THE PERSPECTIVE VIEW OF MALAYSIAN INDUSTRIALIZED BUILDING SYSTEM (IBS) UNDER IBS PRECAST MANUFACTURING

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ABSTRACT
In Malaysia, the prefabrication technology is known as industrialised building system (IBS) which is defined as a complete process system of construction works where almost all the component structures is manufactured onsite or offsite, and the product is transported to the site and to be installed in the high precision coordinate joint as well as achieve high quality works, and accelerate the time of completion of the projects. The benefits of prefabrication helped the Housing Ministries in various countries to fulfil the high demand for housing especially in United States, United Kingdom, Australia, Singapore, Hong Kong and Malaysia. Providing affordable homes are becoming a vital issue to meet the increasing demand for houses with the increase in the population growth. The most popular IBS component used in Malaysia is precast components. Over the years, the total number of IBS precast manufacturing has increased from 15 in 2009 to 36 factories in the year 2011. Geographical information system (GIS) can be seen as an important tool in finding a new location for IBS precast manufacturing by employed the Boolean method. In this research, five data layers consisting of road, infrastructure, environment, population and land-use suitability will be input to the spatial model and all the data layers are buffered according to the literature specification. The research findings will benefit the government or private sector in fulfilling the demand of IBS component in Malaysia where the number of IBS manufacture in Northern Peninsular, West Peninsular, Sabah and Sarawak region are still few.

Keywords: Industrialized Building System (IBS), spatial site selection, land suitability analysis

INTRODUCTION
The trend of the Malaysian construction industry has moved from the traditional method to IBS manufacturing and similarly, the productivity have moved from project based to product based. The phenomenal transition of the construction industry to prefabricate manufacturing has also occurred in Australia, Hong Kong, Singapore, United Kingdom and United States [1-5]. The implementation of prefabrication in the construction industry has enhanced productivity and improved quality as well as several benefits viz. shortened construction time, lower overall construction cost, improved quality, enhanced durability, better architectural appearance, enhanced occupational health and safety, material conservation, less construction site waste, less environmental emissions, and reduction of energy and water consumption [6].

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After the World War II, prefabrication of building was the best method to fulfil the housing demand. In the early 1970s, the US government explored several prefabrication building systems [7]. Among the largest prefabrication building system in the US is the manufactured house (MH) which is the second largest provider of housing units and consist about 20% of the total share of the housing market [8]. The houses are constructed in a controlled factory environment based on the national building code specified by the US and the entire structure is transported to the site and installed onsite [5, 9]. The federal standards regulate manufactured housing design and construction, strength and durability, transportability, fire resistance, energy efficiency and quality. The Department of Housing and Urban Development (HUD) Code also sets the performance standards for the heating, plumbing, air conditioning, thermal and electrical systems. MH provides financial aid, and when compared to the site-built (traditional stick-frame) homes, manufactured homes are about half the cost per square foot.

In the early 1980s, similar action was also taken by the government of Singapore and Hong Kong to spread the use of prefabrication system which was widely used in the building of public housing [10]. Prefabrication is used to build up high rise buildings, and able to deliver the prefabrication components to the limited access area and the component is directly erected from the crane. In 2011, 84% of Singapore’s residents lived in the Housing and Development Board (HDB) flats with 95% owning such homes, is one of the highest achievement in the country [11]. While the Hong Kong Housing Authority (HKHA), has recommended the usage of precast units and reusable formwork in all public housing contracts [7]. Therefore, IBS is suitable for cities and regions faced with the problem of dense population and with insufficient land for housing development.

The Malaysian government has encouraged the construction industry to move towards Industrialized Building System (IBS) which can produce high volume of houses at affordable cost especially low-cost houses. Government agencies such as Jabatan Kerja Raya (JKR) and Construction Industry Development Board (CIDB); and researchers have played vital roles to educate the main players of the construction industry in the form of policies, financial incentives, strategy guidelines, workshops and seminars to increase the awareness among the end users and clients. Industrialization of high rise residential building components is critical to competitiveness and has become a new trend in order to solve the housing problem and meet the demand for affordable homes especially in big cities with limited space for development area.

