THE EFFICACY OF INTEGRATED GREEN DESIGN STRATEGIES IN MEETING GREEN BUILDING CRITERIA: A SOUTH AFRICAN CASE STUDY

ABSTRACT

Two studies were done by the CSIR on proposed private developments with the objective of determining the benefits, if any, of applying an integrated green-based design approach to maximise the rating for a green building using the South African Green Star Office Design v1 (GBCSA 2008) rating tool. The first study was performed on a proposed new building in Groenkloof in Pretoria, while the second study was performed on a proposed new office building in Lynwood Pretoria. Both buildings are offices located on the fringes of a residential area, comprise floors totalling less than 5 000 square meters, and have basement and external parking.
The Groenkloof building has fully utilised developable footprint while the Lynwood building has utilised only 50 per cent due to it being located on a larger land portion. The design and layout of both buildings represent typical office building development in South Africa. In the case of the Groenkloof building the design of the building was substantially complete, base drawings had been submitted to the Local Authority for building approval, and civil works had already commenced on the site by the time the Green Star SA Office Design v1 (GBCSA 2008) assessment study commenced. On the Lynwood building the client put out a tender for architectural submissions based on price, competence and a Statement of Intent with regard to the 'greening' of the project and invited the CSIR to assist in evaluating the submissions. A similar call was made for mechanical and electrical professional services. The Green Star SA Office Design v1 (GBCSA 2008) rating tool was applied to both projects after a full round of consultation with the full professional team and the client. In the case of the first study only minor design amendments could be made while in the case of the second study a green design workshop was held based on preliminary concept drawings. In the second study considerable design development was possible across the range of professional disciplines. Contrary to expectation the study shows no appreciable benefit accruing to rated assessment arising from an early and inter-disciplinary green design approach.

KEYWORDS

Integrated green design; green building rating tool; building services

INTRODUCTION

The implementation or consideration of green building rating tools criteria should improve the environmental performance of a building due to, inter alia, the greater diligence used to commission and optimising the performance of the building services; reduced construction waste; a healthier indoor environmental quality arising out of the use of materials with lower volatile organic compounds (VOC) and formaldehyde content, improved air exchange and flow rates and lower rates of humidity; lower energy demand as a consequence of lower lighting densities coupled to higher daylight lighting, improved insulation of the building envelope reducing the heating and cooling load, the use of more energy efficient heating and cooling equipment, and window-to-wall ratios aimed at reducing heat gain or loss during the day; lower water consumption due to the use of more efficient sanitary fittings and not using potable water for irrigation purposes; and an enhanced post-construction ecological value for the site.

Green building is a recent development in South Africa: a green building council was established in South Africa in September 2007 with the first green building rating tool, a localised version called Green Star SA Office Design v1 (GBCSA 2008) rating tool, first developed in Australia, released in November 2008. The Green Star SA Office Design v1 (GBCSA 2008) rating tool comprises 8 categories namely Management with a maximum of 14 points and a weighting factor of 9 per cent ; Indoor Environment Quality with a maximum of 28 points and a weighting factor of 15 per cent; Energy with a maximum of 30 points and a weighting factor of 25 per cent; Transport with a

maximum of 14 points and a weighting factor of 9 per cent; Water with a maximum of 15 points and a weighting factor of 14 per cent; Materials with a maximum of 22 points and a weighting factor of 13 per cent; Land Use and Ecology with a maximum of 9 points and a weighting factor of 7 per cent; Emissions with a maximum of 17 points and a weighting factor of 8 per cent; and Innovation with a maximum of 5 points and is un-weighted (see Table 1 below).

