# Essential features of a building services standard method of measurement in Malaysia

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## Abstract

**Purpose** – The purpose of this paper is to examine the need to develop building service standard method of measurement (BSSMM) that would provide a home ground advantage and a framework for managing the cost of building services by quantity surveyors.

**Design/methodology/approach** – A review of previous research on the rules of measurement was carried out. This exercise provides the basis for questionnaire design which was administered to quantity surveyors in Malaysia construction industry.

**Findings** – The results indicated the need to develop BSSMM. In total, 23 variables were identified as essential features of such standard method of measurement. These variables were grouped into three categories and a priority ranking of them was carried out. The analysis revealed a strong agreement among quantity surveyors on the priority ranking of the essential features of the BSSMM.

**Research limitations/implications** – Although, the research would assist industry stakeholders in developing BSSMM that reflects local and international best practices, there is need to further investigate how the rules of the BSSMM could be aligned with construction industry classification systems.

**Practical implications** – The availability of information and computer technology (ICT) tools has transformed the traditional practices in the industry and offered values to quantity surveyors, but if quantity surveyors' tools cannot be consolidated and incorporated into emerging ICT applications, then QS collaboration will be difficult, and the requirements for electronic data exchange will be impractical. Therefore, this type of standard method of measurement will facilitate cross-referencing and coordination between BoQ and other documents such as drawings, specifications and tender produced by other project participants and thereby lay efficient foundation for effective collaboration of quantity surveyors in BIM model. In addition, the BSSMM will not only comply with local industry practices, it will also be internationally compatible.

**Originality/value** – Adoption of a structured format based on BSSMM to present building services cost information is essential in view of the increase in the value and complexity of building services in modern buildings. However, there is need to enhance quantity surveyors' knowledge in the technology and cost management of building services so as to ensure the reliability of cost advice provided to clients. This goal would be partly achieved through education and training of Quantity Surveyors/Cost Consultants in the interpretation and use of the rules of an SMM.

**Keywords** Malaysia, Standards, Construction management, Cost estimates, Building services, Quantity surveying

**Paper type** Research paper

## 1. Introduction

Building services is a specialised area of the construction industry in terms of the nature of work, scope, technicality and the parties involved. The design and installations are different from the building structure and finishes and some important design information are often not received in good time or produced until the installation stage. Meanwhile, there is need to have a budget for building services to act as a guide for determining a fair

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price prior to awarding a contract (Swaffield and Pasquire, 2000). However, reliable estimation of costs of building services remains the most difficult to achieve at the early stage of building design process (Aibinu *et al.*, 2015). Industry stakeholders expect the cost of building services to be effectively managed because of the increasing complexity of modern buildings, which has tremendously increased the significance of building services and their relative cost to the total cost of building projects (Yong *et al.*, 2004; CIDB, 2009a, b; Kumar, 2009). The increase in the cost and complexity of building services systems has also increased the range of options available to designers (Churcher, 2009; Cartlidge, 2011; Yik *et al.*, 2013). As a result, building services costs have gone up from the traditional 10-30 per cent of total building cost to between 10 and 70 per cent of the total cost and unless this increase is effectively managed, it will expose clients to a significant cost risk (Langdon, 2010; McCaffrey, 2011). Therefore, detail measurement and quantification of building services is required to improve both clients' satisfaction and the reliability of building services early budget estimate (Babalola, 2012; Ashworth *et al.*, 2013). This may require the input of specialist building services quantity surveyors (RICS, 2000; McCaffrey, 2011).

Following on from that, measurement and quantification of building works based on the rules of standard method of measurement (SMM) is one of the most important traditional role of quantity surveyors (Ashworth *et al.*, 2013), but this is rarely used for services elements (Swaffield and Pasquire, 2000; Sabaria, 2009; CIDB, 2009b; Babalola, 2012). The rules for measuring building services are contained in sections Q (plumbing and mechanical installations) and R (electrical installations) of the existing SMM used in Malaysia (SMM2). These rules are not adopted by practitioners when dealing with building services because quantity surveyors only allow prime cost sums in their BoQ (Kumar, 2009). This is exacerbated by the fact that services engineers who manage the cost of building services are not conversant with the rules of existing SMM (Amuda-Yusuf and Mohamed, 2012). As a result, measurement and quantification of building services is not standardised and there is no uniformity in practice as different consultants use different approaches, vocabularies and naming conventions (CIDB, 2009a, b; Sabaria, 2009).

The consequences of the current practices in cost management of building services, in Malaysia, include disputes in final measurement of work, difficulties in agreeing the value of additional works, dificulties in determining the actual quality of work anticipated at tender stage and problems in tender evaluation (Yong *et al.*, 2004; CIDB, 2009b; Entrusty Sdn Bhd, 2011). Variations of between 10 and 70 per cent in initial and final contract sum of building services are common depending on the complexity of building services projects. Building services related change orders resulting from incomplete information in tender BoQ have been found to account for as much as 15-30 per cent of cost overruns resulting into late delivery of building services projects (Amuda-Yusuf *et al.*, 2013a). The ripple effects of this situation include unhappy clients and non-availability of reliable cost information on previous building services projects. Since building services bills of quantities are not detailed enough, they do not provide sufficient information in order to analyse the relationship between the quality and cost of building services on previous projects. Therefore, this study is put forward based on the assumption that, a building services standard method of measurement (BSSMM) is required to provide a basis for cost management of building services. However, to be acceptable, it must reflect local practitioners' preferences and be adaptable to emerging industry requirements. The purpose of this standpoint is twofold.