Thus, CIDB had implemented the IBS Score in construction industry to measure the level of IBS usage in building and become part of the main monitor system of the IBS construction industry. In the Budget 2005, the policies of the usage of IBS components in government building projects will be increased from 30 percent currently to 50 percent commencing 2005. Housing developers who utilise IBS components exceeding 50 percent, will be given full exemption on levy imposed by CIDB [12]. Base on the CIDB Report (2010), the number of IBS manufacturers is gradually increasing as a result of the government requirement 70% of IBS components must be used in government projects that
valued RM10 million above to receive an exemption of construction levy (CIDB levy – 0.125% of the total cost of the project according to Article 520) for the project [13].

The scoring system is made accordingly to the principles of usage of prefabricated and precast components, off-site production of components, the use of standardised components, repeatability and design building component based on the Malaysian Standard “Guide to Modular Coordination in Building”, MS 1064 [14]. Consequently there is a high demand for the IBS precast concrete among the contractors, whereby they can obtain high IBS Score by using the precast components. The two mandated policies cover for the housing (100% levy exemption with 50% IBS Score) and government buildings (0.125% levy exemption with 70% IBS Score).

The Construction Industry Development Board (CIDB), which forms part of the government agency, conducted a series of surveys in 2003, 2005, and 2008 to authenticate the increasing awareness on the IBS concept in construction [15]. The number of IBS precast manufacturing has significantly increased as pertaining to the IBS Score (1995) and government policy (2008) in using IBS products. This is a good opportunity for the new IBS player to get involved with the IBS precast manufacturing business. Notwithstanding, choice of location decision process is vital to understand the determinants of location by inserting various data layers. Besides, an understanding of the location decision process may improve a local economic activity development and generate the sustainable business environment [16]. Therefore, an appropriate study is required to analyse the potential for IBS precast manufacturing.

IBS PRECAST COMPONENTS ADVANTAGES AND LIMITATION
The benefits of IBS adoption in construction activities in order to reduce dependency on foreign labours, to improve construction’s productivity and quality, reduce wasteful construction method, to become more environmental friendly, to achieve design standardization and to speed up construction time. Anecdotally, based on the IBS Survey 2008, the ranking of IBS benefits listed from the most beneficial to the least beneficial are (1) minimal wastage; (2) cleaner environment; (3) less site materials; (4) reduction of site labour; (5) controlled quality; (6) faster project completion; (7) neater and safer construction sites; and (8) lower total construction costs [15]. The great concern for IBS technology occurred not only in Malaysia but also in other country such as United States, United Kingdom, Australia, Singapore and Hong Kong. Azman et al. [17] reported that the term IBS have similarity with the United States, United Kingdom and Australia. In the US, manufactured home (MH) industry is described as Off-Site Construction Techniques (OSCT) [18]. However in the UK, the Modern Methods of Construction (MMC) is defined in various ways; prefabrication, off-site production and off-site manufacturing [19]. While, the term Offsite Manufacturing (OSM) is the term used in Australia construction industry. In addition, the Singapore and Hong Kong use the same term; prefabrication. Table 1 shows the strength and the limitation of the benefits of IBS precast [20].
Table (1): The Benefits of IBS Precast [20]

