(Re)developing for Environmental Performance:
Learning from the occupants' perspective

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ABSTRACT: This paper presents lessons for future buildings that can be learnt from a Post Occupancy Evaluation (POE) of the Stockland Head Office in Sydney. Designed to improve energy efficiency and workplace quality, the large scale refurbishment within an existing building is noteworthy in the current climate where approximately 98% of buildings are older stock that would require refurbishment at some point in the future. The study incorporates the Building Use Studies (BUS) methodology to evaluate occupant satisfaction with the work environment and identifies factors that influence user experience in the context of design process and interventions, ongoing building management and building environmental performance. The results from the BUS survey are remarkably good with the overall Summary Index in the top decile of the Australian building dataset and top quartile of the International dataset. Outcomes of the study highlight the importance of increased fresh air, daylight, glare control, access to views, noise management and low volatile organic compound (VOC) finishes towards improving indoor environmental quality for occupants. The positive results in terms of energy consumption and occupant feedback seen here reinforce the value of an integrated approach to building design, development and management that is responsive to user needs.
Keywords: post occupancy evaluation, comfort, energy, indoor environmental quality, occupants, integrated design, refurbishment

INTRODUCTION

In response to global concerns for mitigating CO2 emissions and negative environmental impacts from the built environment, we now have a number of rating tools to promote and assess building environmental performance. Many of these such as LEED [1] in the US, Green Star [2] in Australia and BREEAM [3] in the UK focus on the design potential of the building to deliver in terms of environmental performance. In the climate where there is a greater emphasis on performance reporting we have also seen the introduction of measures such EUROPROSPER [4] and NABERS [5] that are designed to measure actual in use environmental performance.

While much attention is paid to the assessment of buildings in terms of technological performance in terms of aspects such as water and energy efficiency, the experience of the building from the occupants' perspective is often overlooked. Buildings that fail to deliver in terms of indoor environmental quality have been noted to affect occupants' well being and productivity [6, 7, 8], and subsequent measures needed to alleviate their discomfort often result in great expense and failure to reach efficiency targets. Further, as noted by a number of researchers [9, 10], the prevalent practice of managing and assessing through a quantitative/technological focus without cognisance of the social/qualitative dimension of occupant needs leads to a "*commitment to an unsustainably standardised future*"[9].

This paper presents lessons for future buildings that can be learnt from a Post Occupancy Evaluation (POE) of the Stockland Head Office (or Stockhome) in Sydney that was undertaken by the author. The study elicits and evaluates occupant satisfaction with the working environment with a view to identifying factors that influenced their experience, in the context of design process and interventions, ongoing building management and building environmental performance.

The study of the Stockland Head Office is noteworthy for a number of reasons. It has been cited for a number of awards including the 2008 Sustainability Award of the NSW Australian Institute of Architecture and as the first project in Australia to achieve a 6 Star Green Star – Office Interiors v1.1 Certified Rating. Against this background, this paper provides crucial information regarding actual performance "in-use" for the building Significantly, the project comprises a redevelopment of an existing building from the 1980's, thereby providing insights of what can be achieved within the constraints of the existing shell of an inner CBD building. Such a development contrasts the approach of developing iconic green buildings with external expression of their

environmental control systems that is seen in a number of recent projects worldwide. The regeneration of existing building stock has a crucial role to play in the current climate where approximately 98% of building stock is existing older stock in most developed countries and would need to be refurbished or replaced at some point in the future.

METHODOLOGY

The study draws on a multi methodological approach of site visits, interviews with key stakeholders (including the client Stockland Pty Ltd, architects Bligh Voller Nield Architecture, environmental consultants Arup, tenant and building managers at the Stockland Head Office) at the start and end of the project, and an independent review of the project information made available. In addition, occupants were surveyed using the Building Use Studies (BUS) methodology [11] that has been used to evaluate over 350 buildings worldwide and over 75 buildings in Australia.

