (ALM'94) stated in his ALM theses that soft factor analysis needs to be taken into account in career assessment and workplace performance evaluation. However, due to the lack of uniform standards linking productivity to soft factors, especially with respect to IAQ, it was necessary to use the results of various research reports, as described below, to take the soft factors into account for a new building.

PRODUCTIVITY DEPENDS ON THE INDOOR ENVIRONMENT

Productivity and the indoor environment are two issues that are closely related and cannot be separated. Clements-Croome stated that research has revealed that the indoor environment has the most significant effect on productivity and that there is a strong relationship between employees' job dissatisfaction and an overall unsatisfactory indoor environment. (Clements-Croome and Li, 1997). The soft factors of the environment are responsible for determining the well being of the room occupants and the quality of their work.

SENSORY PERCEPTION OF THE INDOOR ENVIRONMENT

Community noise (also called environmental noise, residential noise or domestic noise) is defined as noise emitted from all sources except noise at the industrial workplace. Main sources of community noise include road, rail and air traffic; industries, construction and public work; and the neighbourhood. The main indoor noise sources are ventilation systems, office machines, home appliances and neighbours. It results, among other symptoms, in hearing impairment and may have a large temporary, as well permanent, impact on physiological functions. Furthermore, it has been shown that, mainly in workers and children, noise can adversely affect performance of cognitive tasks (WHO Guidelines, 2000).

Light and colours are major factors in the perception of the environment. They have great impact on our psychological reactions and physiological well-being. It is, therefore, hard to disregard the importance of proper illumination, brightness and colour in delivering quality work environments. However, people are also sensitive to form, proportion and harmony. A successful visual environment depends on the successful integration of the lighting system with the overall architecture of the space. Moreover, factors influencing all senses—heat, cold, glare, noise, odour—should be simultaneously dealt with to create a stimulating workplace (AIHA, 2000).

Our well-being and mood is controlled to an extent by what can be termed 'olfactory comfort'. This term refers to air, which contains a balanced blend of natural olfactory substances with a positive stimulating effect, of the kind that we find in nature, but which inevitably gets lost in ventilated buildings. It is known that odours have negative and positive psychological and physiological effects on humans. Even after adaptation, the effect remains and continues to have a considerable influence on performance. It cannot be avoided like sound and light. Air can only be perceived as 'natural' and fresh if olfactory substances with a sufficiently positive effect are present in the indoor air. (von Kempski, 1998).

It is also known that the thermal environment has a considerable effect on performance. Unlike sound and light, the thermal environment affects all workers, regardless of the nature of their activity (Wyon, 1986).

OCCUPATIONAL HEALTH AND SAFETY IN RELATION TO AIR QUALITY

The benefits from air pollution reduction include both health and non-health impacts (WHO, 2000). Fanger has shown that IAQ has a significant impact on the productivity of workers in a positive or negative way (Fanger, 1999). A survey of research studies puts the rate of increased productivity between 2 and 16% (Kroner *et al.*, 1997). A reasonable figure that can easily be achieved is the middle of this range.

THE IMPORTANCE OF INDIVIDUALS' CONTROL OF THE ENVIRONMENT

Individual control of the indoor environment has been shown to lead to a reduction in sick leave due to Sick Building Syndrome and to increases in self-estimates of productivity. This shows that it is very important for individuals with differing requirements of the indoor environment to be able to make their own compromises, instead of having to put up with compromises that have been found to be optimal for the group to which they belong (Wyon, 1993).

