INTERNATIONAL CLASSIFICATION SYSTEMS FOR EMPOWERING STANDARDIZATION AND COST MANAGEMENT OF BUILDING SERVICES WORKS IN MALAYSIA

ABSTRACT

The purpose of this paper is to examine a standard framework for the measurement of building services works for managing construction costs by project team. Building Services (BS) is a specialized area of building projects in terms of the scope, nature of works, technicality and the stakeholders involved. The peculiar nature of BS hinders efforts by project team to set a reliable budget in a standardized format, and there is lack of uniformity in practice. In order to develop systematic and detailed Bills of Quantities (BoQ) with industry requirements, it is important to establish common classification of building services components for building projects. A review of literature on the established classification system was carried out. A survey was conducted using structured questionnaire to identify the current practices in measuring building services works as well as to explicate the essential features of building services standard method of measurement. The findings revealed the need to develop standard framework of building services measurement. In total, 23 parameters were identified as important characteristic of standard method of measurement. It is also indicated that the significant parameters are aligned with international classification system. The international classification system comprises of both superficial/floor area method in preliminary estimates and elemental estimating in detailed estimates which are predominantly used by construction firms. There is need to establish a standard framework for uniformity in measurement with local classification system for efficient collaboration of quantity surveyors (QS) for quantity extraction and estimating of engineering services in Malaysia. Therefore, the integration of international classification system into building services quantity extraction for cost management purposes is a major improvement in construction cost estimating processes.

Keywords: *Measurement, services, classification, quantity, automated.*

1.0 INTRODUCTION

Digital construction technologies are transforming the processes of design, construction and integration in the construction industry (Shin and Cho, 2015; Wang et al. 2014, Harding et al. 2014). The structural engineers are aspiring to greater integration between analysis and design. Same way, it would also be crucial for quantity surveyors (QS) to lay basis for automated take-off and estimating in 3D to 5D model. Automated construction measurement is being carried out in 3D model, but the procedures of the taking-off are not done in accordance with the standard rules of measurement (Jalaei and Jrake, 2014). Hence, the significant disconcord between the established Standard Method of Measurement (SMM) and 3D building model. To meet these requirements, the existing SMM for building works in Malaysia may need to be revised based on local classification systems which will support local practitioners' preferences and lay foundation for cost estimator to use 3D building model for quantity extraction. The automation of quantity extraction could help in accelerating the design process, enhance cost estimating accuracy through just-in-time intelligence and also improve the interference analysis and space conflict identification (Jalaei and Jrake, 2014; Amuda-Yusuf and Mohamed, 2015).It is crucial to make use of the classification systems especially when dealing with cost estimation, structuring of documents and specifications (Asfari and Eastman, 2016).

Therefore, appropriate classification of building information is necessary for successful transmission of information between disciplines in a construction environment. Forecast of the future costs with respect to estimating, planning, cost controlling, and project management are essential to the realization of clients' requirements. In order to meet clients' value criteria of time, cost and performance on construction projects, the enormous amount of information is stored processed and transmitted between the project team (Asfari and Eastman, 2016; Jung et al. 2015; Mokhtariani et al. 2017). If there is no well-defined classification and coding system, it will become difficult to process and transmit information between project participants. This could consequently lead to inefficiency, incorrect forecasts, time and cost overruns and unhappy clients. Adoption of appropriate classification and coding would lead to efficient data and cost management within a quantity surveying organization, and between client and project team members.The use of computer aided quantity take-off, estimating and total cost management requires the development of a fully developed classification and coding system of building data. Effective classification of construction information is essential because, the building and construction industry is characterized by dynamic partnerships between temporary multi – organizations which makes effective communication between different disciplines a critical success factor (Thornley, 2005; Hjørland and Hartel, 2003).Therefore, in order to integrate systematic and detailed Bills of Quantities (BoQ) with automated construction measurement requirements, it is important to establish common classification of building components. Therefore, to enable efficient collaboration by specialist QS in 3D building based quantity extraction and estimating for building works in Malaysia, there is a need for digital technologies to align with the local classification systems. Therefore, the integration of digital technologies into building works quantity extraction for cost management purposes is a major innovation in construction cost estimating processes. It is clearly indicated that current digital technologies have been applied for clash analysis, energy management and design analysis of the architectural works in building (Azhar et al. 2008).