The Building Use Studies (BUS) method was adapted for the PROBE (Post-occupancy Review of Buildings and their Environment) project [12] in the United Kingdom. The system was selected for its capacity to assess individual buildings against norms and best practice and to elicit feedback on a range of 63 variables encompassing overall comfort, temperature, lighting, air movement and quality, noise as well as design, image, productivity, health and workplace needs. Contrary to the use of indicators such as "sick days off" or the efficiency of "key board strokes", the BUS survey elicits occupants' rating of their perceived productivity and health. Such an approach overcomes issues of wide variance in the context specific dependencies of today's diverse workforce and has been argued to provide an appropriate indicator which is consistent for all respondents in a building and enables comparison across buildings. [13].

The survey was first administered while the employees were still at the company's previous accommodation at Liverpool Street. The same survey was completed a second time by the employees 15 months after relocating to the new Stockland Head Office. This approach enabled the building to be compared against the Australian and International benchmarks, as well as their previous accommodation.

DESIGN PROCESS AND OUTCOME

The new workplace for Stockland was envisaged with the aim of setting a benchmark for sustainable office design and ambitions for engaging workplace for its employees while developing a showcase for its office redevelopment capability. The development of the project is characterised by strong client commitment for environmental design. Clear goals for environmental performance were articulated through design targets for the highest levels of rating currently achievable through the Green Star (as designed and built) and NABERS (monitored performance) protocols.

A critical aspect of the project was the multi disciplinary integrated approach that was adopted from the inception of the project which has been noted [10, 14] as being crucial for the success of implementing strategies for sustainability. This included selection of the design team of architects and engineering consultants based on their environmental credentials and experience in delivering contemporary work environments and a strong focus on employee consultation towards developing its functional design brief.

The building selected for the relocation of the Stockland Head Office was a 31 storeyed office tower that was part of the company's property portfolio in the city of Sydney. Selected for it location within the CBD, it posed a number of challenges for the design team. Representative of many buildings from the 1980's, it was a centrally air-conditioned building with an octagonal deep floor plate, a large central core, no other vertical connection between floors and had a poor environmental performance. The nature and extent of modifications possible were constrained by existing retail and office tenants in other parts of the building during the period for refurbishment.

Figure 1:External view - Stockland Head Office, Sydney (Source: Bligh Voller Nield Architecture)

The development at Stockland focuses on a strategic incision for an open stair and void on the eastern side of the floor plate. The void and stair as shown in Figures 2, 3 and 4 is articulated to create a range of spaces of varying spatial quality that negotiates circulation between the eight floors. This move simultaneously draws daylight into the deep floor plate and provides

connections to a number of formal and informal breakout spaces and meeting rooms. Horizontal fire curtain technology was installed for the first time in Australia to enable the resulting space to comply with fire regulations. 80% of waste by weight generated through tenancy fitout works was recycled or reused.

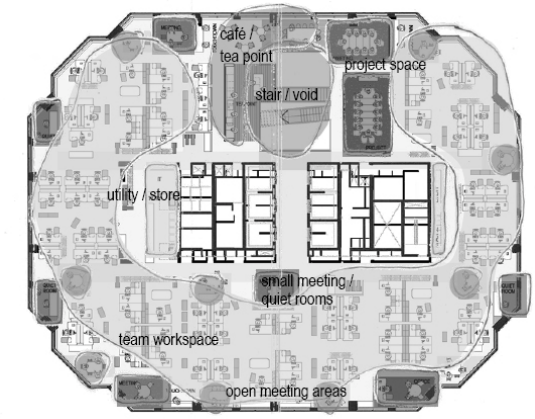

Figure 2: Zoning in a typical floor - Stockland Head Office, Sydney (Source: Bligh Voller Nield Architecture)

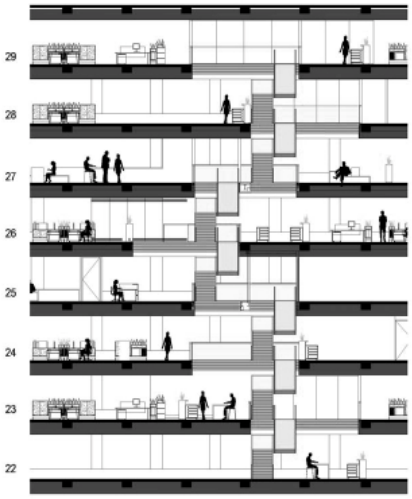

Figure 3: Section through the void across the eight floors (Source: Bligh Voller Nield Architecture)

The move from a predominantly cellular office arrangement in their previous accommodation to one that was totally open plan so as to foster collaboration was carefully supported during the design and relocation process by a number of change management and employee consultation initiatives. The redevelopment also incorporates a number of initiatives to maximise the quality of the work environment and indoor environmental quality. These are discussed in relation to the outcomes for occupants in the sections below.

