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INTEGRATION OF BUILDING INFORMATION MODELLING (BIM) AND INDUSTRIALIZED BUILDING SYSTEM (IBS)

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Abstract:
The Construction industry in Malaysia is always progressively moved ahead with the full support from the Malaysian government through the Construction Industry Development Board (CIDB). As report by CIDB, "there were 34,172 projects valued at RM 407 Billion for the 2006-2010 (9th Malaysia Plan) period, compared to 30,717 projects valued at RM 507 Billion for the 2011-2014 periods. Infrastructure projects such as road, major bridges, railways, ports/airports and other major civil works are avenues for major capital influx into the areas where work will be undertaken. The impact to downstream economy can be immediate at the start of the construction and can continue during the operations itself. It is for this reason that local residents get excited when new major infrastructures are established in their locality. Coupled with the promised economic and financial benefits of the construction industry, the activities themselves generate considerable waste materials at the worksites, workers' campsites, and ancillary facilities. The aim of this research is to investigate the use of BIM as a platform and IBS construction to aid construction waste minimisation, and to develop and validate a BIM-IBS aided waste minimisation Framework in design. Reducing construction waste has been driven by economic and environmental consideration due to the cost of waste, which is about 15 times that of disposal. Thus, the construction industry has been exploring and developing effective and efficient approaches to minimise waste generation In the context of this research, construction waste minimisation (CWM) is a process for preventing, eliminating or reducing waste at its source during design.

Keywords: Integration Building Information Modeling; Industrialized Building System.

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1. Introduction

Construction industry in Malaysia is always progressively moved ahead with the full support from the Malaysian government through the Construction Industry Development Board (CIDB). As report by CIDB, "there were 34,172 projects valued at RM 407 Billion for the 2006-2010 (9th Malaysia Plan) period, compared to 30,717 projects valued at RM 507 Billion for the 2011-2014 periods. These figures reflect an average of ~6,800 projects per year during the 9th Malaysia Plan period and ~7,700 projects per year during 2011-2014. A double digit growth rate in the number

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of projects of about 13 per cent per annum was thus observed between 2010 and 2014" [1]. Also, in the inspiration government plan in construction industry, CIDB has launched the Construction Industry Transformation Programme (CITP) in line with government initiatives for a year 2016 to 2020. The plan was stated in their strategic trust initiatives that the transformation of construction industry will involve reducing irresponsible waste during construction, to accelerate adoption of IBS (mechanization and modern practices) via private sector and to facilitate BIM adoption in construction industry.

In many developing and developed countries or cities, demolition is a quite wasteful activity if the waste is not properly managed. In the UK, the waste amount from C&D activities has remained at around 100 million tons annually in recent years (DEFRA, 2015), while demolition accounted for around 32.7 million tons in 2007 (CRWP, 2009), which means demolition waste takes about 30% of all annual construction waste generated. Another developed country Norway logged 1.8 million tons of C&D waste generated in 2013, 31.3% of which was from demolition activities (Statistics Norway, 2015). Demolition in Hong Kong is estimated to produce, by weight, more than 10 times the amount of waste produced from construction of new buildings (Poon et al., 2001; Lu et al., 2015). In China, annual C&D waste generation reportedly reached one billion tons in 2013, 74% of which resulted from demolition activities (NDRC, 2014; Lu et al., 2016c).[2]

According to [3], it was reported the obtained results, about 82,646,051 m3 of C&D waste (average 16,529,210 m3 per year) were generated during 2011 to 2016 which only about 26% of them has been recycled. Mixing sand and cement, concrete, broken bricks and soil have the highest amount of the composition of C&D waste in Tehran that was 30, 19, 18 and 11%, respectively. Based on the results, about 2,784,158 t of the waste will generate in 2025 and this is approximately 122% higher than wastes generate in 2016. Based on MAPSA's data, 360 teams of personnel cruise and control the illegal disposals, but due to the expansion of Tehran this number of teams is inadequate and can't be effective in controlling the situation.

