On the integration of Green Star rating tools with the acoustic design of offices and educational institutions

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ABSTRACT

The Green Star rating tool promotes initiatives that limit the environmental footprints of new buildings and tenancies, in part achieved with improve efficiencies and productivities in the workplaces. However, we find that current application of the Green Star rating tools is alone insufficient to achieve internal acoustic qualities appropriate to improving productivity. In this paper, we discuss various issues encountered in the practical application of the rating tool and the resultant interior acoustic qualities, good and bad, with regard to the level of building productivity or user comfort. The issues discussed include the effect of using design criteria for compliance, externalities as result of a limited scope and appropriate weighting. Discussion in this paper surrounds Green Star requirements for offices and educational facilities, however many of the arguments apply to other Green Star rating tools.

INTRODUCTION

The series of Green Building Council of Australia (GBCA) Green Star rating tools have been effective in encouraging design initiatives that lead to a reduced environmental footprint. As noted by Green Star, a key aspect in achieving a reduced environmental impact is efficient and productive workplaces. With efficiency and productivity outcomes chained to the staff themselves, the internal working environment is critical to this aim and where internal acoustic qualities would be a key consideration for Green Star.

Perhaps outside observers find that the consideration for acoustics within each of the rating tools are good enough to mitigate against user complaint: we note that at time of writing, the acoustic performance of Green Star certified buildings has not been raised with the GBCA as a key problem for occupants before our initial correspondence. Regardless, the literature clearly identifies scenarios where poor acoustics is a key issue for unhappy office staff.

Jensen, Arens & Zagreus (2005) undertook a wide-ranging post-occupancy-evaluation survey of 142 US commercial buildings with 23,450 participants. The primary findings from this study were that

- dissatisfaction with internal acoustics was the greatest of all the core satisfaction categories; and
- for those in open office layouts, there was marked overall dissatisfaction with speech privacy, with over 50% of the occupants nominating that poor acoustics interfered with their daily work.

Navai & Veitch (2003) have noted in a wide-ranging review that '… there is no question that noise is amongst the most consistently reported problem in open plan offices'. Similar observations are noted in Building Bulletin 93 (DfES 2003) for education facilities where no incentives are given for taking into account internal acoustics.

Our experience of projects post occupancy supports these findings. We find that the current and relatively simple credits relating to internal acoustics are not always effective in yielding highly productivity and user satisfaction.

In this paper, it is argued that the credits as they stand are ambiguous, are not suitably weighted, and as a consequence of the limited scope, do not always promote good internal acoustics. In some aspects we find the control measures in the credits may actually result in more adverse internal acoustic qualities.

The rating and reward of internal acoustic qualities in modern productive spaces have progressed slowly and remain an area for potential improvement. It is our understanding that for Green Star the GBCA found difficulty in obtaining input from professional acoustic consultants initially; however, they have welcomed the many offers of assistance with the tool development process in recent years.

Aimed at acoustic consultants with an involvement in Green Star projects, this paper presents our review of the Green Star rating tools, focusing on offices and education facilities. By reviewing the goals of a 'green' initiative rating tool and comparing to similar international 'green' rating systems, we outline our suggestions for improving the Green Star rating tools to attract better outcomes aligned with the intention of the scheme.

With our recommendations it should be noted that there is built-in flexibility in the Green Star rating framework in the credit interpretation requests and the innovation credits. Rather than meeting the credit criteria requirements, credit interpretations can be claimed in Green Star rating tools where it can be demonstrated that the aims of the credit are still achieved. Furthermore innovation credits can be claimed where, through demonstrating sustainable design, extra points can be achieved beyond the existing credits. In fact the later releases of each rating tool are to be influenced by successful Innovation credit entries.

BACKGROUND

Rating objectives

As a benchmark for assessing the effectiveness and fairness of credits, with reference to Manmit (2007), we suggest measures should aspire to;

- achieve clear links between the aim of the credit and unambiguous design targets,
- demonstrate design targets result in a comparable quality as objectively measurable between projects, and

- mitigate against artificial externalities or barriers to innovation.