2.0 INFORMATION CLASSIFICATION SYSTEMS

Information classification is a means to facilitate communication among a group of people in the field of practice. In the construction sector, classification played a vital role in structuring of documents, calculation of costs and arranging information in specifications (Ekholm, 1996). Goh and Chu (2002) considered the need for a common language if the acclaimed benefits of information and computer technology (ICT) are to be maximized by the stakeholders in the construction industry. However, well-structured and properly organized information using a common language will guarantee timely access for users, faster transmission and exchange (Lee et al. 1989). Goh and Chu (2002) further pointed out that information standardization in the construction industry is primarily adopted to share information relating to specifications, cost information and product information among project participants. Amuda-Yusof and Mohamed (2015) stated that, adoption of the classification systems in SMMs from the other country may not meet the requirements for the local industry practices. Classifications can be considered from the standpoints of construction activities or processes, construction resources, construction result or finished product. Regardless of the purpose or the view point adopted, properties are used to define specific classes (Kang and Paulson, 1997). Ekholm (1996) asserts that construction works are identified base on the various classifications of elements, trades, work sections, building products, space and construction activities. However, building classifications systems is the most commonly used for the classification of construction specifications and elemental identifications (Ekholm, 1996).The standardized national classification systems for buildings started in the Scandinavian countries, in between 1950s and '60s. Some of the national information classification systems which are used for construction works in other countries include:

- The United Kingdom (UK) Common Arrangement of Work Sections (CAWS) and Unified Classification Systems (Uniclass).
- The Swedish Classification System (SfB).

- The American Uniformat, Masterformat and Omniclass.
- The Australian National Specification Systems (NATSPEC).
- The Singapore's Code of Practice for Classification of Construction Cost Information (SS CP80 : 1999) and Code of practice for Classification Construction of Construction Resource Information – SS CP 93:2002.

It is apparent that the classification systems are very important to the establishment of a standard method of measurement as this form the basis for the tabulated format of most of the SMMs in other countries. For instance, the UK SMM7 CAWS, the Classification of Australian SMM5 was based on the Australian National Specification Systems (NATSPEC), and the Singaporean Construction Electronic Measurement Standards was based on Code of Practice for the Classification of Construction Resource Information.

The Swedish Building Classification Systems (SfB)

The Swedish building classification system (SfB) is one of the most important classification systems in use. The SfB is the basis for many existing national knowledge classification systems such as CI/SfB used in the UK (Winch, 2010). The system originated from Sweden and had been in use since 1945. The committee that was responsible for the establishment of SfB was called 'Samarbetskommitten for Byggnadsfragor', from which the acronym SfB was formed. The SfB was centrally adopted in Sweden as the national method for organizing official and national construction industry specifications, price books and building product sheets (Maritz, 2005). The SfB system set-out information in such a way that it can be easily stored and retrieved for quick reuse.The literature survey appears to show that Sweden is regarded as one of the world leaders in the development of building information classification systems. The classification of BS in CI/SFB systems is shown in Table 1. The weaknesses in CI/SFB have been identified (Winch, 2010) as follows:

- It only applies for building, not really suitable civil engineering.
- It does not contain classifications for process elements.
- There are some new facility types which are not included.
- The coding system is unsuitable for computerization.

This limitation associated with SfB leads to the publication and adoption of globally recognized classification principles known as Unified Classification for the Construction Industry (UNICLASS) in the UK published in 1997 (Kang and Paulson, 1997). UniClass is the UK implementation of BS ISO 12006-2. The new code of practice, BS 1192:2007 recommends the use of Uniclass, which is referred to as the collaborative production of engineering, architectural and construction information, which was published in January 2008 (Gelder, 2010).

Table 1: CI/SFB classification of Building Services

Elements		Sub-Elements	
5	Services	50	
		51	Refuse disposal in general
		52	Drainage
		53	Hot and cold water
		54	Gas, compressed air
		55	Refrigeration
		56	Space heating
		57	Ventilation and air-conditioning
6	Installations	60	
		61	
		62	Power
		63	Lighting
		64	Communications
		65	
		66	Transport
		67	
		68	Security

The UK CAWS And Uniclass

The CAWS was first introduced in 1987, in UK, purposely to promote the coordination and standardization concerning BoQ and specifications. The CAWS is the document which used to set – out the National Building Specification (NBS), the National Engineering Specification (NES), and the seventh edition of the UK standard method of measurement (SMM7).

The CAWS comprises 24 levels "1" group headings and about 300 work sections divided between building fabric and services, (an extract of the new classification of disposal systems in CAWS is shown in Table 2, section numbers are kept short and cross references are made to the specification to facilitate consistency among various documents used on building projects. Project specifications are often prepared by designers and arranged on the basis of the CAWS. This is similarly applicable to the library of clauses in both the National Building Specification (NBS) and the National Engineering Specification for services installations.