The past of building–related C&D waste generation in high-rise buildings construction in Bangkok in 2005 were estimated. Four categories of waste were examined, namely residential construction, nonresidential construction, residential demolition and non-residential demolition. The average generation rates of waste from residential construction and nonresidential construction were 56.23 kg/m2 and 30.47 kg/m2, respectively. In the year 2005, 1,675,675 m2 of residential building and 1,135,161 m2 of nonresidential building were permitted for construction. Therefore, approximately 128,811.55 tons of building–related construction wastes were generated in Bangkok in 2005. The average generation rate of waste from residential demolition and nonresidential demolition were 984.66 kg/m2 and 1,803.94 kg/m2, respectively. Since there is no record of permit for demolition, the average ratio of 10 % from new building permit record was used to estimate the areas of residential demolition and nonresidential demolition. Therefore, approximately 369,772.57 tons of building related demolition waste was generated in Bangkok in 2005. The total amount of waste from building–related construction and demolition (excluding renovation) in Bangkok in 2005 was approximately 498,584.12 tons per year or 0.20 kg per capita per day while the generation rate of municipal solid waste was 1.25 kg capita per day. Presently, the volume of construction area obtained from building permit data collected by the National Statistic Office in 2012. Result in average generation rates of waste from total building construction were 56.23 kg/m2, respectively. In the year 2012, The top five of the building

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categories is Residential Building, Condominium, Office Building, Residential (Flat/Apartment/Dormitory) and Commercial Building. More than 80% are high-rise buildings construction. The total area of construction permit as mentioned above as seen in Figure 1. Is total area approximately 72,837,337 m2 of were permitted for construction. Therefore, approximately 4,200,595.85 tons of building–related construction wastes were generated in Thailand in 2014.

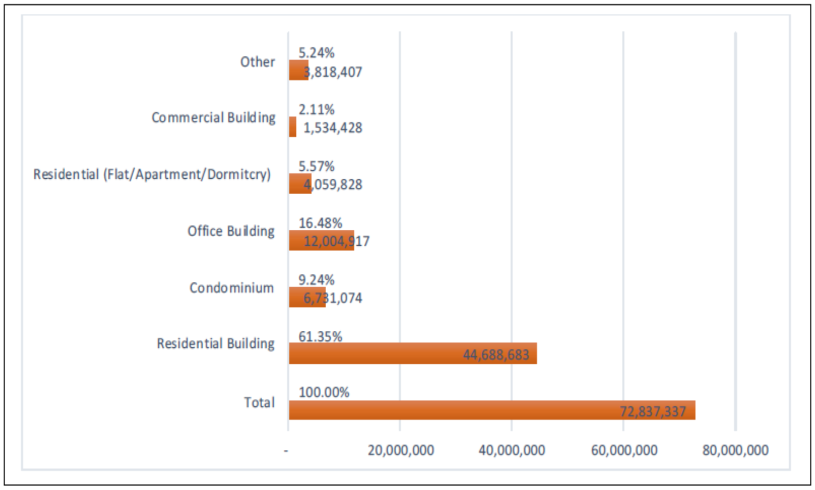

Figure 1: Area of building construction by type of building and area whole kingdom: 2015 [4]

Figure 2 shows the average waste disposal per tonne for each state in Malaysia. Selangor state with the highest population contributes the highest waste disposal daily.