Figure 4: A view of the formal and informal breakout spaces adjoining the void at Stockland Head Office.

USERS' PERCEPTION OF THE BUILDING

The data from the Building Use Studies survey provides a number of useful insights about the building overall and all of the 63 individual variables.

The mean score for each variable from the survey is assessed against upper and lower limits compared with the mean value from the BUS dataset benchmark together with its upper and lower 95% confidence intervals, and the scale midpoint. This creates the criteria for the variables as follows:

◆ Diamonds represent mean values significantly better or higher than both benchmark and scale midpoint (a good score).

● Circles represent mean values that are not significantly different from benchmark and scale midpoint (a typical score).

■ Squares represent mean values significantly worse or lower than benchmark and scale midpoint (a poor score).

Benchmarks are represented by the small rectangle on the top scale of each variable. All variables except Perceived Productivity use a 1 to 7 scale. Perceived Productivity has a minus 20% to plus 20 % scale.

As seen in Figure 5, Stockland Head Office has 11 of the 12 main study variables higher or better than the Australian benchmark (diamonds). While the variable for Noise overall is no different from the benchmark (circle), none of the summary variables are worse than the benchmark.

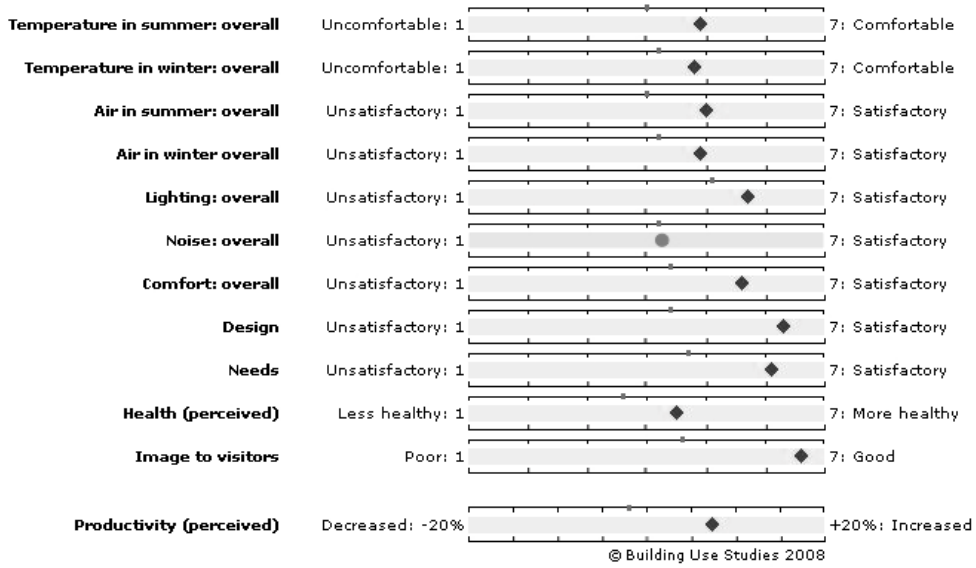

Figure 5:Summary Chart for Stockland Head Office – Australian benchmark

An overall Summary Index provides an alternate way of benchmarking building performance in relation to other buildings in the dataset. It is derived as the average of the Comfort Index and the Satisfaction Index, where the Comfort Index is the average of the z-scores of the variables for overall comfort, lighting, noise, temperature, and air quality, while the Satisfaction Index is the average of the z-scores for design, needs, health, and productivity.