First, it is critical that the BSSMM development involves a combination of knowledge and expertise from services engineers, quantity surveyors, specialist designers and contractors to determine cost significant attributes of building services to be measured. The need to involve a combination of knowledge and expertise is based on the notion that, as in Malaysia, the rules for measuring building services is also contained in existing SMMs from other countries like UK, Hong Kong and Singapore but previous studies seem to suggests that the rules are not widely used for services elements in these countries and the problems associated with the alternative methods used is widely reported (Mok *et al.*, 1997; Nanayakkahara and Fitzsimmons, 1999; Swaffield and Pasquire, 2000; Yong *et al.*, 2004; Buys and Mathews, 2005; Yu and Ive, 2008; McCaffrey, 2011; Babalola, 2012; Ashworth *et al.*, 2013; Aibinu *et al.*, 2015). It is also important to note that there are some specialist QS firms that manage cost of building services in UK and European countries (McCaffrey, 2011), but these firms mostly employed services engineers for M&E quantity surveying work and they adopt their specific organisation's classification and measurement approaches (Maitland, 2009; Amuda-Yusuf, 2009). Since quantity surveyors are not sufficiently skilled in the technology of building services, therefore, difficult for them to routinely use SMM rules for quantification of services elements as done for building fabrics and finishes (Mcmillan, 1992; Swaffield and Pasquire, 2000; RICS, 2000; Babalola, 2012). Thereby, making it difficult to have reliable cost information for building services elements and the existing price indices usually ignore tender price movement of building services subsystems as services elements are mostly not procured through the conventional bills of quantities route (Swaffield and Pasquire, 2000; Babalola and Adesanya, 2008; Yu and Ive, 2008; Babalola, 2012). Meanwhile the services engineers have good knowledge of the supply chain and have established long-term relationships with the specialist designers and contractors (Marsh, 2003; Yik *et al.*, 2013), but they are not conversant with the rules of measurement (Amuda-Yusuf *et al.*, 2013a). In addition, the specialist building services contractors have a more detail and reliable methods for classifying and preparing cost breakdown for building services but these are not in line with any method of measurement and often contains unnecessary details (Swaffield and Pasquire, 2000). It is therefore imagined that BSSMM could be more acceptable and widely used if the views of services engineers, specialist designers and contractors are captured and articulated in the classification of building services components and subcomponents, definition of cost significant attributes of these components and application of the rules in the existing SMMs. The BSSMM may have to take a more inclusive approach to measurement process like the civil engineering standard method of measurement (CESMM) so as to reduce the number of items that have to be measured.

Second, building information modelling signifies a shift away from traditional two dimensional design practices, to 3D design solutions, 4D schedule modelling and five-dimensional (5D) cost management (Arayici *et al.*, 2012; RICS, 2014). Studies have revealed that, 5D BIM may require that the rules of measurement be filtered into a BIM model to enable the automation of quantity extraction and estimating by cost consultants and estimators (Olatunji *et al.*, 2010). However, to enable quantity surveyors to benefit from BIM technology the project team may have to agree on a set of rules which are defined from the cost estimating and planning viewpoint (RICS, 2014). To meet these requirements a BSSMM may need to be based on local classification systems which will support local practitioners' preferences and lay the foundation for quantity surveyors and cost consultants' collaboration in a BIM model.

In essence, adoption of the classification systems in SMMs from other countries may not meet the requirements of local industry practices. For instance, the first edition of the UK's SMM7, published in 1988, was based on the common arrangement of work sections (CAWS-UK-specific classification systems) while the second edition published in 1998 was based on the unified classification for the construction industry (Uniclass – also a UK-specific classification system) (Winch, 2010; Finch, 2012; Cartlidge, 2013). Moreover, in order to satisfy BIM requirements, the SMM7 is now out of date in the UK and has been replaced with the RICS new rules of measurement (NRM2) (Finch, 2012). Although the classification in NRM2 is based on standard form of cost analysis systems, it can still be mapped onto both CAWS and Uniclass (Finch, 2012; Cartlidge, 2013). Similarly, the "Singapore standard code of practice for construction electronic measurement standards" CP97 parts 1 and 2 is aligned with the Singapore classification of construction resources information and construction computer-aided design, to ensure that a common classification and coding system is adopted across the industry (Yong *et al.*, 2004; Boon and Prigg, 2012). Australia's SMM5 is also based on the national specification of Australia (NATSPEC). Therefore, any Malaysian-based SMM needs to be aligned with local classification systems so as to enable efficient collaboration by cost consultants in BIM-based quantity extraction and estimating for building services.

Therefore, the focus of this study is to determine the essential features of a BSSMM that could take into consideration the cost significant attributes of building services components while also reflecting the preferences of local industry practitioners. The study was carried out through a literature review and a questionaire survey. The scope of the study covers the determination of features of a BSSMM that are required to properly define cost significant attributes of the subsystems of building services. Meanwhile, this study was not designed to present an entirely different set of rules of measurement for building services from scratch. Instead, it was intended to suggest improvements to the existing rules of measurement related to building services, especially in the areas of emerging information and computer technology (ICT). In addition, the study set out to establish cost significant attributes of building services subsystems by involving all necessary stakeholders (quantity surveyors; consulting services engineers, building services specialist designers and installers).

A standardised building services BoQ will primarily provide a good basis for tendering and pricing purposes during the pre-contract stage of a construction project. At construction stage, it will assist in the monitoring of progress for interim payments, variations and contractors' claim. Upon completion of the project, the cost data will provide a good basis for cost planning of future projects. All this can be achieved through the use of a BSSMM because the use of a SMM, to prepare building services BoQ, could significantly enhance the reliability of contract prices established at the early stage of building services projects.

