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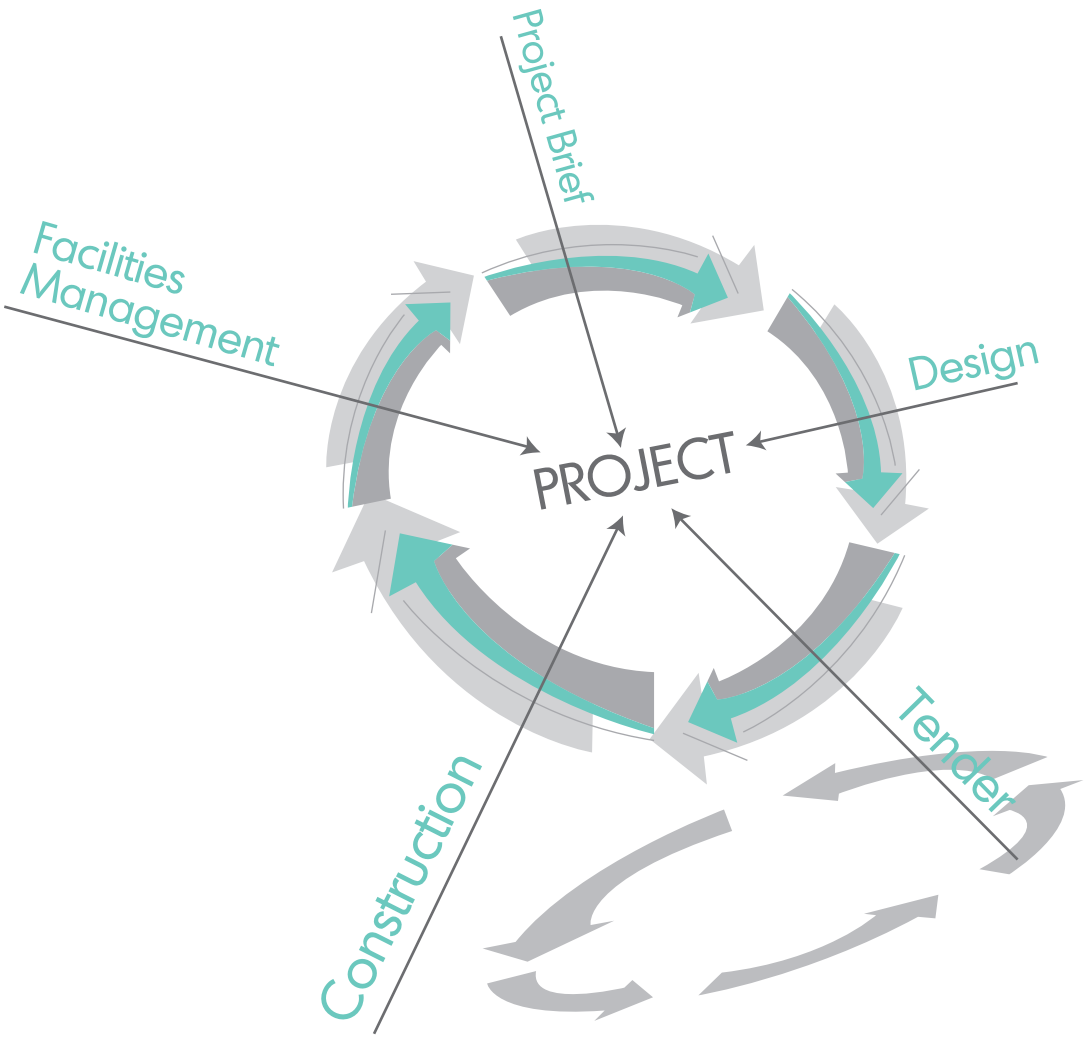

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Construction Research Institute of Malaysia (CREAM)
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No. 100, Jalan Putra,
50350 Kuala Lumpur
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Contents

Editorial Advisory Board

Secretariat:

Editorial

Welcome from the Editors

Welcome to the twenty-ninth (29th) issue of Malaysian Construction Research Journal (MCRJ). In this issue, we are pleased to include eight papers that cover a wide range of research areas in construction industry. The editorial team would like to express our sincere gratitude to all contributing authors and reviewers for their contributions, continuous support and comments.

In this issue:

Agus Maryoto et al., investigated the behaviour of beam-column joint of recycled tyre as reinforcement bars in precast. The reinforcement bar used is four plain steel bars with a diameter of 8 mm. The reliability of the joint connection is determined by using the flexural strength test. The results show the average of compressive strength of three different cylinders is 16.4 MPa which exceeds the designed concrete of 15 MPa. In term of rupture behaviour of specimen, the proposed by connection model for joint beam-column is suitable to be applied in the simple structure made of concrete reinforced with recycled tyre. Another finding in this study is the flexural strength can increase the capacity of the structure to resist earthquake loads.

Mohd Izzat Asyraf Mohamad Kamal et al., studied the performance of cold in-place recycling mix using 50% reclaimed asphalt pavement. Mixed prepared with 50% RAP and 50% new aggregate and 0% RAP; 100% new aggregate as control sample and 2% (by weight of total mix) of cement used in the mixture as additive. The methodology used in this study started by identifying the modified bitumen emulsion and mix design. Results from the penetration test for the bitumen emulsion residue showed the highest value of penetration at 0% NRL which indicates that the emulsion is soft.

Slamet Warsito et al., developed the simulation of public policies on housing development for low income communities. This study has identified the variables affecting the purchasing power of low-income residents and developer's interest. This study also developed the simulation model of the affordable housing problem. The methodology involved in this study are Root Cause Analysis (RCA), Analytic Hierarchy Process (AHP), Dynamic System and Focus Group Discussion (FGD) to achieve the research objectives. The finding shows the absorption of government subsidy for the construction of affordable houses that are not right on target, the gap of affordable house price set by the government is not in accordance with the cost incurred by developers in building an affordable house, resulting in the lack of interest of developers, and the absence of banking access.

Azlan Shah Ali et al., explored the building condition of elderly homes and its maintenance recommendations using case study approach. The method used is Building condition assessment on homes for elderly using two case studies. It is found that 71 defects were found in Case Study A and 67 defects found in Case Study B. the findings prove that the current condition of the elderly homes is not convincing to meet the concept of active aging home. Thus, this study proposed that the homes of aging community should be

maintained in an optimal condition in order to create a conducive surrounding for them to live independently.

Sara M Elseufy et al., identified the factors affecting the productivity of reinforcement work labours in low-cost residential buildings through questionnaire distribution. The questionnaire has been distributed to the consultants and contractors involving six groups associated with rebar workers and related to workers in general. The finding shows that the project type and delayed payment factors were the most important factors which affected the rebar labours. It also shows that the factors in the external group have a negative impact and reduce the productivity growth.

Nur Syaimasyaza Mansor et al., implied the Incomplete Contract (IC) in Malaysian Private Finance Initiative (PFI) projects. From the study, it is identified that twelve (12) clauses that contributed to the incompleteness. This study applied literature review and two round modified Delphi method to carried out IC's implication in Malaysian PFI concession contracts. The findings show that the presence of IC in PFI projects in Malaysia causes positive and/or negative implications. Most of the positive implications mentioned on the flexibility of the incomplete clause to deal with future changes and provide the parties opportunity to renegotiate. Meanwhile, many negative implications refer to delay, disputes, and the risk of opportunistic behaviour.

Nor Khalisah Bidi et al., determined the methodology for quality of cost data as inputs for Life Cycle Cost (LCC) analysis of new flexible pavement construction in the Malaysian construction industry. It has been identified that there are three different phases which are data inputs, conversion and outputs. The methodology proposed for the study is a qualitative research strategy that comprises of literature review and semi-structured interview.

Jati Utomo Dwi Hatmoko et al., assessing the readiness level towards the implementation of Building Information Modelling (BIM) in Indonesia. This study utilizes Company Readiness Index (CRI) to measure the company readiness followed by a gap analysis. The mixed method were questionnaire surveys and interview comprise of three groups which are contractors, engineering consultants and Engineering, Procurement, Construction and Installation (ECPI) department. This study proposed four main elements of readiness including organizational process, management, people and technology. The findings show that the average CRI value of 76.10% indicates that they are ready for BIM implementation.

Editorial Committee

USAGE OF RECYCLED TYRE AS REINFORCEMENT BARS IN PRECAST BEAM-COLUMN JOINT

Agus Maryoto, Nor Intang Setyo Hermanto, Gathot Heri Sudibyo and Yanuar Haryanto
Faculty of Engineering, Department of Civil Engineering, Jenderal Soedirman University, Indonesia.

Abstract
Precast concrete beam with reinforcement bar of recycled tyres have a greater fracture energy as compared to the concrete beam without reinforcement bar. Connections between beams and columns plays an important role on precast concrete segmental to carry lateral load and axial load. This study aimed to determine the structural behaviour of beam-column joint. The specimen used as a beam with dimension of 700 x150 x 150 mm. The beam is connected with a connection model in the form of reinforced concrete columns. The reinforcement bar used is four plain steel bars with a diameter of 8 mm. The flexural strength test is conducted to determine the reliability of the joint connection. The total number of 3 specimens was designed, tested and analysed in this paper. The results show that the flexural failure occurred in the mid-span of the beam. Connection joint remains stable without any cracks or damage. Model connections are shown that the steel bar diameter of 8 mm is safely being used to connect precast concrete with the recycled tyre reinforcement with minimal damage to beam-column joints and at mid-span.

Keywords: *Connection Model; Joint of Beam-Column; Recycle Tyres; Flexural Strength*

INTRODUCTION

Precast concrete is a concrete moulded and cast at the factory or plant, transported to site and installed as building components. The advantages of using precast concrete are more efficient, better quality and material, and faster in the completion of a building. Costs can be saved because the process in the construction does not require any scaffolding and formwork. Completion time is faster because concrete can be cast earlier in other locations that do not interfere with another site work. Unfortunately, the connections between beams and columns require special attention and detailing. This is because the beam-column joint is where the lateral load and axial load transfer to the foundation and required detailing of reinforcement bar.

The stiffness of composite beam-to-column joints was conducted by Odrobinak et al. (2014). They found that the significant influence to the initial stiffness of composite joint was contributed by the growth of reinforcement ratio. Furthermore, in order to enhance the joint capacity, the seismic behaviour of exterior beam-column join using T-type mechanical anchorage with hair-clip bar was investigated by Rajagopal and Prabavathy (2015). It showed that T-type mechanical anchorage system has a better performance than the specimen with conventional anchorage with 90^{o} bent hook. A similar experiment was also performed by Ahmed and Gunasekaran (2014). The slab increased shear stress of the horizontal panel joint. The performance of beam-column joint is affected by amount of reinforcement, detailing of reinforcement, strength of concrete and type of loading (Kaliluthin et al., 2014; Hamid, 2010; Rahman et al., 2008; Yanuar et al., 2017). When the defected i.e. due to corrosion attack (Maryoto, 2015 & 2017) is occurring in the beam column joints, the strengthening using CFRP can be applied (Mahmoud et al., 2014).

Other researchers tried to escalate joint of beam-column capacity by using high performance (Shankar and Suji, 2014 & Parra-Montesinos et al., 2005) and fibre concrete (Muthupriya et al., 2014) to support the external load. The results show that the joint of beam column with high performance and fibre concrete has a better performance in order to resist cyclic loading.

The cyclic and monotonic loading (Priestley and MacRae, 1996; Hamid, 2010; Lu et al., 2012; Kim et al., 2015; Patil and Manekari, 2013) were subjected on the joint beam-column of concrete specimen. The strength capacity increases significantly due to detailing with additional bar at the joint. External ductile detailing of special anchorage beam column joint has a better energy dissipation, ductility and load deformation parameter than internal reinforcement detailing of beam-column joint (Moehle et al., 20105). Figure 1 shows an example of the external detailing of beam-column joint for moment resisting frames.

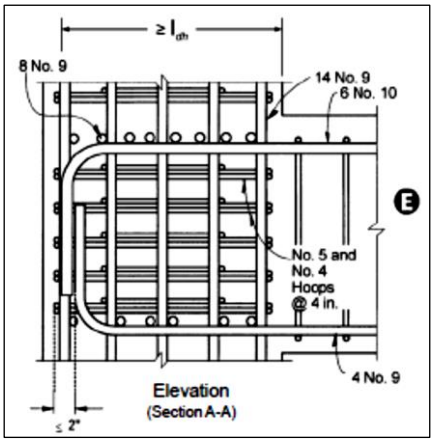


Figure 1. Exterior detailing joint (Moehle et al., 2008)

Some researchers tried to demolish the waste materials by using them in concrete mixes (Maryoto et al., 2015; Maryoto, 2017 & Khaled et al., 2017). Polyethylene Terephthalate (PET) Bottle was used as fibre in concrete (Khaled et al., 2017). The results showed that concrete with PET bottle as fibre with length of 10 mm has highest pull out load compared with those PET with length of 5 mm and 10 mm. On the other hand, Maryoto et al., 2015 stated that waste tyres were produced around 20 million tons annually in Indonesia. Reuse of the waste tyre in the simple concrete beam is one of the methods to dispose them safely and economically. The waste tyre was used as recycled material and additional to reinforcement bars in concrete beam. The segmental precast concrete reinforced with recycled tyre was applied for simple supported beam under three points loads. They found that the flexural strength of concrete beam reinforced with recycled tyre with prestressed force is higher than without prestressed force. Unfortunately, connection model of beam-column joint is not studied yet by any previous researcher.

Based on the previous studies, this study tries to determine the proposed connection model in the joint of beam and column under three points load and to evaluate the failure mode for this study. The three specimens of reinforced concrete beams with recycled tyre were designed, constructed and tested under three-point loads. The detailing of reinforcement bars as shown in Figure 1 is used for this model and represents the external beam-column joint of precast reinforced concrete buildings.

RESEARCH METHODOLOGY

Materials Properties

Cement type I, sand, crushed stone, water, waste tyre, pipe clamp, steel bar diameter 8 mm were used to construct the beam and beam-column joint. The waste tyre and pipe clamp were consumed as shown in Figure 2. Compressive strength of concrete is designed as 15 MPa. This quality grade of concrete is usually utilized in the construction of building with simple structure. Based on the physical properties of material for concrete of 15 MPa, mix proportion of concrete is shown in Table 1. The equipment used in this study were concrete mixer, universal testing machine, balance, sieve, slump test equipment and moulding of concrete beam to determine the compressive strength of concrete.

(a) Waste tyre

(b) Pipe clamp (Maryoto, 2017; Maryoto et al., 2019)

Figure 2. Material for concrete reinforced with recycle tyre

Table 1. Mix proportion of concrete for compressive strength 15 MPa

Weight of materials (kg/m^3)			
Cement	**Crushed stone**	**Sand**	**Water**
360	1070	775	205

Construction Specimens

The 10 recycled tyres acting as reinforcement bar with square dimensions of 10 mm × 10 mm are inserted at bottom of the beam mould. Ends of the recycled tyre were installed at end beam using the pipe clamps. The recycled tyre which represents the reinforcement bar is elongated until its length ranges 140% of the initial length. The waste tyre elongation scheme is shown in Figure 3. Figure 3 (a) shows the recycled tyres were pulled by force P and acting as reinforcement bars. Figure 3 (b) shows the cross-section of beam with ten of recycled tyres. Figure 3 (c) shows the location of recycled tyre at the bottom beam with 700 mm length.

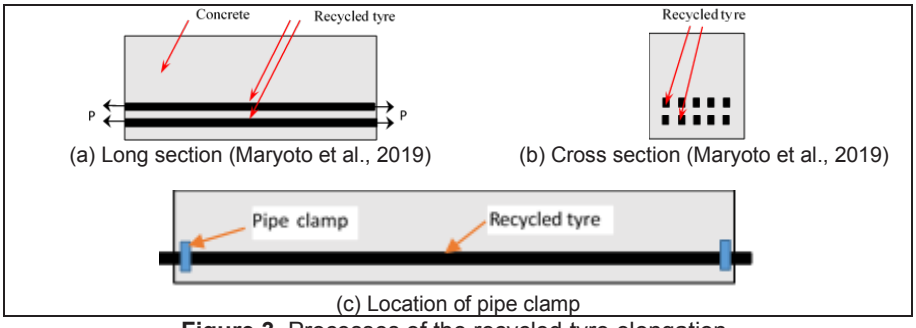


Figure 3. Processes of the recycled tyre elongation

The dimension of the specimen is 700 x 150 x 150 mm. At the ends of the beam was connected to the column. Four steel bar diameter 8 mm are installed at the right and left side of the concrete reinforced with recycled tyre. The length of the connection is 150 mm. The dimension of the column is 350 x 150 x 150 mm. The first casting of concrete is started in the beam (first step), then continued in the left joint (2nd step), and finally ended in the right joint (3rd step). The real processes of making specimen can be observed using Figure 4. The step of casting concrete step is shown in Figure 5. Three concrete reinforced with recycled tyre specimens were casted in the moulding.

Figure 4. The real of making specimen

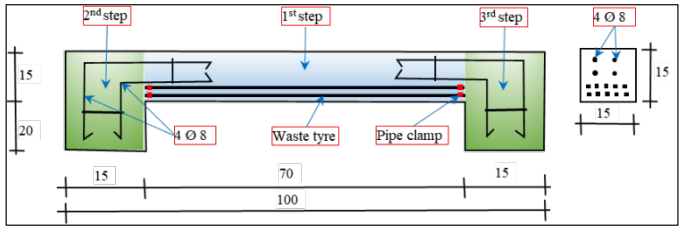


Figure 5. Detailing of beam and beam-column joint with recycle tyres

Testing Procedures

The specimens of flexural strength were cured by covering using wet mattress for 28 days. Therefore, Universal Testing Machine is used to determine the flexural strength capacity of beam with recycle tyres. Three-point loading based on ASTM C 78-95 is referred to conduct the testing. The loading is employed on the surface of the specimen at the third point and a load between 3 and 6% of the estimated ultimate load. Application of the load on the specimen is done continuously and without shock. The speed of loading is generated at a constant rate to the breaking point. Equation 1 is used to determine the rupture load when the initial fracture in the tension surface within the middle third or the span length occurs.

$$R = \frac{PL}{bd^2} \tag{1}$$

If the rupture takes place in the tension surface outside of the middle third of the span length by not more than 5% of the span length. Equation 2 is implemented to determine the modulus of rupture.

$$R = \frac{3Pa}{bd^2} \tag{2}$$

Where, R is the modulus of rupture in mega Pascal's, P is the maximum applied load indicated by the testing machine in Newton, L is the span length in millimetres, b is the average width of the specimen at the fracture in millimetres, d is the average depth of the beam in millimetres, and a is the average distance between the lines of the fracture and the nearest support measured on the surface tension of the beam. Figure 6 shows the experimental setup of the flexural strength of the beam and beam-column joint under three-point loads.

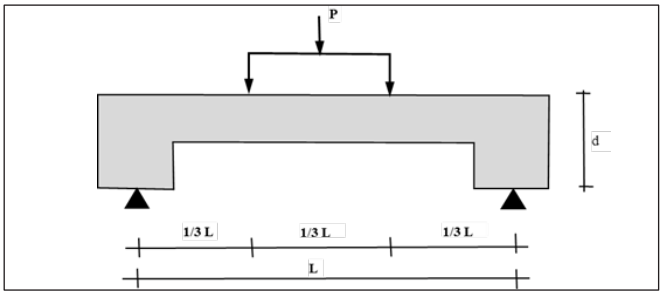


Figure 6. Experimental set-up for flexural test under three-point loads

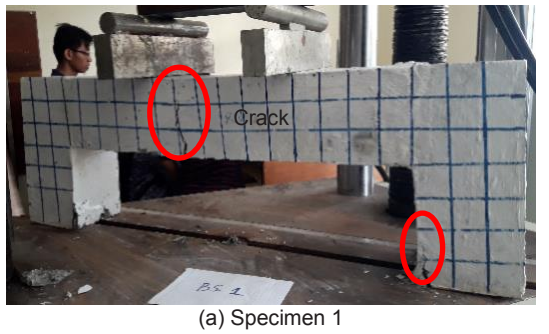
RESULTS AND DISCUSSIONS

Compressive Strength of Concrete

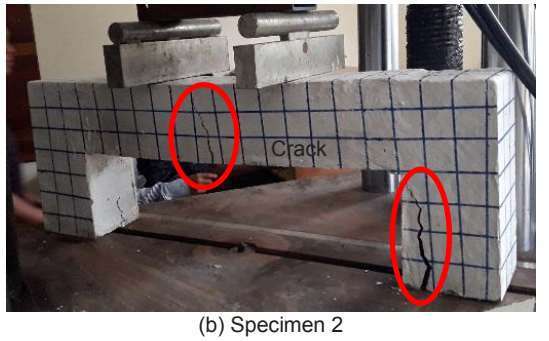
To ensure that the mix proportion of concrete as shown in the Table 1 is achieved with initial planning, the compressive strength test is arranged in the laboratory by using Universal Testing Machine. The dimension of the specimen for compressive strength is a cylinder with 150 mm of diameter and 300 mm in height. After all the three cylinders were being cured in the fresh water for 28 days, they are removed from the water and place them in the ambient room around 3 hours. After that, compressive strength test was conducted under compressive tool. The result shows that the compressive strength of three cylinders is 16.2 MPa, 16.4 MPa and 16.7 MPa. The average of compressive strength is 16.4 MPa and the value is exceeding the designed concrete of 15 MPa.