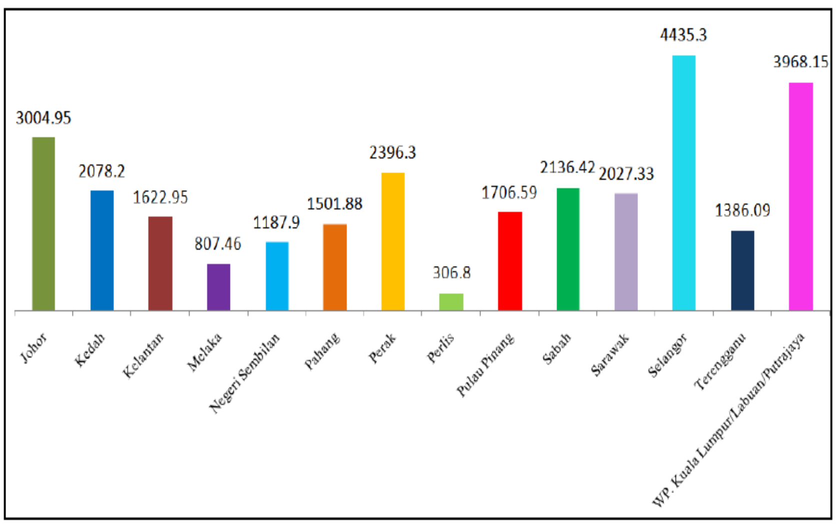

Figure 2: Average daily waste disposal per tonne for each states in Malaysia (Ministry of Housing and Local Ministry, 2012) [5]

Infrastructure projects such as road, major bridges, railways, ports/airports and other major civil works are avenues for major capital influx into the areas where work will be undertaken. The impact to downstream economy can be immediate at the start of the construction and can continue during the operations itself. It is for this reason that local residents get excited when new major

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infrastructures are established in their locality. Coupled with the promised economic and financial benefits of the construction industry, the activities themselves generate considerable waste materials at the worksites, workers' campsites, and ancillary facilities. These waste materials, generally termed as construction waste, are part of construction materials' packaging, containers, and spent machinery and equipment parts that are no longer usable. Hence, with no practical usage of these materials in the construction, there is no reason to keep them and are, therefore, subsequently disposed. If these materials are improperly managed and disposed, they can cause some irreparable and irreversible adverse impact to the environment. Consequently, people's health and welfare can be compromised; foremost of all will be the workers and subsequently, the residents themselves in the vicinity of the project sites. It can end up in a scenario wherein the promised development is overshadowed by an environmental catastrophe. Construction wastes are generally bulkier, heavier and at times more toxic than domestic waste. Their disposal to a local sanitary landfill or dumpsite can prove to be less of a solution but more of an aggravation of the issue in the long run. In some instances, the contractor resorts to inappropriate or even illegal practice such as: (i) illegal dumping in deserted areas; (ii) concealing garbage in wooded or forested areas; (iii) mixing with domestic waste; (iv) burying in abandoned sites; (v) dumping in waterways; and (vi) burning. [6]

Over the decades, building construction activities have generated the largest volume of waste across the globe (Osmani, 2013). This waste could be attributed to the constant uptake of construction, demolition and renovation activities during which villages are built into towns, towns into cities and cities into mega cities (Jaillon and Poon, 2014). In fact, this uptake of building activities results in about 30% of the total annual waste generation worldwide (Jun et al., 2011; DEFRA, 2015; EC, 2015). This thus puts immense pressure on the depleting landfill sites and affects the environment adversely. To ensure the conservation of natural re- sources and to reduce the cost and impacts of waste disposal, effective waste management practices must be put in place. This will ensure the flow of construction material in a closed loop to minimise waste generation, preserve natural resources and reduce demand for landfills. To achieve this, effective management strategies such as waste reduction, component reuse and material recycling are needed to divert Construction and Demolition Waste (CDW) from landfills (Oyedele et al., 2014). This is because they are completely detached from the design process and can only be used after the bill of quantities has been prepared. This makes it too late for architects and design engineers to make major design changes to minimize waste. Although several studies (Ajayi et al., 2015a; Liu et al., 2011; Porwal and Hewage, 2011) have identified that building information modelling (BIM) has potentials for designing out waste, none of the studies has provided clear instructions on how BIM could be used for this purpose. Besides, the lacks of knowledge on stakeholders' expectations on the use BIM for CDW management raises serious concerns on how BIM could be implemented for CDW management. [7]

In recognizing these concerns, the Malaysian government formed the Construction Industry Development Board (CIDB) of Malaysia; one of its aims was to transform the Malaysian construction industry by improving its environmental performance by reinforcing the Malaysian construction industry's commitment to sustainable development through the Construction Industry Master Plan 2006–2015 (CIDB, 2012; Effie et al., 2011) and promoting the use of the Industrialized Building System (IBS) as part of the "IBS Roadmap 2003–2010" programme (CIDB, 2011). The IBS has not been effectively implemented in Malaysia despite having been