There are many inter-dependent factors and a whole-of-system approach needs to be taken to address all the relevant aspects. Priority is given to noise levels, both ambient and occupant generated, and the balance of acoustic privacy and intelligibility (ease of communication).

Green Star

A bit of history: the Green Star system was built on existing 'green' rating tools, including the North American LEED and UK BREEAM. The initiative works by promoting aspirational, best practice 'green' designs with exclusivity in a environmentally conscious market being a real commercial driver.

Accreditation can be either by Design (at the tender stage) or As Built (after practical completion), depending on the rating sought and tool. Office buildings are currently covered by the Office Design and As Build v3 (GBCA 2009a) tools, tenancy fitouts are covered by the Office Interiors v1.1 (GBCA 2009b) rating tool, whilst education facilities are covered in the Education v1 (GBCA 2009c) rating tool.

Within Green Star, internal acoustics is limited to a single 'internal noise level' credit, within the Indoor Environment Quality category (IEQ). The IEQ category rates measures that inform on the satisfaction and comfort of occupants. In terms of acoustics, the internal noise level credit criteria are relatively simple target values or ranges, having been primarily drawn from AS/NZS 2107. A summary of what aspects the tools apply is listed in Table 1.

Table 1. Green Star coverage

	Office		
	Building	**Interior**	**Education**
Building service noise	√		
Ambient noise level	√	√	√
Reverberation time		√	√
Partition performance			√
Design rating	√		√
As-built rating	√	√	√
Compliance coverage	95%	All	All

The Green Star scheme is based on two-tiers of weighting of credits. The first tier applies as each category is weighted as a percentage contribution to the overall Green Star score. The weighting is dependent on the rating tool and building location, for example the Office Interiors v1.1 weights the IEQ category as 25% and the energy category at 21%. The score for a category is the percentage of points achieved out of the points available. The second tier of weighting therefore applies through the number of points available for a credit out of the total number of points available for the category. As an example for the Office Interiors v1.1 tool there is one point available for the internal noise level credit, which assuming all credits for the IEQ category are applicable, weights as 3% of the 34 points available for the IEQ category.

Within the IEQ category, the internal noise level credit counts for 2 of 27 points (typically 1.5 overall weighted points) for the office tools, 1 of 34 points (typically 0.7 overall weighted points) for the office interiors tool and 2 of 26 points (typically 1.5 overall weighted points) for the education facilities tool.

International comparison

Because of its origins, direct comparisons of Green Star can be made to similar voluntary 'green' rating systems, the North American LEED and UK BREEAM. Lam (2009) notes that the overall percentage credit for internal acoustics is similar between the Green Star and BREEAM tools for offices, and is similar for all the tools for education facilities. In the range of office tools in LEED, there are no credits for internal acoustics.

LEED for schools (USGBC 2009) sets mandatory targets for rating for background heating ventilation and air-conditioning (HVAC) noise levels and reverberation time control. As a credit, reward is given for further reducing HVAC noise levels, and ensuring the noise isolation between learning spaces meets ANSI/ASA standard S12.60-2002 (ANSI/ASA 2002) for noise isolation.

BREEAM for offices (BREEAM 2009a) covers indoor ambient noise levels and, for fully fitted buildings, sound isolation between rooms, taken as an overall level difference relative to the background noise. BREEAM for education facilities (BREEAM 2009b) is based on first demonstrating compliance to Building Bulletin 93 (DfES 2003), which has extensive coverage for acoustics in schools including ambient noise levels, reverberation control, noise isolation between sensitive spaces, impact noise isolation between floors and speech intelligibility. Extra credits are given for further noise isolation of music areas and limiting indoor ambient levels during heavy rain.

A comparison of the BREEAM credits to the Green Star credits finds that generally ambient noise limits are equivalent for private and open offices (for open offices, the upper limit is 5dB(A) greater in BREEAM), however the BREEAM coverage extends to general spaces, spaces for speech and informal café / canteen areas. The BREEAM tool for offices does not set targets for reverberation times as in the Green Star credits; however does have sound level difference targets between sensitive spaces.