<table>
<thead>
<tr>
<th>The Benefits of IBS Precast</th>
<th>Strength</th>
<th>Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildability</td>
<td>Suitable for high repetition building especially for the high rise buildings.</td>
<td>Not suitable for less repetitive especially for the low rise buildings.</td>
</tr>
<tr>
<td>Less wastage</td>
<td>The concrete waste can be recycled [21, 22]. The cycle product can be used in the civil engineering work, landscaping and as a substitute for gravel in concrete products [23].</td>
<td>Require initial investment to obtain the basic recycle machine that can be used for crashing, sizing and stockpiling recycled aggregate.</td>
</tr>
<tr>
<td>Constructability IBS</td>
<td>IBS managed to incorporate with new design aesthetics of the variety of shapes, finishes and high quality.</td>
<td>Limitation of new design which required new mould and highly repetitive design.</td>
</tr>
<tr>
<td>Reduce cost construction</td>
<td>Less used of foreign labour and early completion projects helps to gain early payment from clients and reduce the number of working days save the construction cost.</td>
<td>The IBS technology required high initial capital to start up a project. Required a few projects to cover the cost of IBS technology.</td>
</tr>
<tr>
<td>Completion of project</td>
<td>Fast in two cycled projects and can obtained other projects.</td>
<td>Required proper planning sequence work of IBS precast components to overcome the massive IBS precast products at site.</td>
</tr>
<tr>
<td>Maintenance cost</td>
<td>If use mechanization machine and less automation machine the cost will be low.</td>
<td>If used highly automation machine will cause high electricity and high cost maintenance.</td>
</tr>
</tbody>
</table>

The main function of the IBSs is to create synergy, by generating partners in the industry to assist in training, giving exposure on use of IBS techniques, encouraging the setting up of new IBS factories locally, updating on the latest technology, and enhancing current issues on IBS in the local state and international level (CIDB, 2003). The Malaysian construction industry is undergoing a paradigm shift from using conventional technology to a more systematic and mechanized system that utilizes the latest information and communication technology. IBS has become vital component in the industry to move towards global competition and update the new industrial trend.

**CONCEPTUAL OF GIS SUITABILITY MODEL**

The main purpose of this study is to carry out GIS spatial site selection to identify potential locations for IBS precast manufacturing. This research will identify several factors which has direct impact on the site selection of a new IBS precast manufacturing location. Literatures have shown that optimal site selection using GIS is successfully being performed to determine various site location problems. Vahidnia et al. [24] applied
optimum site selection to locate new hospital in the urban area of Tehran by combining Geographical Information System (GIS) analysis with the Fuzzy Analytical Hierarchy Process (FAHP). Cheng and Li [25] used the GIS approach to find the new location of shopping mall in Hong Kong by deriving four criteria viz. (1) minimum distance, (2) maximum demands coverage, (3) maximum incomes coverage, and (4) optimal centre. Various other research works has applied geographical information systems (GIS) to solve or support spatial reasoning problems in different contexts, such as locating convenience stores and other facilities, site selection, screening potential landfill sites, supplier selection and local park planning [24]. The possibility of using GIS in identifying potential location for IBS precast manufacturing can be clearly seen. A similar approach will be used where the GIS-based land-use suitability modelling is applied. The study will concentrate on the scope of land-use suitability with respect to information science perspective and social science perspective.

The proposed land-use suitability model will generate potential sites for the IBS One Stop Centre based on several criterion factor; road , infrastructure, environment, population and land-use. The research was to identify the potential area for the construction site layout. Meanwhile, the study by Warszawski [26] on the suitable distance from the new potential development area to the fabrication plant should be the distance with a variance from 50km to 100km.

In Boolean method, units in each information layer are assigned by zero or one values [27]. This method is mostly used in the first phase of evaluation, to separate suitable sites from non-suitable ones. In this method weights of criteria are not define and cells values are just 0, 1. Although Boolean logic has wide application because of its quickness, it has some limitations and problems. In this model, all input factors have equal values, while selection criteria have various values. Boolean logic cannot separate suitable sites based on their priorities. So with this model, accessing to the goal of optimal decision is impossible. Based on Jiang and Eastman [28], Boolean overlay all criteria of suitability to produce Boolean maps, which are then combined by logical operators such as intersection (AND) and union (OR). According to Chen and Zhu [29], Boolean overlay represents the extreme cases with no trade-off. Boolean AND operator represents the MIN decision-making risk and Boolean OR operator represents the Max decision-making risk.

