Evaluation of Using BEAM-PLUS to Facilitate Waste Reduction in Building Construction

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ABSTRACT

As with many other countries, Hong Kong has experienced severe social and environmental problems because of construction waste. Therefore, promoting resource conservation and implementing waste reduction measures are a priority in the building industry's attempt to achieve sustainable construction goals. Green building construction must be underlain by the consideration of net positive contributions to urban environments, the avoidance of waste generation and the promotion of the material life cycle concept. Sustainability in the industry is also strongly driven by the use of environmental assessment tools for buildings. Accordingly, there is a need to evaluate the effectiveness of such tools in promoting waste reduction.

Since 2011, certification under the Building Environmental Assessment Method (BEAM-PLUS) has been amongst the prerequisites for the granting of gross floor area concessions for Hong Kong's development projects. This research was aimed at evaluating the effectiveness of BEAM-PLUS in facilitating waste reduction in the building construction sector. It assessed the appropriateness of the waste reduction criteria in BEAM-PLUS and the waste reduction level achieved when such criteria are adopted. A questionnaire survey, a case study of recently completed buildings and face-to-face interviews were conducted to collect data. The findings reveal that although waste control awareness has increased in recent years, it remains neglected by the stakeholders of building construction. Incentives provided in the Material Aspect (MA) criteria of BEAM-PLUS can serve as an effective motivation for reducing waste, although some credits may be difficult to achieve. MA credits should be divided into sub-credits to encourage the wider adoption of MA in the building industry. BEAM-PLUS should incorporate additional waste reduction measures to increase the awareness and adoption of life cycle thinking in the construction industry.

Keywords: *BEAM PLUS, green building assessment, waste reduction*

1. INTRODUCTION

Hong Kong is an extremely dense region with a population of about 7.3 million (Censtatd, 2016). It is currently confronted with a shortage of reclamation sites and landfill spaces because of limited available land. The construction industry of Hong Kong accounted for 4.4% of the country's GDP in 2014. It exerts a major effect on economic and environmental issues given that it consumes substantial energy and other resources and generates a significant amount of construction waste. Construction waste accounted for 25% of the total intake at landfills. In 2015, nearly 66,000 tonnes of construction waste were generated each day. With the current waste generation trend, the three existing landfills in Hong Kong will be full by the late-2010s, and public fill capacity will be depleted in the near future (EPD, 2014).

To address the critical issue of construction waste, the Hong Kong government has enacted various regulations, codes and initiatives that promote waste reduction. Amongst these measures, the Construction Waste Disposal Charging Scheme is recognised and proven to be effective at reducing waste that is discharged to landfill sites (Tam, 2008; Lu and Tam, 2013; Yu et al., 2013). Similarly effective regulations are the 3R principles (reduce, reuse and recycle) and the 'polluter pays' principle. Adherence to the 3R principles have become common practice amongst policy makers and practitioners of sustainable solid waste management (Memon, 2010; Napier, 2012).

Amid these achievements, however, an important consideration is that effective construction waste management (CWM) does not depend solely on government efforts but also on collaboration amongst industry players. Poon et al. (2004) reported that on-site waste sorting and recycling are regarded as a low priority by contractors mainly because of low environmental awareness within the industry and because of the constraints represented by limitations in site areas. In an investigation of stakeholders' willingness to apply waste minimisation strategies, only the government showed a positive attitude, whereas clients, contractors and designers remained neutral (Tam, 2008). In recent years, contractors' attitudes and behaviours towards on-site sorting and recycling have improved; such improvement has led to more effective reuse and recycling of resources given that waste sorting is implemented on-site at the source (Yuan et al., 2013). Interestingly, public projects exhibit better on-site sorting performance than do private projects (Lu et al., 2016). Yuan et al. (2013) pointed out that stakeholders' attitudes towards waste sorting in construction sites are still regarded as the most critical factors for enhancing Hong Kong's CWM. As Hong Kong's green building tool, BEAM-PLUS incorporates waste reduction and recycling criteria in the assessment of sustainability in building construction. However, Ng's (2014) examination of 23 platinum projects revealed that Material Aspects (MA) only achieved 50% among all four categories. This percentage was the lowest amongst all the four categories of the evaluation method.