Rupture Behaviour of Specimen

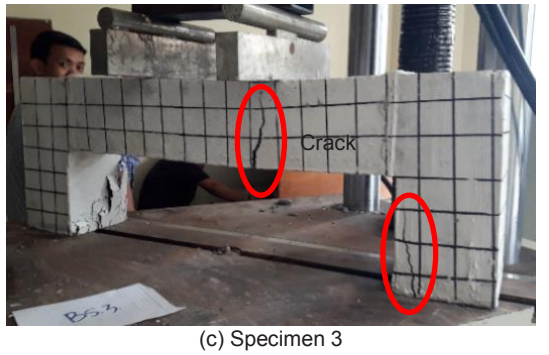
The failure model, crack type and crack propagation can be observed as shown in Figure 7. In the process of flexural strength test, the first crack occurs on the surface of bottom side of the beam. Therefore, the single crack propagates in the vertical direction. The crack is located in the middle third of the beam. This failure is caused by tension stress. The tensile strength of the concrete is exceeded due to tensile load. The crack width develops more than 3 mm, but the beam is still stable on the three supports. It means that the reinforcements from the recycle tyres in the concrete did not reach maximum strain. Another rupture of the concrete part takes place at the inner corner of the right-side column. The part with no cracks happens on the concrete cover for steel bar as the connection between beam and column. Unlike the failure of the concrete at the beam, the failure of the concrete at the column is led by compression force. Modulus of rupture Specimen 1, Specimen 2 and Specimen 3 are 1.89 N/mm^2, 5.89 N/mm^2 and 2.97 N/mm^2 respectively. The relationship between load and deflection is shown in Figure 8.



(a) Specimen 1



(b) Specimen 2



(c) Specimen 3

Figure 7. Crack propagation

Another visual observation is that the pipe clamps anchorage on the recycled tyre still works well and keep hold tightly the recycle tyres in the concrete. None of the ten reinforcement bars from recycle tyre are broken and they behave ductile. The type of failure of the three specimens has a similar pattern and the same tendency which is a single crack on the beam and rupture on the column due to a compression force. The cracks occurred in the middle of the beam.

Based on the appearance of the rupture of the specimens, it can be concluded that the proposed by connection model for joint beam-column is suitable to be applied in the simple structure made of concrete reinforced with recycled tyre.

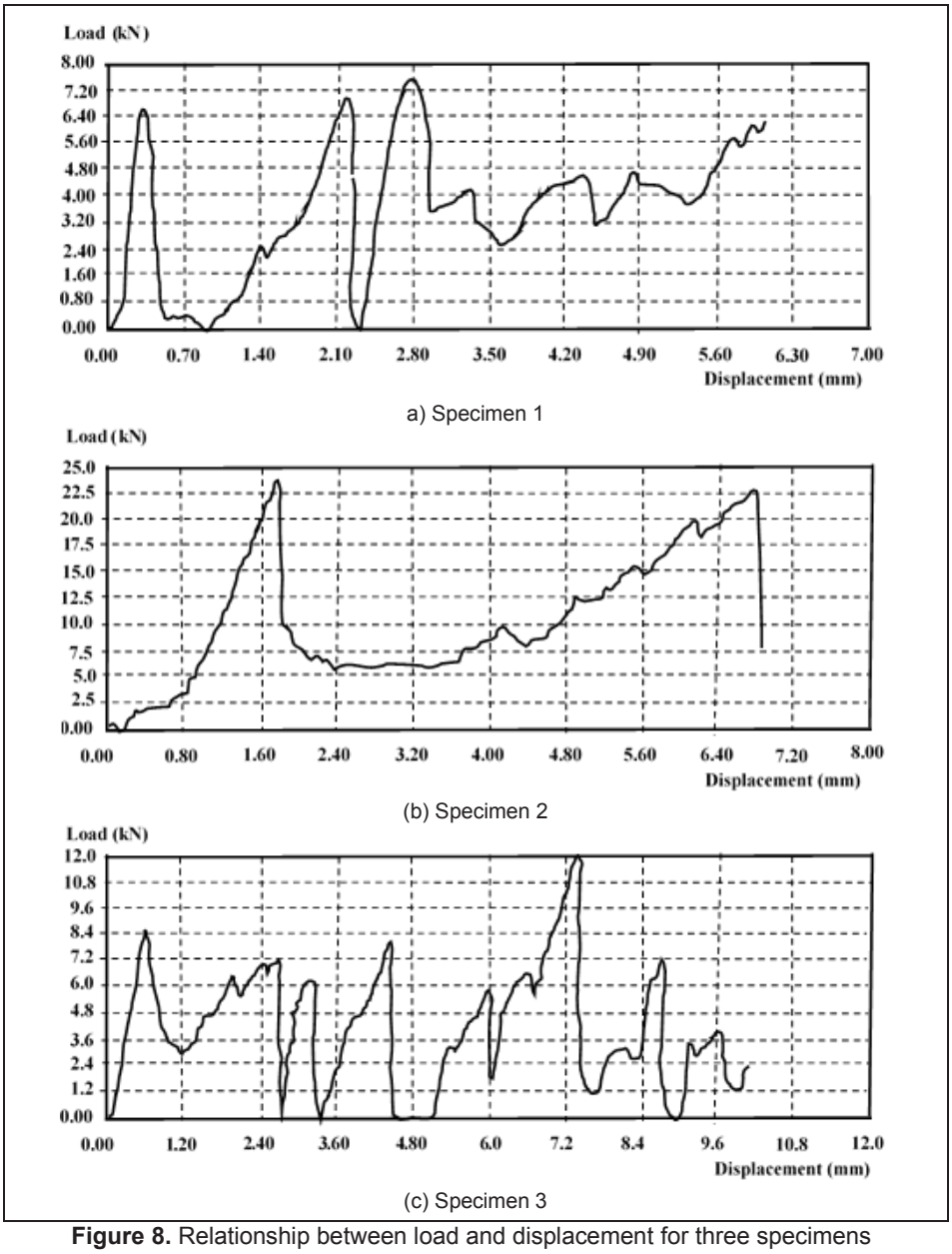


Figure 8. Relationship between load and displacement for three specimens

Flexural Strength

Figure 9 shows the results of the flexural strength test. The graph correlates between strain (%) as horizontal axes and stress (MPa) as vertical axes. The maximum flexural strength of Specimen 1, Specimen 2 and Specimen 3 are 0.35 MPa, 1.00 MPa and 0.54 MPa, respectively. The average flexural strength of three specimens is 0.63 MPa. According to Figure 9, it can be confirmed that after the first maximum flexural strength is reached, then the flexural strength reduces suddenly. But after the minimum flexural strength which is around 0.2 MPa as shown in Figure 9 (b) is achieved, then the flexural strength increases again. This tendency repeated up to 4 or 5 times.

The simple structure of concrete reinforced with recycled tyre is also has a good ductility. It can be confirmed that the strain can be attained more than 10%. The structure remains stable and firmly in place, with no sudden collapse. If the fracture energy is defined as the area under the curve after maximum flexural strength is reached, then the concrete reinforced with recycled tyre has a very large fracture energy. The fracture energy of Specimen 1, Specimen 2 and Specimen 3 are 0.21 N/mm, 0.63 N/mm and 0.47 N/mm, consecutively. This will increase the capacity of the structure to resist earthquake loads. However, this structure should be proven by the cyclic loading in the next study.

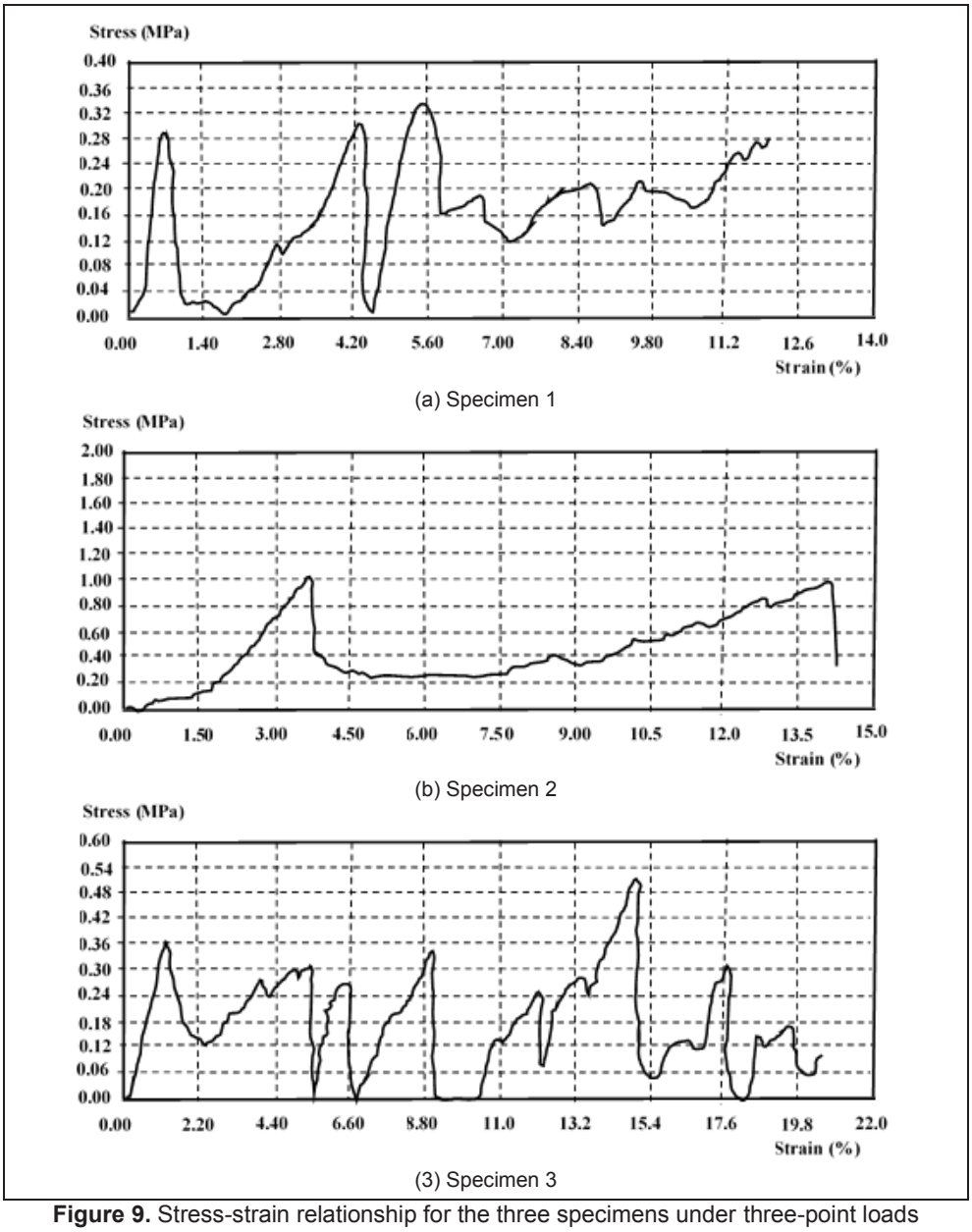


Figure 9. Stress-strain relationship for the three specimens under three-point loads

CONCLUSIONS

Based on the results discussed above, some conclusions can be given as follows.

1. Modulus of rupture Specimen 1, Specimen 2 and Specimen 3 are 1.89 N/mm^2, 5.89 N/mm^2 and 2.97 N/mm^2 respectively.
2. The fracture energy of Specimen 1, Specimen 2 and Specimen 3 are 0.21 N/mm, 0.63 N/mm and 0.47 N/mm consecutively.
3. The maximum flexural strength of Specimen 1, Specimen 2 and Specimen 3 are 0.35 MPa, 1.00 MPa and 0.54 MPa respectively.
4. The proposed model of connection joint between beam and column as shown in Figure 5 is safe to be applied as connection joint for concrete reinforced with recycled tyre.
5. The simple structure made of concrete reinforced with recycled tyre have greater energy because it has remained flexural strength after the maximum flexural strength is reached.

ACKNOWLEGMENTS

We acknowledge the financial support for this work from LPPM, Jenderal Soedirman University, Purwokerto, Central Java, Indonesia and funded through Scheme of *Hibah Penelitian Unggulan Perguruan Tinggi*, BLU Unsoed 2016.

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PERFORMANCE OF COLD IN-PLACE RECYCLING MIX USING 50% RECLAIMED ASPHALT PAVEMENT

Mohd Izzat Asyraf Mohamad Kamal[1], Ahmad Kamil Arshad [2] and Juraidah Ahmad[1]
[1] Faculty of Civil Engineering, Universiti Teknologi MARA (UiTM) Selangor, Malaysia
[2] Institutes for Infrastructure Engineering and Sustainability Management, UiTM Selangor, Malaysia

Abstract
In this study, the performance of reclaimed asphalt pavement (RAP) mixed with polymer modified bitumen emulsion (PMBE) has been investigated to be applied as cold in-place recycling (CIPR). Mixed prepared with 50% RAP and 50% new aggregate and 0% RAP; 100% new aggregate as control sample and 2% (by weight of total mix) of cement used in the mixture as additive. Bitumen emulsion was modified using natural rubber latex (NRL). Distillation process has been conducted to extract the residue from the emulsion and the residue has been used to determine the optimum NRL to be used in the mixture. Performance of mixed based on indirect tensile strength (ITS) soaked and un-soaked and unconfined compression strength test (UCS) was conducted. Results obtained ITS and UCS test for the mixes complied with the requirements of the Road Engineering Association of Malaysia (REAM) specifications. The results exhibited the advantages of 50% RAP mixture as pavement rehabilitation.

Keywords: *Cold-in-Place Recycling; Natural Rubber Latex; Polymer Modified Bitumen Emulsion; Reclaimed Asphalt Pavement*

INTRODUCTION

The CIPR is one of the highway agencies most preferred to use as the structural rehabilitation techniques. It has gained their recognition nowadays due to several advantages such as low cost, less energy used and preservation of the environment. The CIPR is a kind of rehabilitation technique that reuses existing pavement materials at construction sites which are not present in the heat.

The stabilizing agent frequently used for CIPR mixture is cement, bitumen emulsion, and foamed asphalt, which binds the individual aggregate particles together. At present, there is a lack of research performed on CIPR using PMBE. PMBE is not only safe to apply and environmental friendly, but it can also improve the properties of the CIPR mixture. The use of PMBE appears to result in a more evenly distributed polymer network compared to the use of hot polymer modified binders, and they therefore have a greater potential to improve the pavement performance (Forbes et al., 2001). A mixture of cold recycled mixes with bitumen emulsion has a lower modulus compared to cold recycled mixes with foamed asphalt due to less voids and the drop asphalt cohesion method in foamed mixes (Yan et al., 2009). In China, the results of laboratory testing and field inspection showed that the CIPR with bitumen emulsion used as a stabilizing agent is a suitable technique for rehabilitation of deteriorated asphalt pavement (Yan et al., 2010).

The main competitive edge of Malaysia's integrated rubber industry compared to other producing countries is the comprehensive R&D which has largely enhanced Malaysia's productivity in terms of output per unit of land, labor and capital (LGM, 2016). Adding natural rubber into asphalt paving mixtures may be of interest both to producers of rubber and highway engineer. This approach can directly increase demand for commodities and thus boost up the Malaysia's rubber industry. In 2004, Ruggles mentioned that the first ever

application of natural rubber latex in road construction took place in 1929 in Singapore, then the use of NRL in asphalt had been studied extensively in the 1950's and 1960's. He also stated that, at low temperatures the natural rubber reduces thermal cracking associated with bitumen. As a result of this, road surfaces are resistant to defects and the durability of a road surface is increased markedly. Malithong and Thongpin (2010) revealed that by using pre-vulcanized NRL to be modified bitumen emulsion could serve a standard bitumen emulsion and are applicable for highway construction.

Many factors are often referred when considering the use of RAP in asphalt pavement, but the two main factors often taken into consideration is the economic savings and environmental conservation. RAP is a clever approach in replacing virgin material as it can reduce the use of virgin aggregate and bitumen in the production of asphalt pavement (FHWA, 2011). Federal Highway Administration (FHWA) and American Association of State Highway and Transportation Officials (AASHTO) support and promote the appropriate use of recycled materials in highway construction in public policy statements and the resolution of the AASHTO Standing Committee on Highways on "Use of Recycle Materials" (Caltrans, 2005). Researcher found that incorporating RAP improves some engineering properties like tensile strength, rutting performance, fatigue and stiffness (Huang et al., 2004). Based on a study conducted by Yongjoo and Lee (2006), fine RAP gradation was found to produce higher Marshall Stability and indirect tensile strength values compared to coarser RAP gradation.

METHODOLOGY

Phase 1: Study on Modified Bitumen Emulsion

Bitumen emulsion was modified by adding some amount of natural rubber latex (NRL) as a modifier. The slow setting emulsion was used for the modification and mix design. Asphalt emulsion used in this study meets the requirements of the REAM specification for cold in place recycling (REAM, 2005). The amount of modifier used in this study varies from 0 to 12 in weight percentage with an increment of three percent for each blend. Post-blended method has been used to modify bitumen emulsion where the modifier was added into the prepared bitumen emulsion. This method was chosen because it can reduce the effect of heat to the polymer, while reducing the costs associated with the preparation of polymer modified bitumen emulsion. In addition, this method is the easiest method; it can be done at the construction site and does not require complicated equipment (Shafii et al., 2013). A total weight of 300g of mixture containing different percentages of NRL and emulsified asphalt was prepared at 750 RPM velocity for 20 minutes blending time.

Several tests were conducted on the residue obtained from the distillation process of bitumen emulsion to determine the performance and rheological properties. The tests conducted to determine the best NRL content are ductility test, softening point test, and penetration test. Table 1 summarized the test conducted on the residue at different NRL content.

Table 1. Types of test conducted on asphalt residue

Test	Reference
Distillation Test	ASTM D6997 - 04
Ductility Test	ASTM D113 - 07
Softening Point Test	ASTM D36/D36M - 09
Penetration Test	ASTM D5 - 06$^{\varepsilon 1}$

Phase 2: Mix Design

The gradation used for this study was designed to fit in Superpave control points and also to meet REAM grading limit specification. Ordinary Portland Cement (OPC) was used in this mixture and the total amount used is 2% by weight of the combined aggregate as stated by REAM. The combination of aggregate and RAP used are 50:50 to 50% RAP and 50% aggregate, and if 0:100 means 0% RAP for control sample and 100% aggregate. The mix was prepared manually, and materials were weighed by proportion consisting of natural aggregate, RAP, and cement and mixed with bitumen emulsion for 15 minutes or until all the aggregates are coated nicely. Then, the mix was compacted in a 100 mm diameter mold using the Superpave Gyratory Compactor (SGC) by applying 100 gyrations at 1.25° Gyratory angle. The compacted samples were cured at 40°C for 72 hours and allowed to cool to ambient temperature. Prior to testing for UCS and ITS test, the sample has been conditioned in water at 25°C for 24 hours. ITS test and bulk density were conducted on the specimens at various PMAE content to obtain the optimum PMAE. The optimum value of ITS and bulk density was used to determine optimum PMAE for each percentage of RAP by averaging both optimum values. The specimens for the compacted recycled mix were then prepared at optimum emulsion content for every RAP proportion. The specimen was tested soaked and un-soaked for the ITS to obtain the Tensile Strength Retained (TSR) value for moisture susceptibility evaluation and UCS to identify its performance at different RAP contents.