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introduced in the late 1960s (Hamzah et al., 2010). In 2003, 15% of construction projects in Malaysia utilized IBS and by 2006, it had dropped to 10% (Hamid et al., 2008). The IBS which is widely used in Europe, Japan and Singapore is seen as an alternative option to the Conventional Construction in maintaining sustainability in construction through the efficient use of resources, improvements in the quality of constructed buildings and waste minimisation (Tam et al., 2007; Kibert, 2007; Begum et al., 2010). A study by Begum et al. (2006) at an IBS construction project site in Malaysia showed that 73% of its construction waste were reused and recycled; indicating the economic feasibility of waste minimisation and the net benefit calculated in this study was valued at 2.5% of the total project budget. [8]

Construction methods used in this study were defined as:

- Conventional Construction (Category I) this method consists of extensive cast in situ activities. Reinforced concrete frames, beams, columns, walls, and roof are cast in situ using timber formwork while steel reinforcement is fabricated at site. It is labour intensive involving three sep- arate trades, namely steel bending, formwork fabrication and concreting: employing skilled carpenters, plasterers and brick workers (Badir and Razali, 1998).
- Mixed System (Category II) An intermediate construction method, the Mixed System (Category II) is defined by the use of certain elements that are standardized and fabricated in the factory while others are cast in situ at the construction sites. This involves the assembly of precast elements such as in-filled walls, bathrooms and staircases which are incorporated into the main units at the construction sites. Floors, slabs, columns and beams are cast in situ as these are relatively easier and less time consuming parts of the operation (Badir and Razali, 1998). The Mixed Sys- tem, in this study is considered as an amalgamation of the IBS (Category III) and the Conventional Construction (Category I) methods.
- Industrialized Building System, IBS (Category III) The IBS (Category III) is defined as a construction process that utilizes techniques, products, components or building systems involving the use of on-site and off-site (factory producing) pre- fabrications for installation. The on-site pre-casting consists of floor and roof slabs in situ whereas the off-site fabrications of some or all components of buildings are cast off-site at fabrication yards or factories. With the transfer of construction operations to factories or fabrication yards, good quality components have been mass produced and delivered to the construction sites in economically large loads (Badir and Razali, 2002). [8]
- National BIM Standard Definition of BIM; A Building Information Model (BIM) is a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward. A basic premise of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM process to support and reflect the roles of that stakeholder. The BIM is a shared digital representation founded on open standards for interoperability.[9]

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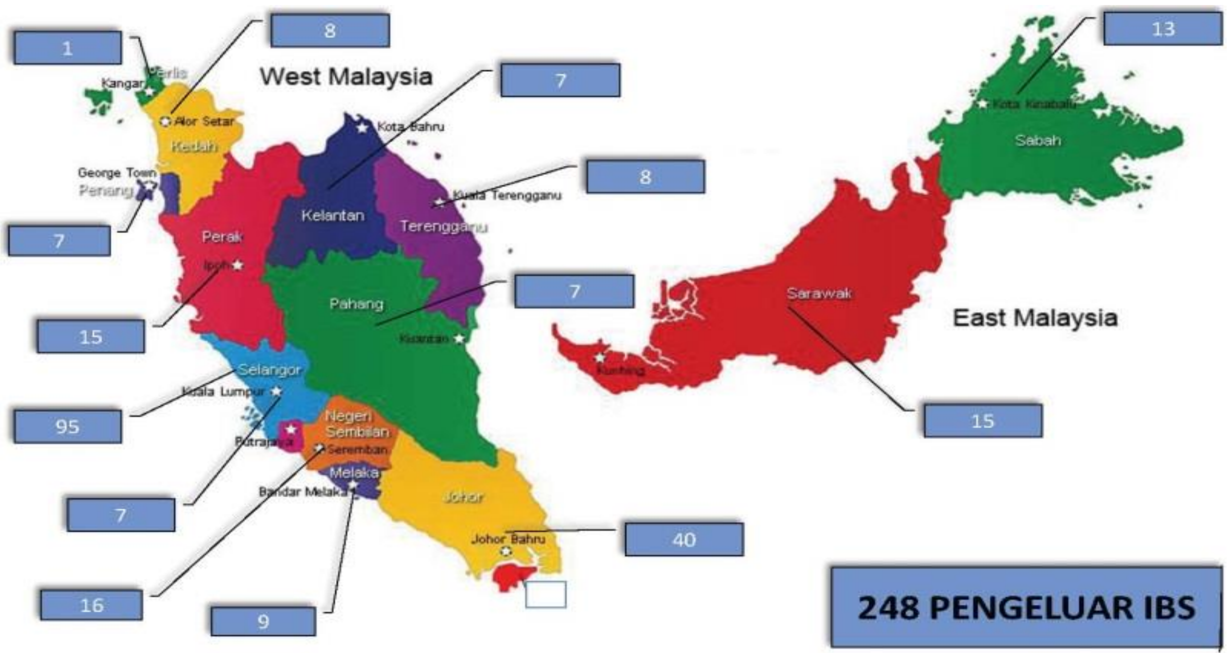