Table 2: CAWS classification of disposal systems (now section J in Uniclasss)

Work Sections		Sub -Sections	
R	Disposal Systems	R1	DRAINAGE
		R10	Rainwater drainage systems
		R11	Above ground foul drainage systems
		R12	Below ground drainage systems
		R13	Land drainage systems
		R14	Laboratory and industrial waste disposal systems
		R15	Ground water pressure relief drainage
		R16	Soak ways, septic tanks and sewage treatment plant
		R17	Pumping stations and pressure pipelines
		R2	SEWERAGE
		R20	Sewage pumping
		R21	Sewage treatment and sterilisation systems
		R23	Sewage treatment systems
		R24	Constructed wetlands
		R3	REFUSE DISPOSAL
		R30	Centralised vacuum cleaning
		R31	Refuse chutes
		R32	Compactors/Macerators
		R33	Incineration plant
		R9	DOMESTIC DISPOSAL
		R90	Waste disposal systems - domestic
		R91	Refuse disposal systems - domestic

The lists of items in each work section are coded so as to allow for completion of specifications and advice on specification preparation by reference to British Standards. The overall aim of this is that, if the descriptions in the BoQ are cross referenced to clause numbers in the specification, then the co-ordination of drawings, specifications and BoQ will be improved and the risk of inconsistent information will be reduced (Ashworth, 2004; Brook, 2008; Seeley, 1989; Seeley and Winfield, 1998).

The major limitation of CAWS is its inadaptability to computerized applications. This is due to the fact that the alphanumeric orders in CAWS are not so organized in elemental format, which is the reason for its unsuitability in object naming in the software models. Therefore, table "G" building elements in Uniclass are often used by software vendors. An extract of elemental classification of disposal systems in Uniclass is presented in Table 3.

Table 3: Uniclass elemental classification of disposal systems in section G for building services

Elements	Sub - Element		
G58:Disposal Systems	**G581 Drainage**		
		G5811	**Foul Drainage**
		G58111	Laboratory and industrial waste disposal systems
		G58112	Soak away, septic tanks and sewage treatment plant
		G58113	Pumping stations and pressure pipelines
		G58114	Sewage pumping
		G58115	Sewage treatment and sterilisation systems
		G5812:	**Surface water drainage**
		G58121	Groundwater pressure relief drainage
		G58122	Rainwater drainage systems
		G58123	Land drainage systems
		G58124	Sewage treatment systems
		G58125	Constructed wetlands
		G582	**Refuse disposal**
		G5821	Centralised vacuum cleaning systems
		G5822	Refuse chutes
		G5823	Compactors/macerators
		G5824	Incineration plant

However, "Uniclass" is a more recent classification system which is introduced in 1997, in UK, mainly for the UK construction Industry. The Uniclass was made of a new work section classification which incorporates CAWS in Table J and replaces the conventional CAWS published in 1987. Uniclass also incorporates the electronic product information co-operation (EPIC) which is a new European standard for structuring product literature and product data. The elemental classification of building products is incorporated in Section G of Uniclass. The need for specification of designs and classification systems to accommodate civil engineering and process engineering, as well as architecture and landscape is one of the main reasons for this development. Another reason for the development of Uniclass is the requirement for the classification of works to include a description of all anticipated works that a contractor may carry out on a project. Therefore, the classification must provide homes for every conceivable system to describe systems in performance terms. Unfortunately, the CAWS cannot accommodate these requirements. The scope of the Uniclass new classification is also shown in Table 3. The classification comprises 20 Groups, numbered in "5s", each is containing up to 20 Subgroups. In turn, these contain up to 20 Sections, more in some cases.

The main function of Uniclass system was to unify all available classification systems developed in UK; Uniclass was based on CI/SfB, CAWS, CESMM3 and EPIC and the tables are arranged to represent the different facet of construction information unified with sub-titles and coding system. This approach according to (Gelder, 2010; Finch, 2012) lay an efficient basis for computer applications and can be used in:

- Establishing product literature.
- Organizing project information.
- Developing technical and cost information.
- Structuring frame of reference for databases.
- Setting - up Libraries.