EXPERIMENTAL RESULTS

Polymer Modified Bitumen Emulsion

The amount of polymer used to modify bitumen emulsion is in the range of 0 to 12 percent by weight of bitumen emulsion. The different increment in percentage of polymer and test conducted is tabulated in Table 2. From the results, softening point present a trend where the temperature is directly proportional with a percentage of NRL which showed at 0% to 9%; every increment of NRL increased the temperature. As NRL is at 9%, the temperature reached its peak. This occurred due to the nature of the NRL because it consists of chains of complex molecules which stiffen the emulsion. However, with a further increment of NRL, the temperature began to decrease. The drop of temperature may have been caused by excessive NRL which affect the spreading of rubber in the bitumen emulsion which cause the emulsion to become softer.

As for the ductility tests, the trend was as same as presented by softening point. The elongation is lowest when the NRL use is 12%, which gave a value of 33 cm and the highest recorded when at 105 cm at NRL 9%. All the ductility test results passed the REAM specification with the allowable minimum ductility value is 40 cm, except for NRL 12%. The decreasing ductility value probably indicates excessive of NRL in the bitumen emulsion which may affect the homogeneity of the mixture.

Results from the penetration test for the bitumen emulsion residue showed the highest value of penetration at 0% NRL which indicates that the emulsion is soft. As NRL increases, the penetration gave the lowest value of 103 at 9% NRL. Further addition of NRL showed that the penetration value began to increase again in 109 to 12% NRL. Penetration index (PI) represents a quantitative measure of bitumen reaction to temperature change. Higher thermal susceptibility is represented by low PI values. Therefore, 9% NRL content was selected as the maximum useful amount of PMAE.

Table 2. Physical properties of bitumen emulsion residue with different NRL content

% of NRL	% of Residue	Softening Point (°C)	Ductility (cm)	Penetration	PI
0	61.8	48	67	130	1.1
3	61.8	58	87	110	3.0
6	62.1	61	92	105	3.5
9	63.0	69	105	103	4.9
12	62.6	66	33	109	4.6

Mix Design

This section will be focusing on the design of gradation and determination of optimum polymer modified bitumen emulsion. The process for this study was initiated by obtaining RAP and new aggregate. RAP materials were taken from the milled section of the old pavement under restoration (Klang Valley area) while the new aggregate was taken from the quarry (Kajang Rock Quarry). Natural rubber latex and bitumen emulsion was supplied by ACP-DMT Port Klang.

Gradation

Figure 1 shows the gradation that was designed to fit in Superpave control points and also to meet REAM grading limit specification. Ordinary Portland Cement was used as mineral filler in this mixture and the total amount used was 2% by weight of the combined aggregate as stated by the specification.

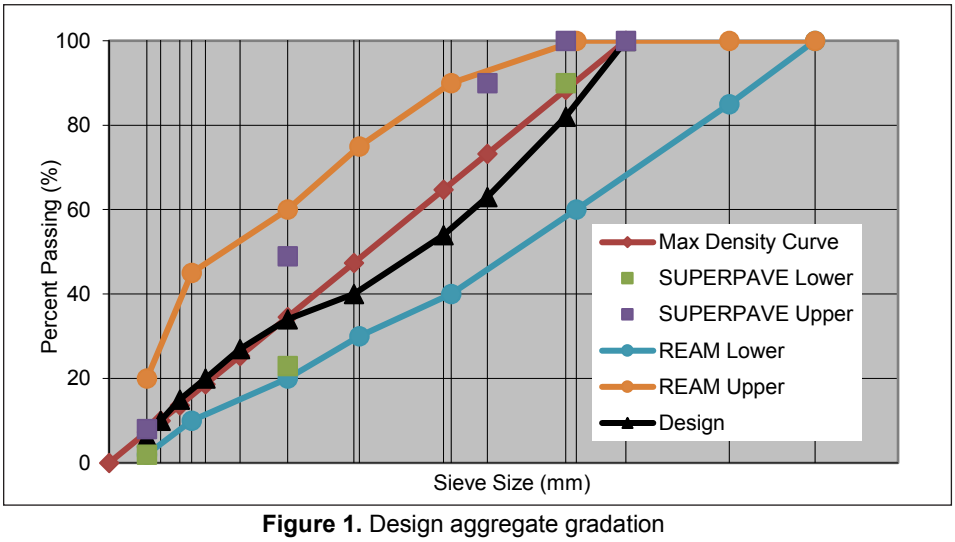

Figure 1. Design aggregate gradation

Optimum Polymer Modified Bitumen Emulsion

ITS test and bulk density of the various polymers modified bitumen emulsion contents were conducted on the specimens to obtain the optimum polymer modified bitumen emulsion. The optimum value of ITS and bulk density was used to determine the optimum PMAE for each percentage of RAP by averaging both optimum values. The variation of ITS in PMAE content is presented in figure 2. It could be seen that the higher use of RAP in the mixture will give the least optimum PMAE; this may be due to the existence of bitumen in the RAP. Figure 3 shows the bulk density with total PMAE content. It is observed from the figure that, the optimum value of bulk density for each percentage of RAPs is nearly the same within the range of 5.0 to 5.2. This might be due to the same amount of cement used (2%) in all proportion of RAPs which did not affect the overall mixture.

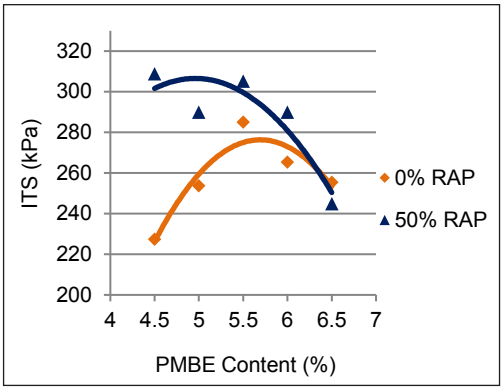

Figure 2. Variation of ITS value with total PMBE content

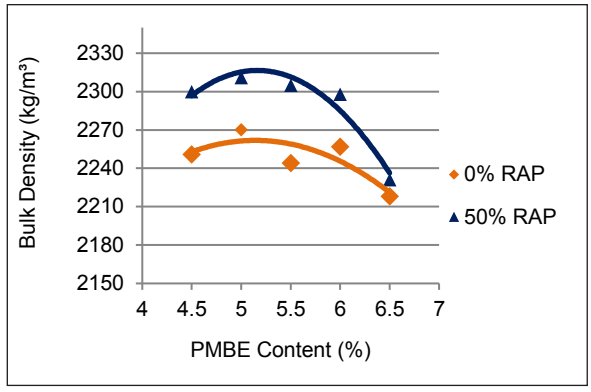

Figure 3. Variation of bulk density with total PMBE content

Table 3 presents the summary of the mix design, test results for each percentage of RAPs conducted to obtain optimum PMBE. The presence of RAP directly affects the value of optimum PMBE; this is because the existing bitumen in RAP. These optimum PMBE contents were used for preparation of specimens for performance evaluation.

Table 3. Optimum PMBE for each percentage of RAP

Percentage of RAP	ITS	Bulk Density	Optimum PMAE
0%	5.7	5.1	5.4
50%	4.9	5.2	5.1

Performance Test

Effects of the Indirect Tensile Strength (ITS)

Figure 4 presents the indirect tensile strength for un-soaked and soaked sample for each percentage of RAP. It shows that both un-soaked and soaked at different percentages of RAP complied with the minimum strength specified by the specification. ITS values for un-soaked specimen for both mixes gave the same ITS values of 0.254 MPa and for soaked specimen, mix with 50% RAP gives higher value (0.236 MPa). Figure 5 shows the TSR for different percentages of RAP. The highest TSR value was observed for samples with 50% RAP. This is likely due to the amount of water absorbed into the natural aggregate particles that cause a

decrease in resistance to moisture susceptibility. A lower percentage of RAP used have a greater capacity to absorb water, while for the mixture containing higher percentage of RAP, the existing bitumen in RAP coat the aggregate particles that prevents water to be absorbed. All samples exceeded the minimum TSR requirement of 75%.

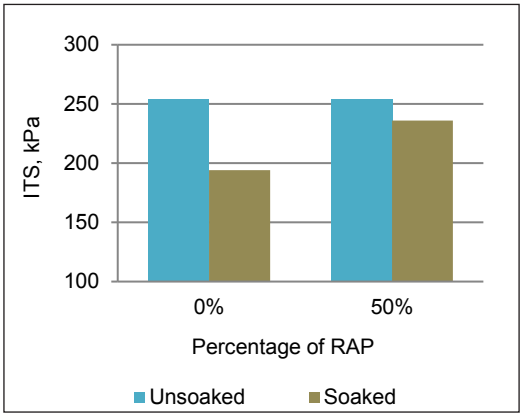

Figure 4. Indirect tensile strength for un-soaked and soaked conditioned for each percentage of RAP

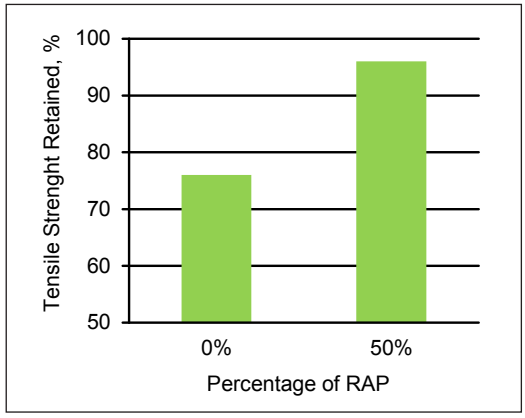

Figure 5. Tensile strength retained (TSR) for each percentage of RAP

Effects of Unconfined Compression Strength (UCS)

Figure 6 shows the results of UCS test prepared for both mixes. Generally, the result shows that the compression strength increases to the optimum value as the percentage of RAP increase, however a further increase of RAP percentage results in a decrease in compression strength. The high compressive strength value is 2.963 MPa at 50% RAP; this may be due to the lower fines aggregate content that can be mixed with the bitumen emulsion and therefore, the excess bitumen emulsion acts as a lubricant and reduces the strength. However, the UCS value for all samples exceeded the specification, minimum UCS requirement of 0.7 MPa.

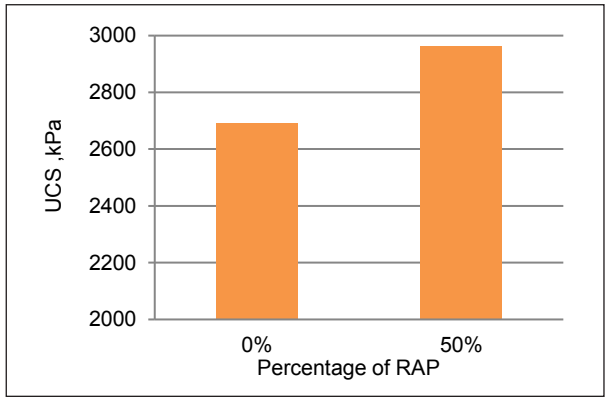

Figure 6. Unconfined compression strength for each integer of RAP

CONCLUSION

The results drawn from this study are as follows:

1) Natural rubber latex (NRL) can be used to modify bitumen emulsion and improves the physical properties of bitumen emulsion. 9 percent of NRL content was optimum amount that could be added to prepare modified bitumen emulsion. Based on these properties, it can be pointed out that the use of modified bitumen emulsion into cold mix asphalt has the advantage when compared to unmodified mixture in terms of strength and durability.
2) CIPR mix with 50% RAP is at its best to be used because the results presented in ITS and UCS are better compared to 100% usage of new aggregate.

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SIMULATION OF PUBLIC POLICIES ON HOUSING DEVELOPMENT FOR LOW INCOME COMMUNITIES

Slamet Warsito[1], Jati Utomo Dwi Hatmoko[1] and Rizal Z. Tamin[2]
[1]Department of Civil Engineering, Faculty of Engineering, Diponegoro University, Indonesia.
[2]Faculty of Civil and Environmental Engineering, Bandung Institute of Technology, Indonesia.

Abstract
Low developer's interest to build affordable housing and low capacity of low-income residents in buying affordable house are some of the causes of the lack of proper subsidy policy for affordable housing development. The affordable house development policy needs to be formulated appropriately, in order to encourage developers' interest in building affordable housing to meet low-income residents' purchasing power needs. However, policy formulation is often constrained by the impact of the policy by both low-income residents and developers. In this research, the following stages are done; identification of variables affecting the purchasing power of low-income residents and developer's interest, development of simulation model of the affordable housing problem, and policy simulation analysis of affordable housing problems. The methods used in this research are: Root Cause Analysis (RCA) applied to identify problems and related variables, Pairwise Comparison (Analytic Hierarchy Process method) to identify the weight of related variables, Dynamic System to develop a policy model, and Focus Group Discussion (FGD) were used to validate the affordable housing subsidy policy. The result of the research shows the absorption of government subsidy for the construction of affordable houses that are not right on target, the gap of affordable house price set by the government is not in accordance with the cost incurred by developers in building an affordable house, resulting in the lack of interest of developers, and the absence of banking access. The results of this study can provide various causes of the implementation problems of affordable housing.

Keywords: *Affordable house; Low Income Residents; Simulation; Dynamic System.*

INTRODUCTION

The realization of a simple and affordable housing program for low-income resident is still not well achieved. This is because in the implementation of public housing in this reform era there are still some weaknesses, such as lack of consistency, synergy, coordination, integration and sustainability in implementation (Koto, 2011). According to Tanjung (2010), that the implementation of the politics of affordable housing until the reform era is still not able to prosper in the lower middle-class people, especially low-income residents. This is evident from the backlog / deficiencies that are getting bigger every year and still many low-income residents occupy inadequate dwellings (on river banks, along railway tracks and others). This condition must be dealt with comprehensively through appropriate policies and supported by the politics of housing development that really pro person. In addition, improper residential locations can cause environmental damage (Yep, 2015). Formal housing and public housing have a long history in Indonesia. From the mid-1970s, both central and local governments have tried to utilize the welfare concept of housing by developing public housing and urban renewal projects (Iriansyah, 2011). Perum PERUMNAS, the National Housing Corporation is the institution who is in charge of the implementation the housing projects. Walk-up flats were introduced under redevelopment or urban renewal programs by central and local government (Winayanti and Lang, 2004).

Although the government has facilitated by building affordable houses or low-income homes for low-income communities through the Housing Financing Liquidity Facility

program, but in its implementation still faces many problems, among others: the realization of affordable housing development is not on target, the lack of interest of developers to Building affordable house and low ability of low-income residents' purchasing power. Similarly, the policy regulation is often changing, making the implementation of public housing runs not directed and not sustainable.

The various problems that cause high cost economy in the implementation of the public housing need to be handled seriously by all parties involved in it. If this is not done, then the low-income residents are increasingly unable to meet the needs of houses and affordable residence as promised by the government in the 1945 Constitution Article 28 H paragraph 1. Therefore, the fulfilment of the needs of the house that is feasible and affordable for low income residents is something that must be fought for to fulfil people's basic right, that is the realization of a life of dignity, prosperity and inner birth. It is a shared responsibility between government, employers and the public to realize a viable and affordable housing for low-income residents can actually be realized.

Bappenas (2015) explains that in realizing technically, administratively and ecologically appropriate public housing, as well as issues of untreated / purchasing power of low-income residents, interventions should be made by the central and regional governments in terms of:

1) Achieve a fast, easy, cheap and transparent licensing service.
2) Housing finance policies that can be fulfilled the requirements, low mortgage rates, low advances and loan periods according to the ability of low-income residents.
3) A synchronous and pro-people tax policy.
4) Involvement of central and local government in providing land / land for the location of the construction of affordable houses and infrastructure development.
5) Allowing all types of taxes and user charges for the purchase of affordable houses for low-income residents.

The various problems are suspected to occur because there is something not right in the formulation (formulation) policy. This conjecture is based on the idea that "More important in terms of the process of implementation is the fact that the decisions made at the design or formulation stage have considerable impact on how the implementation proceeds" (Grindle in Wibowo, 2011). In addition, at the stage of policy formulation, as stipulated by Imron in Nugroho (2008), policy boundaries concerning time, human resources, institutional, and funding or budgeting were established. Therefore "even though it has been ratified, does not mean that the policy formulation has been free from problems".

Assessment of this policy formulation process is very useful for obtaining the information necessary to develop adequate policies, as suggested by Kerr in Wibowo (2011). Kerr's opinion in Wibowo (2011) asserts that a description of how a policy is made can provide us with the information needed to make good decisions, which must be taken in policy-making. The policy- making review is a description of the decision-making behaviour, which does not recommend an action, but can provide important information to meet the accuracy of decision-making as a policy should be established.

Policies are the result of politics, or the result of the allocation of values, i.e. what the government chooses to do, including not to work (Wibowo, 2011; Jalil et al., 2017; Mohd

Azmi et al., 2018). In this regard, policies (including affordable house development policies) are operational tools, or guidelines for governments to implement decisions established by political institutions. Referring to the above background, it can be concluded that the affordable house development policy is a series of government decisions and / or actions that have specific objectives to solve problems or affairs in the field of affordable housing development and the results have an impact on the people especially for the Low Income Residents. However, in its implementation is still less effective, based on data from BPS (2013) there are 11.8 million households do not have a home. As for the causes of the effectiveness of the implementation of government policies include unidentified variables affecting the purchasing power of low-income residents and developer interest, and there is no simulation model of policy on the problems of affordable housing development. In order to address problems in the development of affordable housing development policies and reduce the impact of the policy testing, this research utilizes dynamic system methods in testing the policy scenarios taken and then validated using the Focus Group Discussion (FGD) approach. Utilization of dynamic systems in the development of policy models so that the impact of policy testing can be known before it is implemented. The Marzouk & Azab Research (2016) also utilizes a dynamic system to analyse the sustainability of development projects for Low Income Communities in Egypt. The results of this study can help governments and developers in minimizing Life-Cycle Cost.

METHODS

The development of a policy model using the dynamic system approach in social and technical research has been done a lot. In general, the research piker framework through three major stages, namely: System Conceptualization, Model Formulation, and Simulation and Validation. This is in line with research conducted by Elsawah et al. (2017) reviewing the use of dynamic system methods in five socio-ecological cases. Figure 1 shows the research methodology on simulation of public policies on the housing development for low income communities.

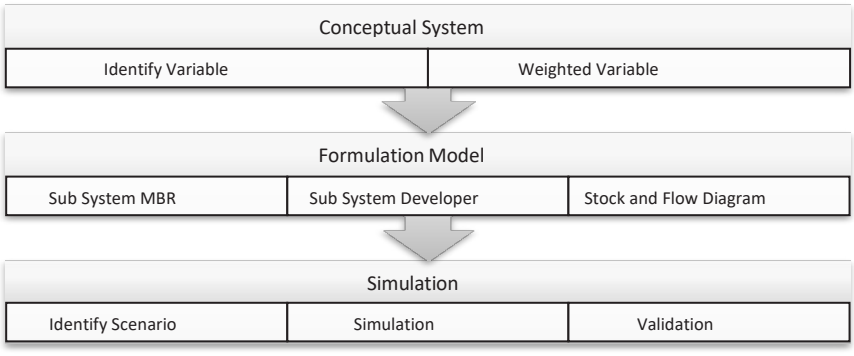

Figure 1. Research Methodology

Conceptual System

System conceptualization is an early stage in preparing the components that are considered influential in the system. The relationships of these components are illustrated in the cause and effect diagrams. This causal diagram will be used as a tool to determine the effect of feedback caused by the interaction of various components affecting the variables of

the affordable house development model. This stage consists of two specific stages of variable identification and weighting of variables.