AN OFFICE AND RETAIL BUILDING

The five-floor office and retail building that was analysed is situated in the heart of Berlin with a good infrastructure. It is an historic building that was completely restored and modernized while preserving as much as possible of the old structure. The technical equipment meets the highest requirements of comfort and convenience. A great attention is paid to detail. Among other features, the architect designed a new Corporate Identity for the building including lamps and doorknobs. An elevator and garages have been integrated into the building. At first, the investor and the developer undertook a market study. By communicating with potential tenants, they established their needs and wishes. The investors targeted a return of investment of at least 5% (defined by the rent income as a proportion of the asset cost). However, even as the project commenced, it was still not certain that the extra investment in the high technology building would initially achieve a higher rent than 'normal' buildings in the market. After researching the market needs, the investors based their requirements for the office building on the six parameters mentioned above and the requirement to conserve energies. Since personnel costs are always considerably higher than the costs of office space, investing in the quality of the work environment is the most effective way of combating performance inefficiencies and loss of property value (Clements-Croome and Li, 1997). The higher rent was justified by the expectations of a high standard performance-based building.

The market situation in 1999 was difficult since Berlin had an 8% vacancy rate out of 1 239 000 m^2 (Jones Lang LaSalle, 2001; Eureal, 2002). A further difficulty was that big enterprises wanted bigger spaces than this office building could provide. At that time, rents within a surrounding 1 km radius were an average of €22/m^2 per month for a new fully equipped office building (Jones Lang LaSalle, 2001) and rents were declining. The investors wanted the building to achieve a rent of €26/m^2, justified by the high-performance specifications.

It would be beyond the scope of this paper to describe every issue fully. Therefore, only a brief description of the chosen parameters as implemented follows. The investor insisted on an excellent air quality in the building. Therefore, odorous emissions of the building were dealt with by choosing building materials with as neutral odours. A double filtration system was installed in order to eliminate outside pollution and to keep the costs for the second high quality filter low by avoiding frequent changes. The filter system is controlled by sensors and pressure. Furthermore, a relatively high ventilation rate of three to six air changes was chosen to dilute the bioeffluents and the emissions from office equipment. An add-on component to the partial air conditioning system for olfactory comfort was installed to guarantee a positive hedonic value for a 'natural' fresh perception of the indoor air resulting in an olfactory comfort (von Kempski, 1999).

The building was equipped with a partial air-conditioning and refrigeration system of 30 000 m^3/h including the add-on component for olfactory comfort. The system runs mostly on 100% outside air. Therefore, the outside air intake is much higher than dictated in DIN 1946 Part 2 (1994) that demands a minimum of 40 m^3/h per person or 4 $m^3/h/m^2$. The air-conditioning process controls temperature, velocity of motion and radiant heat energy levels, including consideration of the need for removal of airborne particles and contaminant gases. All the components had to fulfil the requirements of VDI 6022 Part 1 (1998). Cooling systems such as cooling ceilings guaranteeing a maximum temperature of 22–26°C in summer. Furthermore, individual control systems were implemented in each room. For energy conservation, the *h,x*-diagram (Mollier, psychrometric calculation based on air pressure 980 mbar) was incorporated in the control system, securing a pre-determined level of thermal comfort with optimum energy savings.

The lighting system is automatically controlled depending on the brightness or darkness of the outside and the use of the building. Noise was reduced through absorbent materials in walls, ceilings, floors and windows.

The following calculation was based on data provided by the contractor (Schwanewilms, 2002), a 50-year lifecycle for the shell and 15 years for services. The investor faced no additional ancillary costs for maintenance of the public space and façade due to the higher than normal specification of the building. However, all additional operating costs due to the higher specification of the building have been included (e.g. higher energy consumption) in the cost benefit calculations for the tenant. A full analysis of the total investment from the investor's perspective would need to take into account many parameters (such as the real estate market value of the building when eventually sold) and so is beyond the scope of this paper.