The American Uniformat, Masterformat And Omniclass

Uniformat and Masterformats are widely used in the United State of America and Canada. Uniformat classification was developed in North America in the early seventies. The system was further enhanced in 1993 to organize information for design costing analysis and estimation of projects' major components. Uniformat is a uniform classification system which is used for arranging preliminary construction information on the basis of assemblies and systems without regards to the materials and methods used to accomplish them into a standard order. Uniformat is mainly used at the early design stage of a project for preliminary project descriptions, performance specification and cost estimating. The Masterformat breaks down the information by work results or construction practices that result from a combination of products and techniques and the information is used throughout the facility cycle (Dagostino, 2008).The structure breaks building products systems into different categories such as substructure, superstructure, frame, interior construction, as well as shell. It is further divided into subcategories - such as roof, floor, internal and external walls and windows construction and exterior walls and windows (Sabol, 2008). MasterFormat has been used for over forty years. It is basically a specifications-writing standard established by the Construction Specifications Institute (CSI). The MasterFormat organizes information by activities, products and construction requirements. Also, this structure is usually applied during the construction documentation phases of a construction project, especially when the detailed information is already organized and developed (Sabol, 2008).However, the growing experience with classification systems and the development of ICT led to the development of OmniClass for entire North American Market. It is developed for North American architectural, engineering and construction (AEC) industry by the CSI (Gelder, 2010). The OmniClass is a Construction Classification System (OCCS) for use in the construction industry. It is a multi-table system for organizing information used by the AEC industry. OCCS is used to organize project information, to provide a classification structure for electronic databases. It comprises other classification methods currently in use as the foundation of many other tables like UniFormat systems for group of elements, MasterFormat for work product results, and Electronic Product Information Cooperation for structuring products. Similar to UK Uniclass systems, OmniClass classification builds on ISO 12006-2 (ISO/FDIS 12006-2, 2001).

The Singaporean SS CP 80:1999 And SS CP 93:2002

The SS CP 80:1999 was developed to serve the key purpose of allowing the exchange of data and information so as to guarantee effective communication of construction, design and contractual matters relating to cost through a uniform and accepted classification format. The standard was developed in 1999 to suit local use by adapting a few international standards and reviewing relevant international standards. The main components of the standard are:

- A work-section classification.
- An elemental classification.

- A mapping dictionary for work sections and elements; and
- A set of guidance notes.

The long-term benefits for users include an increased familiarity with a uniform standard leading to an overall increase in productivity and efficient information exchange between different parties, reduction in duplication of work between the different disciplines for the company as well as the industry. Generally, the users of this standard in Singapore are contractors, architects, civil and structural engineers, mechanical and electrical engineers, quantity surveyors and property developers. In Singapore, the Construction Industry IT Standards Technical Committee (CITC) formed in 1993 and the Construction and Real Estate Network (CORENET) formed in 1998 helped in ensuring that national standards are aligned with international standards as well as other industry de facto standards. Leading to the publication of the following Singapore standards (Goh and Chu, 2002):

- Code of practice for classification of Construction Cost Information – SS CP 80:1999.
- Code of Practice for Construction Computer – Aided (CAD) – SS CP 83:2000:2004.
- Code of practice for Classification Construction of Construction Resource Information – SS CP 93:2002.
- Code of Practice for Construction Electronic Measurement Standards (CEMS) (in 2 parts) – SS CP 97 2002: 2003; and
- Code of practice for Information Exchange and Documentation at Handing/Taking –Over Building upon Completion.

The main purpose of the standard is to develop and provide a standardized format to facilitate procurement activities in the construction industry as construction projects are used for a broad range of products and services. Therefore, to ensure a consistent and structured way of information exchange and storage, there is a greater need for a classification standard (Goh and Chu, 2002). The Singapore Standard Code of Practice for Classification of Construction Cost Information is to ensure that construction cost information is structured and stored in a way that is reliable and consistent within and between the different disciplines so as to reduce any duplication of work. In addition, the Code of Practice for the Classification of Construction Resources Information will present a uniform system for classifying information relating to materials, machinery, services and construction products.

The Australian NATSPEC

Construction Information Systems Australia (CISA) was established in 1975 with the primary responsibility to develop, produce and maintain the national building specification in Australia. The Australian NATSPEC was developed and published by the CISA. Moreover, NATSPEC is arranged around work sections that are broken down into subsections, clauses and then sub-clauses. The work sections are not numbered and are classified into five packages for different applications as follows:

- Basic,
- Building,
- Site Structure,
- Services, and
- Domestic.

NATSPEC also covers contract issues, quality assurance, preliminaries, and tendering procedures. The 5th edition of the Australian Standard Method of Measurement is linked to the structure of NATSPEC. These basic classifications provide a comprehensive classification system for knowledge of the construction process and constructed product 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 the layering of CAD models covered by the ISO 13567 series also rely on ISO 12006. Moreover, Uniclass incorporates the UK classification standards for the construction process CAWS and is, therefore, compatible with both CESMM3 and SMM7 (Eastman and Liston, 2008).