Identify Variable

System approach is a way of thinking in solving a problem by taking into account the elements associated with the problem thoroughly and rationally. Systems thinking is a way of thinking that sees problems as an interconnected system whose focus lies in the interrelatedness of the problem with time. The benefits of thinking thoroughly at thinking systems have grown tremendously in all aspects of life. The thinking system requires skill and ability to formulate problem and completion thoroughly. We must be able to imagine the initial conditions to the end thoroughly. By thinking the system, we will be able to identify everything that will be involved and its influence in achieving the desired goals.

The system is a collection of entities, people, or objects that have a linkage and organized in achieving certain goals. Daelennbach and McNickle (2005) suggest systems are entities or people relating to each other in a field and organized (following applicable rules that have a particular purpose). The designation of this system is subjective because it depends on the viewpoint of the person who sees the system (Daellenbach & McNickle, 2005). According to Daellenbach and McNickle (2005), the system has several characteristics, including:

1. The system is a unity of organized components.
2. Each component has a role in the system. If any component is not working or missing, then the system will change.
3. A collection of components - components in the system can form a subsystem. These subsystems form the whole system.
4. A system has an environment that can provide input for the system and receive output from the system.

According to Daellenbach and McNickle (2005) the model is a delineation of the existing system. Ljung (1994) explained that the model of a system is a tool that we can use to answer questions about the system without doing experiments. The model is a representation of a system developed to study the system and serve as a substitute for the real system. Modelling is needed in every research because the model facilitates the search for important variables in the research and can save research costs and save time. In making the research model we can search the first model which have been used to solve research problems almost same. If we find a standard model in a library, then we change the model live according to the problems we left. If the standard model cannot be obtained, then we must create a new model.

According to Daellenbach and McNickle (2005), a model is good if it satisfies several conditions such as a model should be easy to understand, cover all the important aspects that affect the purpose of the system, easy to manipulate and communicate, and able to adapt with the environment. When there is a change in the uncontrolled input, the model can be valid, adaptive and robust. In this study, a description involves aspects of "Affordable House Development Realization" was identified through a Fishbone diagram.

The shape of fishbone diagrams is look like fishbone are often called Cause-and-Effect Diagrams or Ishikawa Diagrams which introduced by Dr. Kaoru Ishikawa. He is a quality

control expertise from Japan with seven basic quality tools. Fishbone diagrams are used when we want to identify possible causes of problems, related variables and especially when a team tends to fall into thinking on routines (Tague, 2005).

Weighted Variable

After going through the stage of Identifying the variables of affordable house Development Policy then each variable / causal category is weighted by involving experts in their respective fields using pairwise comparison method. The purpose of Pairwise Comparison is to analyse the priority of criteria in the hierarchy. Priorities are determined based on the views and judgments of experts and stakeholders on decision making (Saaty, 1998) (Wang & Pan, 2012) (Bukhori, Widodo, & Ismoyowati, 2015.

Formulation Model

Is a process done to change the concept of the system or structure of the model that has been compiled in the form of equations in computer language. It is also a transformation from an informal conceptual concept with a formal conceptual view (model quantitatively).

Stock and Flow

In representing activity on a feedback loop, two main types of variables called levels and rates are known as stock and flow. Level states the condition of the system at any time. The level is an accumulation in the system. The equation of a rate variable is a policy structure that explains why and how a decision is made based on information available within the system. Rate is the only variable in the model that can affect the level.

Equation

At this stage a mathematical equation will be used in the existing model. The equation refers to the related theory. Equation symbols are not only easy to manipulate, but also easily captured. Stock and flow diagrams are used to represent the detailed flow structure of the system in the form of a policy structure so that it can be used to construct mathematical models.

Simulation

An event is formed by structure and behaviour. Structure is an event-forming element and shows the pattern of interrelationship between the elements. The structure of the dynamic system is depicted in the Rich Picture Diagram (RPD). While behavior (behavior) is a change of a quantity or variable in a certain period (growth, decrease, oscillation, stagnation, or a combination). To find out the behavior and characteristics of the observed system model, the best way is to simulate the model that has been compiled for a certain period of time. Simulation is an attempt to understand the behavior (behavior) of a system through its model. Simulations study and predict something that has not happened by imitating or creating a model system that is learned by using a computer. The model simulation in this research uses Powersim Studio software tool.

Simulation is a mimicking operation, by time, a process or a real-world system. Simulations can be done either manually or with the help of a computer (Law & Kelton, 1991). The real step in the simulation develops a simulation model and evaluates the model, to estimate the expected characteristics of the model (e.g. weight of each aspect / variable against the system objectives). While the simulation model itself has the following characteristics (Banks, 2010).

1. A simple representation of a system (or process or theory), not the system itself.
2. Models should not have all attributes; They are simplified, controlled, generalized, or idealized.
3. For a model to be used, all of its relevant characteristics must be defined in a practical way, expressed in a reasonable reasonably defined set of descriptions.
4. A model should be validated.
5. Once validated, a model can be used to investigate and predict the behavior of the system, or to answer the "what-if questions" to sharpen the understanding, training, prediction, and alternative evaluation (later referred to as a policy simulation).

Policy simulation is one of the common ways to take a public policy. In this research, some scenarios for policy simulation are related to "Realization of Development Subsidy of Targeted and Right Targeted affordable house". The policy simulation in this research is intended to know the impact of each scenario on "Realization of affordable house Development". The policy simulation aims to analyse the impact of the policy of altering the value of its policy variables. Before the model is first modelled simulation is done (in this study will be represented by the FGD activities conducted by the expert) to see whether the value of the alleged model in accordance with the actual value of each endogenous variable (Pindyck & Rubinfield, 1991).

RESULTS AND DISCUSSION

In the exposure of the Director of Housing and Housing, Ministry of PPN / Bappenas 2015, that in housing problems there are four common problems that occur in housing Indonesia, among others: imbalance between supply and demand, lack of synergy between government institutions in policy formulation. Supporting the growth of the housing market for low-income residents, as well as no population, administration system with a single identity number. Figure 2 shows the fish bone for the root cause analysis of public policies on housing project for low income communities.

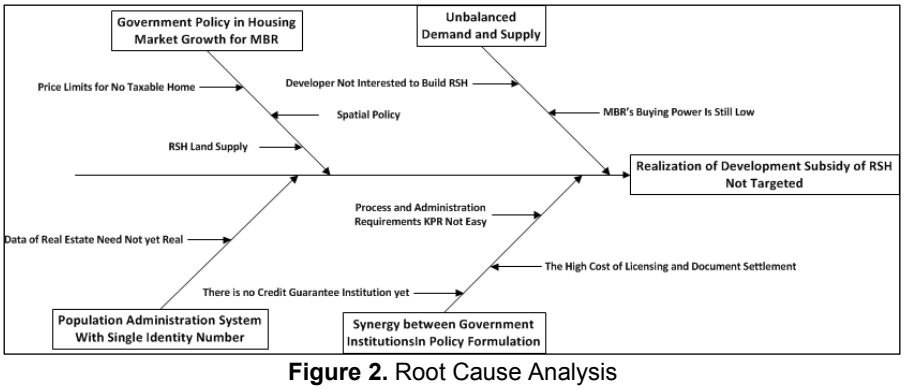

Figure 2. Root Cause Analysis

The imbalance between supply and demand is defined as a mismatch in the provision of proper shelter for low-income residents. The supply comes from the developers in providing shelter for low-income residents and demand come from low-income residents that requires proper occupancy in accordance with the ability to buy. The low supply of decent shelter for low-income residents, among others, is caused by the Developer still rely on formal financing facilities while the number of people with informal employment status amounts to 51%. Another reason is the higher house prices (land and buildings). While on demand aspect caused by low-income residents, which is non-bankable and limited of affordability from low-income residents.

The lack of synergy among government institutions in formulating housing policy is indicated by several conditions, such as restrictions on non-taxable house prices, spatial policy, and land provision. The absence of government policies that support the growth of the housing market for low-income residents is indicated by several conditions such as the absence of ease in the process and administrative costs of building the house low-income residents and the requirements for filing a mortgage is quite complicated. There is no population, administration system with a single identity number such as the existing data cannot describe the needs and quality of the house in real terms, and population data are the main base of the Housing Career System implementation.

Another data, known subsidy policy of affordable housing development has been running for a long period of time. Its implementation is based on Permenpera which is published at every stage of implementation, but the result is not maximal yet. As with the issuance of Permenpera Number: 7 / Year 2012 dated May 16, 2012 as a substitute Permenpera Number: 4 / Year 2012, on Procurement Housing Through Credit / Financing Home Ownership Sejahtea with FLPP Support (Liquiditas Housing Financing Facilities). During implementation, there are still many obstacles and problems faced. The main problem that occurs is the realization of the policy of subsidizing the construction of affordable houses are not on target. After investigation of the problems that occurred in the field, it was found that many causes and the root cause of this problem is the implementation of the subsidy policy for affordable houses. Figure 3 shows demand and supply causes using fish bone diagram.

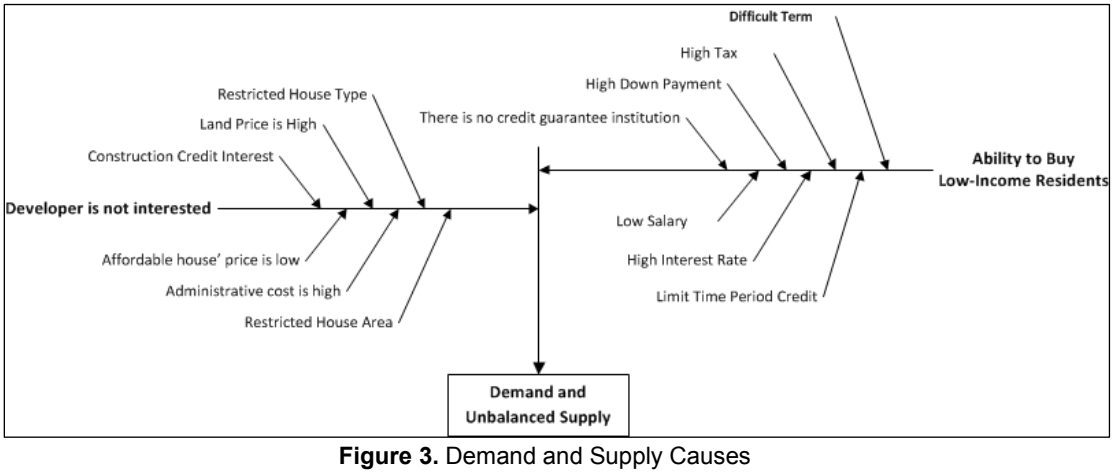

Figure 3. Demand and Supply Causes

In order to know the factors that cause problems which influence the implementation of the policy, it will be appropriate to analyse the structure of the problem by using RCA (Root Cause Analysis) method with Fishbone diagram as shown in Figure 3. As disclosed by Dennis (2015), the causal diagram is a structural approach that allows a more detailed analysis to find the causes of an existing nonconformity and gap problem. The results of field investigation have identified the causes and root causes of the problem, namely: Why is the realization of subsidy of affordable housing development not in line with the target and not on target? These causes are as follows:

A. Demand and Supply are unbalanced
   i. Developers are not interested to build affordable housing.
   ii. The ability / purchasing power of low-income residents is still low, so the subsidy of affordable housing development is enjoyed by non-low-income residents' group.
B. Lack of synergy between government institutions in policy formulation.
C. There is no government policy that supports the growth of the housing market for low-income residents.
D. There is no population, administration system with a single identity number.

After going through the stages of identifying the cause of "Realization of Development Subsidy affordable house Not Target and Not Exactly Goals", then each variable / category of causes weighted by involving experts (expert) in their respective fields using the method pairwise comparison. The purpose of Pairwise Comparison is to analyse the priority of criteria in the hierarchy. Priority is determined based on the views and judgments of experts and stakeholders in decision making (Saaty, 1988). Based on RCA analysis, there are 8 main causes of "Realization of Development Subsidy of affordable house Not Targeted and Inappropriate Target", as listed in Table 1.

Table 1. Root Cause List

No.	Root Causes	Code
1.	Developer Not Interested to Build Affordable House	A1
2.	Ability / Power Buy MBR Still Low	A2
3.	Process and Cost of KPR Administration Not Easy	B1
4.	KPR Submissions and Requirements are Complicated	B2
5.	House Price Limit Not Taxable	C1
6.	Spatial Policy Related	C2
7.	Land supply	C3
8.	Data of Real Estate Need Not yet Real	D1
9.	No Credit Guarantee Institution	D2

Based on the main causes identified and then compiled in the form of paired questions addressed to the expert. The answer from the pairwise comparison method is start -9 (Absolute Very Less Important), 1 (Equally Important), and 9 (Absolute Very More Important). Based on the results of question 8 main causes of the expert obtained the following results:

Table 2. Pairwise Comparison Matrix

Pairwise Comparison Matrix	A1	A2	B1	B2	C1	C2	C3	D1	D2
A1	1	1	5	3	3	5	5	5	3
A2	1	1	5	3	3	5	5	5	3
B1	1/5	1/5	1	1	1	1	1	3	3
B2	1/3	1/3	1	1	1	1	1	3	1
C1	1/3	1/3	1	1	1	1	1	3	1
C2	1/5	1/5	1	1	1	1	1	3	1/3
C3	1/5	1/5	1	1	1	1	1	3	1/3
D1	1/5	1/5	1/3	1/3	1/3	1/3	1/3	1	1/3
D2	1/3	1/3	1/3	1	1	3	3	3	1

The results of data collection and processes have several times of iteration to achieve the value of Consistency Ratio (5%). Based on the results of data processing found the main causes that have the highest level is A1 (Developer Not Interested Build affordable house) and A2 (Ability / Power Buy low-income residents Still Low). Table 2 shows the result of weighting using pairwise comparison method. Meanwhile, Table 3 shows nine numbers of root causes together with code and the percentage of weight variance.

Table 3. Weight Variables

No.	Root Causes	Code	Weight
1.	Developer not interested to build affordable house	A1	25.3%
2.	Ability / power to buy affordable house is still low	A2	25.3%
3.	Process and cost of KPR administration not easy	B1	8.6%
4.	KPR submissions and requirements are complicated	B2	7.7%
5.	House price limit not taxable	C1	7.7%
6.	Spatial policy related	C2	6.3%
7.	Land supply	C3	6.3%
8.	Data of Real Estate need not real	D1	3.1%
9.	No credit guarantee institution	D2	9.6%

A dynamic system is a method that used in this research to describe the relation between variables in affordable housing development in analysing the effect of policy on the realization of subsidy. This dynamic system model describes the behavior of variables within a certain time so it can be seen the influence of policy on this model. Identification of models based on observations and data from the Ministry of Settlements and Housing. There are two subsystems in this affordable housing development system such as Low-Income Capacity System and Developer Interest System.

The dynamic system model is then utilized in policy simulation. Policy simulation aims to analyse policy alternatives by changing the values of policy variables. Policy variables in the simulation of affordable housing development system policy are divided into two namely quantitative and qualitative. Quantitative variables are the variables used in the two main sub-systems (Low-Income Residents Capacity and Developer Interest). The quantitative variables of policy in this study are tabulated in Table 4.

Table 4. Scenario Policy

No	Variable	Now	Scenario 1	Scenario 2	Scenario 3
1	Price House	121,5 Bil.	115 Bil.	112,5 Bil.	110 Bil.
2	Down Payment	5%	4%	3%	1%
3	Interest Rate	5%	4%	3%	3%
4	Time Period	20 Years	20 Years	20 Years	25 Years
5	Tax	5%	4%	3%	0%
6	House Type	T.36	T.32	T.30	T.27
7	Large Lot	70 M2	68 M2	65 M2	60 M2
8	Salary Residents	2,5 Bil.	2,5 Bil.	2,5 Bil.	2,5 Bil.
9	Administrative Cost	Expensive	Minimizing	Minimizing	Minimizing

No	Variable	Now	Scenario 1	Scenario 2	Scenario 3
10	Land Available	Hard/ Expensive	Government Assistance	Government Assistance	Government Assistance
11	Guarantor	Not available	It needs	It needs	It needs

CONCLUSION

This research succeeded in formulating the right affordable house development policy to encourage developer interest in building affordable house and fulfil the requirement of purchasing power of Low-Income Residents. With the implementation of policy formulation is often constrained related to the impact of the policy, either by Low-Income Residents or Developer, is the ability of purchasing power of Low-Income Residents and low Developer interest. The results of this study can provide a fundamental understanding of the various causes of the implementation of the policy of an affordable housing development subsidy that its realization is not on target and not on target. Furthermore, this policy model can be grounded to formulate a policy of subsidizing affordable housing development properly.

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A CASE STUDY ON THE BUILDING CONDITION OF ELDERLY HOMES AND ITS MAINTENANCE RECOMMENDATIONS

Azlan Shah Ali, Cheong Peng Au-Yong and Shirley Jin Lin Chua
Centre for Building, Construction & Tropical Architecture (BuCTA), Faculty of Built Environment, University of Malaya, 50603 Kuala Lumpur, Malaysia.

Abstract
Creating flexible and comfortable homes contribute an environment that is conducive for active aging people to live. This indirectly leads to more productive ageing environment. One of the main issues for active ageing homes is inability to adapt in ecologically ways when condition change. Ageing people need homes that can sustain and enhance their quality of life and well-being. Unsatisfactory home conditions lead to needs of modification, which could effectively decrease difficulty in mobility and performing daily activities. It is therefore of paramount importance to evaluate the physical condition of active aging homes. This research aims to evaluate the condition of homes for elderly by case study approach. Building condition assessment was carried out on homes for the elderly. Two case studies were selected, and field study was carried out to investigate the existing condition of elderly homes. There were 71 defects found in Case Study A and 67 defects found in Case Study B. Based on CP BS101, the condition of the buildings in both case studies were rated fair and good. However, the findings proven that the current condition of the elderly homes is not convincing to meet the concept of active aging home. The finding of the research provides an insight to the maintenance personnel on the ways to maintain the homes for active aging community in order to create a quality aging life. The homes of aging community should be maintained in an optimal condition in order to create a conducive surrounding for them to live independently. The finding of this research attempts to improve the maintenance of active aging homes to create a better quality of life to the aging community.

Keywords: *Building Condition Assessment; Active Aging; Elderly; Building Defects; Building Maintenance*

INTRODUCTION

The World Health Organization (2012) claimed that the population of people aged 60 will hit 1.2 billion whereby 80 percent are from developing countries. As the population of aging community is increasing, the quality of living and provision for aging people to live independently needs to be increased as well. Active ageing is defined as "the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age" (World Health Organization, 2012). A house or home is the shelter for human being; thus, it is considered as one of the most important necessities of life. The quality of a house will affect the health, well-being and daily activities of the building occupants.

As people grow older, their ability to perform even basic tasks diminishes leading to them requiring special services and accommodation (Queensland Government, 1999). There are challenges to the provision of homes for older population to actively age in. These challenges also relate to how these buildings could be appropriately maintained. In the construction industry, building maintenance restores the building components' condition and extends the building service life in order to fulfil the occupants' needs. It plays an important role to achieve sustainable building (Au-Yong et al., 2014). Unfortunately, building maintenance

culture generally in Malaysia over the years has been poor (Mazlan & Mohammed, 2008; Moore & Finch, 2004; Zawawi et al., 2010).

With the aging population a significant part of the population demographics, it is important to understand the characteristics of this population demographic as well as their building functionality requirements and derive appropriate maintenance strategies for buildings they occupy. Ahluwalia and Hegazy (2010) noted that maintenance and upgrading works are crucial and they require frequent inspection and assessment of condition with time. In addition, Che-Ani et al. (2016) also claimed that maintaining the quality of building to ensure it performs optimally is crucial. Building condition assessment is one of the approaches to evaluate the performance of the building and facilities in following aspects (Brandt & Rasmussen, 2002; Douglas & Ransom, 2007):

- Degree of physical degradation
- Cause of the deterioration
- Extent of any deterioration
- Extent of necessary works to remedy the building and facilities
- Remedial costs
- Preventive measure to minimize the deterioration

Building deterioration leads to the occurrence of defects on building components and poor performance of buildings. Thus, surveyors determine deterioration by inspecting the condition and performance of building and components. Building diagnostics is defined as the investigations and analyses of problems with specific systems and equipment that are performed during operations and monitoring of building and components (House & Kelly, 2000). Since building diagnostics deals with methodologies and techniques for identifying the condition and performance of the building, it is embedded in the building condition assessment (Douglas & Ransom, 2007).