For educational facilities, the coverage in LEED is less than Green Star, being only classroom and core learning spaces. Building services noise level targets in LEED are comparable to Green Star; however are limited to HVAC noise only, so no comparison is possible for ambient noise levels. Between the tools it is not possible to make direct comparison of reverberation times either, as for rooms below 566 m^3 volume, LEED targets are specified in terms of absorptive coverings. The extra credits in LEED for STC ratings regarding noise isolation correlate with higher performance levels than that promoted by Green Star, and as the coverage is for the building shell and classroom partitions, also wider application.

Compared to Green Star, the BREEAM educational facilities credits give greater coverage of internal acoustics with consideration of speech privacy, impact noise isolation and sound isolation for all sensitive spaces, including internal partitions. Ambient noise level limits are lower than Green Star, whilst reverberation time targets, although listed as an upper bound only, are generally equivalent with Green Star. The extra credit for consideration of rain noise in BREEAM extends beyond Green Star in consideration of external noise ingress.

APPLICATION OF THE INTERNAL NOISE LEVEL CREDIT

In this section we discuss some of the major aspects as to where we see the current Green Star internal noise level

credit is not effective in promoting more efficient workplaces. The following discussion incorporates previous public submissions to the GBCA by the Association of Australian Acoustical Consultants (AAAC) (Stead 2007, pers. comm. 7 Dec) and Marshall Day Acoustics (Griffin 2008, pers. comm. 18 August) regarding the internal noise level credits (a 30 June 2009 response from the GBCA was not available at the time of submission).

The following section initially reviews how the existing internal noise level credit is achieved and discusses the alignment of credits to design decisions. The second part of this section centres on the wider concept of how the credit addresses internal acoustics, with a focus on the limitations of the credit scope and weightings.

Linking to a design standard

The internal noise levels credit specifically references AS/NZS 2107:2000 (Standards Australia 2000). AS/NZS 2107:2000 is a well-known standard to building acoustics professionals and lists recommended internal design criteria for a variety of spaces and usages. Internal noise level credit criteria either copy recommendations of AS/NZS 2107:2000, or directly reference the standard. We suggest that this leads to ambiguity in applying the credit criteria. We find that using AS/NZS 2107:2000 design recommendations for compliance criteria leads to uncertainty in room definitions, building services and ambient noise level targets, reverberation targets and accounting for annoying sources.

Room definitions

AS/NZS 2107:2000 lists recommendations based on the room type, however does not contain any rules for classifying them. It is understood that the intention is the most appropriate or critical classification is to be used. However, when applied as a compliance target, directly referencing AS/NZS 2107:2000 leads to uncertainty, as the design intent may not match an independent assessment. As an example, a group training room with a dedicated projector in an education facility could reasonably fall under a range of categories, which Table 2 indicates could cover a range of different targets for ambient noise levels and reverberation times.

Table 2. Potential design targets for a generic 'training room'

Room	Recommended sound level, dB(A) ('satisfactory' / 'maximum')	Reverberation time, RT_{60} (s)
Audio-visual	35 / 45	0.6 – 0.8
Teaching lab.	35 / 45	0.5 – 0.7
Lecture room	30 / 35	Curve 1
Secondary school classroom	35 / 45	0.5 – 0.6

Source: (AS/NZS 2107:2000)

For office interiors, spaces are classified only as 'general office' or 'private office', without any clarification as to the specific definition. It is not clear whether the criteria should be applied to permanently occupied enclosed offices, or all enclosed spaces, such as meeting rooms or personal quiet spaces.

Building services and ambient noise level targets

We argue that internal noise level credit criteria do not align with the recommendations of AS/NZS 2107:2000 for internal noise levels. AS/NZS 2107:2000 lists two recommended values; 'satisfactory', a noise level that is presumed acceptable and not intrusive for the majority of occupants, and 'maximum', cited as an upper limit for satisfaction.

Where credit criteria directly reference AS/NZS 2107:2000, as for educational facilities, credit criteria either state '… in accordance with' or '… below the lower limit'. We believe these terms are not clear prescribed compliance targets. 'In accordance with' could be interpreted as a target level below 'maximum' (i.e. most people are not annoyed), below 'satisfactory' (i.e. guarantee most people are satisfied) or any other variant. Similarly, the term '…below the lower limit' appears to suggest the target ambient noise level should be below the 'satisfactory' level, which in reference to the definition for 'satisfactory' is somewhat restrictive.