## 2. Literature review

### *2.1 Standard method measurements*

An SMM can be described as an agreed set of rules defining what and how an item is to be measured. The first SMM was published by the RICS in 1922 and the latest edition is the seventh edition (SMM7), which has been replaced by the RICS NRM2 in 2013. According to the Institution of Surveyors Malaysia (2000), the drafting and arrangement of work sections in the SMM of building works (SMM2) currently in use in Malaysia is based on the British SMM6. Unlike the traditional

arrangement of work sections in SMM2, the British SMM7 and SMMs in other countries such as Singapore, Australia and New Zealand are based on the construction industry classification systems (CICSs) used in their respective countries. CICSs are used to support the information management process in the construction industry. The classification structure in a CICS defines the concept hierarchies that can be used for document classification, thereby providing a common framework for document organisation and management among project participants (Caldas and Soibelman, 2003). Examples of CICSs include the Master format and Uniformat used in North America, CI/SfB used in Europe, and Uniclass used in the UK (Winch, 2010).

According to Kang and Paulson (2000), CICSs consist of both a work breakdown structure for classifying information that comes from actual construction phases and an information management system for classifying materials. The British SMM7 was prepared to conform to the CAWS (Seeley, 1989; Goh and Chu, 2002; Gelder 2010), and the rules of measurement for each work section is in the same sequence. The construction electronic standards in Singapore were based on a code of practice for the classification of construction cost information (Goh and Chu, 2002; Yong *et al.*, 2004). A review of the fifth edition of Australian standard method of measurement (ASMM5) also shows that it was based on the NATSPEC.

Although the use of BoQ for procurement purposes is diminishing in more developed countries (Cartlidge, 2011), there are significant differences in the construction industries in developing countries and those in the developed or industrialised world (Ofori, 2000, 2014; Smith, 2002). As an example, the use of BoQ under traditional procurement system is still a common practice in Malaysian construction industry (Entrusty Sdn Bhd, 2011), and clients still insist on full BoQ under design and build procurement route in the country (Keat, 2013). Similarly, BoQ required for a lump sum contract based on the firm or approximate quantities will normally be prepared by the employer's quantity surveyor. Whereas under a design and build contract, the employer's project team will prepare the employers' requirements and the BoQ or quantified schedules of work will be prepared by either the main contractor or, the main contractor's work package contractors (RICS, 2012). Under the lump sum-plan and specification contracts, the contractors are still expected to quantify and calculate tender price based on the design and specifications provided by the client. Although this may be prepared by a QS engaged by the contractor and could be prepared based on one of three options: a full SMM BoQ, a builder's BoQ or an elemental cost plan. In this way it is more convenient for estimators to price an SMM-based BoQ more accurately than one which is not prepared to any particular method of measurement. In addition, price obtained by subcontractor based on this kind of BoQ will be more reliable (RICS, 2012).

### *2.2 Primary functions of SMM*

The primary functions of SMM according to Hughes (1981) are:

- standardising the system of subdividing construction work into component parts for the purposes of separate measurement and description;
- defining the limits of items inclusion and exclusion;
- defining items of temporary works as distinct from permanent construction;
- indicating the circumstances under which work will be carried out;

- indicating the circumstances which can affect costs significantly; and
- prescribing the method of determining the dimensions and calculating the quantities of the several items.

However, considering the current industry practices and emerging ICT in the global construction marketplace, for an SMM to perform its primary function as a standard framework for presenting cost information on construction projects it must lay efficient foundation for automation of taking off process to facilitate effective electronic document transfer in building information modelling (RICS, 2014). Nani *et al.* (2008) explained that certain SMM characteristics such as consideration for cost significant, ease of location of items, conciseness, consideration for cost analysis and consideration of users opinions are important for a good SMM. According to Nani *et al.* (2008) SMM development or revision are based on emerging technology, industry culture and legal framework which often differ from one country to the other. This underscores the desires for SMM with different characteristics in different countries.

### *2.3 Measurement of building services*

Building services systems comprise of all engineering systems associated with buildings other than civil and structural engineering works (Gura, 1984). According to Tao and Janis (2001), building services can be classified into mechanical systems, electrical systems and building operation systems. Similarly, sustainable enhancements, according to McCaffrey (2011), include the installation of combined heat and power; district cooling and heating; ground source heat pumps; and wind turbines, which are conventionally not included in the cost management of building services.

The primary objective of measuring and describing is to give the unit cost of a particular component (Fussell, 1971). The manner and method of presenting this information are set out under the appropriate heading of the detail rules of measurement. The measurement of building services can be simplified into three functional elements that apply to all types of supply installations, namely, source (e.g. boilers, air-handling equipment, transformers, standby equipment); distribution (e.g. piping, ducting, cable, wiring, conduit); and outlets (e.g. radiators, air grilles, lighting points, power outlets). For instance Murray (1997), considered plant and equipment as "source" and are usually enumerated in all cases, services run as "distribution" and are measured in linear metre from the source to the outlets while appliances are referred to as "outlets" and are also enumerated.

*2.3.1 Plant and equipment (source).* The cost of plant and equipment constitute a significant proportion of the building services cost. The cost could range between 25 and 70 per cent of the building services cost depending on the size of the building (Potts, 2008). There are varieties of equipment from different manufacturers with varying quality and lifespan. One of the most important information to determine the cost of the source equipment is the function of the building and the design standards applicable to each services component (Mathew and Howell, 2005). A specific design solution may increase the initial cost of building services equipment but could significantly reduce running cost. It is therefore, important that adequate information be given by services engineer before the correct price/cost could be determined prior to installations. Because of the composite nature of equipment, the rules of measurement require that they are enumerated (measured in numbers) (Murray, 1997; Oforeh and Alufohai, 1998; Oforeh, 2008).

*2.3.2 Services runs (distribution).* Services runs or distribution refereed to the medium through which the outputs of the plant or equipment are transferred to the endpoint. For example, cables are used to distribute electricity to various sockets of different rated capacity and lighting points. These distributions are concealed by using conduit pipes. Similarly, for water supply, these pipes are used to transfer water from the source to different sanitary wares and taps in a building. The waste water is also conveyed from sanitary fitting to septic tank and soak away or public sewer through pipes. This system is referred to as services run/distribution. The rules of a SMM require these items to be measured in linear metre and the accessories are enumerated. Where there is a need for any incidental work, they are measured in line with the rules of measurement which may be defined in other sections of SMM (Murray, 1997; Oforeh, 2008).