Building condition assessment represents one of the main functions of asset management. It is a logical and systematic process of predicting the maintenance strategies and repairs needed for existing components, fittings and physical of the building (Syed Mohamad & Wan Annuar, 2011). This is agreed by Queensland Department of Housing and Public Works (2012) that building condition assessment is the technical inspection to investigate the existing condition of the building elements and services to identify the scope of maintenance, rank the maintenance work according to priority and mitigate any possible risk accordingly. It is also useful in ranking the amount of repair and cost needed. In addition, building condition assessment is also very vital for valuation of a property to value the building based on the current building condition. Without proper building assessment to evaluate the physical state of the buildings, the life cycle of the services and assets could be shortened resulting in higher repair and replacement costs and affecting the service delivery quality and performance of the assets (Queensland Department of Housing and Public Works, 2012). Generally, the data involved in the building condition assessment are background of the building and construction technology, appearance and physical condition of the building, maintenance management scheduled and unscheduled work, surrounding buildings, damage and repair methods, cost of repairs and maintenance as well as proposed maintenance improvements (Mohd Tawil et al., 2011).

This research attempts to investigate the building condition of the homes of the elderly. The findings of the research will provide an insight on how to maintain the building in a more proper way in order to provide a more conducive, comfortable and optimum surrounding for elderly, and hence realizing the active aging home concept.

ACTIVE AGING HOMES

It is generally agreed that as people age, their ability to continue to be active decreases. Physical, perceptual and cognitive changes such as decrease in strength, loss of hearing and vision, and decline of working memory, etc. are evident (Fausset et al., 2011). This can, coupled with other unpredictable incidents, such age-related changes pose challenges for the elderly's ability cope with their environment's demands (Seidel et al., 2009). The need therefore arises to create activities and initiatives that assist and ensure a comfortable aging process for the elderly. This process is referred to as active aging. "Active" refers to continued participation in social, economic, cultural, spiritual and civic affairs, not just the ability to be physically active or to participate in the labour force. Active aging applies to both individuals and population groups, allowing them to realize their physical, social, and mental well-being potential throughout the course of life as well as participate in society while providing them with adequate protection, security and care when they require assistance (World Health Organization, 2012).

In Malaysia, the aging population is defined as people aged 60 and above, the age at which public sector workers reach mandatory retirement age, and private sector workers according to the Minimum Retirement Age Act 2012 reach minimum retirement age (Zawawi, 2013). Changes in age structure as a result of fertility decline and longer life expectancy have been identified as crucial factors contribution to Malaysia's aging population. As of 2013, the life expectancy in Malaysia was 72.3 and 77.2 for male and female respectively (Zawawi, 2013). It is therefore crucial in enhancing the comfortable aging process of the elderly.

The elderly is often associated with assisted living conditions in order to live conveniently through their later years. Some of these involve special facilities and some involve providing an interface that enables a smooth interaction between the elderly and their environments. One of these aspects, known as aging in place, is regarded as the ability of the elderly to live in their own homes with functional requirements where they could conveniently age (Cutchin, 2003). Aging in place is a process involving both the person and the environment; it is a continuous dynamic interaction as both the person and the environment change (Fausset et al., 2011). Thus, the ability for buildings to care specifically for the needs of the elderly or aging is a crucial aspect of contributing to a comfortable aging experience. With increasing decline in both physical and mental capabilities of the aging population, it is safe to contend that, the environment within which they live and interact, in this case the buildings they occupy, should be designed and maintained in such a manner to meet their demands. In order to improve the design and strategy to maintain the building of active aging are living, investigation on the existing condition of the building play an essential role. Without examining the current condition of the building, the needs and the challenges faced by the active aging could not be determined. This is very crucial to provide an insight on how optimal maintenance should be implemented and what sorts of building design and facilities should be provided.

METHODOLOGY

This research adopted case study approach to investigate the building condition of selected cases. This approach allows the researchers to understand complex phenomena and retain the holistic and meaningful outcomes of real-life events, such as the change of building condition in this study (Yin, 2009). Two case studies were selected to evaluate their current overall building condition by identifying the number, condition and priority of defects. Both case studies were homes for the elderly. Generally, Case Study A is a community association established in 2004 located in Pahang. It consists of orphanages, homes for the elderly and centre for religious studies. It is a non-profit organisation giving shelter to orphans and underprivileged children as well as elderly. The home provides lodging and free education to its dependents at their in-house religious school.

On the other hand, Case Study B was established in 1965 and inaugurated by the Minister of Welfare. Case Study B is located in Selangor. It was demolished and re-constructed in December 2007 and began operation on 2nd August 2010 with the entry of personnel. The residents started to move in from other state community centre in Malaysia to a total of 40 residents on December 6, 2010. The maximum number of occupants was 336 people. The similarities of these two case studies are the group of residents who are elderly, and the main function of the building is to provide care, treatment and protection to the poor elderly to ensure the well-being and quality of life.

There are two building rating systems applied in Malaysia which are CP BS101 Code of Practice for Building Inspection Report (for building condition survey) and Building Condition Maintenance Assessment System (BCMAS) (Mohd Tawil et al., 2011). BCMAS was developed by the Malaysian Public Works Department (PWD) based on the requirement of Government Total Asset Management Manual and Building Condition Inspection for Existing Building Manual (Yacob, Ali, & Peng, 2016). The main purpose of BCMAS is to improve the existing inspection process and standardise the building inspection work. BCMAS is applied to all building inspection work for Malaysian Government asset. On the other hand, CP BS101 was developed by Royal Institution of Surveyors Malaysia which has been mostly applied for private buildings by most of the professionals such as building surveyors, engineers and architects in building inspection work. Consequently, this study applied the concept of CP BS101: Code of Practice for Building Inspection Reports. CP BS101 employs Building Assessment Rating System (BARIS) Assessment to rate the condition of the defects (Royal Institution of Surveyors Malaysia, 2010). Then, the overall building rating is produced from accumulation of overall number of defects in a building.

Field inspections were carried out which aimed to detect the defects and measure their severities on the components, structure, fittings and physical of the building. Thus, the study began with inspecting the buildings to examine the condition and significant defects. The inspection of the building was conducted by using appropriate tools and equipment for rating and measurement, such as measuring tape, camera and ladder. This equipment was essential in order to record the defect found in the building in regards with the plan of building to identify the exact location of the building. Furthermore, defects were documented by taking photographs and sketching. In addition, some technical provisions were used to express the findings.

Upon completion of the building inspections, the conditions of the building defects were rated and presented using Schedule of Building Condition. Practically, there were two ratings required in Schedule of Building Condition, which included condition assessment and priority assessment. A 5-point rating for condition assessment and 4-point rating for priority assessment as shown in Table 1 and Table 2 (Royal Institution of Surveyors Malaysia, 2010) was used. After that, the defect rating for each of the defects was computed using the following formula:

$$\text{Defect Rating, } \mathbf{c} = \mathbf{a} \times \mathbf{b} \quad (1)$$

Where,

a is Condition Assessment
b is Priority Assessment

Table 1. Condition Assessment

Condition	Scale Value	Description (Value)
1	New/ As New	Minor Servicing
2	Fair	Minor Repair
3	Poor	Major Repair/ Replacement
4	Very Poor	Malfunction
5	Dilapidated	Damage/Missing

Table 2. Priority Assessment

Priority	Scale Value	Description (Value)
Normal	1	Functional, only cosmetic defect
Routine	2	Minor defect, but can lead to serious defect if left unattended
Urgent	3	Serious defect, cannot function to an acceptable standard
Emergency	4	Element/ structure does not function at all, OR Risks that can lead to fatality and/ or injury

The surveyors adopted the rating system to analyse the building condition. Whereby, the defects and overall building rating could be classified as good, fair and dilapidated as shown in Table 3. All the defects found were listed and rated in the Schedule of Building Condition for Case Study A and Case Study B respectively (see Appendix A and Appendix B). The information of the defect was recorded on the defect sheet and the exact location of the defect was indicated on the plan floor of the building. For example, the first and eighth defects recorded in Schedule of Building Condition (SBC) (see Appendix B. Building Assessment Rating System for Case Study B), the defect sheet was coded as 1A (1) and 1A (8). The coding 1A indicated the unit number and (1) indicated the defect sheet number. The location of the defect was indicated in the floor plan and some information such as unit number, date of inspection, weather and remarks were recorded below the floor plan (see Appendix C). In addition, the photograph, the rating given according to Building Assessment Rating System (BARIS) and the information of defect such as defect description and possible causes of the defect was recorded in defect sheet (See Appendix C). Thus, each defect needs to have one defect sheet. There are two examples of defect sheets shown in Appendix C and the location of the defects are tagged in the floor plan. Subsequently, an overall building rating was computed for each studied case to determine the overall building rating by using the following equation:

$$\text{Overall Building Rating} = \sum \mathbf{c} / \mathbf{e} \quad (2)$$

Where,

c is Defect Rating
e is Number of Defects

Table 3. Defect and Overall Building Rating

No	Defect & Overall Building Rating	Score	Colour Coding
1	Good	1 to 4	
2	Fair	5 to 12	
3	Dilapidated	13 to 20	

FINDINGS AND DISCUSSION

In order to identify the defects at the studied cases, surveyors carried out inspections to document and record the defects accordingly. Based on the inspections, numerous types of defects were identified in the studied cases, namely:

- Cracking (wall, floor slab and others)
- Broken components (door, window and others)
- Peeling paint
- Sign of dampness
- Non-functioning devices (lighting device and others)
- Unpatched hole
- Poor workmanship defects
- Termite attack

Overall, the surveyors detected 71 defects at Case Study A. Among the defects, 24 were in acceptable rating, 47 in fair rating and none in poor rating. At Case Study B, the surveyor recorded total of 67 defects. A total of 53 of the defects were in acceptable rating, 13 in fair rating and 1 in poor rating. The comparison on the rating of the defects in both case studies is shown in Table 4. The overall building ratings of both case studies are presented in Table 5. Next, the types of defect were compared between the two case studies. The number of defects is illustrated according to the types of defect in Figure 1.

Table 4. Comparison on the Defect Ratings

Rating	Colour Coding	Score	Number of defects	
			Case Study A	Case Study B
Good		1 to 4	24	53
Fair		5 to 12	47	13
Dilapidated		13 to 20	0	1

Table 5. Comparison on the Overall Building Ratings

	Case Study A	Case Study B
$\sum \mathbf{c}$	451	285
e	71	67
$\sum \mathbf{c} / \mathbf{e}$	6.35	4.25
Overall Building Rating	Fair	Good
Colour Coding		

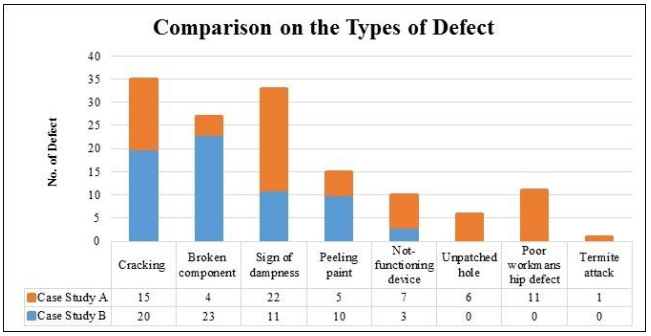

Figure 1. Comparison on the types of defect

The most occurring defects type in the observed buildings were cracks compared with other types of defect. The surveyors recorded a total of 35 cracking defects in both case studies. Out of 35, Case Study A had 15 cracking defects and the remaining 20 cracking defects were observed at Case Study B (see Figure 1). All the documented cracks were hairline cracks; no structural cracks were identified. This defect type was mainly caused by the drastic change in weather between sunny and rainy condition. The frequent change in weather condition lead to the extension and contraction of the surface layer of structures built of concrete or mortar. There was no critical hazard like safety and health risks exposed to the occupants. Nevertheless, repair of the defect was recommended to restore the aesthetic value of the buildings and to prevent further cracking from the existing defects.

The second most occurring defect at the case studies was sign of dampness. The inspection results noted 33 cases of dampness, 22 at Case Study A and 11 at Case Study B (see Figure 1). Dampness defects have various causes, such as roof leakage, defective pipework, as well as penetration of water through floor, wall, concrete roof and gutter. The surveyors determined that most of the defects were caused by water penetration from the structures as a result of high volume of rainwater; while a few occurred because of water penetration from bathrooms or defective pipework. Dampness provide fodder and accelerate the growth of mould and fungal, which poses serious health risk to the occupants. Therefore, it must be remedied promptly.

Broken components were the third most occurring defects at the observed case studies. In total, 27 of this defect types were identified with majority of the defects (23) occurring at Case Study B while only 4 were recorded at Case Study A (see Figure 1). The broken components identified included broken door and window locks, doorknobs, hinges, louvre gallery, window glass, etc. The defects were mainly as a result of improper or excessive usage by the occupants. They should be replaced to ensure security or safety and protect from risk of break-ins and theft as well as prevent injuries that could be caused by broken glass.

In addition, the surveyors discovered some other defects during the inspections. In total, 15 paint peeling defects were identified, 5 at Case Study A and 10 at Case Study B (see Fig. 1). Possible causes include dampness and improper paint application. Subsequently, 10 cases of non-functioning devices like the lighting fittings were also identified, 7 at Case Study A and 3 at Case Study B (see Figure 1). This defect was unavoidable due to the end of service lifetime. Thus, routine repainting work and regular inspection of broken lighting devices are suggested.

Furthermore, there were three types of defect detected only at Case Study A. the surveyors found 6 spots of unpatched holes (see Figure 1), which was the effect of removing nail used to hang stuffs like wall clock, photo, poster, and others. Then, 11 poor workmanship defects such as rough patching were documented (see Figure 1). The repair of these defects could be implemented simultaneously during the repainting of buildings. Lastly, the surveyors identified defects consistent with termite attacks (see Figure 1). Termite attack is a critical defect, which spreads very fast and leads to damages of timber structure and furniture. Hence, repair and treatment works must be performed immediately.

In summary, Case Study A and Case Study B were rated as fair and good respectively. The inspection results determined that the buildings are safe to be occupied. There was no significant difference between the studied cases in overall building conditions. Nevertheless, the inspection results revealed that most of the identified defects require specialist to maintain or repair them, except replacing the simple broken components and non-functioning devices. The existing building design is not appropriate to act as an active aging home for the elderly people. As such, all the maintenance activities require and rely on the attendance of a maintenance specialist. Meanwhile, the active elements such as physical activity and social activity facilities are still lacking.

RECOMMENDATIONS

Based on the inspection results, the study demonstrates that the existing buildings for the elderly are not suitable as active aging homes. Thus, several plans and actions should be imposed in maintenance and upgrading aspects.

Due to the tropical climate in Malaysia, high volume of rainwater and sunshine are inevitable. This is supported by Suffian (2013) that Malaysia has relatively high annual average rainwater intensity and tropical climate causing more damages to buildings. Unfortunately, it is almost impossible that the elderly can manage the structural defects by themselves. The capability of the elderly to carry out daily routine is weakened by age as they faced various types of chronic illnesses from day to day (Arokiasamy, 1997). Moreover, the elderly is more vulnerable to the risks of hazardous living space in terms of safe and health due to their frail and feeble conditions. Therefore, it is vital to have an experienced and responsive maintenance team serving the active aging homes scheme, which is led by a competent and committed maintenance manager (Au-Yong et al., 2017). The maintenance personnel must handle critical defects instantly. The maintenance work will be more costly and become worse if left unattended (Suffian, 2013).

Parker et al. (2004) stated that elderly spent most of their time at home. Thus, the elements installed at homes for elderly should consider the safety, health and quality of living. In order to give elderly maximum leeway for independent life and involve some minor maintenance activities, the components and devices can be installed at lower height or location that will not endanger the elderly when doing the maintenance work. Selection of materials is also important that it should be elderly-friendly. For example, anti-slip floor material should be used to install on the slippery floor such as in bathroom and kitchen. Then, lever-style door handle is more suitable instead of doorknob. This is supported by (Burgun, 1983) that elderly need designs that can provide security, independence, involvement and privacy.

Availability of facilities for physical and social activities is vital to encourage the active lifestyle of the elderly. The elderly also has the rights to enjoy the environment and do some leisure activities (Burgun, 1983). For the existing buildings, it is recommended to add on and allocate some spaces for the activities such as gardening area, exercise equipment and space, community area, and others. These add-on facilities must comply with the safety and health guidelines to the elderly. The safety and health remain the top priority to maintain the active aging home. It can be seen that a well-maintained home for elderly is very essential where the quality of living depends on what type of building, we are living in.

CONCLUSION

Growth of aging population is an inevitable trend. When people grow older, they tend to spend more time at home. Gradually, their ability to be active starts decreasing. Nevertheless, it is important for the elderly to maintain active and healthy lifestyles. In this circumstance, maintenance and upgrading of the elderly homes to be active aging homes is of vital. Therefore, this study aimed to investigate the building condition of elderly homes. The surveyors found that the most occurred defects were cracking, dampness and broken components. Most of the defects required a maintenance specialist to repair them, except simple replacement of building component and device. Yet, the buildings lacked active elements such as physical and social activities facilities. This is in contrast to the concept of active aging homes. Hence, several actions were recommended to enhance the existing elderly home. Though active aging home concept encourages the elderly to carry out daily tasks independently, an experienced and responsive maintenance team is still necessary to perform sophisticated maintenance tasks. Then, use of elderly-friendly materials is essential to enhance the safety and health of the elderly residents. Lastly, upgrading work to add on the active elements like gardening area, exercise and community spaces is great for encouraging active lifestyle among the elderly.