Table 1: Green Star SA Office Design v1

Category	Total Points Available	Weighting (%)
Management	14	9
Indoor Environment Quality	28	15
Energy	30	25
Transport	14	9
Water	15	14
Materials	22	13
Land Use and Ecology	9	7
Emissions	17	8
Innovation	5	-

Two studies were undertaken: the first study was performed on a proposed new building in Groenkloof in Pretoria, while the second study was performed on a proposed new office building in Lynwood Pretoria. The two sites are approximately 20 kilometres apart. Both buildings are offices located on the fringes of a residential area, comprise more than one floor totalling less than 5 000 square meters, and have basement and grade parking. The Groenkloof building has fully utilised the coverage footprint of the site while the Lynwood building has utilised only 50 per cent due to it being located on a larger land portion. The design and layout of both buildings represent typical office building development in South Africa. In the case of the Groenkloof building the design of the building was substantially complete, base drawings had been submitted to the Local Authority for building approval, and civil works had already commenced on the site by the time the study commenced. On the Lynwood building the client put out a tender for architectural submissions based on price, competence and a Statement of Intent regard to the 'greening' of the project and invited the CSIR to assist in evaluating the submissions. A similar call was made for mechanical and electrical professional services. The Green Star Office Design v1 (GBCSA 2008) rating tool was applied to both projects after a full round of consultation with the full professional team and the client. In the case of the first study only minor design amendments could be made while in the case of the second study a green design workshop was held with the full professional team based on concept drawings. In the second study considerable design development was possible across the range of professional disciplines.

The goal of this research was to evaluate the intrinsic value of adopting an integrated green-based design approach to improve the weighted score of a green building using the Green Star SA Office Design v1 (GBCSA 2008) rating tool. Green-based design in the context of this study means designing "the human habitat with a sensitivity to ecological principles" (Wines 2008a:14); "a more socially responsible and environmentally integrated approach" (Wines 2008b:14); design that mirrors "nature's deep interconnections in our own epistemology of design" (Van der Ryn and Cowan 1996a:x); "any form of design that minimises environmentally destructive impacts by integrating itself with living processes" (Van der Ryn and Cowan 1996b:x); an architecture that basically comes "down to three purposes – first, to advance the purely selfish motive of survival by a cooperation with nature; second, to build shelter in concert with ecological principles as part of this objective; and third, to address deeper philosophical conflicts surrounding the issue of whether we really deserve the luxury of this existence, given our appalling track record of environmental abuse" (Wines 2008c:20); and "making thoughtful design choices and using ecological materials in ways that create quality, long-lasting environments with minimum damage to the planet" (Hall 1996:14).

MATERIALS AND METHODS

Study 1. The Groenkloof project is located on land that was previously used as a large residential premise with a substantial garden. The house and the garden (largely consisting of alien vegetation) were demolished and all the materials removed. The top soil of the land portion had also been carted away. The site is well served by public transport and other social amenities. The project comprises two below ground basement parking levels totalling 168 bays; three 1 640 square meter floors; 52 parking bays at ground floor; and external site landscaping. The building is divided into two office blocks of 684 square meters each joined to a central service core of 272 square meters. The width of a wing is 18 meters. The north facade is orientated 20 degrees west of north, with the longest facade of the office floor facing north and south and the shortest facade facing east and west. The south and north facades are treated similarly architecturally as a punctured wall with horizontal screens to the fenestration: the fenestration on the east and west facades has been restricted to a minimum with the exception of the entrance on the east that is treated as a three storey glazed element. The walls of the building are 330 millimetres wide consisting of two clay masonry skins and an internal cavity: this has been done to allow the outer skin to go past the face of the 230 millimetre reinforced concrete columns. The roof comprises of an insulated light roof finish on steel trusses. The external finish is plaster and paint to the north and south facades and facebrick to the east and west facades while the central service core is tiled.

No design interventions were proposed as the plans had already been submitted to the local municipality for building approval and construction had commenced on site. Recommendations were however made with regard to the landscaping particularly to make use of xeriscape gardening in order to eliminate the need for irrigation with potable water.