*2.3.3 Appliances (outlets).* The appliances/outlets are the endpoint of services runs where the building users make use of the services output. For example, the conditioned air generated by the chillers and transferred by air-handling unit through air conditioning ducts are discharged into the comfort zone through diffuser. Similarly, socket outlet enable electricity generated to be used by building users. Appliances/outlets are generally measured in numbers according to the rules of measurement (Murray, 1997; Oforeh, 2008).

### *2.4 Cost significant attributes of building services subsystems*

According to Murray (1997), cost significant attributes of building services components to be included in items description could be simplified as: general size and duty; if purpose made; method of fabrication; finish or treatment; materials; trade name/brand; reference to appropriate standards and required test; manufacturer's name and address; use or function; components; insulation; labours and ancillaries. Similarly, descriptions give the requirements for the information to be provided for each item measured. These descriptions must be derived from the tabulated rules. For example, the description of an item is required to include the types and qualities of materials, critical dimensions of materials, method of fixing, whether installing or incorporating the goods or materials into the work, and the nature and type of receiving background (Seeley, 1989; Ashworth and Skitmore, 1999; Dell'lsola, 2002; Nani *et al.*, 2008).

Dell'lsola (2002) observed that the description of cost significant attributes of items of work for the purpose of pricing and effective cost control can take the following forms:

- qualitative: what are the qualitative and performance properties of the components, including physical form, appearance, capacity and the desired level of workmanship;
- functional: this means the purpose that the building services components will serve after installations;
- materials: this has to do with the type of materials that makes up the component;
- installation methods: what methods will be required to put the components in position;
- locational: the part of the building where the items is located in the building (i.e. external, internal, plant rooms or roof top);

- dimensional: what are the physical dimensions of the components; and
- quantitative: information regarding the number of such components that need to be provided.

Critics of methods of measurement argue that a BSSMM will result in lengthy bills and for some types of work may seem to give an unnecessary number of items, or to divide work into such details that considerable time and thought will need to be given to billing and pricing (Yong *et al.*, 2004; Azman *et al.*, 2012). However, a BoQ can either list the work to be done in great detail or can use fewer items, some of which may contain "deemed to be included items". It is considered in this study that the measurement of building services can be broken down into three key components, namely: plant and equipment (standby equipment, boilers, central AC chillers and blower unit, water pump, transformer), services runs (services cables, cold and hot water supply pipes, HVAC ducts) and appliances (lighting fittings, radiators, closed circuit television, heating appliances).These three key components could form the basis for classification of building services with their associated cost significant attributes. Then the cost significant subcomponents to be included in item description or deemed included must be defined and agreed by practitioners (quantity surveyors, services engineers, specialist designers and contractors). As an example, in the quantification and billing of building services components (plant and equipment, services runs and appliances), the meaning and scope of each components and subcomponents must be indicated and must cover information such as qualitative, functional, materials, locational, installation methods and this information must be expressed in clear and precise terms as earlier explained.

This approach seems to be in line with traditional thinking of estimating which holds that, if items of work are properly defined (identification and description of cost significant attributes), then a more reliable rate values could be obtained which will serve as basis for cost monitoring and control (Skitmore, 1991; McCaffer *et al.*, 1999; Towey, 2013). Therefore, adopting a structured approach based on BSSMM for managing the cost of building services could ensure that (Molloy, 2007; Maritz and Du Rand, 2009; Cartlidge, 2013):

- good practice in the measurement of building services is achieved;
- the extent and quality of work envisaged will be visible;
- there is a uniform basis for preparing building services BoQ and pricing the associated items;
- there is reliable guidance on the effective communication of information relating to the quality and quantity of building services components to be provided; and
- there is a reliable basis for cost monitoring and control during site operations.

### *2.5 BIM and the rules of measurement*

BIM is an emerging technology that offers the capability to generate, take-off, count and measure directly from a model; however, the type of information on the model and type of cost estimate needed depend on the phase of the project, ranging from high-level schematic models during preliminary phases to detailed estimates as projects enter construction (Sabol, 2008). RIBA (2012) pointed out that the methodology adopted by cost consultants to provide and integrate cost information into the BIM model

will need consideration along with common methods of outputting area and quantity information into a robust cost plan that would take due cognisance of project-specific cost drivers and market trends.

Boon *et al.* (2011) investigated the evolution of quantity surveying practices in the use of BIM in New Zealand. They considered that to automate pricing by reference to a standard rate library, it is necessary to develop a coding system and use it consistently, as this is believed to be possible within the current context of BIM development. However, they reported that it is difficult to prepare quantities directly from BIM according to the rules of measurement contained in existing SMMs due to the composite nature of objects within the model. In another study, Boon and Prigg (2011) observed that there is significant non-alignment between the objects in BIM models and the trade items in an SMM because the objects in a 3D BIM model represent the components of the finished product, whereas the SMM calls for the quantification of the work to create that component on a trade-by-trade basis. However, Boon *et al.* (2011) stated that the Singapore construction industry seems to have made the most progress in agreeing a coding system to facilitate the exchange of information between computer-based design models and costing systems. They explained that the Singapore standard CP97: Parts 1 and 2 2002 "Code of Practice for Construction Electronic Standards" is aligned with Singapore Standards CP 93: 2002 Classification of construction resources information and CP 83: 2000 Construction computer-aided design, to ensure a common classification and coding system is adopted across the industry, which could provide a good basis for rule-based automated quantity extraction in a BIM model.