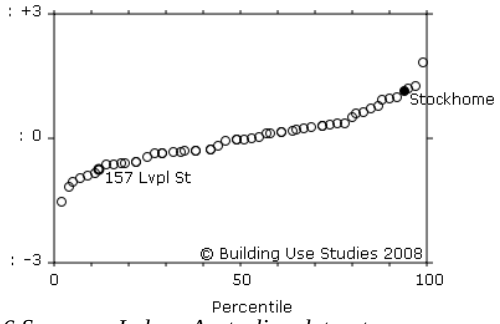

Figure 6 Summary Index - Australian dataset

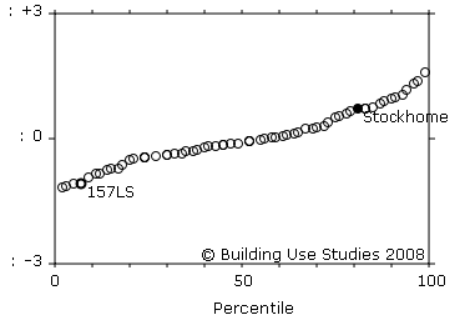

Figure 7 Summary Index - International dataset

Figures 6 and 7 indicate the Summary Index for buildings in the Australian and International datasets respectively. As seen here, Stockland Head Office (denoted as "Stockhome") with a Summary Index of 1.32, lies in the top decile of the Australian dataset, and in top quartile of the International Green dataset, and rates significantly better than the previous tenancy at Liverpool Street (denoted as "157 Lvpl St" and "157LS") where the index was -0.64.

The post occupancy rating for the Stockland Head Office at the top end is significant given its size and central location within the city. As noted elsewhere [8] most buildings at the top end of the Australian dataset tend to be smaller buildings with a limited number of occupants where carefully integrated designs are easier to realise. That study also noted that all buildings at the top end of the scale incorporate a number of well liked features which reinforce one another in a virtuous circle. This latter aspect was consistent for Stockhome. With positive indices for Comfort (0.98) and Satisfaction (1.67) the tenancy was placed in the 90th percentile for Comfort and 92nd percentile for Satisfaction in the Australian dataset, and 75th for Comfort and 90th for Satisfaction in the International benchmark.

KEY THEMES AND LESSONS LEARNT FROM THE POST OCCUPANCY EVALUATION

In the subsequent sections, the outcomes for the occupants are discussed in relation to relevant aspects of design process, features and interventions, ongoing building management and building environmental performance. A number of interesting insights are apparent.

Temperature Thermal comfort is affected by ambient temperature, humidity, air speed as well as level of activity and clothing. The facilities and commissioning team have been trialling the use of a floating set point. Based on an adaptive model of comfort, the use of the floating set point in sympathy with outdoor conditions has the capacity to reduce energy for space conditioning while still maintaining comfort [15] According to in-house personnel, the set point generally varies from 21-23ºC and its setting is determined by a function of outdoor temperature averaged over the preceding six days. It has a deadband of + 1.5 degree C. If significant complaints due to variability are made on a floor plate, then variable air volume (VAV) boxes are over-ridden to 22.5ºC set point. At the time of the survey, about 90% of the VAV boxes operated on the floating set points on most floors.

The results from the survey provide some useful insights. While users rated Temperature overall in summer and winter above the Australian benchmarks, the open ended comments indicate more concerns of feeling "too cold" both in winter and in summer. In addition, when asked about behavioural changes in response to environmental conditions, many employees reported using a coat or jumper to cope with feeling cold across the year. The occupant comments are corroborated by the mean rating for Temperature (too hot/too cold) which lies on the colder side of neutral for both summer and winter. While the potential range of 19.5-24.5ºC does not push the boundaries of temperature limits to those seen in passive buildings, such an approach of a variable set point in sympathy with outdoor conditions could be seen as a first step to breaking the cycle of constant thermal environment in air-conditioned offices. A detailed analysis of space temperatures has not yet been possible due to difficulties in accessing temperature history from the Building Management System.

Ventilation and Air Quality The tenancy integrates a high efficiency variable air volume air conditioning system which aims to improve control of air distribution and increase the rate at which fresh air is drawn into the space. By providing twice the minimum fresh air requirement to the office workstations, the overall fresh air ventilation rates including the void within the building is one and a half times the minimum requirements of the Australian Standard (AS) 1668 Part 2 [16]. In addition, all paints, carpets, and composite wood products in the tenancy comply with the benchmarks for low Volatile Organic Compound (VOC) content and low formaldehyde emission under the Green Star protocol.

