BUILDING ADAPTION FOR WASTE MINIMISATION IMPACT OF POLICIES

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ABSTRACT

Construction and demolition waste represents a significant wastage of natural resources and energy while also contributing to air pollution. Measures to reduce construction waste include achieving flexibility in design of new buildings, and recovery of materials and components from existing buildings or adaptation of existing buildings to new uses. Although prolonging the building life through designing for adaptation can reduce the rate of demolition, the low rate of building renewal means that material recovery and whole building reuse are equally important in minimising construction waste. While the quality of recovered material/component depends on the original design and recovery process, there is a lack of measures to promote the use of recovered materials. Changes in decision-making on how buildings are designed, demolished and reused can therefore significantly improve the resilience of building stock and reduce the adverse impacts. While theoretical underpinnings of designing for deconstruction or adaptation of existing buildings are well established, their practice depends more on location, policy issues and incentives. This paper discusses the preliminary findings from a research project which aims to develop a set of guidelines on designing buildings for flexibility, based on life-time environmental and financial performance of alternative strategies, and generate data on relative environmental performance of recovered construction materials/components compared with virgin alternatives used in Singapore.

BACKGROUND

Buildings are central to the fabric of everyday life, embedded in the spatial form, character and skyline of a location. However in some extreme cases, buildings are being replaced only 10–15 years after construction (Building Construction Authority, 2010). This not only removes any traces of heritage, it is also wasteful in terms of large volumes of resources embodied in buildings and construction waste that ends up in landfills. Construction waste is generated by activities such as clearing building sites and construction of buildings and infrastructure. Apart from conserving limited landfill space, construction waste minimisation is also helpful in safe-guarding limited natural resources, reducing energy use for manufacture of building materials and products, and reducing hazardous emissions released as a result of product manufacturing and building demolition processes.

The quality and the quantity of construction materials recoverable at the end of the useful life of a building however, depend on two factors; the original design of the building and the demolition process employed. While the demolition waste recovery rates vary depending on the construction material, and may even be more energy-intensive compared with the use of new materials (Brown & Buranakarn, 2003), the general perception of designer/public/developer that 'new is better' together with uncertainty on the suitability of the recovered material for the intended purpose are barriers to wider uptake of recovered materials. This suggests that decisions on sustainability of the building sector should extend beyond design, construction and operation phases and selection of low impact materials and systems to include designing for deconstruction and adaptive reuse, and strategies to recover and manage demolition waste.

While using a life cycle perspective can promote waste minimisation through matching construction material properties with intended building use and useful life, designing for deconstruction or adaptation can reduce demolition waste by enhancing the potential for reuse of buildings or building components. Although the concept of deconstruction and design principles to facilitate it are well-documented (Chini, 2001; Crowther, 2002; Douglas, 2006; Kibert, 2003), these are currently neither considered nor practiced in the design process unless there is a specific requirement in the design brief to do so, generally for economic reasons. With the rate of renewal of buildings reported to be as low as around 2% (Holness, 2008; Ravetz, 2008; Wilkinson et al., 2014), continued use of existing building stock by maintaining, refurbishing, and adapting to new uses could be far more effective in reducing construction waste than any measures to reduce waste from new buildings. Adaptation of buildings should also receive focus in attempts to achieve a more sustainable building stock, as the reuse of buildings could save as much as 95% of the energy embodied in the existing building stock as reported by an Australian study (Australian Government, 2004), in addition to social and environmental benefits. Studies in the UK have also shown that regenerating areas by converting disused buildings to be multi-functional activity centres can improve sustainability through increased activity levels during day and night times and use of sustainable modes of mobility to support local economy (Bromley et al., 2005).

With this background, this paper focuses on building adaptation as a measure to minimise construction waste in land and resource-scarce Singapore. The paper presents preliminary findings from research investigating the current building adaptation practices in Singapore using two case studies to determine factors influencing the adaptation strategy employed. The paper is organised as follows: First, the current knowledge in building adaptation is discussed and then the study location Singapore is introduced along with unique characteristics of the location and relevant development policies. Then the selected case studies are presented, along with the drivers applicable to each case and the adaptation strategy employed. Results on waste minimisation and sustainability achieved by the projects are then presented and conclusions are drawn.

BUILDING ADAPTATION – CURRENT STATE OF KNOWLEDGE

The term 'adaptation' describes any work other than general building maintenance, which can change performance, capacity and function of a building (Wilkinson et al., 2014). While adaptation can facilitate reuse of a building either for same (in-use adaptation) or a different (across use adaptation) use, it can also delay demolition of buildings due to obsolescence. However, age and condition are important determinants of suitability for reuse, while flexibility of design, location characteristics, local policy and market forces play an important part in reuse of buildings (Ball, 2002). The level of adaptation necessary prior to reuse depends on the in-built adaptability of existing buildings (Kincaid, 2000). A Norwegian study (Arge, 2005) investigating in-built adaptability of buildings found that level of in-built adaptability depended on the time frame of interest in the building, i.e., whether the building is for sale or own use. This could be expected as a high degree of adaptability was reported to add 20-25% to the total cost of an office building and without a long-term interest in the building, developers would be unwilling to bear the additional expenditure. The most commonly used adaptive measure according to this study was elasticity, the least expensive, which allows the building to be divided to parts which could be rented or sold separately.