Another instance where there is poor correlation is for office interiors where target ambient levels are set between the 'satisfactory' and the 'maximum' level. Clearly by the AS/NZS 2107:2000 definitions of 'maximum' and 'satisfactory', this strict definition does not correspond to an optimum range for occupants. In AS/NZS 2107:2000 the wording suggests occupants would likely be satisfied with levels less than 'maximum', and for high-quality spaces, the 'satisfactory' level.

We support the view that for office buildings, ambient noise level targets below the recommended 'satisfactory' level are too conservative when compared to AS/NZS 2107:2000, and below the targets for 'general offices' as per the office interiors tool. We support the comments by Marshall Day Acoustics (Griffin 2008, pers. comm. 18 August) that similarly note that targets that are too restrictive may result in cases such as over-specifying the performance for external glazing or penalising natural or mixed mode ventilation configurations as a result of increased external noise ingress.

Finally it is not clear why credits make the distinction between base-building and ambient noise. The distinction is not made in AS/NZS 2107:2000, and for the occupant it is the overall experience that often dictates satisfaction with a space. Discussion of annoying sources is a separate consideration provided below.

Accounting for annoying sources

The internal noise level credit directly reference AS/NZS 2107:2000 for guidance on noise measurement and modelling. Although AS/NZS 2107:2000 contains guidance on identifying and weighting tonal sources, it does not state how to account for other annoying sources. The reason being, the scope of AS/NZS 2107:2000 is limited to non-time varying noise sources and is not appropriate for time varying external nose ingress, such as train, aircraft noise or infrequent traffic or internal noises with annoying characteristics, such as those with pulsating or modulating characteristics. Consider a quiet corner office next to binding or vending machines, or desks located on highly trafficked passageways with hard flooring. Ambiguity therefore exists as to whether these scenarios prevent compliance with the credit.

Building noise phenomena with unpredictable occurrence are unlikely to be covered by the rating tools, and include noise arising from high-wind interaction with façade elements (Swift & Stead, 2008) and rain noise.

Reverberation time targets

A condition where we find inconsistency between the intent of AS/NZS 2107:2000 and the credit criteria, is in applying the recommendations for optimum reverberation time. AS/NZS 2107:2000 states that the optimum is dependent on the room volume. However credit criteria have no provision for tailoring targets for different room sizes. Furthermore, for some rooms AS/NZS 2107:2000 references a mean curve for reverberation time for spaces that are considered to have

good acoustic properties (AS/NZS 2107:2000 Appendix A). It is not clear how this compliance target may be enforced.

We also find inconsistency in the stated aim of the internal noise level credit to achieve appropriate internal noise levels. Where reverberation times are set as part of the credit criteria, it suggests that the intention is to limit internal noise levels. Internal noise level credit criteria directly reference the relatively small reverberation time ranges from AS/NZS 2107:2000. AS/NZS 2107:2000 however has specific advice that, when designing for noise control purposes, the reverberation time should be reduced 'as far as practicable'. Setting a lower limit directly contradicts this advice, leading to a disparity between the aim of the credit and the credit criteria targets.

Alignment of credits to design decisions

Rating tools must align credits with the stage where the relevant design decisions occur, matching the reward for achieving the Green Star points with the cost. A case that has been identified where the credits do not align is in reverberation time control for office buildings.

Unless delivered as shell-and-core or integrated fitout, the ceiling and floor material selection, which are major design decisions affecting room reverberation control, are made at the office building stage. However, the credit for reverberation control is applied at the office interiors stage. The AAAC (Stead 2007, pers. comm. 7 Dec) submission to the GBCA notes this discontinuity as a particular concern for 'green' designs, where the benchmark reverberation control typically starts from a poor base as a result of Green Star promoting designs that reward natural lighting and external views.