**METHODOLOGY**

Currently, the total number of IBS precast manufacturers registered with the Construction Industry Development Board (CIDB) Malaysia is 36 [30]. However, based on the CIDB secondary data, there are 28 out of 36 IBS precast manufacturers which have factories while the others have temporary factories which based on the term of the construction project. From the IBS precast manufacturer’s addresses given by the CIDB, the location of the 28 IBS manufacturers have been identified by using Google Map coordinates web search. To obtain the actual coordinate for the IBS precast manufacturer location, these coordinates are validated by using GPS tool and also through phone calls for coordinates
validation process. These 28 coordinates of IBS precast manufactures is overlay on the Malaysia’s GIS map.

On the other hand, Penang will be chosen to be the calibration spatial model by following the guidelines of Boolean intersection procedure as shown in Fig 1.

RESULTS AND DISCUSSIONS FOR 28 IBS PRECAST MANUFACTURER

Based on the registered address of precast manufacturer plant 2011 with CIDB and validation process as mentioned in the methodology part; the mapping location of 28 IBS manufacturers managed to obtain by using GIS. The results of 28 IBS precast manufacturer is shown in Fig 2. The highest number of IBS precast manufacturing is located in Selangor (9) followed by Johor (4) and Negeri Sembilan (3). Based on the growth domestic product (GDP) 2009 report, construction sector was dominated by Selangor with 37.8 per cent, WP Kuala Lumpur (15.8 per cent) and Johor (10.5 per cent) [31].
Figure (2): List of 28 IBS Precast Manufacturer in Malaysia
Due to the high growth of construction sector in Selangor, there are high demand of the precast products and contribute the growth number of IBS precast manufacturing. Its economy is highly diversified, Selangor is adjacent to the Federal Territory of Kuala Lumpur, and there are many resultant close economic and social ties between them [32]. While the nearest state next to Selangor is Negeri Sembilan which also contribute the impact of economic growth in IBS precast manufacturing due to the high demand of precast product in Selangor.

Initially in 2009, there is only one IBS precast manufacturer in Johor as reported by Azman et al. [33]. But in 2011, the number of IBS precast manufacturer has been increase into four factories which there are demand from Iskandar regional development authority, Nusajaya development and construction industry development from Singapore. Kimlun Corp Bhd manage to obtain the big tender in mass rapid transit (MRT), which worth of RM59.2 million [34]. Kimlun Corp Bhd had been supported by concrete products division under SPC Industries Sdn Bhd that supplies to the construction industry needs in Malaysia and Singapore that cover the comprehensive range of concrete products for both infrastructure and building construction industries. Kimlun Corp Bhd had occupied another two companies to supply the precast concrete; Hume Concrete and HL-Manufacturing. Therefore, Kimlun share the economic growth of precast concrete demand with other manufacturers.

Perlis and Kelantan do not have any IBS manufacturer and this will be contributed the benefit of the manufacturers in Kedah and Pulau Pinang to supply the IBS precast product especially for the government projects. While Perak, Terengganu, Pahang, Sabah and Sarawak are still in the initial state of marketing the use of IBS precast components and educate the contractors and installers. In the circumstances, it is not easy to setting IBS precast manufacturing. Most of the IBS precast manufacturer was concerned on the value obtained from the project before the setting up the IBS IBS precast manufacturing and rule of the thumb for the profit margin IBS project is around 10% [20].

RESULTS AND DISCUSSIONS FOR SUITABILITY SITES IN PENANG

This study describes a type of multi-criteria decision analysis method, called Boolean intersection in a GIS, to evaluate the suitability of the new potential site for precast manufacturer plant. The presented method evaluates the entire study area, using scale from 0 to 1, where 0 denotes sites fully unsuitable for IBS while 1 shows sites suitable for IBS. The evaluation criteria used in this study are distance from road, land use, population, distance from infrastructures, and distance from environment area which cover the river, slope and reserved forest.