3.0 ANALYSIS OF BUILDING SERVICES SECTION OF EXISTING SMMS

Based on the graphical concept of tracking ships, radar diagrams can be used to inform decision making for any combination of criteria and perspectives to suit any needs (Bitman and Sharif, 2008; Weng Low and Goulding, 2008). The radar diagram was adopted to evaluate the level of strengths and weaknesses of the seven SMMs. Therefore, when compared to one another, the areas plotted through the radar diagram represent areas of strength or weaknesses for each standard method of measurements. It is possible to extract the best practices from some of these standard methods of measurement comparison to assist in the development of BSSMM in a future date. The assessment of the evaluation of the SMM systems is carried out under six different headings, with defining characteristics so as to:

- Ensure consistency of work products over time and from project to project. The ability of the SMM to provide a uniform basis for assessing and pricing of items of construction work by end users. This is an important feature of an SMM to reduce the level of variance in understanding by different users (client, contractors and subcontractors).
- Provide a frame of reference for collecting and managing cost information as well as reliable feedback. This is related to the completeness of the references in the SMM to all cost significant items of work that need to be priced by the contractors. This will eventually serve as the basis for cost data for the purpose of analysis and application on another project.
- Provide a checklist to aid in decision making. This characteristic has to do with the ability of SMM to ensure that all items of construction works required are captured. Thereby reducing the tendency of omission of that could result into variation and disputes during project execution.
- Facilitate clear communication among all disciplines. The ability of SMM to ensure that all project participants understand what is measured and implication of the rules of measurement contained in the tender documents based on SMM. This is one of the most important characteristics of the current day SMM, because of the need for electronic document transfer. This function is best performed when the classification of SMM is based on industry classification systems if it is available. Similarly, involvement of industry's key players is very important during the development of SMM.
- Establish a basis for continuous training of estimators. This particular variable is in regard to the application of long standing rules and format of preparing SMM – based bill of quantities in the industry. If the rules are clear and consistently applied over time, this will enhance the ability of each contracting organization develop estimating manual that could be used in training new estimators in their organization.
- Lay an efficient basis for automation. Automated quantity extraction and estimation in line with the rules of measurement is only possible when the rules of measurement followed established classification system. This will make the computer application for bill preparation and estimation simple. This characteristic is important considering current trend in the industry. The evolution of BIM is transforming the construction industry globally. This may require that the rules of measurement align with certain information classification system to be useable under BIM model quantity extraction and estimating. Therefore, for an SMM to be

adjudged to have laid efficient foundation for automation, the classification must have aligned with accepted information classification system in the industry.

Table 4 shows the assessment of the evaluation of the SMM systems. Each of the characteristics outlined above was then rated on a maturity model from 1 (the lowest score) to 5 (the highest score). There are many methods to rate the maturity model, one of the most popular methods is to rate in the scale of 1 to 5 (Gabriel et al., 2012; Nizam Akbar et al., 2015; Robert et al., 2013). The radar diagram framework and weightings are shown in Figure 1, where a generic scoring system is allocated to show the strengths and weaknesses of each of the standard methods of measurement. The assessment was done by one senior and experienced officer of CIDB, two RISM member and 4 researchers. They are all quantity surveyors and highly experienced in the use of standard method of measurement and their judgment have been based on experience, some of the respondents have earlier participated in the first phase of the study (Bitman and Sharif, 2008; Weng Lou and Goulding, 2008; Blumer, 1969). The completed diagram is presented in Figure 1. Mean Average of the ratings is calculated, rounded off and inputted.

Table 4: The assessment of the evaluation of the SMM systems

Evaluations SMM Systems	**Ensure consistency**	**Provide frame of reference**	**Provide checklist to aid decision**	**Facilitates clear communication**	**Establish basic for training**	**Lay efficient foundation for automation**
ASMM5 (Australia)	4	5	4	4	4	4
BESMM3 (Nigeria)	4	4	4	3	4	2
CP CEM5 (Singapore)	5	5	5	5	4	5
SMM7 (UK)	4	4	4	4	4	4
RICS NRM (UK)	5	5	5	5	5	4
SMM2 (Malaysia)	4	4	4	3	4	2