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Appendix A. Building Assessment Rating System for Case Study A

BUILDING ASSESSMENT RATING SYSTEM (BARIS) FOR CASE STUDY A					
Schedule of Building Condition (SBC)					
Defects	**BARIS**				
	Condition Assessment [a]	**Priority Assessment [b]**	**Matrix Analysis [c] = (a x b)**	**Defect sheet**	**Defect Indication Code**
	2	3	6	A-3-50(1)	
	2	3	6	A-3-50(2)	
	2	3	6	A-3-50(3)	
	2	2	4	A-3-50(4)	
	2	3	6	A-5-81 (1)	
	2	2	4	A-5-81 (2)	
	2	2	4	A-5-81 (3)	
	2	2	4	A-5-81 (4)	
	2	2	4	A-5-81 (5)	
	3	3	9	A-5-81 (6)	
	2	3	6	A-5-81 (7)	
	2	1	2	A-5-81 (8)	
	2	2	4	A-5-87 (1)	
	2	3	6	A-5-87 (2)	
	3	4	12	A-5-87 (3)	
	2	1	2	A-5-87 (4)	
	2	3	6	A-5-87 (5)	
	2	2	4	A-5-87 (6)	
	2	2	4	A-5-87 (7)	
	2	2	4	A-5-87 (8)	
	2	2	4	A-5-87 (9)	
	2	2	4	B-1-13 (1)	
	2	1	2	B-1-13 (2)	
	3	3	9	B-1-13 (3)	
	3	3	9	B-1-13 (4)	
	2	1	2	B-2-38 (1)	
	2	3	6	B-2-38 (2)	
	3	4	12	B-2-38 (3)	
	2	2	4	B-3-54 (1)	
	2	3	6	B-3-54 (2)	
	2	3	6	B-3-54 (3)	
	2	2	4	B-3-54 (4)	
	2	3	6	B-4-75 (1)	
	2	3	6	B-4-75 (2)	
	2	3	6	B-4-75 (3)	
	2	3	6	B-4-75 (4)	
	2	3	6	B-4-75 (5)	
	2	2	4	B-4-75 (6)	
	2	2	4	B-4-75 (7)	
	2	2	4	B-4-75 (8)	
	3	4	12	B-4-78 (1)	
	3	4	12	B-4-78 (2)	
	2	1	2	B-4-78 (3)	
	3	3	9	B-4-78 (4)	
	3	3	9	B-4-79 (1)	
	3	3	9	B-4-79 (2)	

	3	3	9	B-4-79 (3)	
	2	1	2	B-4-79 (4)	
	3	3	9	B-4-79 (5)	
	3	3	9	B-4-79 (6)	
	3	3	9	B-4-79 (7)	
	3	3	9	B-4-79 (8)	
	2	3	6	B-5-91 (1)	
	3	3	9	B-5-91 (2)	
	2	3	6	B-5-91 (3)	
	2	3	6	B-5-91 (4)	
	2	2	4	B-5-91 (5)	
	2	3	6	B-5-91 (6)	
	2	2	4	B-5-91 (7)	
	3	3	9	GURFAH 2 (1)	
	3	4	12	GURFAH 2 (2)	
	3	3	9	GURFAH 2 (3)	
	2	3	6	GURFAH 2 (4)	
	3	3	9	GURFAH 2 (5)	
	3	3	9	GURFAH 2 (6)	
	2	3	6	GURFAH 2 (7)	
	3	3	9	GURFAH 11 (1)	
	2	2	4	GURFAH 11 (2)	
	3	3	9	GURFAH 11 (3)	
	2	3	6	GURFAH 11 (4)	
	3	3	9	GURFAH 11 (5)	
Total marks [d] (∑ of c)			451		
Number of defects [e]			71		
Total score (d/e)			6.35		
Overall building rating			Fair		

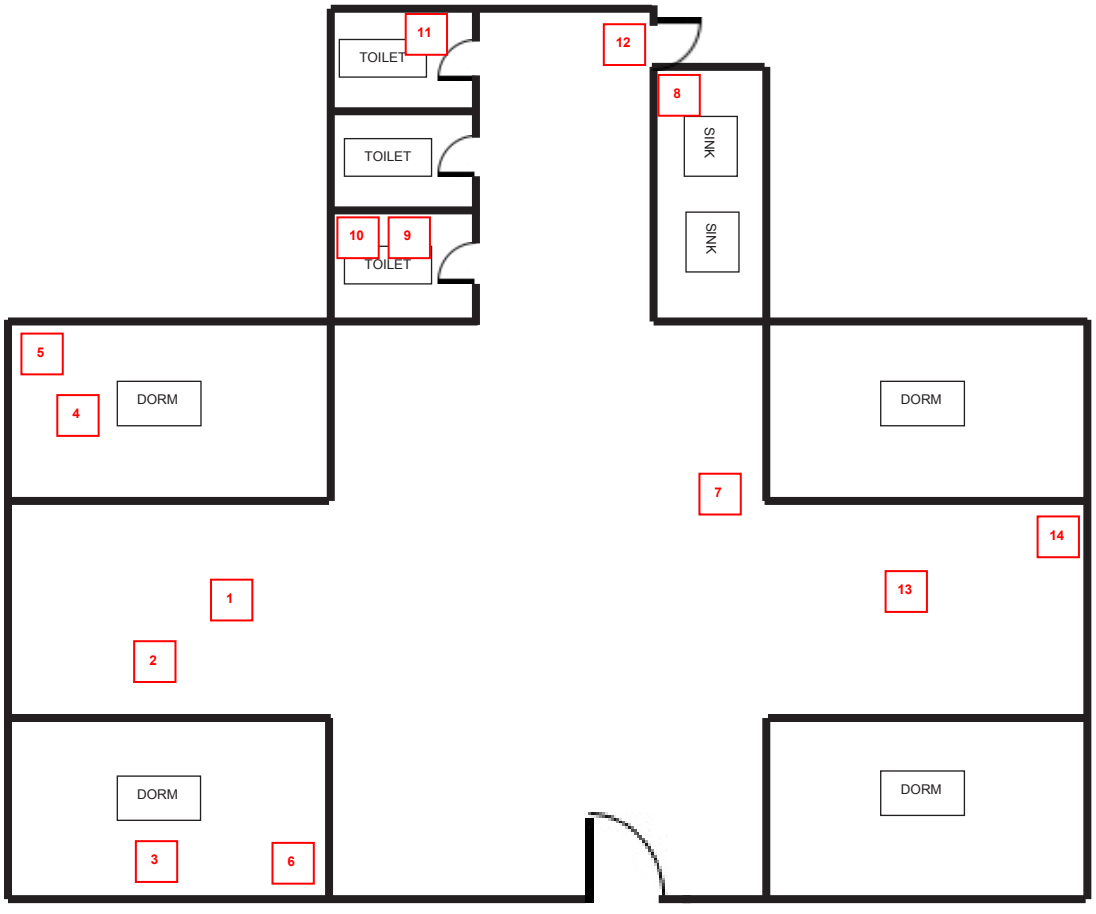
Appendix B. Building Assessment Rating System for Case Study B

BUILDING ASSESSMENT RATING SYSTEM (BARIS) FOR CASE STUDY B					
Schedule of Building Condition (SBC)					
Defects	BARIS				
	Condition Assessment [a]	Priority Assessment [b]	Matrix Analysis [c] = (a x b)	Defect sheet	Defect Indication Code
	2	2	4	1A (1)	
	2	1	2	1A (2)	
	2	2	4	1A (3)	
	3	2	6	1A (4)	
	2	2	4	1A (5)	
	2	2	4	1A (6)	
	2	2	4	1A (7)	
	4	4	16	1A (8)	
	2	1	2	1A (9)	
	3	2	6	1A (10)	
	3	2	6	1A (11)	
	2	2	4	1A (12)	
	2	2	4	1A (13)	
	2	2	4	1A (14)	
	3	2	6	1B (1)	
	2	2	4	1B (2)	
	2	2	4	1B (3)	
	3	2	6	1B (4)	
	2	2	4	1B (5)	
	3	2	6	1B (6)	
	2	1	2	1B (7)	
	2	2	4	1B (8)	
	3	2	6	1B (9)	
	2	2	4	1B (10)	
	2	2	4	1B (11)	
	3	2	6	1B (12)	
	2	1	2	1C (1)	
	2	1	2	1C (2)	
	2	2	4	1C (3)	
	2	2	4	1C (4)	
	2	2	4	1C (5)	
	2	2	4	1C (6)	
	2	2	4	1C (7)	
	2	2	4	6A (1)	
	2	2	4	6A (2)	
	2	1	2	6A (3)	
	2	2	4	6A (4)	
	2	1	2	6A (5)	
	2	2	4	6A (6)	
	2	2	4	6A (7)	
	2	1	2	6A (8)	
	2	2	4	6A (9)	
	2	1	2	6A (10)	
	2	2	4	6A (11)	
	2	2	4	6B (1)	
	3	2	6	6B (2)	

	2	2	4	6B (3)	
	2	1	2	6B (4)	
	2	1	2	6B (5)	
	2	1	2	6B (6)	
	2	2	4	6B (7)	
	4	3	12	6B (8)	
	2	1	2	6B (9)	
	3	2	6	6C (1)	
	2	2	4	6C (2)	
	3	2	6	6C (3)	
	2	2	4	6C (4)	
	2	2	4	6C (5)	
	4	3	12	6C (6)	
	2	1	2	6C (7)	
	2	1	2	6C (8)	
	2	1	2	6C (9)	
	2	1	2	6C (10)	
	4	3	12	6C (11)	
	2	1	2	6C (12)	
	2	2	4	6C (13)	
	2	1	2	6C (14)	
Total marks [d] (∑ of c)			285		
Number of defects [e]			67		
Total score (d/e)			4.25		
Overall building rating			Good		

Appendix C. Example of Property layout & Defects Indication Plan and Defect Sheet

Property Layout & Defects Indication Plan (Illustrate)



ITEM	DESCRIPTION
Unit No	1 (A)
Date	12 January 2016
Weather	Sunny
Remarks	-

Defect Sheet

Defect Sheet No.<*1*>	**Level**	**Ground floor (Internal)**		
	Location	**1A**		
	Element	**Ceiling**		
	Component	**Plaster**		
SKETCH/PHOTO	**BARIS**			
	Condition	***Priority***	***Matrix***	***Color***
	2	***2***	***4***	
	Defect Description			
	Broken and hollowness			
	Possible causes			
	External Forces and poor workmanship			

Defect Sheet

Defect Sheet No.<8>	**Level**	**Ground floor (Internal)**		
	Location	**1A**		
	Element	**Beam**		
	Component	**Plaster**		
SKETCH/PHOTO	**BARIS**			
	Condition	***Priority***	***Matrix***	***Color***
	4	***4***	***16***	
	Defect Description			
	Broken and Sign of dampness			
	Possible causes			
	Possibly Due to Water From (Other Failure of Component)/ Leakage			

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FACTORS AFFECTING THE PRODUCTIVITY OF REINFORCEMENT WORK LABOURS IN LOW-COST RESIDENTIAL BUILDINGS

Sara M Elseufy[1], Ayman Hussein[2], Mohamed Badawy[3] and Khaled Alnaas[4]
[1]Postgraduate Student, Department of Structural Engineering, Ain Shams University, Cairo-Egypt.
[2]Prof., Structural Engineering Department, Faculty of Engineering, Ain Shams University, Cairo-Egypt,
[3]Dr., Eng., Structural Engineering Department, Faculty of Engineering, Ain Shams University, Cairo-
[4]Consolidated Contractors Group (CCC), Doha-Qatar.

Abstract:
It is important to identify the factors affecting labour productivity to enhance productivity. Although there have been many previous studies about the factors affecting productivity, there is a gap in identifying factors affecting the rebar workers. Therefore, the present study tries to bridge this gap. Thus, a questionnaire has been distributed to a group of consultants and contractors. There have been six groups: one associated with the rebar workers and five related to workers in general. 140 questionnaires have been received. SPSS program has been used to statistically analyse the data. In order to show the effect of different analytical methods on the ranking of the outputs, the analysis is done using two methods. The first method measures the effect after applying PMP matrix method, while the second method depends on the probability and the influence to validate the results of the first method. The results indicate that "project type" and "delayed payment" factors were the most important factors that have determined some factors that affect rebar labours. They further show that factors in the external group have a negative impact on and reduce productivity growth. Finally, the application of factors, influencing the productivity of the rebar's labour, has led to a model where an equation is applied using some tests, namely reliability, factor analysis, and regression to assess the impact of the factors on the variation of labour productivity and measure productivity growth in a low-cost Residential building in a later work.

Keyword: *Productivity; Rebar's workers; Construction; Relative Importance Index; Low-cost; Regression; Egypt.*

INTRODUCTION

The construction sector is one of the most extensive areas of industry affecting the economy of any nation. In addition, productivity is one of the most important influential factors that contribute significantly to the economy of any country; therefore, it is essential to identify the factors that directly affect the construction sector; accordingly, actions should be taken to improve these factors to achieve low cost and less time and to ensure high quality.

Therefore, various studies have shed light on the development of buildings and increase in the production rate to ensure the reduction of the considerable costs in construction projects where labour productivity is considered one of the most critical factors that affect the physical progress of any construction project.

The overall construction productivity depends heavily on labour productivity. Saari (2006) found that the cost of labour represents 30% to 50% of the total cost of the project. Consequently, any delay in the completion of construction projects is highly related to the increase in the cost of the project, reduction of quality, waste of time which in turn reduce productivity.

There are many factors that can change the labour cost. The labour cost can be considered as the highly variable and unpredictable than the other cost components of the project. Thus, it is necessary to understand the effects of different factors on labour productivity.

The main objective of this research is to identify and calculate the relative importance and the Importance Index of the factors perceived by owners, consultants, project managers, engineers, and contractors that can affect the productivity of rebar's workers, especially in a low-income construction. So, the top critical factors can be identified.

Multiple previous studies only relied on examining the impact of factors in the ranking calculation and the arrangement of factors. Whereas other studies investigated factors by using methods that separated calculation both of the probability and the impact; that are, they have calculated first the averages of the factors followed by the ranking the factors.

Based on the above, Does the ranking of factors differ when using only impact compared to the use of both probability and impact? This paper uses the PMP matrix method which comprises the multiplication of probability for each factor by its impact. The purpose of this approach is to test whether same results are obtained if compared to its impact only.

LITERATURE REVIEW

The following review presents different factors that influence the productivity of construction projects, especially building. It further displays numerous studies which ranked these factors differently.

For the purpose of this study, qualitative research approach has been adopted A comprehensive review of research articles was undertaken by using keywords such a factor affecting labour productivity, rebar's labour, Relative importance index. This provided a set of articles that helps in the review. Review of these articles helped identify factor affecting labour productivity in various countries. that it has been relied upon in the work of the questionnaire. And making a comparison of factors in countries with Egypt in discussion.

Factors Affecting Labour Productivity in General

Ranking Factors Depending on Impact Only

In Gaza strip, Enshassi (2007) identified 45 factors affecting labour productivity, namely heads materials/tools, supervision, leadership, quality, time, manpower, project, external, motivation, and safety. Materials shortage and lack of labour experience were found to be highly significant.

In Indonesia, Soekiman (2011) has identified 113 variables affecting construction labour productivity. These factors are grouped into 15 groups of factors according to their characteristics. These main categories are designed, execution plan, material, equipment, labour, leadership and coordination, organization, owner/consultant, project factor, quality, financial, health and safety, supervision, working time and external factor.

In Egypt, El-Gohary, K. M., & Aziz, R. F. (2013), have identified these 30 factors, but classified them into three categories.

In Trinidad and Tobago, Hickson and Ellis (2014) have studied the causes and factors that have an impact on the labour productivity in construction, through the work of a questionnaire published on the contractors in these two towns to make recommendations to resolve this problem. The study came up with some factors that have affected productivity such as lack of supervision, weak payment, and poor communication among employees and employers.

In Zimbabwe, the results of another research conducted have shown that the top five factors affecting labour productivity were the availability of materials, payment of wages on schedule, the suitability/adequacy of equipment, supervision, and workforce skills. The research further recommends that any company should have a professional work planning, efficient resources, regular payment of wages, and continuous development for labours in order to improve the on-site labour productivity (Benviolent &Tirivavi Moyo,2014).

In Bahrain, there is another study that has been conducted to identify, explores, and ranks the critical factors influencing labour productivity of construction industry. The study has included a questionnaire survey consisting of 37 productivity factors categorized into four major groups: (i) management; (ii) technological; (iii) labour; and (iv) external. The study has applied the technique of the relative importance index. The study has concluded that the key factors affecting on labour productivity are labour skills, delay in responding to requests for information, coordination, supervision, rework, inspection, errors in design drawings, lack of incentive plan, working overtime, and weather condition (Jarkas, A. M., 2015).

In Thailand, Porntepkasemsant and Charoenpornpattana (2015, March) has conducted a research using a questionnaire survey technique and determined the key factors affecting productivity in construction projects. The five top ranking factors affecting labour productivity, according to this study, are absenteeism, rough drawings, financial shortage, workforce skill, and inspection delay.

Another study in Gwalior has been done to identify and rank the relative importance of factors affecting the labour productivity on construction projects. The data has been calculated from various professionals such as project managers, site engineers, architects, and others working on different levels. Using a questionnaire, factors are divided into nine groups. The results of the questionnaire have showed that the key factors which affect labour productivity in construction are "late paying, poor health, lack of skill and experience, low amount of payment, poor work planning, design changes, lack of empowerment, lack of labour safety, safety precautions, equipment/tools" (Trivedi & Pandey, 2016, p. 256).

Ranking Factors Depending on Both Impact and Probability

In Malaysia, Abdul Kadir (2005) establishes the critical factors by two ways: their impact and their frequency. He found out that material shortage at site and non-payment to achievement have topped the list of 50 factors that affect labour productivity in both ways in Malaysia. Concerning the impact way, the key factors include elements of the change order, late drawing by consultants, and the incapability of contractors' site management. Regarding

influence, the late payment to the main contractor, lack of workers, and coordination problem are the main factors.

In the United States, another quantified survey of 83 factors to determine the critical factors has been applied in the United States in 2009. The results show that the most crucial factors that has an enormous impact on the craft workers' perspective are engineering drawing, materials, tools, and construction equipment (Dai, 2009).

In Malaysia and China, Xuan (2011) identify the factors that have a negative impact on the productivity of projects in a joint building. The research is based on a questionnaire to find out the reasons behind the adverse effects on productivity in quantities and qualitative forms. the study concludes that joint projects between the two towns are greatly affected by the contract JV due to lack of items completeness and lack of provisions stipulate how to settle differences and problems arose from the Chinese partners to develop their methodology to solve disputes between subcontractors.

A study in Bangalore has classified the ranking factors according to their relative importance through a questionnaire containing 61 factors collected by the construction managers and contractors. The elements classified into six groups, namely labour, management, design and buildability, tools & equipment, natural, and miscellaneous (Rao & Prasad Babu, 2015).

Another study in South African has concluded that the top factors affecting labour productivity in construction projects are late drawing, late issue of specifications, delay replay in RFI, illegal strike action by labour, and civil unrest in the nearness of project labour (Bierman et al., 2016).

Another study in Cambodia has investigated the key factors regarding the labour productivity in residential projects. The labour factors are classified into four groups: site management, external, workforce, and resource factors. The key factors were leadership, management of change orders, defective work, and cash flow (Durdyev & Mbachu, 2017).

Factors Affecting on Rebar's Workers' Productivity

The factors which affect the productivity of labour and structural reinforcement element (beams) are the variety of beam sizes, steel diameter, stirrups diameter, reinforcement quantity, beam dimensions, and span geometry. These are concluded by collecting data and information from the sites and analysing them using specific interaction-regression method (Jarkas, A. M., 2010).

Jarkas (2012) studies the factors affecting the buildability in columns R.C and their impact on the productivity of rebar's workers during installation. The most important factors are the variety of column sizes, rebar diameter size, reinforcement quantity, and column geometry. The analysis shows that the size and shape of the circular column hurt labour efficiency, while the size of the diameter of steel and quantity has a positive impact. All these factors improve productivity, raise the work efficiency, and reduce the cost of their pay.

Wei investigating the performance of labours has concluded, "the only way to achieve higher productivity is through the application of (B. F. Skinner) theory" (2014). The theory advocates the monitoring of labour's performance and the application of moral and material bonuses outside salaries to promote and raise the labour's level and performance to improve productivity.

The main objective of this research is to identify and rank the factors affecting the productivity of rebar labour in the construction of a low-cost residential building.

QUESTIONNAIRE SURVEY

The main objective of this questionnaire is to identify the most critical factors affecting the labour productivity based on the opinion of some specialized experts, engineers.

The questionnaire is developed in two (2) significant parts (A and B). Part (A) includes the personal information of the respondent collected (e.g., work experience of construction projects, work position, etc.). Part (B) it is designed to ask to rate those initially identified thirty-nine factors according to their frequency and the severity.

The probabilities of occurrence of the factors and their impacts are classified into five categories, namely weak, low, medium, high, and very high. The risk is calculated by multiplying the Impact of the factor by Probability for each other. It is found that the resulting risk scale tripled as shown in the Table (1).

Table 1. The Probability and the Impact Matrix

			Impact				
			Very High 0.8	**High 0.4**	**Medium 0.2**	**Low 0.1**	**Very Low 0.05**
Probability	Very High	0.90	0.72	0.36	0.18	0.09	0.05
	High	0.70	0.56	0.28	0.14	0.07	0.04
	Medium	0.50	0.40	0.20	0.10	0.05	0.03
	Low	0.30	0.24	0.12	0.06	0.03	0.02
	Very Low	0.10	0.08	0.04	0.02	0.01	0.01

DATA DEMOGRAPHICS

The respondents are 78 contractors and 22 consultants in a different experience. 31 respondents have less than five years of experience. 31 respondents have experience between five to ten years. 19 respondents have experience between 10 and 15 years. 19 respondents have experience between 15 and 20 years.

A total of 140 Questionnaire has been distributed. Of these, 100 Questionnaire have been successfully filled. That means that the response rate was 71.43%. All data were entered into the (SPSS) program for statistical analysis to determine the most critical factors affecting the productivity of rebar's workers to improve the productivity.

METHODOLOGY

The methodology that has been adopted has proceeded according to a set of steps to reach the desired objective of the research. The objective of this research is to identify the factors

affecting the productivity of rebar workers, including general and special factors. Then, it is used to improve these factors to increase the production rates in Egypt.