Office Building Berlin Mitte

Real Estate Investor's Perspective

Building data		
Letting area	3,000	m^2
Basic Costs - **Low technology building**		
Property and building	€ 14,730,000	
Technical Equipment (without HVAC & R)	€ 2,450,000	
Subtotal	**€ 17,180,000**	
Extra Costs - **High technology building**		
Property and building	€ 14,730,000	
HVAC & R	€ 400	per m^2
HVAC & R costs	€ 1,200,000	
Other technical equipment	€ 2,450,000	
Subtotal	**€ 18,380,000**	
Additional cost for high technology building	**€ 1,200,000**	
Rent Income for low technology building	€ 22	per m^2 per month
Rent Income for high technology building	€ 26	per m^2 per month
Additional rent income for high technology building	**€ 144,000**	
PAYBACK PERIOD - IN CURRENT TERMS	**9.5**	**years**
D.C.F.YIELD - IN CURRENT TERMS	**6.7%**	
D.C.F.YIELD - IN CONSTANT TERMS	**4.1%**	

Assuming tax deductability and depreciation over 15 years.
Inflation set at 2.5%, tax rate at 43%, 15 year life of equipment
D.C.F. Yield =discounted cash flow yield

Tenant's Perspective

Low technology building		
Building costs		
Rent	€ 22.00	per m^2 per month
Ancillary Costs (building)	€ 3.50	per m^2 per month
Subtotal Building costs	€ 918,000	p.a.
Employee Costs		
Employee productivity	100	Index
Sickness/Absenteeism	6%	days p.a.
Workforce (Full time equivalents)	120	FTE
Salaries	€ 3,100	per FTE per month
Other employees costs/benefits	38%	of salary
Office equipment & supplies	€ 200	per FTE per month
Subtotal Employee costs	€ 6,448,320	p.a.
Total building & employee costs	**€ 7,366,320**	

Tenant's Perspective		
High technology building		
Building costs		
Rent	€ 26.00	per m^2 per month
Ancillary Costs (building)	€ 4.75	per m^2 per month
Subtotal Building costs	€ 1,107,000	p.a.
Employee Costs		
Employee productivity	106	Index
Sickness/Absenteeism	4.2%	days p.a.
Workforce (Full time equivalents)	120	FTE
FTE reduction (productivity improvemer	(6.8)	FTE
FTE reduction (sickness reduced)	(2.0)	FTE
Salaries	€ 3,100	per FTE per month
Other employees costs/benefits	38%	of salary
Office equipment & supplies	€ 200	per FTE per month
Subtotal Employee costs	€ 5,973,800	p.a.
Total building & employee costs	**€ 7,080,800**	
Overall savings	**(€ 286,000)**	**p.a.**
equivalent to	**(3.9%)**	**of operating costs**

DISCUSSION

Similar results have been achieved in other buildings (Fisk *et al.*, 1997; Oseland *et al.*, 1999). The goal of a 5% yield and an increase in the building value was achieved for the investor. It clearly shows that the rent of a high technology building can be increased and the required investment is in both the investor's and the tenant's interest. In this research, the productivity improvements and sickness reduction were estimated by the tenants themselves. However, sensitivity analysis on the improvements in productivity and sickness rate shows that the project would still be justified even if the changes had been less than was experienced. Roughly, half of office relocations are due to a move from an old building to a higher technology building. The competitiveness of a high technology building diminishes the challenges of letting and finding a quality tenant. Furthermore, the building offers the tenant advantages and benefits since the building technology is based upon multidisciplinary studies using the findings of neuroscience, aromachology, physiology and psychology combined with existing standards and guidelines.

CONCLUSION

The above results show clearly that it is of significant value to the investor to have an outstanding building that distinguishes itself through the application of high technology and that it benefits the tenant by significantly reducing the rate of absenteeism and increasing productivity. This outcome makes it imperative for building engineers and architects to broaden their knowledge of the soft factor well being and the effect it has on occupants. Only by taking these factors into consideration will the demands of the market be met. The benefits that accrue to a performance-based building which addresses the well being of its occupants will generally outweigh higher investment and ancillary costs. It is up to the HVAC community to demonstrate the new approach to the facility managers and investors. The change in approach would not only benefit the health of the occupants but also the corporations and the economy in general.

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