Figure 3: IBS supplier registered with CIDB (up to July 2017) (CIDB, 2017)

2. Problem Statement

Construction waste is any material for construction considered to be redundant caused by various design and construction activities throughout the project lifecycle. Currently, the UK construction industry produces 120 million tonnes of waste (UK Green Building Council, 2013), of which 13 million tonnes of materials that have been delivered to the site but have never been used (Environment Agency, 2003). Owing to a continuous increase of construction waste entering landfill, the Strategy for Sustainable Construction 2008 (HM Government, 2008) identified construction waste as a priority waste stream and set a waste reduction target halving construction, demolition and excavation waste to landfill by 2012 compare to 2008, as such the Strategic Forum for Construction has been commissioned to monitor the waste reduction target. Consequently, halving waste reduction has been achieved except for increased excavation waste (Defra, 2013c, WRAP, 2013b). Defra (2013c) called for more waste prevention actions to reduce the arising waste destined for landfill. Moreover, reducing construction waste has been driven by economic and environmental consideration due to the cost of waste, which is about 15 times that of disposal (NSCC, 2007). Thus, the construction industry has been exploring and developing effective and efficient approaches to minimise waste generation In the context of this research, construction waste minimisation (CWM) is a process for preventing, eliminating or reducing waste at its source during design. [11]

3. Research Aim and Objectives

The aim of this research is to investigate the use of BIM as a platform and IBS construction to aid construction waste minimisation, and to develop and validate a BIM-IBS aided waste minimisation Framework in design. In order to achieve this, the following six objectives are proposed:

1) Explore construction waste minimisation drivers and examine construction waste causes.

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2) Examine and evaluate current construction waste minimisation practices including approaches, techniques and tools.
3) Examine and evaluate current BIM and IBS practices including approaches, techniques and tools.
4) Explore the potential use of BIM as a platform and IBS construction to aid construction waste minimisation during design.
5) Assess the relationship between construction waste causes and BIM-IBS practices; and investigate the potential use of BIM-IBS to assist architects in reducing waste throughout the design stages.
6) Develop and validate a BIM-IBS aided waste minimisation Framework to reduce construction waste during design.

4. Scope and Limitation of Study

Studies in the field of construction waste minimization (CWM) indicated that the majority of current CWM practices were mainly focused on on-site construction stage and less effort was investigated to reduce waste during design. Construction waste forecasting tools, such as design-based waste assessment (Ekanayake and Ofori, 2004) and online waste forecasting (WRAP, 2011), have been used to assist construction waste reduction during design stages. However, these tools aimed to capture live data of waste and provide improvements to resource efficiency in terms of waste minimisation. None of them have taken CWM decision making into consideration during design stages and early design stages in particular. [11]

The study undertakes to identify the integrations BIM process and IBS construction toward waste minimization in construction industry. The study area selected around peninsular Malaysia such as Penang, Perak, Kedah and Kelang Valley area

5. Research Methodology

The method of research will be used as shown below;