In developed countries where the majority of the future building stock is already in existence, due to low renewal rates, the expenditure on building adaptation as a percentage of the total spent on construction is high at 42% in the UK and close to 18% in Australia (Goodier & Gibb, 2007; Wilkinson et al., 2014). Where there are low-grade buildings that do not meet the current regulatory environment or modern performance expectations, adaptations can be an alternative to new constructions. The drivers for building adaptation could be as diverse as, conservation of historic buildings or retrofit of disused buildings for regeneration of derelict areas, and horizontal or vertical expansion of existing buildings to maximise the allowable floor space while accommodating contemporary building demands. Reuse of derelict buildings in a precinct augmented by some new buildings can provide variety and character, which is not feasible in an entirely new development, and thereby attract people and businesses to an otherwise abandoned area. Nonetheless, anecdotal evidence suggests that adaptation of contemporary buildings for same or different uses is uncommon in Singapore.

SINGAPORE CONTEXT

Singapore is a highly urbanised thriving city state with an affluent population, a very high per capita GDP (SGD 71,000 in 2014) but with no natural resources and limited land mass to accommodate her 5.5million population (Department of Statistics Singapore, 2015). Although Singapore has increased its land area by almost 25% over the years through land reclamation, the population has also steadily increased, while the demand for floor space continues to grow due to economic growth. As such, urban planning and land use policies of the government are critical to the liveability and sustainability of the built environment of Singapore. Due to the land scarcity the government of Singapore takes a long-term approach to optimise the use of land, thereby determining the land requirements for various development needs along with the pace of development.

The main policies governing land use and development controls in Singapore are, Concept Plan and Master Plan. While the Concept Plan guides long-term (over 40 to 50 years) broad development objectives, the five-year Master Plan provides detailed strategies for implementation (i.e., land use zoning, intensity for each land parcel, etc.) over short-term (over 5 to 10 years). In order to address the increasing demand for land for development activities, the government releases new and reclaimed land through government land sales (Urban Redevelopment Authority Singapore, 2015). To ease the pressure on the old Central Business District (CBD), government released the land reclaimed in 1970s to construct the Marina Bay Financial Centre which was completed in 2013. The high cost of land reclamation and land scarcity means that development controls such as building heights and Gross Plot Ratio (GPR) are continually revised to meet the market trends and demand for floor space through intensification. As a result, existing buildings may not be utilising the maximum allowable gross floor area due to changes introduced by Master Plan since the time of their construction.

Even with the heightened pressure for intensification the average annual building renewal rate in Singapore is only marginally higher at 5% (Building Construction Authority, 2010), compared with 2 to3% of other developed countries such as UK, USA and Australia. As such, while the perception is that Singapore buildings are renewed at a higher rate, the majority of the building floor space at any given time comes from existing constructions. A study (Hwang & Yeo, 2011) considering perceived benefits of construction waste reduction in Singapore, revealed that waste management is perceived to be beneficial for large projects and those using steel construction but not for smaller maintenance and renovation projects, or for concrete constructions. In 2014, construction and demolition waste contributed 17% to the total solid waste generated in Singapore (National Environment Agency, 2013). Although the rate of construction waste recycling in Singapore is reported to be 99%, recycling process also uses limited natural resources while anecdotal evidence suggests that currently reuse of recycled materials in building or other projects is relatively low. Therefore, continued use of existing building stock by adapting to new uses should receive focus in attempts to minimise construction waste and to achieve a more sustainable building stock.

POLICY MEASURES GOVERNING BUILDING ADAPTATION IN SINGAPORE

Despite an initial lack of emphasis, employing mass demolition to facilitate urban redevelopment (Jones & Shaw, 2006; Loh, 2009), since late 1980s, conservation has been an integral aspect of Singapore's urban planning. While conservation is recognised as important to retain the inherent values that the heritage buildings possess, the process of conservation involves some degree of intervention which results in changes to the historic fabric. Given the land scarcity, conservation guidelines allow modifications including reconfiguration of interior spaces and intensifications to accommodate modern uses so that the conserved building remains relevant in present times. The focus of conservation policies has been that all buildings remain in use and those which are not religious buildings remain economically sustainable as well. According to the latest policy document, the level of modifications allowed depends on historical significance, context of the surroundings and long-term development goals for the area (Urban Redevelopment Authority Singapore, 2011).

However, the studies suggest that there is wide disparity between the intentions of the conservation guidelines and adaptations that have been already completed, (Belle et al., 2012; Yeoh & Kong, 2012) as evident from Boat Quay area in the 'Historic District' where buildings are to be retained and restored.