This is done through a systematic engineering concept that is qualitative, which is the data collection of the factors affecting productivity. The factors are classified into groups at this stage. This classification is done according to the literature with content:

- The Factor is related to Rebar's workers: There are (12) factors that include all the factors that labours may be exposed to during the implementation of all structural elements such as Isolated Foundation, Base Slabs, Columns, Walls, Beams, Slab Panels, and Stairs.
- General Factor is affecting labour productivity: This includes (27) factors divided into (5) categories: Design – External - Financial – Management – Project.

The re-examination of the adequately classified elements and reclassification of the factors that are not found in the previous literature review and the re-analysis.

Hence, it is using flowchart to describe it. A flowchart is a picture of the separate steps of a process in sequential order. As shown in the following Fig. (1).

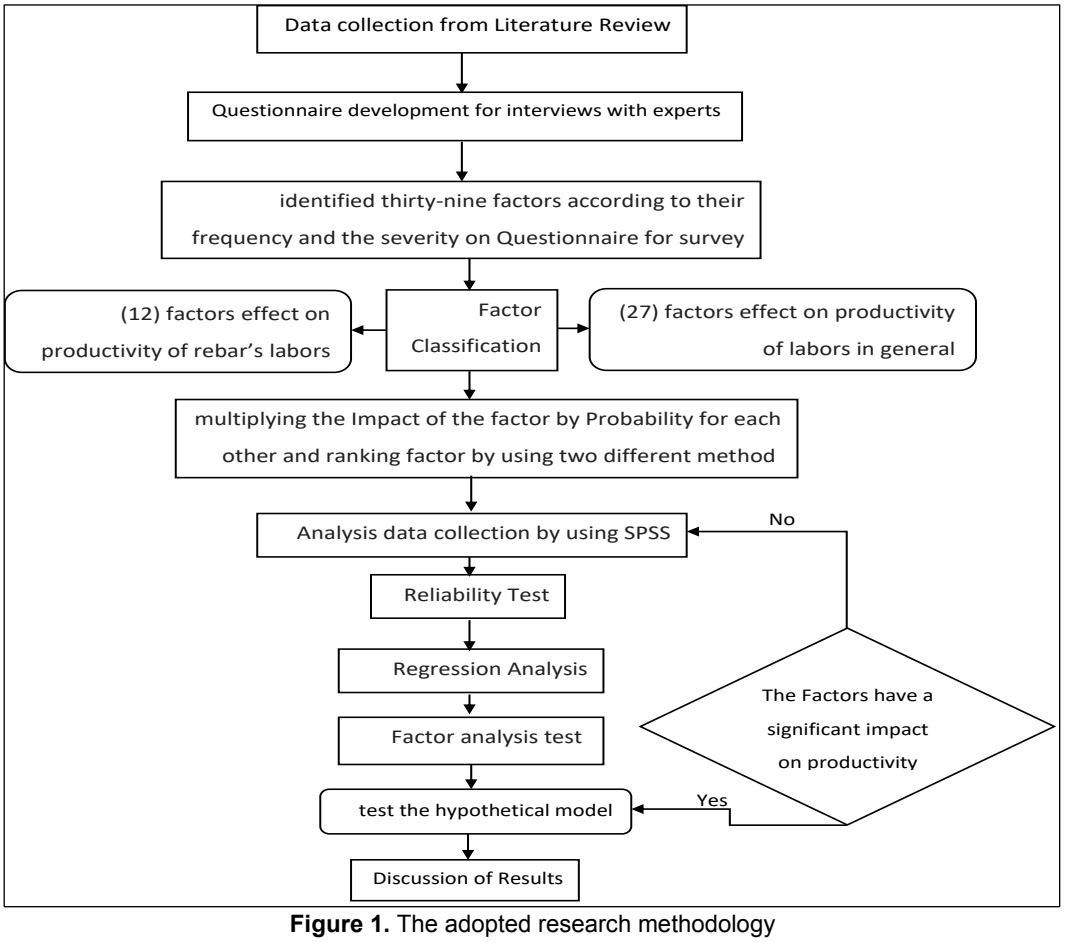

Figure 1. The adopted research methodology

ANALYSIS AND RESULTS

The respondents are 78 contractors and 22 consultants in a different experience. 31 respondents have less than five years of experience. 31 respondents have experience between five to ten years. 19 respondents have experience between 10 and 15 years. 19 respondents have experience between 15 and 20 years.

A total of 140 Questionnaire has been distributed. Of these, 100 Questionnaire have been successfully filled. That means that the response rate was 71.43%. All data was entered into the (SPSS) program for statistical analysis to determine the most critical factors affecting the productivity of rebar's workers to improve the productivity.

Ranking Factor

In this study, the risk of each factor is calculated by multiplying its impact by the probability of its occurrence. These values are mentioned in the method Probability-Impact matrix for each factor that is mentioned in the questionnaire to be able to calculate the rank by the first method (RII). Then, the data is entered into the SPSS program where the second method (IMPI) is applied to verify the previous method which depends on PMP matrix method:

Relative Importance Index Technique

The relative importance index (RII) is calculated as stated below (Iyer & Jha, 2005)

$$RII = \sum W / A * N \quad (1)$$

Where; "W" is the weight given to each factor by the respondents. "A" is the highest weight = 0.72. "N" is the total number of responses collected for the ordinal scale.

Importance Index Technique

In this technique, both frequencies of occurrence and severity are categorized on (5) scales.

Frequency Index (F.I.) is based on frequencies of occurrence as identified by the participants.

$$\text{Frequency Index (F.I.) (\%)} = \Sigma\, a\, (nf/N) * 100/5 \quad (2)$$

Severity Index (S.I.) is based on the severity of the factor.

$$\text{Severity Index (S.I.) (\%)} = \Sigma\, a\, (ns/N) * 100/5 \quad (3)$$

a is the constant expressing weighting given to each response (from 1 to 5), nf is the frequency of the responses of frequency, ns is the frequency of the responses of severity and N is the total number of responses.

Importance Index (II) was calculated as s function of both frequency and severity indices, as shown in Eqn. (4)

$$\text{Importance Index (II) (\%)} = [\text{F.I. (\%)} * \text{S.I. (\%)}] /100 \quad (4)$$

Ranking factors according to the relative importance index (RII) and Importance Index (II) of each factor were shown in the table (2).

Table 2. Ranking of Rebar's labours factor

Factor	RII	Rank	F.I	S I	I.I%	Rank
Method of installation of Stirrup steel	0.59	1	71.2	68.0	48.41	1
Bending method of reinforcement fixed	0.56	7	69.0	68.4	47.19	2
Diameters of Stirrup steel used	0.56	5	75.4	62.0	46.74	3
The method of installing the main reinforcement fixed	0.56	4	70.2	65.4	45.91	4
Number of rows of reinforcing steel	0.56	6	67.0	66.8	44.75	5
Diameters of main reinforcement fixed steel	0.50	9	72.4	61.6	44.59	6
Removing method of reinforcement fixed	0.59	2	68.4	64.6	44.18	7
Position the structural element	0.55	8	71.2	61.4	43.71	8
The presence of an upper layer of Steel	0.58	3	69.4	62.4	43.30	9
Ratio of reinforcing steel to concrete	0.49	11	65.8	62.0	40.79	10
Structural elements of non-traditional shapes	0.50	10	62.6	64.2	40.18	11
Dimensions of structural element	0.47	12	60.6	63.8	38.66	12

Table 3 shows the top factors affecting labours in general and the Ranking of the various factors according to their significance while calculating their Relative Importance Index (RII) of factors to determine the most critical factors affecting the productivity of labours in Egypt.

Table 2. Relative Importance Index (RII) for General labours factor

Factor	RII	Rank	F.I.	S.I.	II %	Rank
Type of the project	0.76	1	79.4	75.6	60.02	1
Payment delay	0.73	9	76.0	77.6	58.90	2
Project Scale	0.75	2	78.4	74.4	58.32	3
Financial Incentive programs	0.75	5	75.6	76.0	57.45	4
The economic situation of the country	0.73	11	77.2	74.4	57.43	5
Political Issues & Surrounding events	0.75	3	75.8	75.6	57.30	6
Unfriendly working atmosphere	0.73	10	75.2	75.8	57.00	7
Over time	0.74	6	75.4	75.2	56.70	8
Labour operating system	0.70	16	77.2	73.2	56.51	9
Injury or accident involving a labourer	0.75	4	75.2	74.6	56.09	10
Weather effect - Climate conditions	0.73	8	77.4	72.2	55.88	11
Physical fatigue	0.71	14	75.6	73.8	55.79	12
Availability of materials on time	0.74	7	70.6	78.4	55.35	13
Labours training	0.72	13	75.8	73.0	55.33	14
Work interruptions	0.71	15	74.6	73.8	55.05	15
Distance between the site and cities	0.72	12	74.6	73.2	54.60	16
Work at heights	0.69	19	73.8	71.6	52.84	17
Moral incentives	0.70	18	73.0	72.2	52.70	18
Design complexity level	0.70	17	70.6	74.4	52.52	19
Rework	0.68	20	71.4	71	50.69	20
The weakness design and a lot of mistakes	0.65	23	69.0	73.4	50.64	21
The simultaneous involvement of labour in several tasks	0.67	21	70.6	70.8	49.98	22
Experience and skill of project manager	0.66	22	69.0	71.8	49.54	23
The extent of variation/change in drawings	0.61	24	69.2	70.8	48.99	24
Labourer experience and skill	0.60	26	73.8	65.2	48.11	25
legibility of Project specifications	0.61	25	63.8	70.2	44.78	26
Absence ratio among labours	0.57	27	63.8	69.8	44.53	27

Reliability Analysis

The Cronbach's alpha method is used to verify the validity of the factors contained in the questionnaire to eliminate those factors which are not related to the productivity and do not affect the average correlation between the measured factors. This method is used to combine the split-half method and item-total correlation to all the factors. The values of Cronbach coefficients and the entire relationship between factors should be more than 0.6 and 0.3, respectively. Consequently, if the results of either test are significant ($p<0.05$). this rejects the null hypothesis which means rejecting the assumption of normality for the distribution (Field, 2013 and Pallant, 2013).

The analysis shows that all the factors that affect the productivity of the rebar's workers affect factor "Diameters of the main reinforcement fixed steel." Three factors have been eliminated from the general factors, specifically "Labour operating system," "Moral incentives," and "Project Scale" because they have no effect on productivity and the deletion of these factors led to an increase in Alpha Cronbach's factor as well as an increase in the confidence in the validity of the questionnaire. So, the external group is removed because the loading score is less than (0.6).

Table 4. The reliability analysis

Groups	Reliability
Reinforcement Factor	0.868
Design Factor	0.733
External Factor	0.574
Financial Factor	0.679
Management Factor	0.625
Project Factor	0.635
Total	**0.845**

Factor Analysis (KMO and Bartlett's Test)

It is necessary to introduce all the factors that describe of the most significant number of variables in a smaller group of component variables. That is applied to the systematic correlation between a total of variables that have explicitly been observed on the common elements.

In this study, the KMO value of measuring sample is (0.715), which is higher than 0.5 This means that the analysis is likely to factor well so it has been taken into consideration and in Bartlett's test the significant value is lower than 0.05, which is different from the correlation matrix and an identity matrix.

The Eigenvalue is an index which is applied to the interpretative authorities of the corresponding component and is usually extracted from the number of the components that have a value of 1 or more.

In Table (5), there are components where the initial Eigenvalues are more significant than 1, while (11) components are extracted during the analysis. These eleven components can explain 68.652 % of the information contained in the original factors.

Table 5. Eigenvalues

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.693	20.282	20.282	3.383	10.251	10.251
2	3.113	9.433	29.715	2.709	8.209	18.460
3	2.132	6.461	36.176	2.542	7.702	26.161
4	1.724	5.224	41.400	2.218	6.721	32.883
5	1.572	4.763	46.163	2.092	6.340	39.222
6	1.431	4.336	50.499	1.927	5.840	45.062
7	1.372	4.159	54.658	1.814	5.497	50.559
8	1.274	3.861	58.518	1.650	4.999	55.558
9	1.196	3.625	62.144	1.561	4.732	60.290
10	1.109	3.359	65.503	1.401	4.247	64.536
11	1.039	3.149	68.652	1.358	4.115	68.652
12	.972	2.947	71.598			
13	.903	2.736	74.334			
14	.828	2.510	76.844			
15	.708	2.144	78.988			
16	.676	2.047	81.036			
17	.620	1.879	82.915			
18	.604	1.829	84.744			
19	.554	1.678	86.422			
20	.531	1.610	88.032			
21	.501	1.517	89.549			
22	.456	1.382	90.931			
23	.440	1.333	92.264			
24	.359	1.089	93.353			
25	.348	1.055	94.408			
26	.327	.991	95.399			
27	.275	.832	96.231			
28	.268	.811	97.042			
29	.239	.723	97.765			
30	.221	.670	98.436			
31	.199	.602	99.037			
32	.183	.555	99.592			
33	.135	.408	100.000			

Multiple Regression Analysis

The theoretical model of this study has proposed six independent groups that affect the variation of Labour Productivity in the construction projects, namely reinforcement, design, external, finance, management, and project. The six independent groups are ranked based on Relative Importance Index (RII). The Importance Index ranking method is done to only confirm the ranking of each factor.

The result shows that R equals 0.945. This indicates that the model is reliable where (R) value is more than (0.6) which is considered to be a moderately reliable result. The results also show that the coefficient of determination (R^2) equals 0.894.

All these results show that Project, Financial, Reinforcement, Management and Design can explain 89.4% of the variations in labour productivity and 10.6% cannot explain. The P value of 0.000 implies that labour productivity is significant at the 5 percent significance level. This indicates that the model is adequate in the prediction of the response of the dependent variable. The F value of (157.809) indicates that the overall regression model is significant and has some explanatory value (P-value $p = 0.00 < 0.05$). This too indicates that there is a significant relationship between the predictor variables, namely Project, Financial,

Reinforcement, Management, and Design and the response variable (labour productivity variation).

The regression model is fitted in the following equation (5)

$$LPV = 0.021 + 0.195(R) + 0.182 (D) + 0.204 (F) + 0.218 (M) + 0.138 (P) \text{ ... eqn. (5)}$$

LPV is the labour productivity value, which is the dependent variable, while the independent variables are Reinforcement (R), Design (D), Financial (F), Management (M), and Project (P).

The Hypothesis:

- Null Hypothesis (H0): These are the factors affecting the rebar's workers group and have no impact on the labour productivity variation.
- Research Hypothesis (H1): This includes the factors affecting the rebar's workers group which have a significant impact on the labour productivity variation.

The testing for Hypothesis is conducted. The Standardized Regression coefficient (beta) of the rebar's workers Factor group on LPV is (0.263) and the value of t-test is (6.410 >2) and p = (0.000 <0.05). That means at 95 % confidence level, there is a statistic evidence. To conclude, there is a positive impact on the Factor affecting Rebar's worker's group on the variation of labour productivity. Therefore, Hypothesis H1 is accepted. Furthermore, the results of the other hypothesis test of the research are presented in Table (6) as follows.

Table 6. The hypothesis tests

Group	T-test	Sig.	Decision
Reinforcement Factor	6.410	.000	Accept H1
Design Factor	7.974	.000	Accept H1
Financial Factor	11.220	.000	Accept H1
Management Factor	5.134	.000	Accept H1
Project Factor	7.646	.000	Accept H1

The results show that the labours productivity variation (LPV) depend on Reinforcement, Design, Finance, Management, and Project.

DISCUSSION

General Factors Affecting the Labour Productivity

Table 7 Comparison with previous studies

Table 7. Comparison with previous studies

Factor	Previous studies	The rank in this research
Type of the project	El-Gohary & Aziz (2013) rank as the thirtieth in all factor ranking.	1
Project scale	El-Gohary & Aziz (2013) rank as the nineteenth in all factor ranking.	2
Political Issues and the Surrounding Events	El-Gohary & Aziz (2013) rank as the seventh in all factor ranking.	3

Factor	Previous studies	The rank in this research
Financial Incentive Programs	Horner et al. (1989) rank as the fifth among the thirteen explored factors in the UK.	5
Over time	El-Gohary & Aziz (2013) rank as the fifth in all factor ranking.	6
Availability of Materials	The top-ranked factor (Enshassi et al., 2007; Abdul Kadir et al., 2005)	7
Payment Delay	Enshassi et al. (2007) rank it as the first factor in (6) factor in motivation group. El-Gohary & Aziz (2013) further grade it as the first factor in management Category	9
Unfriendly Working Atmosphere	It is ranked as the ninth factor in Nigeria (Ameh & Osegbo, 2011)	10

Comparison Analysis

Comparing between the two methods using the SPSS software program, results show that the relationship between the two axes is definite, positive (directly proportion), and statistically significant (sig = 0.000). The correlation between the two methods is also strongly correlated with the coefficient of correlation = 0.771. [The range between (0.7-0.9): is strongly correlated].

The results of the research show that by using both methods, it is clear that ranking factors are important in two ways and give the same ranking. Since all the factors that located in the first top ten are the most important factors as they are but differs in the arrangement only regarding importance.

Regression Modelling

The theoretical model finds that the variation of Labour Productivity depends on five independent groups Formed in rebar's workers' factor and design, reinforcement, finance, management, project group.

$$LPV = 0.021 + 0.195(R) + 0.182\ (D) + 0.204\ (F) + 0.218\ (M) + 0.138\ (P) \quad (6)$$

In another study, it has been proposed that seven independent groups affect the variation of Labour Productivity in the construction projects. These groups are Manpower (F1), Managerial (F2), Motivation (F4), Material/ Equipment (F5), Schedule (F6), Safety (F7), and quality group (F8) [Shashank et al., (2014)].

$$LPF = -3.105+0.233F1+0.199F2+0.344F4+0.225F5+0.124F6+0.218F7+0.168F8 \quad (7)$$

CONCLUSION

The goal of this study is to apply a different method for productivity analysis to identify factor affecting in rebar's labour. Thus, we try to resolve these factors to reach the productivity of a higher level. Then, we measure production rate in later works and compare them with the previous results.

The results of reliability analysis show that all factors of reinforcement group influence the productivity except "Diameters of the main reinforcement fixed steel." Three factors,

specifically "labour operating system" from finance group, "moral incentives" from management group, and "project scale" in project group do not affect productivity. When these factors are deleted, this leads to an increase in Alpha Cronbach's factor.

The results of multiple regression analysis show that project, finance, reinforcement, management, design are independent groups, which have a positive impact on the labour productivity variation, while the external group has no impact on the labour productivity variation. The regression model is represented by the following equation: LPV = 0.021 + 0.195(R) + 0.182 (D) + 0.204 (F) + 0.218 (M) + 0.138 (P).

The regression models developed in this study suggest that there is a direct effect of factors on productivity. The modelling described can also be used for labour-intensive tasks, other than concrete pouring, formwork, concrete finishing and granular fill.

This study has developed two different methods to rank factors affecting productivity growth in Egypt. First, the relative importance index (RII) method is used. Second, by applying the importance index (IMPI) method. The results of the research show that by using both methods, it is clear that ranking factors are important in two ways: they give the same ranking and prove that the first method is considered a reliable method.

RECOMMENDATIONS

The motivating's Factor for labours help to stimulate the work and ensure high performance in its completion.

There is a need to find solutions for different opinions among engineers, because this is one of the main reasons for poor productivity.

Periodic meetings should be held by experienced supervisors in the construction companies to discuss the problems in the sites to avoid delay in time to raise productivity.

According to above-mentioned findings, following points can be recommended in order to raise labour productivity such as:

- ✓ The owner must pay progress payments as fast as possible on time.
- ✓ Delivery of the construction equipment and materials on site should not be late in order to execute work in the planned order.
- ✓ The quality and experience of labour supply may have a major impact on projects.
- ✓ Site management and supervision should be done in a proper manner.