Study 2. The Lynwood project is located on a vacant and previously un-developed portion of land. The ecological value of the site is low due to the predominance of alien vegetation, especially large gum trees. The site is poorly served by public transport and is relatively isolated from social amenities. The project comprises of below ground basement parking of 110 car bays and 20 bicycle bays; a 2 000 square meter ground floor comprising boardrooms, IT services, a staff kitchen and dining facility, a library, and visitor facilities; a 2 000 square meter first floor predominantly arranged into cellular offices with centrally-located open plan offices; and a second floor entertainment area at roof level. The remainder of the site comprises parking at grade for 50 vehicles and landscaping. The building is divided into three wings joined by a central connector. The typical width of a wing is 18 meters including a 1,200 meter deep vertical sunscreen on each façade to screen the 2,100 meter high fully glazed walls. The wings are orientated at 45 degrees off north to optimise sunlight and external views to each façade and particular design effort has gone into the design of the screen to reduce direct sunlight and heat into the office spaces while ensuring maximum view out. The centrally located open plan offices are afforded natural daylight through rooflights. The roof is designed as an extensive green roof consisting of indigenous grasses in a shallow media depth requiring minimal maintenance on a reinforced concrete slab.

Design interventions that were implemented early in the concept stage were the over-excavating of the basement to facilitate natural lighting and ventilation; the formation of landscaped berms with the excavated material to act as noise attenuators on the boundary abutting a local service road; the use of natural ventilation to the central connector; the use of solar-heated water to heat the central connector and to supply the hot water requirements of the complex; maximising the southern façade of the connector to bring in cool air at ground level and which is exhausted through the roof lights; orientating and shaping the rooflights to reduce direct sun into the central open plan office area and optimising the solar-water heater installation; and using the roof lights in conjunction with below-floor displacement ventilation and a building management system to exhaust hot and stale air.

RESULTS AND DISCUSSION

Study 1. Applying the Green Star SA Office Design v1 (GBCSA 2008) rating tool resulted in a weighted score of 50 points: the project scored well in Management (64.2 per cent); Indoor Environment Quality (70.3 per cent); Transport (71.4 per cent due to its favourable location); and Materials (64.7 per cent largely due to the use of recycled rebar steel); while scoring poorly in Energy (36.6 per cent); Water (42.8 per cent due to the use of potable water for irrigation purposes); Land Use and Ecology (14.2 per cent due to the restricted landscaping); and Emissions (29.4 per cent).

Study 2. Applying the same rating tool resulted in a weighted score of 55 points: the project scored well in Management (71.4 per cent); Indoor Environment Quality (59.2 per cent); Water (78.5 per cent); Materials (58.8 per cent); and Land Use and Ecology (80 per cent due to the use of xeriscape gardening and the removal of alien vegetation); while scoring poorly in Energy (36.6 per cent); Transport (35.7 per cent due largely to its predominantly residential location); and Emissions (43.7 per cent).

Table 2: Comparative Analysis

Category	Study 1 (%)	Study 2 (%)
Management	64.2	71.4
IEQ	70.3	59.2
Energy	36.6	36.6
Transport	71.4	35.7
Water	42.8	78.5
Materials	64.7	58.8
Land Use & Ecology	14.2	80.0
Emissions	29.4	43.7
Innovation	0	0

The difference between the two projects is more a consequence of the weighting factor value rather than the actual number of points achieved. Both projects scored relatively well in Management; Indoor Environment Quality; and Materials and both scored relatively poorly in Energy and Emissions. Study 1 performed better in Transport due to its more favourable location while Study 2 performed better in Water and Land Use and Ecology.