Users rated the Air overall well above both Australian and International benchmarks with mean scores at 4.97 in summer and 4.87 in winter on an A type scale of 1-7 where 1=unsatisfactory and 7=satisfactory. In addition, the ratings for air freshness and odourless air across both summer and winter placed the building in the top 10 percent of Australian benchmark buildings, and top 15 percent of International benchmark for these variables. Clearly these survey results indicate that the efforts to increase fresh air supply and ensure low VOC material selection have improved occupant satisfaction in terms of overall quality, freshness and odour.

Lighting and Access to Views A number of strategies were introduced to enhance and manage daylight. Besides the strategic incision of the floor plates to create a light well/void that draws light to the interior of the floor plate described above, the façade glazing to the void was retrofitted with high performance glazing (T_{vis} 0.6, SHGC 0.38 and U value 1.8 $W/m^2.K$) to allow higher levels of daylight while continuing to manage heat gain. The open plan office layout also ensures 60% of workstations have a direct line of sight to an external outlook, and 30% of the workstations were located in an area where the daylight factor was greater than 2.5%. In addition, the fluorescent luminaires across the workstations at Stockhome are fitted with high frequency ballasts. These serve to avoid the low level flicker known to cause eye strain and fatigue [16].

The efficacy of the above efforts is borne out by the survey results. The open ended comments and ratings better than benchmark for Lighting overall (mean score = 5.66 on an A type scale where 1=unsatisfactory and 7=satisfactory) indicate that occupants were very happy with the open feel of the offices with good access to natural light and views. The occupant feedback also represented a marked improvement from their assessment of inadequate natural light in their previous accommodation.

While it was not possible to add external shading devices to the existing façade, glare to the workstations was designed to be controlled via translucent blinds provided to all windows. During the year, the facilities and commissioning team have been proactive in understanding user needs and constraints. In order to mitigate glare from the morning sun, the translucent blinds on the east façade are drawn shut by cleaners the night before. In addition, the western windows have been retrofitted with block out blinds. On visiting the building it was possible to observe how users progressively drew the blinds down on the west. However many of the blinds remained closed on the eastern facades even in the afternoons when the sunlight had ceased to fall on those windows. Although further investigation would be required to ascertain location

specific causes, this reinforces the general indifference on the part of occupants to change the status-quo unless problems arise [18]. In the survey, employees commented positively about their ability to operate the installed blinds in order to manage glare.

Noise, Privacy and Office Layout The development of green offices over the past decade has coincided with a large cultural shift: moving from individual offices to open plan. Whereas other building studies have encountered substantial dissatisfaction when users move from a closed office layout to one that is more open plan in nature [7, 14] it does appear that the provision of alternate break-out spaces for meetings and quiet rooms has alleviated concerns for privacy and interruptions.

The BUS ratings for Noise overall were no different to the Australian and International benchmarks. Employees commented positively to the manner in which the open plan facilitated both formal and informal collaboration. However these views are tempered by concerns of noise from neighbouring colleagues, unwanted interruptions particularly affecting workstations close to the photocopiers kitchen areas and tea-points. During operation, there have been some efforts to manage these issues through glass screens in some of the open stair areas and introduction of acoustic treads to central stairs. Nevertheless, this experience reinforces the need for continued attention to cultural change processes and protocols for office etiquette regarding phones and conversations around desks in offices.

Perceived Health and Productivity The Stockland Head Office was rated in the 90th percentile for perceived Health amongst buildings in the Australian benchmark dataset with a mean score of 4.51on a A type scale where 1= Less Healthy and 7=More Healthy. A number of occupants commented that the fresh air, natural light and high quality of the work environment contributed to their well being, although there were also some perceptions of illness spreading faster through open plan offices. Occupants were also appreciative of plants in the office areas.

In addition, when asked to assess whether their productivity increased or decreased as a result of the environmental conditions of the building, the respondents returned a perceived Productivity rating of +7.21% on a 9-point scale of "-40% or less" to "+ 40% or more". This is a significant improvement from the mean rating of -2.39% rating for their previous accommodation. The positive responses to both health and productivity were corroborated by the majority of the open ended comments.