ASSESSMENT OF INTERNAL ACOUSTICS

The discussion in the following sections progresses from consideration of the aims of the internal noise level credits to the wider scope of internal acoustics. As stated, it is our assertion that the internal noise level credit criteria are not effective in promoting good internal acoustics. Discussion is split into the limited scope of the internal noise level credit and the relative weighting for internal acoustics.

Limited scope of the credit

The most critical aspects of internal acoustics we believe that are not adequately considered in the current credit criteria surround speech privacy, both for enclosed and shared spaces, and for occupant noise.

On a separate note, consideration of vibration is beyond the scope of this paper but should be considered if it can be demonstrated that there are identified opportunities for improving occupant comfort and well being beyond established building codes of practice.

Speech privacy in enclosed private spaces

Satisfaction with speech privacy in enclosed private spaces is governed by operational requirements and expectations of quality. For typical offices, the primary aspects dictating speech privacy in an enclosed space are the combination of the noise isolation performance of the partition, source levels (e.g. spoken word or loudspeaker) and ambient noise levels in the associated spaces. It is our assertion that adequate speech privacy standards are not addressed in the office rating tools (buildings or interiors.), as only considers the ambient noise level, ignoring other factors.

Under the education facilities tool, there is a requirement for airborne noise isolation performance between sensitive spaces, however the provision only applies if walls are base building and if they are structural walls of any internal space, with the explicit statement that tenancy installed partitions are not to be included. Furthermore, the requirement is expressed as a weighted sound reduction index (R_w) rating, not a level difference determined between occupied spaces. This creates the risk that if adjacent floor, ceiling and wall elements are not properly considered as a system, flanking paths may significantly impact the noise level difference between spaces. On this basis we believe that could not guarantee acceptable levels of speech privacy on the basis of compliance with the education facilities tool alone.

Speech privacy in open plan spaces

Speech privacy in open plan spaces is particularly important for 'green' designs where there are incentives in design for reducing the size and scope of partitions. Within the Green Star tools, this incentive comes from the Built Zone Area, Daylight and External Views credits. Also, as noted by Boglev (2008), under the rating tools there are incentives towards natural ventilation / chilled beam mechanical services, leading to low building services noise levels and reduced speech privacy levels.

Many of the complaints in open plan offices are of distractions caused by colleagues and their activities. Whilst acknowledging the inherent limitations of open plan design, many common complaints that arise from no acoustic coordination or design input may be avoided and include

- flooring selections affecting footfall noise within the space as well as impact noise to the space below;
- irregularly used office machinery equipment, such as coffee machines, microwaves and binding equipment;
- functional space layouts such as quiet rooms and individual desks next to breakout areas.

The ISO 3382.3 standard under development (ISO 2009) is expected to facilitate design of open plan offices in regard to setting an equitable balance of privacy and intelligibility. Effective designs need to coordinate ambient noise controls, with appropriate internal surfaces and office joinery in conjunction with the unique workspace layouts and staff groupings. These considerations are not yet promoted within the Green Star tools.

Appropriately weighted

The basis for the Green Star rating system is to promote the consideration of sustainable outcomes in designs that, due to inherent barriers in the building industry, are not adequately priced for in the normal building process, despite there being a market demand. As noted in Green Star (GBCA 2009c) '… these barriers relate to developer/contractor/owner divisions or split incentives that often result in benefits of efficiency or improved performance measures not accruing the party that initiated them'.

Appropriate weightings of Green Star credits therefore need to compare the relative outcomes achieved by each credit in aid of sustainable design, tempered by how well they are achieved with established and acceptable building practices.

Relative influence to sustainable design

Not all credits in Green Star are for promotion of environmental initiatives, as sustainable design also has to considering the functional usage of the space. For IEQ category credits (of which the internal noise level credit is a part), the measurable payback for sustainable design is increased

worker productivity, reduced instances of the range of costs associated with 'Sick Building' syndrome and increased building / fitout life.

We argue that the existing internal noise level credit is underweighted in respect to the influence that internal acoustics can have on worker productivity, relative to other measures in the IEQ category. Whilst is beyond the scope of this paper to argue for a particular target weighting for internal acoustics, as to do so requires a holistic approach to considering all the other IEQ credits, as previously shown there is considerable evidence that appropriate internal acoustics have a significant influence beyond that currently recognised by each rating tool.