1 – Ineffective at all *2 – Slightly effective* *3 – Moderate effective*

4 – Effective *5 – Extremely effective*

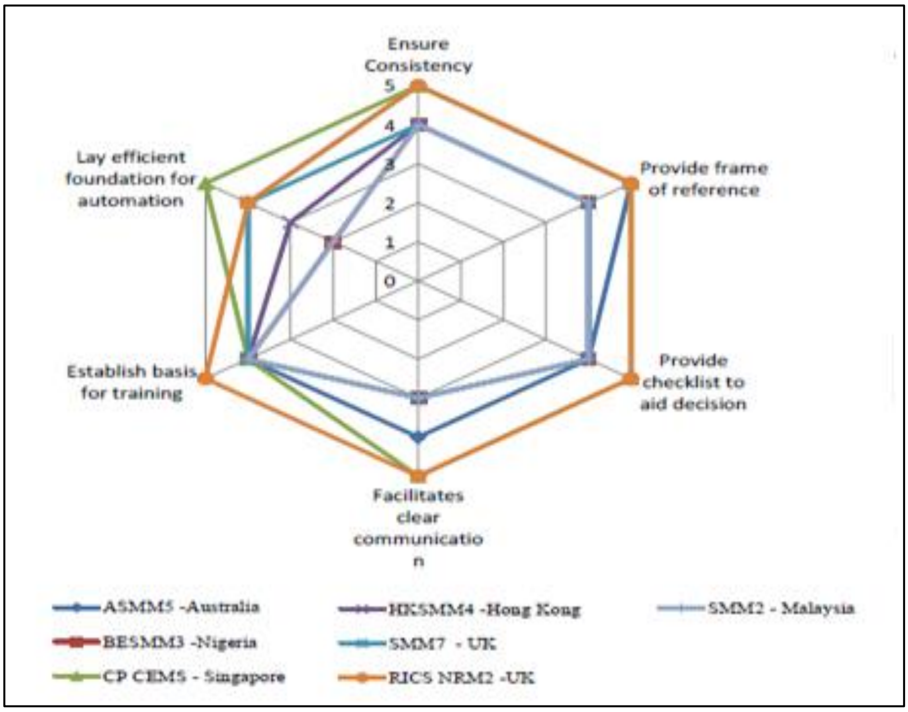
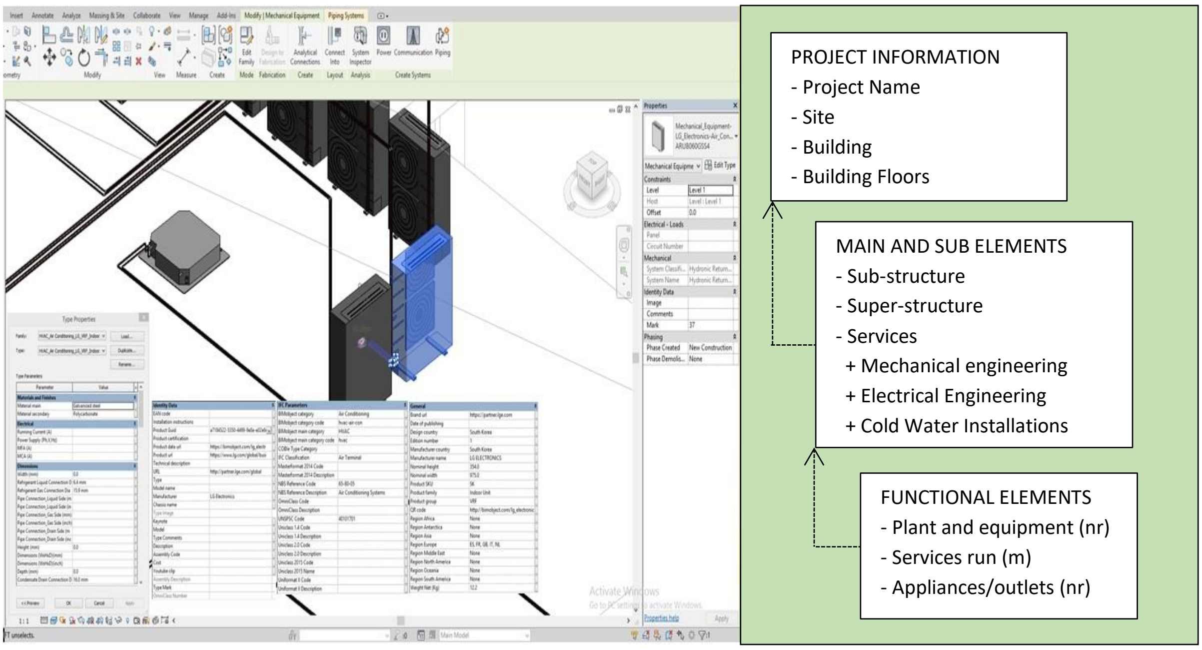


Figure 1 Rating of the SMMs on radar diagram.