The focus of guidelines on adapting contemporary buildings for modern use published by the Building Construction Authority (Building Construction Authority, 2010) remains on energy and water efficiency, with volume of general waste and Indoor Environment Quality being the other considerations. While the Building Retrofit guide touches on the reasons, benefits and even necessity of retrofitting an old building with green systems, it primarily deals with how the shell of the building is kept intact while its old systems are replaced with new, greener systems. However, careful examination of Urban Redevelopment Authority (URA) procedures (URA, 2013a) reveals that measures to facilitate changes to the shell are incorporated into the implementation measures. This indicates that the need for buildings to remain economically sustainable by facilitating new uses takes precedence over preservation of original structure.

Two case studies of building adaptations – a shop house and a contemporary office – in the CBD of Singapore, that come under the above adaptation guidelines are presented to discuss the sustainability implications of the building adaptations practised in the Singapore context. The main methodology used in this research is deductive reasoning based on published information on the two buildings selected.

BUILDING ADAPTATION AS A MEASURE TO MINIMISE CONSTRUCTION WASTE – CASE STUDIES

Traditional Shophouses in Singapore are a building typology that is subjected to conservation guidelines. The selected case study, the former Lucky Book Store, now a private residence (in Joo Chiat Place in the east of Singapore), is a conversion project that won URA Architectural Heritage Award in 2013 (Urban Redevelopment Authority Singapore, 2013). The current owners, having grown up in the area, have an affinity to the location. This is evident in the result, which is more sympathetic to the original design. The façade which was covered in several layers of paint has been exposed and preserved with clear sealant, unlike the joyful colours of certain other adaptations, such as Boat Quay. Although the interior is modern it retains its original character and details of the building. However, some internal partition walls and service area of the original building have been demolished to accommodate modern living requirements along with connectivity with a new section constructed at the rear of the property. Being located in an area classified as 'secondary settlement zone' by the conservation guidelines (Urban Redevelopment Authority Singapore, 2011), the focus is on preserving the streetscape and new rear extensions with a maximum four-storey height are permitted. However, the rear section, in this case is single-storey so that the spirit of shophouse living – which is urban liveability at low-resource cost involving natural ventilation and lighting achieved through the use of courtyards or air-wells – is preserved.

The contemporary adaptation case study selected is the former East Asia Bank building also known as 137 Market Street (137MS). Originally constructed with pre-stressed RCC in 1970s style with a masonry façade, the 14-storey building was destined for demolition as 25% of the floor space was vacant while the M&E system and the façade were also outdated (Ho, 2014). While enlarging the lift core to accommodate modern office demands was considered impractical, the existing foundations were not sufficient to support the additional floor space that was allowed by the Master Plan revisions since the initial construction. Located in the CBD with the building occupying the whole site, demolition and reconstruction was considered to be not only disruptive to neighbouring premises but also lengthy due to the need to schedule construction work during off-peak times.

Adaptation used a load-balancing strategy of replacing four levels of the heavy concrete structure with six levels of lighter steel structure. The use of steel in the expansion also enabled offsite fabrication of entire sections of the building which were hoisted into place overnight. This was valuable as space for storage of construction materials was very limited on site. The new façade uses staggering high performance bay windows with low-e double glazing, which can remain open even during rainy weather. The adapted building which used 50% of the existing structural elements, high use of green concrete, recycled materials and a pre-engineered building system in addition to 25% lower than the target energy use achieved only Green Mark GoldPlus rating rather than Green Mark Platinum rating.

DISCUSSION AND CONCLUSIONS

Currently efforts to minimise construction waste in Singapore seem to focus on the management of end-of-life waste from buildings. With building renewal rate being as low as 5%, measures to adapt and reuse existing buildings can be much more effective in reducing construction waste, while eliminating the need to recover and recycle construction waste, and can therefore be more sustainable.

While motivation for adaptation is generally the desire to reuse buildings with historical significance, in the Singapore context, where land and resource scarcity drives the policy decisions, this is driven mainly by the desire to maximise the allowable floor space. As guidelines are focused on heritage buildings being relevant to current times and also economical, if in prime locations, historic buildings are often treated primarily as shells with façades preserved while the interiors almost completely gutted and re-constructed while intensification of use is achieved by vertical and horizontal additions. As seen from previous adaptations, the desire to achieve economic sustainability can at times conflict with conservation guidelines unless there is personal attachment to the place as seen from the shophouse case study presented here. Evidence suggests that this is generally the exception rather than the norm.

Although adapting existing buildings to modern requirements could be more sustainable than reconstruction, current development policies and building rating scheme in Singapore do not appear to promote adaptive reuse. Currently, the focus of Singapore building rating system Green Mark is on energy efficiency with sustainable material use being limited to around 10% of the total score for any variation of the Green Mark scheme. As evident from the contemporary case study of 137MS, which achieved only Green Mark Gold Plus rather than Green Mark Platinum, measures to adapt and reuse buildings are currently not rewarded by the rating scheme.

The main findings of this investigation are:

- Waste minimisation needs to cover all life stages of a building and different measures such as management, avoidance, recovery and reuse;
- Adapting existing building stock for modern uses is more important compared with strategies to reduce construction waste from new buildings;
- Context-specific drivers determine the level of success of measures; and
- Building rating tools and incentives can promote more sustainable practices.

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