However, with regard to the goal of the research, the difference in score between Study 1 and Study 2 had more to do with location, land use and ecological restoration than the design of the building. This result runs counter to what was expected and thus further investigation was required to determine why this outcome was produced. Each category was carefully analysed to assess whether or not design intent could materially affect the points scored. In the category of Management only one sub-section may materially be influenced by design, namely air tightness. With careful design detailing the leakage rate could be restricted to less than 15m3/hr/m2 at a relative pressure of 50Pa. However, the value of this sub-section is one point and it is very difficult currently to assess accurately in South Africa. In the category of Indoor Environment Quality the sub-sections of daylight glare (one point), external views (two points), and daylight factor (three points) may be directly influenced by ‘green’ design. In the category of Energy only the sub-section on total energy use (maximum of twenty points) can be directly influenced by ‘green’ design and then only with regard to reducing energy demand. In South Africa this is limited to passive design strategies as the use of renewable energy technologies to substitute energy from the grid is not economically viable due mostly to the extraordinary low cost of electricity and the high cost of renewable energy installations. In both studies energy modelling will be undertaken to determine with greater accuracy the likely energy performance of the two buildings having regard for the demand-side interventions introduced. Unfortunately the modelling will not be

completed in time for this paper[1]. In the category of Transport none of the sub-sections can be directly influenced by 'green' design. In the category of Water the sub-sections on reducing potable water consumption (five points) may be partially influenced by 'green' design as the calculator is predominantly based on the flow rates of the sanitary fittings. The sub-section on potable water use for irrigation purposes (three points) has more to do with the landscaping design than the design of the building although rain water harvesting can be a design feature in this sub-section. In the category of Materials the sub-section for the reuse of an existing building may be applicable in some cases (two points), the use of reused products and/or materials may be applicable (one point), the selection of locally sourced materials may be applicable (two points), the reduction of the absolute quantity of Portland cement may be applicable (three points), designing for disassembly is directly applicable (one point); and the reduction in the mass of materials used may be applicable (one point). In the category of Land Use and Ecology only the sub-section for the improvement of ecological value may be applicable if extensive green roofs are used with indigenous grasses and then only to a limited number of the maximum number of points available (four points). In the category of Emissions only the sub-section for façade lighting applies (one point). The category of Innovation holds the greatest potential although the requirements for qualification are so strict that achieving the five points is highly unlikely in the kind of property developments forming the basis of this study.

From the above it may be concluded that the rating tool is predominantly driving designer's attitudes to building performance improvement through the building equipment and services, rather than through 'green' design. This conclusion is supported by the rankings established by the weighting factor: the highest weighting factor, 25 per cent, is allocated to Energy, with only two out of the five sub-categories possibly addressing green building design. The second highest weighting factor, 15 per cent, is allocated to Indoor Environment Quality with three out of the seventeen sub-categories possibly addressing green building design. The third highest weighting factor, 14 per cent), is allocated to Water all of which address equipment and services. The fourth highest weighting factor, 13 per cent, is allocated to Materials with eight out of eleven sub-categories addressing procurement choices. The fifth highest weighting factor, 9 per cent, is shared between Management – with possibly only one of the eight sub-categories addressing green building design – and Transport, where none of the sub-categories address green building design. The sixth highest weighting factor, 8 per cent, is allocated to Emissions with possibly two out of the nine sub-categories addressing green building design. The seventh highest weighting factor, 7 per cent, is allocated to Land Use and Ecology, with only one sub-category possibly addressing green building design.

It may be that integrated green design strategies rather than attention to weighting factors become more prominent in buildings aiming to achieve higher rating scores: however for buildings aiming for four stars the evidence from this comparative study suggests that integrated green design plays a lesser role than maximising mechanical services in the determination of the 'greenness' of the building largely due to the relative importance of the weighting factors as contained in the Green Star SA Office Design v1 (GBCSA 2008) rating tool and the current pricing and payback periods for energy efficiency and renewable energy options at this time in South Africa. In addition, a single study of this nature cannot be regarded as conclusive and, due to the unexpected findings of these two studies, further studies will be undertaken on the additional four green buildings that the CSIR is engaged with to determine whether 'green' design can be used to minimise mechanical services and what influence such a design approach would have on the overall score.

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[1] The results will however be completed in time to be included in the presentation of this paper at the conference.

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