## 3. Research methods

### *3.1 Data collection*

From the literature reviews (Murray, 1997; Dell'lsola, 2002; Nani *et al.*, 2008; RICS, 2012), a total of 33 variables were identified as desired characteristics of an SMM that could be adopted to determine cost significant attributes of items of building works. These variables were grouped and categorised under three main headings, namely; SMM structure (14 variables); SMM items descriptors (14 variables) and the determination of measurement unit (five variables). A questionnaire was designed with the objective of determining the more important variables under the SMM characteristics. Respondents were requested to provide information on their perception on the need for separate building services SMM and the expected features of the proposed building services SMM. Questions related to the need to develop a building services SMM were measured using a five-point Likert scale with endpoints of "strongly disagree" and "strongly agree". On the features of SMMs, a five-point Likert scale with endpoints of "not significant" and "highly significant" was used to measure items. The target sample frame consists of quantity surveyors in consulting, contracting, clients and multidisciplinary firms as well as academia.

The target sample frame consists of quantity surveyors in consulting, contracting, clients and multidisciplinary firms as well as academia. Detailed information about quantity surveyors that are registered with the Board of Quantity Surveyors Malaysia (BQSM) from the board web site. The list of contracting firms registered and active with selected client organisations in the Southern Peninsular Malaysia in grade categories G5-G7 was obtained and questionnaire were sent to them. The decision to limit the sample to contractors between grade cadre (G1-G7) with a tendering capacity for only jobs ranging between RM200,000 and RM3,000,000 may not have QS in their permanent employment. A total of 400 questionnaires' were sent out to QSs in clients' consulting/multidisciplinary and, contracting organisations. A total of 98 valid

responses were thus received, representing an effective response rate of 25.4 per cent, as shown in Table I.

Previous studies in the construction industry show that the return rate achieved is fair and acceptable. The normal response rate to survey questionnaires in the construction industry is between 20 and 30 per cent (Akintoye, 2002; Dulaimi and Hwa, 2003). Similarly, a 20 per cent response rate was achieved by Adnan and Morledge (2003), in a survey of joint venture projects in Malaysia.

### *3.2 Content validity*

Prior to the commencement of actual data collection, the content validity of the instrument was determined by grounding it in the existing literature, including 18 existing SMMs from various countries. The pilot study of the measurement instrument before data collection was carried out. Researchers as well as practicing quantity surveyors were involved in the pilot study process. They were asked to review the questionnaire for structure, readability, ambiguity and completeness (Kumar, 2011). Specifically, questions relating to SMM development procedure and stakeholders to be involved were removed. In addition, the desire to include consultants' services engineers as survey respondents was cancelled based on the argument that they were not trained to use SMM and may not be able to correctly identify its desired features. Therefore, a semi-structured interview was used to obtain information from consultant services engineers. The final survey instrument reflected the observations and corrections made during the pilot study. The revised questionnaire was again sent to three quantity surveyors and a researcher owing to the corrections suggested in the first round of the pilot study. This process was to ensure that the questionnaire is a valid survey instrument that could elicit the desired opinion from industry experts on the essential features of an SMM (Kumar, 2011; Creswell, 2012). Approximately 48 per cent of respondents are registered quantity surveyors with BQSM and 56 per cent are from consultancy/multidisciplinary types of organisations, while none of the respondents has fewer than five years working experience, as shown in Table II.

## 4. Research findings

### *4.1 Need to develop a building services SMM*

On the need to develop an SMM for building services in the Malaysian construction industry, the results show that there is a need to develop an SMM for the cost management of building services (see Table III). About 75 per cent of respondents agreed that the use of an SMM would lead to more reliable estimates for building services. On the need for the industry to develop an SMM based on local best practices, 26 per cent strongly agree, 34 per cent agree, and 17 per cent moderately agree, while the remaining 23 per cent disagree. Approximately 60 per cent of respondents agree

**Table I.** Questionnaire distribution and response rate

| Type of organisation | No. of questionnaires Sent | Return | % return |
|---|---|---|---|
| Consulting/multidisciplinary | 215 | 59 | 27.44 |
| Contracting | 75 | 13 | 17.33 |
| Clients | 58 | 15 | 25.86 |
| Academic | 52 | 11 | 17.31 |
| Total (overall) | 400 | 98 | 24.5 |

| | Count | % |
|---|---|---|
| *Qualification* | | |
| Registered QS with BQSM | 47 | 48 |
| QS with MSc and above | 24 | 23 |
| Graduate QS | 21 | 25 |
| Others | 6 | 6 |
| *Years of experience* | | |
| 1-5 years | 0 | 0 |
| 6-10 years | 8 | 8 |
| 11-15 years | 49 | 50 |
| 16-20 years | 19 | 19 |
| Above 20 years | 22 | 23 |
| *Category of organisation* | | |
| Client | 16 | 16 |
| Contracting | 11 | 11 |
| Consultancy/multidisciplinary | 55 | 56 |
| Academic | 16 | 16 |

**Table II.**
Respondents' profiles

| Need for BSSMM | Strongly disagree (%) | Disagree (%) | Moderately agree (%) | Agree (%) | Strongly agree (%) | Total responses (%) |
|---|---|---|---|---|---|---|
| The use of an SMM for building services could lead to the production of more reliable estimates | 14 | 9 | 0 | 32 | 43 | 100 |
| The Malaysian construction industry should develop a local building services SMM | 0 | 23 | 17 | 34 | 26 | 100 |
| The proposed SMM should be developed along similar lines to those in other countries | 0 | 8 | 31 | 57 | 3 | 100 |

**Table III.**
Responses on the need for a building services SMM

that the proposed BSSMM should be developed along similar lines to those in other countries. The respondents' agreement on the need for building services SMM may be as a result of the problems with the current practices of using lump sum and performance specifications for the procurement of building services as found in the first phase of this study. In the first phase, Amuda-Yusuf *et al.* (2013b) found that clients had problems with lump sum contract for building services; variation orders are difficult to assess leading to arbitrary claims, arbitration and litigation; difficult to detect overdesign and over specification in building services installations and wide differences between as tender detail abstract (initial contract sum) and final detail abstract (final account). About 45 per cent of the interviewee believed that the use of SMM for building services could lead to improvement in the current practices, but they pointed out that not all items included in the existing SMM can be measured. Meanwhile, 10 per cent of the services engineers interviewed considered that they do not have knowledge of how to interpret the rules of measurement.