Energy Given the redevelopment nature of the project in an existing shell with existing tenants in other floors, there were severe limitations for any major modifications to the air-conditioning plant. Key changes to the "base" building included installation of Variable Speed Drives for ventilation and high efficiency VAV boxes coupled with the floating set point trial, and the retrofitting of high performance glazing to the tenancy floors.

Energy efficient triphosphor T5 lighting is installed within the tenancy. The system integrates readily accessible switches and motion detectors to allow for turning off lights in unoccupied zones. Importantly there was a commitment to minimising energy use through floor by floor submetering, monitoring and energy audits. A significant aspect of energy management was the proactive measures to involve the occupants. These included monthly competitions between the eight office floors to switch computers off, and campaigns and signage to encourage users to power down the photocopiers and turn printers off.

The results of the monitored performance reflect the efforts that have been put in. The Stockland Head Office achieved the highest level or 5 Star NABERS Energy Office Tenancy rating with normalised carbon dioxide emissions of 61 kg $CO_2/m^2/yr$ (356 $MJ/m^2/yr$) for the period 1 October 2007 to 30 September 2008. This includes 187 MWh of accredited "green power" (purchased during the period) generated from renewable resources for the tenancy's electricity requirements. Purchased "green power" constitutes 18.75% of the tenancy's total electricity consumption. The tenancy rating includes energy consumed for light and power, including air-conditioning of meeting rooms and tenant computer server rooms. With 2.5 Stars representing average performance under NABERS, the consumption at Stockhome is a 50% reduction on the industry average. A Base Building rating which covers central services and common areas of a building was also undertaken. The building was rated at 4 Stars in 2007 (95 kg $CO_2/m^2/yr$ with no green power included) which represents a 35% reduction on industry average.

The building is currently bringing a tri-generation system online whereby 70% of the tenancy power needs and 30% of the total base building power consumption will be supplied through electricity generated from an onsite gas turbine as opposed to electricity generated from coal. Additionally, the waste heat will be used for cooling via an absorption chiller and to generate hot water for space heating. This is expected to reduce carbon dioxide emissions by a further 20%.

CONCLUSION

The Stockland Head Office project studied here achieved positive feedback from its occupants while successfully meeting its design targets for a 6 Star Green Star Rating and a 5 Star NABERS Energy Rating. In the current climate of an economic downturn, where the imperatives for reducing our carbon emissions remain ever urgent, much more attention is needed in the area of sustainable refurbishment of the existing building stock. The positive outcomes of this project demonstrate that it is possible to remodel an existing shell and secure a workplace that enhances workplace quality.

The study highlights the importance of increased fresh air, daylight, glare control, access to views, noise management, low VOC finishes towards improving user experience of indoor environmental quality. In order to incorporate these aspects, it is necessary that all of these attributes must be "designed-in" at the inception of the design process. This in turn reinforces the importance of an integrated approach to building design and development that includes the owner, developer, design team and user groups. [7, 14]. Of particular note is the requirement for innovative approaches such as the lightwell/internal street with adjoining breakout spaces seen here that are capable of addressing multiple objectives for functionality, aesthetics and environmental benefit.

Together with the positive perceptions of health and productivity, the positive survey results for overall comfort, lighting, temperature and air corroborate other studies that emphasise the importance of indoor environmental quality attributes in maintaining worker productivity [6, 7, 8]. Although the experience at Stockland remains inconclusive as to the potential for floating setpoints based on the adaptive model, the subject is worthy to pursue.

Additionally, the study highlights the importance of user engagement in the ongoing management of the building. This is crucial not only for facilities personnel to understand user needs but also to enable users increase their understanding of the design intent of building and develop a sense of "ownership and pride in their workplace", and to ensure that the building reaches its energy targets through their participation.

ACKNOWLEDGEMENTS. This paper draws on findings from an independent post occupancy evaluation that was undertaken by the author for Stockland Pty Ltd using the Building Use Studies questionnaire under license. The author wishes to acknowledge the range of stakeholders for Stockland Head Office project whose support and participation made the study possible. The author thanks staff at Stockland, in particular G. Johnson, D. Rooney, C. Hughes, J. Metske, and J. Zannino for their generous assistance with the study over its two year course. Thanks are also due to A. Galvin of Bligh Voller Nield Architecture, and H. Schepers of Arup for providing insights into the building's design and functionality.

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