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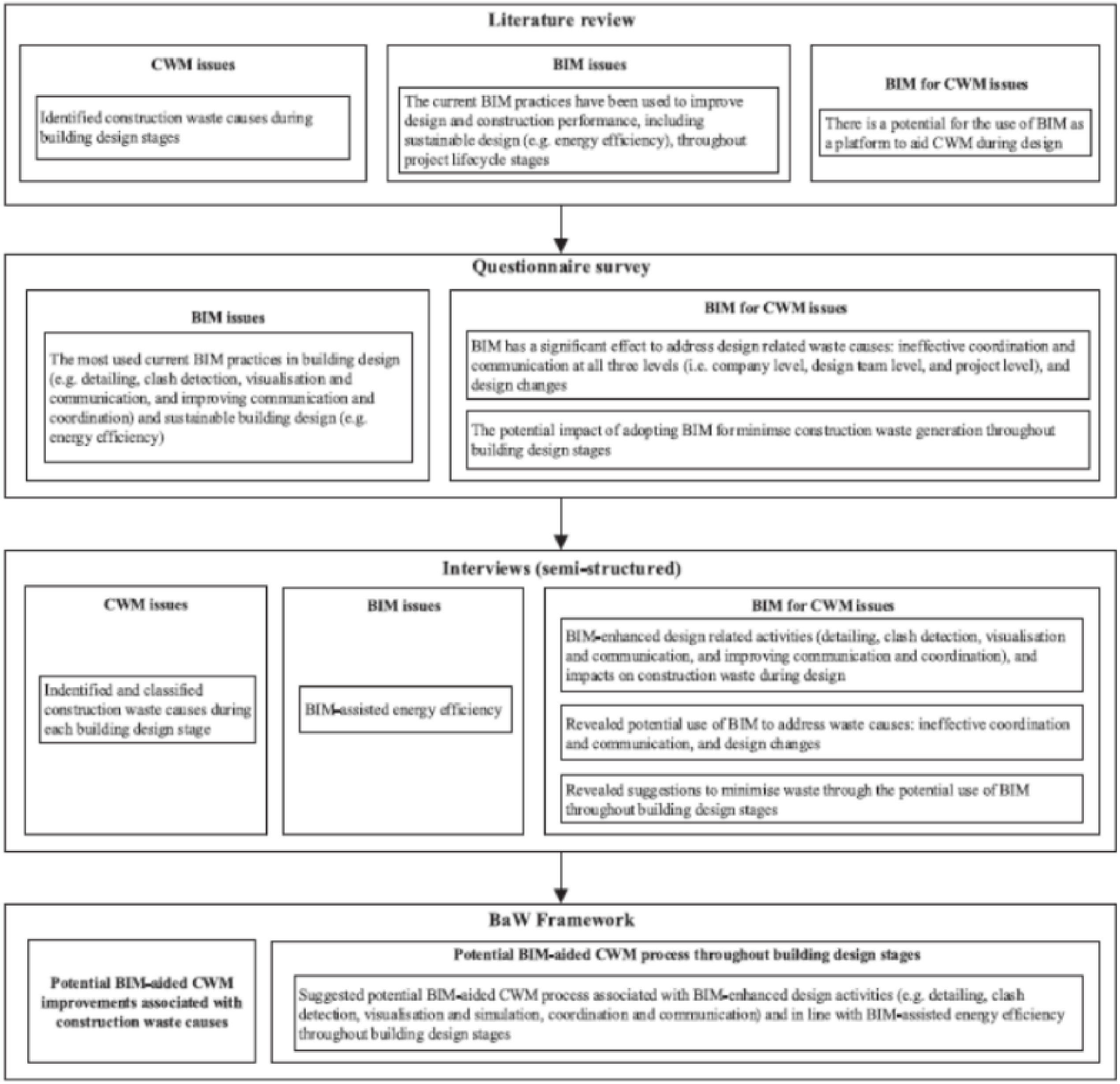

Figure 2: Schematic Diagram of Methodology

6. Significant of Study

Thus, the significance of this study is to highlight the importance of developing accident prediction model for construction works. Addressing these issues will help to reduce the numbers of accident happen in the construction industry at the post-construction stages and help stakeholder in decision making at the pre-construction stages to estimate the overall cost project impact by numbers of accident occurred in construction projects.

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