Figure 1 shows the seven standard methods of measurements from six (6) countries scored highly in ensuring consistency of work, providing a frame of reference, as well as providing a checklist to aid decision making as well as establishing a basis for training estimators. This is likely because all of the SMMs compared with the exception of ASMM5 are modified fashion of British SMM and these features are principally the core purpose of a standard method of measurement. The Singaporean CEMS, the British SMM7 (UK) and the new RICS NR2 (UK) are the only SMMs that scored highly in facilitating clear communication among all disciplines and in laying an efficient base for automation. In this case, the Singapore CP CEMS scores highest in the area of laying an efficient base for automation. This is because; the classification systems in the CEMS have already aligned with Industry Foundation Classes and other important classification systems in the Singaporean construction industry. The BIM authoring software is adaptable to all IFC compliant classification systems, and this would make the adoption of CEMS easier when BIM is fully deployed in Singapore construction industry. However, the UK SMM was based on the Common Arrangement of Work Sections and the Unified Information Classification Systems (UNICLASS). The relevance of CAWS is declining in the UK because of the limitations in computer applications (Gelder, 2010). The RICS NRM2 was based on the BCIS Standard form of cost analysis and can be mapped into both CAWS and Uniclass, but nothing has been reported on the adaptability into BIM automated quantity extraction. Therefore, the scoring of these two SMMs from UK is lower than Singapore CEMS. Although, the Nigerian BESMM3 and Hong Kong HKSMM4, presented information on measurement rules in a tabular format, and they will support computer applications, but they are not aligned with their respective industry specific national classification systems that could facilitate collaboration and easy information exchange.

4.0 FRAMEWORK FOR AUTOMATED CONSTRUCTION MEASUREMENT

The process of manual quantity extraction from 2D drawings is complex and is prone to human error because of organizational as well as technological problems (Boon and Prigg, 2011). The automation of the quantity take-off process by using the current advances in Information and Computer Technology (ICT) can provide a solution to these problems (Arayici et al., 2012). For instance, the introduction of Computer Aided Design (CAD) software facilitates the use of three – dimensional (3D) models between planning and design phases (Goedert and Meadati, 2008). The four – dimensional (4D) models refer to 3D models linked to a schedule and is used for space conflict identification and interference analysis (RIBA, 2012). The five – dimensional (5D) model integrates a 3D drawing with cost estimates and time, could help in accelerating design process and ensuring that client's budget is not exceeded (Boon and Prigg, 2012). Building Information Modelling (BIM) is a procedure to integrate digital descriptions of all the building objects and their relationships to others in a precise manner, so that stakeholders can query, simulate and estimate activities and their effects on the building process as a lifecycle entity (Arayici et al., 2012). With the BIM implementation, it can help by providing the required value judgments for creating a more sustainable infrastructure, which satisfies their owners and occupants (Matipa et al., 2008).



MECHANICAL ENGINEERING INSTALATIONS

	ITEM OR WORK TO BE MEASURED	UNIT	LEVEL ONE	LEVEL TWO	LEVEL THREE
Mechanical Works - Primary Equipment					
1	Air Conditioning & Mechanical Ventilation Services	No	1 Unit system 2 Package system 3 Central system 4 Central system (modified)	1 (Brand) or other equal and approved, (dimensional description), (capacity) tonne, (load) rating, associated integrated or remote ancillaries, controls, and indicators	1 fixed to ceiling 2 fixed to wall 3 fixed to roof slab 4 floor standing 5 fixed to plain metal 6 fixed to glass
Pipeworks					
8 9 10 11 12 13 14	Refrigerent pipe Suction pipe Drain pipe Gas service pipe Fire fighting pipe Cold water pipe Chilled water pipe	m	1 Galvanised iron 2 Copper pipe 3 PVC pipe 4 HDPE pipe 5 Special made pipe 6 Pre-insulated G.I .Pipe	1 fixed to wall 2 fixed in risers or service duct 3 embedded in brickwall 4 embedded in concrete 5 fixed to soffits of slab 6 fixed through wall/floor including sleeves 7 laid in trench; including all necessary excavation and reinstatement	1 (dia) diameter/(x-sectional dimension)

Figure 1 Coding and classification system for automated construction measurement.

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. But this will have to be done using a method which can be changed into a robust cost plan that also takes due cognizance of project-specific market trends and cost drivers (RIBA, 2012). Classification systems differ greatly from country to country such as Masterformat and Uniformat in the US and Canada (Goedert and Meadati, 2008; Boon and Prigg, 2012); Uniclass in UK (Dell'lsola, 2002); in Finland Building 2000 is supported because it supports BIM (Firat et al., 2010). Basically, the classification systems constitute the backbone of effective model-based quantity take-off. Matipa et al. (2010) assessed the impact of new rules of measurements (NRM) on the cost planning techniques in the BIM environment. Matipa et al. (2010) pointed out that, in the BIM environment, the information model plan which represents data under different domains is developed using the information model. While some domains may have physical or actual data types, to ensure that it is incorporated into the plan, the NRM can only be modelled using the “process model”, which requires an abstract data type objectification (Matipa et al., 2010).