Examples that highlight the major influence internal acoustics has in sustainable design include Schwartz (2008), which highlights the direct economic case through linking poor internal acoustics to 'Sick Building' syndromes. Furthermore, Sykes (2004) lists an increasing number of recent studies that highlight and seek to quantify the link between internal acoustics and productivity.

Market provisions for good internal acoustics

Providing cost effective, sustainable outcomes in acoustics requires early and ongoing detailed design input and coordinated selection of equipment, construction and materials with significant upfront engineering cost implications. In our experience, this limits the market provision of cost efficient high-quality internal acoustic qualities unless the client specifically seeks such and is willing to pay for it; however the consideration and specification of building services noise levels, in the absence of other important acoustic qualities, is common practice (Boglev, 2008).

RECOMMENDATIONS FOR CREDITS

Following from the issues that have been raised, this section lists recommendations for improving Green Star credits through the promotion of good internal acoustic qualities and outcomes. Recommendations are separated into improving the existing internal noise level credit, and the creating of a new credit, expanding on the scope of the internal noise level credit.

These recommendations reflect our recommendations to changes to the existing internal noise level credit. In the Green Star rating system where innovation points can be targeted in areas that exceed the existing requirements and/or promote the improved methods, points can potentially be achieved with the current rating tools for and outcomes aspired to in this paper.

Revision of the internal noise level credit

Our suggestions for improving the existing credit includes revision of the credit coverage, better alignment with AS/NZS 2107:2000, increasing requirements for partition performance and accounting for specific noise characteristics.

Credit coverage

We suggest that there is scope for the internal noise level credit to better reflect the usage of each type of space. Reverberation controls could be amended to be included as part of the office buildings tool, rewarding early selection of base building elements such as flooring and ceiling elements at the base building stage. Possible credit criteria should be compatible with established properties, such as minimum Noise Reduction Coefficient values or frequency dependent absorption properties for a targeted minimum coverage for ceiling tiles and flooring. Such measures would further align with the goals of Green Star by limiting the impost for churn in new tenancy fitouts replacing flooring and ceilings.

To achieve an equivalent level of quality across education facilities we suggest the removal of the provision that partition ratings only apply to base building and structural walls, to include *all* partitions between nominated sensitive spaces, such as classrooms and dedicated teaching spaces.

Align targets with AS/NZS 2107:2000

Clear room definitions are critical to defining the compliance targets. We suggest that the credit criteria should include guidance as to the classifications or specific definitions. For offices, particular attention should be given to whether meeting rooms should be considered as 'private offices' or 'general offices'. As an often-used space where ambient noise control and reverberation control would be assumed to be critical to satisfaction with the space, we suggest meeting rooms should be included in the definition of 'private offices'. The BREEAM for offices rating tool (BREEAM 2009a) includes definitions for spaces that clearly identify room classifications.

To limit ambiguity in interpreting the internal noise level credit criteria and to align with the intention of AS/NZS 2107:2000, we suggest all contributors to ambient noise level targets should align with the 'satisfactory' recommendations of AS/NZS 2107:2000, including building services. We find no overall benefit to the end user in assessing building services noise separately.

Our recommendation to align with the 'satisfactory' level should be interpreted as the target ambient level with a range for compliance. We suggest a range of 5dB above the 'satisfactory' to be a suitable band for compliance means without materially altering the alliance with AS/NZS 2107:2000. Only where it is appropriate for speech privacy should a lower target level for ambient noise be set. We suggest upper and lower limits should only apply to 'general office' or open plan classrooms. As the lower limits is critical for speech privacy, we suggest a target should be set by further research as to the most effective targets. The AAAC submission to the GBCA (Stead 2007, pers. comm. 7 Dec) suggests levels of 37-45dB(A) to be appropriate for open offices.

We suggest reverberation times should be amended to a single upper limit target value, commensurate with the goal of affecting noise control. Only where a lower reverberation time limit is appropriate, for example for educational facility music spaces or in or educational facilities where speech clarity is critical, should the credit criteria nominate a range for target reverberation times.