Given this backdrop, the current research was conducted to assess the use and achievability of waste-related MA credits and their effectiveness in reducing waste generation in Hong Kong projects. Data were collected through a questionnaire survey and interviews. An in-depth case study was also carried out. On the basis of the results, recommendations for the construction industry were formulated.

2. METHODS

As previously stated, data were collected through a survey and individual face-to-face interviews that were targeted towards various professionals in the construction industry. The survey was designed to assess the appropriateness of the waste reduction criteria in BEAM-PLUS. The face-to-face interviews served as supplementary avenues from which to investigate the issues addressed in the survey. These issues included challenges and opportunities and recommendations for strengthening waste reduction through BEAM-PLUS. A total of 32 respondents participated in the survey, and 20 professionals participated in the interviews.

The survey respondents and interviewees were asked to assign Likert scale rating that reflects the perceived importance or effectiveness of each item studied. The rating ranged from –2 (e.g. lowest importance) to 2 (e.g. highest importance). The data collected were then analysed using statistical methods, and presented in tables with rankings.

The in-depth case study involved a project-oriented survey and a face-to-face interview. The project-oriented survey consisted of questions regarding the BEAM-PLUS criteria that practitioners have attempted to satisfy, and detailed information related to the perceived relevance and achievability of the criteria within the MA category. The examined project was completed in 2015 (Table 1). The survey data were collected from a Hong Kong building industry contractor who was involved in the project. Additional data were derived via a face-to-face interview with the contractor to substantiate the survey data.

Project description	3 towers with around 27 floors 2-level podium
Year of construction	2013-2015
Site area (m^2)	8,250
CFA (m^2)	66,000
BEAM Plus version	BEAM Plus New Buildings version 1.1
BEAM Plus rating	Provisional Gold
Podium construction	Cast-in-situ (Timber formwork)
Tower construction	Prefabricated non-structural elements and cast-in-situ (95%Steel formwork and 5% Timber formwork)
Precast % (by volume per typical floor)	15%
Type of prefabricated elements	Precast external facade walls and curtain wall
Design characteristics	Repetition on every typical floor Variations of layout on each towers

Table 1: Details of Hong Kong BEAM-PLUS case study

The total amount of construction waste generated and the total amount of construction waste recycled in the project were recorded by the contractor in tonnes per month, as reflected in the landfilling documentation (by truck) and receipt from the recycling company. The waste quantity was calculated with the same method adopted by Jaillon et al. (2009) and expressed in Equation 1. The data were then compared with those on the projects constructed under Hong Kong's Joint Practice Notes (JPN) policies of 2001 and 2002 (see Jaillon et al., 2009). The average waste quantity generated by the JPN-regulated residential building projects of the private sector was 0.23 tonnes/m^2. The calculation method for comparing our case project with the projects investigated in previous research is shown in Equation 2. The calculation method for comparing the recycled construction waste is indicated in Equation 3.

Ratio of Waste Quantity: Cw (ton)/ CFA (m^2)

Equation 1

Where Cw = Construction waste generated; CFA = Construction floor area

Level of reduction: (Pn - Po)/ Po x 100%

Equation 2

Where Po = Waste quantity from the average of projects using prefabricated technology from the private sector (Jaillon et al., 2009); Pn = Waste quantity from the project in this research.

Rate of recycled construction waste: Wr/ Cw

Where Wr = Recycled construction waste; Cw = construction waste generated

Equation 3

3. RESULTS

The survey findings reveal that factors 4, 9 and 15 were the most frequently attempted MA credits (Table 2). The results also reflect that, overall, MA credits are satisfied to a lesser extent than are other credits. Ng's (2014) study confirms these results.