However, the Industry Foundation Classes (IFC) that is used to model building products is a neutral file (Building Smart 2012). Although, the IFC plan has no domain for quantity surveying, (Matipa et al., 2010) pointed out that, there are many domains that contain necessary data that could be used for elementary quantity surveying such as IFC quantity resource. However, the quantity resource may not articulate the necessary processes that are now covered in the NRM. However, the NRM plan provides the basis of a codified framework for elemental cost planning that, if incorporated into the IFC plan, could enhance the involvement of a quantity surveyor in the provision of early cost management services to the project team. In the NRM, no mention is made concerning possible applications of building information modelling tools. Matipa et al. (2010) concluded that BIM would improve the speed as well as create a consistent approach to the allocation of cost resources as it would make a positive impact on the overall cost planning process. Nevertheless, they pointed out that, to improve the consistency and efficiency of BIM based estimating approaches; there is a need for cost consultants to consolidate the BIM plan with the information from NRM/SMM. Eastman et al. (2011), suggested that designers and estimators will need to coordinate the methods to standardize building components and the attributes associated with those components for quantity take-off in a manner that it can be easily understood by practitioners to fully optimize the capabilities of BIM. In addition, to generate accurate quantities of subcomponents and assemblies, it may be necessary to modify the object definitions in the BIM system to capture the quantities needed for cost estimating. Though, (Kraus et al., 2007) observed that the main challenge of estimating using BIM is in “how the objects in the building model relate to items in a typical estimating database”. Kraus et al. (2007) suggest that, there is a need to be able to develop and adhere to standards for mapping the objects from the BIM model to the estimating database for efficiency estimating in a BIM environment. Boon and Prigg (2012) investigated into the development of quantity surveying practice in the use of BIM in New Zealand. Boon and Prigg (2012) considered that it is necessary to develop a coding system and use it consistently to achieve automation of pricing by reference to a standard rate library.

Based on the current development in BIM, this is believed to be possible integrated systematic rules of measurement into BIM models. There is difficulty with preparing quantities derived from a construction ready model in accordance with a standard method of measurement such as the UK SMM7 or New Zealand Standard NZS4204 (1995). This is mainly due to the composite nature of objects within the model. The objects typically contain more than one trade, for instance an internal wall may include dry lining, framing, decorating trades and finishing. There is a significant non-alignment between the objects in BIM models and the trade items in the SMM because the objects in a BIM 3D model represent components of the finished product while the SMM requires details rules for quantity extraction. Although, software is now available for taking off quantities from the BIM model, most BIM modellers are not familiar with the rules of measurement but the situation could be significantly improved if there is a BIM-based measurement standard to serve as guidelines for modellers to follow. In Singapore, the construction industry appears to have made the most progress in approving a coding system to facilitate the exchange of information between computer-based design models and costing systems. The Singapore standard code of practice for construction electronic measurement standards (CEMS)” CP97 part 1 & 2 therefore is aligned with Singapore standards CP 93:2002 classification of construction resources information and CP 83: 2000, construction computer-aided design. This is made to ensure a common classification and coding system is adopted across the industry. It was also found out that, in New Zealand, the NZIQS have a sub-committee which is reviewing the NZ standard method of measurement (NZSMM) so that rules of measurement will possibly align and be adaptable for model quantity extraction. However, Ashworth (2011) pointed out that BIM originates from the USA and their systems have never been compatible with the UK practice. Moreover, Europe uses different procedures compared to the UK. Therefore, BIM should not be considered as a black box that provides just what is required because unless work is shown on the drawings, BIM cannot quantify it, and contractors will require payment for such work. Ashworth (2011) further explained that completely drawn information was one of the aspirations of SMM7 published in 1998. It is also observed that, it may take some time for BIM to be used routinely on refurbishment and modification projects, and this represents half of the industry workload.

5.0 CONCLUSION

In project cost management, it is important to develop systematic rules of measurement as the baseline to effectively manage construction projects in terms of time and cost. However, it is still less effort undertaken by quantity surveyor to automate the rules of measurement and integrate with 3D models for cost estimating in current practice. This paper provides information on the theory of information classification systems. The basic principle behind SMM classification was explained, and the relationship between building classification systems and the SMM was established. It was also established that, for SMM to be adaptable in BIM for automated quantity extraction and estimating, the purpose of the rules must be consolidated for quantity surveyor's specific domain applications. This may require that the SMM classification system be aligned with an agreed construction industry information classification system. The findings from this comparative analysis would assist in the next direction to be focused on addressing new rules of measurement for Malaysian construction industry. This statement is reinforced by the assumption that to prescribe a process for developing SMM for building elements to be adopted by industry practitioners, there is a need for a general understanding of current industry practices in relation to the expected changes in the global construction market place.

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