*4.2 Analysis and ranking of the essential features of building services SMM*

The essential features of an SMM were identified and grouped under three headings, namely, the structure of an SMM (14 variables), item descriptors (14 variables) and the determination of the unit of measurement (five variables). Severity index analysis was computed on the sample data by using statistical package for social sciences (SPSS) to rank the essential features of an SMM in order of their relative importance. Severity indices were used rather than mean scores because the data were ordinal in nature. The frequency analysis was first carried out to obtain the percentage rating (which was given as valid percentage by SPSS) of different features of SMM. The percentage ratings were then used to calculate the severity indices by adopting the formula in Equation (2) (Idrus and Newman, 2002):

$$SI = \left( \sum_{(i=1)}^{5} wi \right) X\, fi \times \frac{(100\%)}{n}, \tag{1}$$

where $SI$ is the severity index, $i$ the rating scale 1-5, $fi$ the frequency of responses, $n$ the total number of responses, and $wi$ the weight for each rating, while 100 per cent is the valid percentage of the rating scales (i.e. 1-5) as calculated by the SPSS.

The summaries of the statistical analyses are presented in Tables IV-VI. A total of 23 factors maintained a severity index between 65 and 95 per cent. The severity indices of the remaining ten factors fell between 50 and 65 per cent. This indicates that of the 33 variables identified as the essential features of SMMs, only 23 were regarded as more important by quantity surveyors.

*4.3 Tests of agreement between quantity surveyors*

The coefficient of variation (COV) was employed to compare the variability of different responses on the variables as suggested by Elhaq *et al.* (2005). The COV expresses the standard deviation as a percentage of the mean as shown in Equation (2):

$$COV = \frac{S}{X} \times 100\% \tag{2}$$

where $COV$ denotes the COV, $S$ the standard deviation, and $x$ the weighted sample mean.

The results show that the variation in responses on the essential features of SMMs is relatively low, as indicated by the COVs shown in Tables IV-VI. This is an indication that there is strong agreement between quantity surveyors on the selected variables. A total of 22 of the 23 factors identified had COVs ranging between 10 and 40 per cent. The COVs for the factors that were not selected were generally higher and ranged between 40 and 55 per cent. This was further analysed using Spearman's rank correlation coefficient.

*4.4 Kendall's test of agreement between ranks*

Kendall's concordance test and $\chi^2$ test was carried out to ensure that the variables (features of SMM) as ranked by quantity surveyors in various organisations were a result of consensus agreement between the different groups within the survey and to determine how significant the agreement is. In order to calculate Kendall's concordance test, the responses from quantity surveyors in each organisation were grouped into three, with academia grouped with consultants/multidisciplinary firms. The ranks

| Variables (SMM features) | COV | Severity index | Group ranking | Overall ranking |
|---|---|---|---|---|
| Easy to locate work items | 17.35 | 78.38 | 6 | 16 |
| Concise (avoid unnecessary detail) | 24.68 | 72.23 | 9 | 20 |
| Precise (rules not open to misinterpretation) | 21.59 | 78.89 | 5 | 15 |
| Simple to use | 43.05 | 32.49 | 14 | 33 |
| Thorough (logical inclusion of all works) | 44.43 | 36.25 | 13 | 32 |
| Reflection of local (Malaysian) practices and procedures | 15.69 | 85.87 | 2 | 9 |
| Adaptability to all procurement systems | 18.16 | 83.85 | 4 | 12 |
| Consideration of cost significant items | 17.19 | 83.20 | 3 | 13 |
| Consideration of cost analysis | 26.11 | 76.93 | 8 | 17 |
| Based on essential good practices | 21.51 | 76.50 | 7 | 18 |
| Consideration of stakeholder opinions | 39.81 | 55.82 | 12 | 27 |
| Accommodation for custom classification | 28.34 | 63.84 | 10 | 24 |
| Consideration of local jargon | 26.25 | 67.45 | 11 | 23 |
| Adaptability for automated quantity extraction in BIM | 18.04 | 91.63 | 1 | 2 |

**Table IV.** Ranking of the desired structure of BSSMM

| Variables (BSSMM features) | COV | Severity index | Group ranking | Overall ranking |
|---|---|---|---|---|
| Identity of work item | 18.30 | 85.99 | 3 | 6 |
| Materials required for the work | 21.32 | 85.92 | 4 | 7.5 |
| Location of the work item | 20.18 | 87.35 | 2 | 5 |
| Standard of workmanship required | 22.16 | 84.08 | 5.5 | 10.5 |
| Function of elements produced by the work | 31.78 | 59.80 | 12 | 26 |
| Dimension of the M&E components | 20.05 | 73.47 | 8 | 19 |
| Treatment of materials involved | 21.47 | 81.43 | 7 | 14 |
| Handling of materials | 43.60 | 68.98 | 9 | 21 |
| Geometry or shape of the component involved in the work item | 50.71 | 60.82 | 11 | 25 |
| Number of discrete items in a lumped quantity | 37.40 | 67.76 | 10 | 22 |
| Restriction to work (if any) | 44.77 | 55.71 | 13 | 28 |
| Sundry components (e.g. fittings) | 37.44 | 54.90 | 14 | 29 |
| The background to which item is fixed | 13.84 | 90.82 | 1 | 3 |
| The quantity involved | 33.19 | 84.08 | 5.5 | 10.5 |