Factor No.	Factors	Rank
1	MA 1,1 credit for the reuse of 30% or more of existing sub-structure or shell	10
2	MA 1,2 credits for the reuse of 60% or more of existing sub-structure or shell	13
3	MA 1,1 additional BONUS credit for use of 90% or more of existing substructure or shell	16
4	MA2, 1 credit for demonstrating the application of modular and standardized design	2
5	MA3, 1 credit when the manufacture of 20% of listed prefabricated building elements has been off-site	4
6	MA3,2 credits where the manufacture of 40% of listed prefabricated building elements has been off-site	14
7	MA 4, feasible and at least 50%of the listed items in the relevant BEAM checklists could be achieved in residential development	10
8	MA 4, feasible and at least 70% of the listed items in the relevant BEAM checklists could be achieved in other building types	9
9	MA 6, 1 credit for demonstrating at least 50% of all timber and composite timber products used in the project are from sustainable sources/ recycled timber	3
10	MA 7, 1 credit for the use of recycled materials contributing to at least 10% of all materials used in site exterior surfacing work, structures and features	6
11	MA 7, 1 credit where at least 10% of all building materials used for facade and structural components are recycled materials	8

12	MA 7, 1 credit where at least 10% of all building materials used for interior non-structural components are recycled materials	6
13	MA 10, 1 credit for demonstrating that at least 30% of demolition waste is recycled	5
14	MA 10, 2 credits for demonstrating that at least 60% of demolition waste is recycled	15
15	MA 11, 1 credit for demonstration that at least 30% of construction waste is recycled	1
16	MA 11, 2 credits for demonstration that at least 60% of construction waste is recycled	12

Table 2: Frequency of MA credit attempted in respondents' company's BEAM-PLUS NB projects

3.1 Appropriateness of MA credits

The MA category of BEAM-PLUS can be regarded as a guideline for measuring waste reduction in the construction industry. Appropriate requirements for acquiring MA credits should be practical and efficient to promote construction waste reduction. These credits are key to encouraging the increased adoption of waste reduction measures and advancing the implementation of BEAM-PLUS measures.

As shown in Table 3, the survey respondents identified factors 1 and 2 and factors 6 to 8 as having appropriate percentage levels. However, for factors 1 and 3 to 5 and 9 and 10, the respondents suggested reducing the required percentage levels. Most of the interviewees opined that some of the credits are difficult to achieve because of high requirements and limitations with respect to building types, land area restrictions and material specifications. In factors 9 and 10, (MA 10 - Demolition Waste Reduction and MA 11 - Construction Waste Reduction), which directly affect the waste diverted to landfills, 1 and 2 credits are awarded for at least 30% and 60%, respectively, of demolition/ construction waste recycled. Most of the respondents expressed a preference for lowering the percentage levels to 10% to 20% given that the original levels are ambitious. That is, they are difficult to achieve because of time limitations (demolition and sorting of waste/ materials require additional time) and lack of on-site storage and sorting spaces (small sites in dense urban areas). With regard to the second credit for the recycling of demolition/ construction waste, the majority of the respondents prefer lowering the percentages to 10% to 40% because satisfying a 60% recycling rate is laborious. The interviewees also mentioned that most existing buildings are demolished prior to the awarding of construction projects. Some architects pointed out that waste recycling may be difficult for them to control/ monitor given that contractors take the lead in handling both demolition and construction waste. Additionally, most of the contractors stated that recycling companies accept only some recycled materials and may be the primary handlers of waste at construction sites located near recycling points. Furthermore, the labour cost associated with sorting waste into recyclable material is high. To conclude, the recycling rate at construction sites can be increased if sufficient time and space are provided and if the market for