The approach of layer preparation is explained below:

1) Distance from road [26]: For deriving this layer, 1:25,000 topographic map was used and then the map of distance from roads was produced. All roads and the areas
within 50,000 m of them are considered suitable and to keep costs of development down.

2) Land-use [35]: Some of land use such as urban area, protected forest, utilities, water body and residential are not suitable for IBS construction while agricultural land, potential agricultural land, manufacturing zone, pastures, and scrub. Those chosen based on the less cost of land.

3) Population [36]: For this purpose, the data were obtained from Malaysia statistics department and then import to IDRISI® to produce a population map. People with more than 800 are considered suitable for allocating IBS manufacturing and give opportunity unemployed to apply new job.

4) Infrastructure [35, 36]: Water supply structures and 2,000 m around them are considered unsuitable for allocating IBS. Electricity structures within 500 m of them are considered unsuitable. Airport and seaport and 50,000 m around them are suitable for construct IBS. Railway and 50 m around them are considered unsuitable.

5) Environment [35, 37]:
   a. Rivers and areas within 100 m from rivers are considered unsuitable for an IBS establishment. So that can be protected from pollution.
   b. Slope: A topographic map was used (1:25,000) for driving Digital Elevation Model (DEM) and then the slope layer derived from DEM. Areas sloped higher than 10% are considered unsuitable for allocating IBS.
   c. Reserved forest: The reserved forest layer was extracted from land use map. In this study only forest area are protected and forbidden to allocate IBS.

For each criterion, a map was produced based on distances and buffers defined above. Then Boolean intersection in the IDRISI® software was used to convert the data layers into Boolean maps, which the suitable sites for IBS is showed as 1 value and unsuitable sites is showed as 0 values. Finally, all the Boolean maps were overlaid by ‘AND’ operation and obtained the final suitability area as shown in Fig 3. The role of GIS in site selection analysis via spatial model has evolved along with the changing perspectives of planning from scientific approaches to collective design approaches [38]. Spatial model was used as a platform enabling the management of the criteria data and production of constraint maps, carrying out the combining Boolean maps by the Boolean method as well as production of the potential site maps. This model has been verified to ensure the development of the model in correct manner and based on its specifications.

In addition, GIS can support a wide range of spatial queries that can be used to support location studies as well as play a significant role in future location model development and application. The value of a GIS map has changed the transition of the media used from pen and ink to computer graphics which are more meaningful represented in the form of colourful pictures and attractive maps in the form of spatial data. The GIS data refers to the process of referencing data to a particular location or address. In addition, the GIS map will be easy to be modified and update the spatial data by increasing the rate of data acquisition from the user needs.
Figure (3): Spatial Site Selection for the IBS precast manufacturing in Penang
CONCLUSION
In conclusion, the IBS technology must be affordable, ability to suit to the climatic condition in Malaysia using environmental friendly method and contribute to the sustainable development of the construction industry. Also the need to reduce the knowledge gap between the government and IBS players, and future research should be continued to educate the existing and new IBS players.

Geographical Information System (GIS) can be a computer aided tool to analyses the results with more accessible information, visualization of data, higher quality of data and established procedures for repetitive analyses. The GIS manage to identify the 28 manufacturers in Malaysia and understanding the pattern development of IBS precast manufacturing. Most of the IBS manufacturers is located in Selangor, Negeri Sembilan and Johor. While other states still in the process of growing number IBS precast manufacturing as to comply the government mandated rules in using IBS.

In the further extent research recommendation, the spatial model GIS in locating new IBS precast manufacturing in Penang can be solved by using Boolean method. The main parameter needs to be considered are road, infrastructure, land use, population and environment factor. It will definitely help in manufacturing new location and knowing the flow of transporting IBS component from IBS manufacturer to the site construction. Hence, the spatial model is applicable to be applied to other states by following the guidelines as proposed in the present research.

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