**Table V.** Ranking of SMM item descriptors

| Variables (BSSMM features) | COV | Severity index | Group ranking | Overall ranking |
|---|---|---|---|---|
| Physical state of building services components (solid, liquid or gas) | 10.91 | 92.25 | 1 | 1 |
| Shape of components of work | 17.74 | 85.92 | 3 | 7.5 |
| Number of dimensions of components | 18.35 | 88.37 | 2 | 4 |
| Units of quantifying in a factory (for prefabricated items) | 54.73 | 52.04 | 4 | 30 |
| Unit as available in local markets | 40.35 | 44.10 | 5 | 31 |

**Table VI.** Ranking of measurement unit determination

resulting from the percentage ratings and severity indices shown in Tables IV-VI were used to calculate Kendall's coefficient of concordance ($W$) between ranks using the formula (Siegel and Castellan, 1988):

$$W = \frac{s}{k^2\left(N^3 - N\right)/33} \tag{3}$$

where $s$ is the sum of squares of deviation of ranking sum from mean, $k$ the number of respondent groups (three groups in this study) and $N$ the number of variables (33 features of SMM). Kendall's $W$ represents agreement, where 0 means no agreement at all and 1 represents perfect agreement (Legendre, 2005). The Kendall's coefficient of concordance between the quantity surveyors in clients, contracting and consultancy types of organisations ranking is 0.71. This indicates that there is good agreement between the three groups. It is therefore reasonable to state that there is general agreement among QSs on the essential features of building services SMM. In addition, it is also important to find out the significance of the value of coefficient of concordance computed to ensure that the agreement between the three rankings (QSs in clients' consulting and contracting organisations) were not as a result of pure chance. Therefore, the $\chi^2$ test was adopted to find out the probability of occurrence of a relationship between the three sets of rankings.

However, with a concordance coefficient $W$ of 0.71, and the ranks ranges between 1 and 18. The $\chi^2$ value computed was 35.96 for 17 degrees of freedom. Reading from the $\chi^2$ distribution table, the null hypothesis that there is no relationship between the sets of ranks' by the three groups has a probability of occurrence of $p < 5$ per cent. Therefore the alternative hypothesis can be accepted at 95 per cent confidence level. This shows that the agreement among the three groups on the ranking of the features of BSSMM is statistically significant and not as a result of mere coincidence.

## 5. Discussion

Table II shows that the majority of the respondents (62 per cent) are from consulting firms. In addition, most respondents (93 per cent) have a qualification above diploma level, with registered quantity surveyors accounting for about 45 per cent of the sample population, while none of the respondents had fewer than five years' experience in the construction and measurement of building works. They have been using SMMs for BoQs and post-contract cost management (consulting), the interpretation of BoQs for estimating and tender adjudication (contracting) and interpretation and demonstration to teach students (academics). Therefore, their judgement on the features of an SMM and descriptors of building services components can be considered to be valid and indicative of the opinions of QS in the industry. The results of the survey also show the need to develop building services SMM that can reflect local best practices and procedures and comply with international best practices.

### *5.1 Desired structure of BSSMM*

From the perspectives of respondents, ten variables were considered to be significant and desirable for inclusion in the structure of an SMM. Under this category, adaptability for use in the BIM ranked first under the desired structure of BSSMM and second in the overall features. This variable has a severity index of about 92 per cent. This ranking might be the result of the emphasis of industry stakeholders on the need to adopt BIM by practitioners. Traditionally, incomplete design, communication gap

and poor coordination of the various design inputs are the major barriers to measurement of building services by quantity surveyors (McCaffrey, 2011; Amuda-Yusuf *et al.*, 2013a). Since BIM has the capability to capture, manage and deliver information from QSs point of view (RICS, 2014), aligning building services SMM with BIM models could significantly improve QSs efficiency in managing the cost of building services. As it is generally believed that the main responsibility of QSs in a 5D BIM model is to integrate design with the estimating function to provide early cost advice on a building project. However, according to Eastman *et al.* (2011), there is no BIM tool that provides the full capabilities of an estimating package, and thus estimators must identify a method that works best for their specific estimating processes. The RICS (2014) also suggested the need for project teams to agree on a set of requirements, which are defined from the viewpoint of cost estimating and planning to enable QSs to use BIM more effectively.

The development of a local SMM would lead to reflection on local best practices and procedures ranked second in this category and ninth in the overall ranking with a severity index of about 86 per cent. This finding is in line with the suggestion made by Ofori (1994) that imported building regulations and standards used in a developing country's construction industry should be continually revised to reflect the technical, administrative, social, economic and climatic circumstances of the country. He suggested that such standards should be drafted in a language appropriate to the educational backgrounds of the majority of users. Similarly, reflection on local practices and procedures can also be achieved through the alignment of CICSs and existing industry standards. These basic classifications provide a comprehensive classification system for knowledge of the construction process and constructed products, which can be used for the storage of both physical media such as catalogues and drawings and digital media in databases (Winch, 2010). International standards for layering CAD models, covered by the ISO 13567 series also rely on ISO 12006, while Uniclass incorporates the UK classification standards for the CAWS and is therefore compatible with both SMM7 and CESMM3 Eastman and Liston (2008). Therefore, in order to develop an acceptable SMM for use in the Malaysian construction industry, there is need to reflect the preferences of local best practices to create a home ground advantage for clients and professionals. This is particularly important because of the proposed liberalisation of the Malaysian services sector with the tendency of attracting international contractors with different construction experiences and backgrounds.