Factor No.	Factor	Decrease the level	Remain the level	Increase the level
1	MA2, 1 credit for demonstrating the application of modular and standardized design (over 50%)	✓	✓	✕
2	MA3, 1 credit when the manufacture of 20% of listed prefabricated building elements has been off-site	✕	✓	✕
3	MA3,2 credits where the manufacture of 40% of listed prefabricated building elements has been off-site	✓	✕	✕
4	MA 4, feasible and at least 50%of the listed items in the relevant BEAM checklists could be achieved in residential development	✓	✕	✕
5	MA 4, feasible and at least 70% of the listed items in the relevant BEAM checklists could be achieved in other building types	✓	✕	✕
6	MA 7, 1 credit for the use of recycled materials contributing to at least 10% of all materials used in site exterior surfacing work, structures and features	✕	✓	✕
7	MA 7, 1 credit where at least 10% of all building materials used for facade and structural components are recycled materials	✕	✓	✕

8	MA 7, 1 credit where at least 10% of all building materials used for interior non-structural components are recycled materials	✕	✓	✕
9	MA 10 and 11, 1 credit for demonstrating that at least 30% of demolition and construction waste is recycled	✓	✕	✕
10	MA 10 and 11, 2 credits for demonstrating that at least 60% of demolition and construction waste is recycled	✓	✕	✕

Table 3: Appropriateness of percentage level in MA credits to promote construction waste reduction

3.2 Effectiveness of MA credits in reducing waste

The examined project attempted to achieve the following MA waste-related credits:

- MA2 modular and standardised design: Over 50% of building elements are designed as modular and standardised components to minimise construction cut-off waste.
- MA4c adaptability and deconstruction: A total of 50% or more of the structural design is created for flexibility in future use to reduce demolition waste from future changes.
- MA6 sustainable forest products: A total of 50% or more of timber and composite timber products are obtained from sustainable sources or recycled timber to help reduce resource extraction and protect forest ecology.
- MA7b recycled materials: A total of 10% or more of the building materials used in façade and structural components are recycled materials to encourage waste to be recycled and indirectly reduce waste disposal.
- MA11 Construction Waste Reduction: Approximately 35% of construction waste is recycled to help reduce the disposal of construction waste.

According to the data, the waste generated from the case project was 0.21 tonnes/m^2 (all construction waste generated per CFA). Data from Jaillon et al. (2009) show that the quantity of waste generated per CFA for high-rise residential buildings in the private sector was 0.23 tonnes/m^2 when prefabrication techniques were used and 0.30 tonnes/m^2 when conventional methods were adopted. The construction waste generated in the project examined in the present study was 30% lower than those produced with conventional techniques (Jaillon et al., 2009). As indicated in the interview data, the recycled waste in our case project were mainly steel (95.5%) and paper/ cardboard packaging (4.4%). Steel formwork was reused on typical floors, whereas timber formwork was reused only two to three times.

As shown in the survey, 45% of participating professionals believe that BEAM-PLUS cannot promote waste reduction, whereas 34% expressed neutral attitudes. These findings may be attributed to the achievability and appropriateness of the BEAM-PLUS credits. They also reflect that the BEAM-PLUS credits still have room for improvement in terms of promoting waste reduction. A necessary requirement is to compel contractors to quantify generated waste for practitioners to effectively reduce waste.

4. CONCLUSION

The effectiveness of waste reduction via BEAM-PLUS was assessed on the basis of a survey, face-to-face interviews and a case study. The waste reduction criteria in BEAM-PLUS were evaluated as insufficient given that waste reduction is not regarded as a priority in the Hong Kong building industry and that practitioners rarely satisfy MA criteria owning to low overall weighting, lack of required minimum thresholds and difficulty in achieving credits. Furthermore, the MA category provides no criteria for enhancing cooperation between builders and designers in waste reduction, and no accurate figure reflects the amount of waste reduced after attempts to acquire MA credits. On the basis of the interview findings, the following recommendations were developed:

- Break down credits into sub-credits and provide detailed explanations and more specific environmental measures for easier attainment of MA credits.
- Provide a criterion that enables requests to reduce waste generation (tonnes/m^2), on the basis of total waste generation data collected over the last few years through BEAM-PLUS (MA 11) and EPD (trip ticket system).
- Providing a ratio of MA aspects according to the scope of BEAM-PLUS as a minimum threshold may be un-suitable.

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