Partition ratings

Critical partitions nominated in the education facilities internal noise level credit should be rated on the basis of a weighted level difference (i.e. D_w) instead of the weighted level reduction (i.e. R_w) that may be assigned to individual building elements. This method is robust in setting an equivalent level of airborne noise isolation between spaces.

Noises with annoying characteristics

The requirement for the acoustic consultant to advise of any annoying characteristics should be expanded to specific penalties if they form part of the ambient noise level. For internal sources, we suggest the elimination or masking of any perceptible annoying characteristics from sources on site should be a design requirement.

For external noise sources, where control of the source may not be possible, consideration of background and / or peak noise characteristics should be used, as they may more closely align with satisfaction with the space. Appropriate weightings and/or definitions for annoying characteristics could be derived from existing environmental noise regulations, suitably conditioned for internal workspaces.

Recommendations for an internal acoustics credit

With an increased scope with resultant increased influence on sustainable design it follows that additional credit points be assigned. A tiered point approach, where one or several points can be awarded, would accommodate different levels of priority given to internal acoustics on each project.

Coverage of the credit

Consideration of speech privacy and speech clarity beyond AS/NZS 2107:2000 is recommended. For a new internal acoustics credit, we suggest as a benchmark the UK BREEAM for offices, and for educational facilities Building Bulletin 93 (DfES 2003). Coverage should be extended from credit criteria targets of the internal noise level credit (i.e. ambient noise level, reverberation time and partition performance) to include

- speech privacy in enclosed sensitive spaces, covering speech confidentiality and noise intrusion; possible design targets could be partition performance tailored to the characteristics of the space as per Building Bulletin 93 (DfES 2003),
- open office speech privacy, with possible speech privacy modelling design targets;
- speech clarity for large spaces or where speech is critical (e.g. lecture theatre / large boardroom or classrooms), with possible speech clarity modelling targets; and
- occupant generated noise with possible material or equipment selection design targets.

Open plan office speech privacy is an area where consistent dissatisfaction is reported, and where significant contributions towards sustainable design can be made. We suggest credit criteria could for example be expressed in terms of an agreed speech privacy modelling or parameter such as that from AS2822 (Standards Australia 1985), with similar application to that used for the Green Star thermal comfort credit. As Green Star is targeted towards 'top-end' sustainable design, we see the provision for speech privacy modelling to be appropriate for internal acoustics credit criteria.

Weighting

To quantify what we suggest is a more appropriate weighting for internal acoustics we suggest a survey based study of the individual ratings within the IEQ category, such as by Chiang & Lai (2002) or Jensen, Arens and Zagreus (2005) be conducted. Similar studies conducted in Australian workplaces would be of particular relevance.

CONCLUSION

This paper constitutes a critical review of whether the Green Star internal noise level credit for offices and educational facilities promotes a suitable level of sustainable design specific to internal acoustics. Overall we have argued there is poor provisioning as a result of how the current credits apply and limitations of the scope and weighting of each associated credit.

We have noted that ambiguity in applying the internal noise level credit can be traced to linking credits to AS/NZS 2107:2000 and not accounting for discrepancies of applying a design standard for compliance credit criteria. The discrepancies highlighted surround the design intention, room definitions, target values for ambient noise levels and reverberation times and in accounting for annoying characteristics. It has been argued that aspects of speech privacy and occupant-generated noise are not adequately considered. The argument was also made that weighting for internal acoustics belies the importance and consideration that should be given for Green Star.

Recommendations have been suggested for improving the internal noise level credits to account for the issues raised in attempting to apply the credits for projects. As for the wider scope of internal acoustics, recommendations have been made for a new internal acoustics credit with wider scope and weighting. In response, we suggest a tiered approach be implemented that rewards different levels of consideration commensurate with the weighting that is given to the aspects of the credits.

Finally, to encourage change we offer a means for new credits in Green Star that differ from prescribed innovation points available. The AAS is invited to provide feedback to the GBCA on any credits in Green Star tools. However, we suggest that if consultants do want to see an expanded scope for internal acoustics in Green Star, then innovation points should be targeted in areas that exceed the existing requirements and/or promote the improved methods and outcomes aspired to in this paper.

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