Consideration of cost significant items with a severity index of 83 per cent ranked third and 12th in the overall ranking. Considering the nature of building services, not all items can be measured. According to the established 80/20 rule by Pareto, 20 per cent of the items that have the highest value are generally referred to as cost significant Muns and Al-Haimus (2000). One of the problems of SMM-based BoQs is the large number of small items required for estimating Muns and Al-Haimus (2000), Tas and Yaman (2005), making it difficult to identify the important items in the BoQ, while considerable effort and time is also associated with pricing the items by estimators. It is therefore essential to note that not all items of building services can be measured; therefore, the identification of 20 per cent of the cost significant items of building services should be carefully considered in the development of building services SMM.

The need for building services SMM to be adaptable to all procurement systems ranked fourth in the category and 13th in the overall ranking. This finding seems to be one of the purposes of the RICS new rules of measurement (NRM2): detailed measurement for building works. For instance, under all contract strategy (traditional

lump sum; design and build; management and construction management), quantification of employers requirement will need to be prepared by the contractor's, employers or work package subcontractor's quantity surveyors, therefore, adaptability of measurement rules will allow bills of quantities or quantified scheduled of works and description of items to be determined in line with the rules of measurement (RICS, 2012). This variable is followed by the need for rules to be precise to prevent misinterpretation by users, which had a severity index of 79 per cent. This factor is crucial because the method of measurement must support consistent use of terms and language in a structured format that contributes to better communication. Otherwise it can be a source of serious errors in estimating, and cost control will be complicated. Tendering is generally regarded as a procurement process, while estimating is a predictive process (Dell'lsola, 2002). Thus, QSs often adopt SMMs as a basis to prepare BoQs to invite tenders to be submitted on a proposed project. Therefore, in order to ensure that successful procurement occurs, bidding information must convey equal meaning and portray a clear and unambiguous message to all parties. Other variables identified under the structure of an SMM include easy to locate work item, which had a severity index of 78 per cent, consideration of cost analysis (76.93 per cent), based on essential best practices (76.50 per cent), concise (avoid unnecessary details) (72.23 per cent) and consideration of local jargon (67.45 per cent).

### *5.2 Descriptors of work items*

Since construction cost is obtained from the materials, labour and plant necessary to put the materials/components in place, it is important to identify significant cost drivers and concisely include them in the definition rules of an SMM for describing the items of BoQs. The ten most important descriptors identified as essential for the identification and estimating of building services components include the background to which the item is fixed, which ranked first in the category and third overall with a severity index of 91 per cent; and location of the work (second, fifth overall, 87 per cent); identity of the work (third, 86 per cent). Other significant descriptors in descending order of their severity indices were the materials required for the work item; the standard of workmanship required; the quantity involved; treatment of materials involved; dimension of building services components; and handling of materials. This finding corroborates the argument of Swaffield and Pasquire (2000) who identified that cost information on building services is required to enable relationships to be established between building services costs, installations as well as establishing a good basis for collecting historical information on building services. Similarly, Buys and Mathews (2005) considered building services installations to be unique in nature and that their cost drivers vary from project to project. Therefore, their components need to be separated into smaller segments in such a manner that their costs and cost significant attributes can be easily identified. Hence, early budget estimates for building services installations are unrealistic unless the component design, quality and marketplace attributes as well as the manufacturer are somehow fixed.

### *5.3 Determination of measurement units*

The common units of measurement in use are enumeration, length, area, weight and volume. To determine the appropriate unit of measurement, three of the five variables are considered to be significant. The most significant is the physical state of building services components with a severity index of a 93 per cent, which ranked first both

under the category ranking and overall. The number of dimensions of components ranked second with a severity index of 88 per cent and an overall ranking of fourth. The third most significant variable is the shape of components with a severity index of about 86 per cent. From the perspectives of QSs, these three variables are considered to be significant in the determination of measurement units for building services components. The two factors considered to be non-significant are the unit of quantifying in the factory with a severity index of 52 per cent and a rank of number 30 overall, and the unit as is available in the local market, with a severity index of 44 per cent and a rank of number 31 overall.

## 6. Conclusions

The study investigated the need to develop an SMM for building services. The main aim was to identify the essential features of building services SMM suitable for the Malaysian construction industry. The procedures for developing locally based SMMs in other countries as well as selected SMMs from other countries were reviewed. In total, 33 variables considered to be essential features of an SMM were identified through a literature review. These factors were grouped into three broad categories: the desired structure of an SMM, item descriptors and the determination of measurement units. The COVs computed for the variables were relatively low for the selected features of the SMM under each category. Kendall's concordance test indicated that there is good agreement among the three groups (i.e. quantity surveyors in clients' contracting and consulting organisations) and the $\chi^2$ test shows that agreement among the groups on the ranking of features of SMM are statistically significant and not as a result of mere coincidence.

The classification approach rules, codification of items and measurement rules will be highly influenced by the rules of measurement and classification approaches for building services in other countries in order to enhance the SMM features locally identified. Coverage rules and ancillary information and descriptions in SMMs prescribe the information required for the description column of the BoQ. The measurement rules and coverage rules determine the information (descriptors) provided in the description column of the BoQ and explain how they are interpreted. The units of measurement requirements in the SMM determine the entries for the BoQ units in the measurement column and influence the quantities generated and inserted in the quantity column of a BoQ. Finally, the estimator inserts price rates for each measured item in the BoQ by interpreting the item code, item description and item quantity based on the prescription of SMM provisions.

In order for the BSSMM to serve its purpose under current industry practices, it is expected to lay an efficient base for automation. This can only be achieved through appropriate classification systems. The current industry development that needs to be considered in the classification and coding of any rules of measurement for adoption in the construction industry is BIM. As the deployment of BIM in the global construction marketplace increases, the practicability of automated quantity extraction in BIM models should be considered in the development of the rules of measurement. This can only be achieved by aligning the rules of measurement with the construction information classification system in the country. The development of a standardised system of classifying information is generally believed to be an important approach to the successful adoption of ICT in the construction industry. This will facilitate the use of a common language between the building services design team, quantity surveyors, and contractors in the downstream sector of the supply chain.

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