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IMPLICATION OF INCOMPLETE CONTRACT (IC) IN MALAYSIAN PRIVATE FINANCE INITIATIVE (PFI) PROJECTS

Nur Syaimasyaza Mansor[1], Khairuddin Abdul Rashid[2], Mohd Fairullazi Ayob[3] and Sharina Farihah Hasan[3]
[1]School of Housing, Building and Planning, Universiti Sains Malaysia, Penang, Malaysia
[2]Independent Consultant
[3]Department of Quantity Surveying, Kulliyyah of Architecture & Environmental Design, International Islamic University Malaysia, Kuala Lumpur, Malaysia

Abstract
Theoretically, contracts are inevitably incomplete. Incomplete contract (IC) is characterized by the absence of clearly defined, in its entirety, ex-ante the parties' requirements, rights and obligations and there are gaps, missing provisions, and ambiguities in its terms. On the one hand, IC exposes the contracting parties to the risk of opportunistic behavior, haggling, and disputes, but on the other hand, it allows flexibility to deal with uncertainty and change. Private Finance Initiative (PFI) contracts in Malaysia also cannot avoid being incomplete and there are twelve (12) clauses that contribute to the incompleteness. Literature review and two-round modified Delphi method were carried out to assess IC's implication in Malaysian PFI concession contracts. This paper aims to report on the said assessment. The findings showed that the presence of IC in PFI projects in Malaysia causes positive and/or negative implications. Most of the positive implications mentioned on the flexibility of the incomplete clause to deal with future changes and provide the parties opportunity to renegotiate. Meanwhile, many negative implications refer to delay, disputes, and the risk of opportunistic behavior. Input from this paper will facilitate contract designers, and those involved in PFI projects in emphasizing or giving attention to the aspect that contributes to contracting incompleteness and its implications and consequently improves the provisions when drafting new contracts.

Keywords: *Incomplete contract; Private Finance Initiative; Concession contract; Implication*

INTRODUCTION

The concept of incomplete contract (IC) concerns the substance of a contract. In principle, a contract must state the parties' responsibilities and the required actions in dealing with all anticipated incidents (Onishi et al., 2002). The contracting parties need to identify and address all uncertain situations which might occur in the agreements, where the potential future contingencies might be too numerous and/or too difficult to anticipate (Domingues & Sarmento, 2016). Hence, failing to identify future uncertainties and contingencies make a contract incomplete. Theoretically, a complete contract cannot be achieved and most contracts are inevitably incomplete (Domingues & Sarmento, 2016; Nur Syaimasyaza et al., 2017a). When there is IC, there is potential for inefficiency (Garvin, 2009) and dispute (Grant et al., 2012).

In Malaysia, the government is actively procuring infrastructure projects via Private Finance Initiative (PFI). However, past studies revealed that PFI contracts in Malaysia are incomplete, and the areas and clauses that contribute to the incompleteness has been identified (Nur Syaimasyaza et al., 2017a; Nur Syaimasyaza et al., 2017b). Hence, it is important to assess the implication of IC for the improvement of future PFI contracts.

This paper reports part of a four-years research programme regarding incomplete contract in PFI, which focus on the assessment of IC's implication based on PFI concession contracts in Malaysia through a two-rounds Modified Delphi with PFI experts. The remaining parts of the paper are structured as follow: a review of the literature on IC, PFI, and IC in PFI, descriptions of the methodology used, presentation of the results and the ensuing discussions. The paper concludes by highlighting the study's key findings.

LITERATURE REVIEW

Incomplete Contract (IC)

IC is defined as a contract that fails to clearly spell out ex-ante the parties' requirements, duties and obligations for every realized contingency and it has gaps, missing provisions, and ambiguities in its terms (Hart, 1995; Yates, 1998). A complete contract is just an imaginary concept used by people to define one endpoint of completeness (Craswell, 1999) as it is almost impossible to achieve complete contract (Grant et al., 2012; Habets, 2010) because parties always face with uncertainties which consequently requires them to renegotiate, breach or litigate.

A contract can be incomplete due to long-duration project (Iossa et al., 2007), high risk and uncertainty (Ya-zhuo & Fan, 2011), high transaction cost (Hart, 1995), bounded rationality (Kostritsky, 2004), and asymmetric information (Robinson & Scott, 2009). Table 1 presents the characteristics of IC. If a contract has in its provisions any one or more of the listed characteristics, then the contract is deemed incomplete.

Table 1. Characteristics of IC

No.	Characteristic	Keyword
1.	The contract has gap or loophole	GAP
2.	Contract has vague or ambiguous clauses	AMBIGUOUS
3.	There are additional work and changes	CHANGE
4.	The contract is renegotiated	NEGOTIATE

(Nur Syaimasyaza, 2017; Nur Syaimasyaza, Mohd Fairullazi, et al., 2017a)

Although the contract is incomplete, the contracting parties still can complete the transaction. However, under the existence of IC, the project's success may be affected either positively or negatively. Positive implication means that the presence of IC may help smoothen the progress of the project (Guasch, 2004) while negative implication refers to any implication that might disrupt the progress of the project or compromise the success of the project (Robinson & Scott, 2009).

Positive Implication

IC is flexible in dealing with complex and uncertain future (Boukendour, 2007; Miller et al., 2013). For long duration contract, such as toll road concession contract, flexible IC is preferred as the uncertainty of traffic flow is high (Athias & Saussier, 2010). IC allows the contracting parties to renegotiate when the need arises, to provide supplement terms to fill the missing terms or provided a solution to the contingency that they cannot forecast before (PPIAF, 2009). In some situation, a complete contract might jeopardize the ability to adapt to changing circumstances. The perfect example is in the case of chef Jamie Oliver criticizing

the quality of school dinner in Britain. As the schools are locked in 25 years PFI contracts, they cannot rid their menus of junk food as it is stated in the contract (Ellman, 2006). Besides that, the transaction cost for IC is claimed to be lower than complete contract (Miller et al., 2013) as the contracting parties sometimes leave out certain contingency when it is deemed not significant (Ya-zhuo & Fan, 2011), or the probability of the contingency to occur is very low (Triantis, 1999). Consequently, the process of drafting the contract can speed up by leaving out the contingency.

Negative Implication

IC exposes the contracting parties to the risk of opportunistic behavior, haggling, and disputes (Domingues & Sarmento, 2016; Ho & Tsui, 2009). Renegotiation conducted due to IC could also affect the project negatively as its execution will impose several costs (Bajari et al., 2014; Domingues & Sarmento, 2016; Guasch, 2004; Hart, 1995) i.e. extra cost, manpower, time. Conflicts and disputes happen when there are ambiguities in the contract, variations, and additional works. When variation and additional works are needed in the contract, it could cause time and cost overruns (Peter et al., 2010). Therefore, it could imply that by having IC, the project might experience time and cost overruns.

Private Finance Initiative (PFI)

PFI is an alternative procurement strategy that had been introduced to undertake some of the development of public infrastructures and services on behalf of the public sector. In PFI, the public sector will specify the required output and purchase the services provided by the private sector. On the other hand, the private sector will be responsible to finance, design, construct, manage, operate and maintain the project until the end of the concession period. Normally, the contract period expands to 20-30 years. United Kingdom (UK) becomes the pioneer in PFI when they introduced the procurement strategy in 1992. Malaysia started to implement PFI in 2006 and later it becomes a subset of Public-Private Partnership (PPP). PFI involves complicated contract structures as it involves a contract with various entities. The main contract i.e. concession contract is formed between government (public sector) and the special purpose vehicle (SPV). While SPV formed contracts with other entities to commence the project i.e. finance provider (i.e. debt provider, construction investor, facilities management investor and other investors), construction contractor and facilities management operator.

Some countries such as the UK, Northern Ireland, and Japan, have designed their own standard PFI contract. While in Malaysia, there is a standard template for PFI contract which is drafted by Attorney General's Chambers of Malaysia, but it is private and confidential. However, the standard contract can also become incomplete. Especially for standard PFI contract which has long contract duration, the provisions stated in the contract can easily become obsolete after some time. The prolonged contract duration exposes the PFI project to many risks and uncertainties. The risks include changes in social, economic, political and technological (Froud, 2003). Among past studies that contended that PFI contracts are inevitably incomplete are Guasch (2004), Iossa et al. (2007) and Ho & Tsui (2009).

IC in PFI

Seven (7) areas in PFI contract that are deemed incomplete from past studies were identified and they are: 1) concession charges; 2) service delivery; 3) design of output specification; 4) variation; 5) quality; 6) contract monitoring; and 7) sustainable element (Nur Syaimasyaza, 2017). These areas were used to identify the presence of IC in PFI projects, and the method is named as *PFI Area Rule*. The clause is categorized as incomplete if it matches with any one or more area that has been identified by past studies. Besides that, *IC Characteristic Rule* was used to identify the presence of IC, where the clause is categorized as incomplete if any one or more clause/sub-clause of the contracts show signs of IC characteristics (refer Table 1). By using the above methods, an analysis of eight Malaysian PFI concession contracts was carried out and the results found 12 clauses that are deemed incomplete (in a typical PFI contract). The clauses are as follow: 1) Condition precedent; 2) Concession charges; 3) Design and construction of the project; 4) Delay of the construction works; 5) Asset management services; 6) Service levels; 7) Additional works; 8) The concession company; 9) Force majeure; 10) Project monitoring committee; 11) Dispute resolution committee; and 12) Occupational safety and health requirements (Nur Syaimasyaza, 2017).

RESEARCH METHOD AND DESIGN

Intensive literature review and two rounds of modified Delphi (MD) were carried out to achieve the research objective. Literature review involved a review of past research to identify implications of IC, with specific reference to the twelve incomplete clauses identified. Data collected from literature review were then become input for the development of semi-structured questionnaires for MD.

Table 2. Administration of the MD technique

	Description
Panelist criteria	• Knowledge wise - possess at least a Degree in the area related to the practice of PFI for construction works, e.g. architect, quantity surveyor, engineer, banker, etc. • Skills - ability to make a sound judgment based on: 1) knowledge and experience in PFI implementation and contracts through involvement in PFI projects e.g. in the form of policy, planning, implementation, supervision etc.; or 2) the evidence of expertise such as past studies, publications, and positions. • Having worked experience in PFI projects in Malaysia.
Sample size	• Expert was identified from literature searches, pilot study, and web-search. • Snowball technique. • 23 experts were identified and invited to be the panelists. • 18 participated in Round 1 (78.2% rate of response), 13 participated in Round 2 (72.2% rate of response).

In the current study, two (2) rounds of MD involving 18 and 13 Malaysian PFI experts respectively were conducted (Table 2). MD is a variation of the Delphi technique. Delphi is a widely used method in achieving a consensus of experts' opinions concerning real-world knowledge on a specific area of studies. The techniques may be carried out in several styles (see discussions on MD in Mohd Fairullazi & Khairuddin (2016); Mohd Fairullazi (2014); Nur Syaimasyaza (2017); Nur Syaimasyaza et al. (2017a)).

For the first round MD questionnaire, the panelists were required to rate their level of agreement with the implications stated, on a 5-point Likert-type scale (i.e. 1. Strongly disagree, 2. Disagree, 3. Neutral/Not sure, 4. Agree, 5. Strongly agree) and they were also asked to give suggestions of other implication of IC with specific reference to each clause identified.

In the second round, the panelists were provided with descriptive statistic results obtained in the first round i.e. their mode score and descriptive statistic of the group response (mode and standard deviation (SD)). The mode score was calculated to determine the value that has the greatest frequency in the data set and SD score was calculated to measure the variability of response in the data set and the level of consensus achieved. In this round, the panelists were given the opportunity to re-rate their proposed scores in the first round and they were encouraged to provide the reason(s) if they decided to do so. Apart from that, the additional suggestions and comments received in the first round were consolidated and presented in a 5-point Likert type scale (i.e. 1. Strongly disagree, 2. Disagree, 3. Neutral/Not sure, 4. Agree, 5. Strongly agree). The panelists were required to state their degree of agreement of each item responses and the scores provided were then analyzed using the relative importance index (RII) technique in order to determine the ranking of the item responses (Mohd Fairullazi, 2014). The RII technique was used to identify which item responses that are important and significant to be included in the answer set of the question (Mohd Fairullazi, 2014). Higher RII score means higher ranking for the item. A 'cut-off' relative index of 0.60 on the 5-point Likert scale was applied (Muhwezi et al., 2014) and items that score RII 0.80 and above are categorized as 'Very significant' (Hamimah & Morledge, 2003; Mohd Fairullazi, 2014), while items that score between 0.79 and 0.60 are categorized as 'Significant'. Table 3 and Figure 1 present the indication and formula used to interpret the SD score and RII formula respectively.

Table 3. Standard deviation and level of consensus

Standard Deviation (SD)	Level of consensus achieved
$0 \leq X < 1$	High level of consensus
$1 \leq X < 1.5$	Reasonable/ fair level of consensus
$1.5 \leq X < 2$	Low level of consensus
$2 \leq X$	No consensus

(Mohd Fairullazi, 2014 and Nur Syaimasyaza, 2017)

$$RI = \frac{n1(1) + n2(2) + n3(3) + n4(4) + n5(5)}{5N}$$

Where:
n1 = Number of respondents for "Strongly disagree"
n2 = Number of respondents for "Disagree"
n3 = Number of respondents for "Neutral/Not sure"
n4 = Number of respondents for "Agree"
n5 = Number of respondents for "Strongly agree"

Figure 1. RII formula (Nur Syaimasyaza, 2017)

RESULTS AND DISCUSSION

Out of nine (9) implications presented to the panelists, only one implication (Code: 450) achieved mode score '2' for both rounds, which indicates that most panelists 'Disagree' with the implication (Table 4). Meanwhile, the remaining implications achieved mode score '4' which means that most panelists 'Agree' with the implications identified for each clause and

the level of consensus indicate 'high level of consensus' achieved as the SD scores are below 1.00.

Table 4. Mode and SD score for Round 1 and Round 2 MD (Nur Syaimasyaza, 2017)

[1]Code	Implications	1st round		2nd round	
		Mode	SD	Mode	SD
	Clause B - Concession Charges				
370	Renegotiation creates room for opportunistic behavior	4	0.42	4	0.49
380	The failure to forecast future demand with confidence could affect the concession company's profit flow.	4	0.84	4	0.76
	Clause E - Asset Management Services				
390	The difficulties in specifying soft service delivery due to the problem of subjectivity cause dispute over the interpretation of: a) the levels of service; and	4	0.65	4	0.00
400	b) standard	4	0.65	4	0.00
	Clause F - Service Levels				
410	Unanticipated service delivery problem	4	0.67	4	0.89
420	Risk of opportunistic behaviour	4	0.00	4	0.00
	Clause G - Additional Works				
430	Enormous time was spent to make changes/variation.	4	0.84	4	0.79
440	Changes to the contract represented a fertile area for opportunistic behavior	4	0.97	4	0.98
	Clause J - Project Monitoring Committee				
450	Lack of efficient monitoring system is one of the reasons for the failure of PPP contracts	2	0.95	2	0.98

Additional implications suggested by the panelist in Round 1 MD were consolidated into 50 implications and they were presented to the panelists in Round 2 to be rated. Scores obtained from the panelists in Round 2 MD were transformed into important indices factors using RII formula (Figure 1). Table 5 below presents the RII score for each implication. From the list, implication 460, 510, 520, 590, 600, 640, 650, 660, 700, 710, and 870 are considered 'Very significant' with RII scores 0.80 and above. Implication 550 and 890 did not achieve the 'cut-off' relative index of 0.60 and they were excluded from the final result. Other implications achieved RII score 0.60 to 0.79 and they are considered 'Significant'.

Table 5. RII score for additional implications obtained from Round 1 MD (Nur Syaimasyaza, 2017)

Code[1]	Suggested implications	RII	Rank	Significant
	Clause A - Condition precedent			
460	**Negative implication:** Delay in concluding the document to be submitted and consequently affecting the project execution	0.82	1	Very significant
470	Failure to prepare the document (originally not specified in the contract), when the need arises	0.74	4	Significant
480	Exploitation of the contract clause (incomplete contract) by involved parties	0.75	3	Significant
490	The dispute in interpreting the ambiguous clause (determining the required document)	0.78	2	Significant
500	**Positive implication:** Provides flexibility to deal with future uncertainty, e.g. the party can request for additional documents if needed in the future	0.69	1	Significant
	Clause B - Concession Charges			
510	**Positive implication:** Allow for any improvement to be made when there are changes to asset management service charges	0.83	1	Very significant
520	Allow the parties to deal with uncertainty and benefit from the renegotiation	0.80	2	Very significant

Code[1]	Suggested implications	RII	Rank	Significant
	Clause C - Design and Construction of the Project			
530	**Negative implication:** The additional cost to the concession company, because they usually will have to comply with the request for the variation at their own cost.	0.66	2	Significant
540	Delay and dispute in the project due to changes in design	0.71	1	Significant
550	The additional cost to the government due to changes in design (the government need to bear the cost to make changes)	0.58	3	
560	**Positive implication:** Minimal interruption of the construction works from the government (in the case where the clause did not specify the possibility for the government to make changes)	0.71	2	Significant
570	Allow the government to request for changes without any cost implication (since the clause is silent on the Government's rights to issue change, the Government can persuade the Concession company to make the change without cost increment)	0.62	3	Significant
580	Provide flexibility to implement a new and better technology/specification	0.78	1	Significant
	Clause D - Delay of the Construction Works			
	-No suggestion has been made-			
	Clause E - Asset Management Services			
590	**Negative implication:** Time-consuming for the approval process of variation due to several rounds of negotiation	0.83	2	Very significant
600	Dispute arises due to incomplete contract	0.85	1	Very significant
610	**Positive implication:** Provide flexibility to improve and revise the necessary level of service and standard	0.78	1	Significant
620	Allow both parties to deal with uncertainty and future changes	0.78	1	Significant
	Clause F - Service Levels			
630	**Negative implication:** Unable to apply the true Asset Facility Management (the clause only focuses on the aspect of maintenance)	0.66	1	Significant
640	**Positive implication:** Improve or refine the quality of maintenance	0.83	1	Very significant
650	Provide flexibility to cater future change	0.83	1	Very significant
660	Provide an opportunity for the parties to renegotiate, to deal with future uncertainty.	0.82	3	Very significant
	Clause G - Additional Works			
670	**Negative implication:** Risk of opportunistic behavior, e.g. the SPV increases the price for Additional Works.	0.78	1	Significant
680	**Positive implication:** Provide flexibility to deal with future changes	0.78	3	Significant
690	Fair to both sides to deal with uncertainty and future changes	0.78	3	Significant
700	Provide an opportunity for both parties to achieve a win-win solution	0.80	2	Very significant
710	Allow the government to request additional works in the future	0.82	1	Very significant
	Clause H - The Concession Company			
720	**Negative implication:** Change in shareholder could affect project performance	0.72	5	Significant
730	Change in shareholder may result in a change in work culture	0.71	6	Significant

Code[1]	Suggested implications	RII	Rank	Significant
740	Leeway for the concession company to escape from their responsibility (The clause 'Change in Shareholding' could cause the Concession company to have the mindset that they can withdraw from the contract and thus they design and construct the project without considering the maintenance phase)	0.66	9	Significant
750	Negatively affect the government due to the uncertain performance of the new shareholders	0.68	8	Significant
760	Tedious work to prepare the paperwork for the change in shareholding	0.66	9	Significant
770	Revise terms and conditions in the agreement might put the concession company on the disadvantage side	0.71	6	Significant
780	Cost and time implication due to negotiation process	0.77	1	Significant
790	Risk of opportunistic behavior, e.g. the party refuses to agree on the calculation of the Refinancing Gain.	0.77	1	Significant
800	The dispute in determining the basis and method of calculation for Financing Gain	0.74	3	Significant
810	Delay in determining the method and calculation of the Refinancing Gain	0.74	3	Significant
	Positive implication:			
820	Change in shareholder could strengthen the whole corporate structure.	0.68	3	Significant
830	Allow the government to revise any terms and conditions in the agreement to benefit the government in the event there are changes in shareholders.	0.66	4	Significant
840	Allow both parties to deal with uncertainty and future changes	0.77	1	Significant
850	Allow the parties to refer to the latest method and calculation of Refinancing Gain	0.72	2	Significant
	Clause I - Force Majeure			
	Negative implication:			
860	Disputes in interpreting the term 'substantial cost'	0.78	1	Significant
	Positive implication:	0.82	1	Very
870	Allow both parties to deal with uncertainty and future changes			significant
	Clause J - Project Monitoring Committee			
	Negative implication:			
880	Disputes due to lack of guidelines on what the Project Monitoring Committee could do and cannot do	0.72	1	Significant
890	Delay in project performance	0.58	3	
900	Unfair practice or unfair decision making due to lack of guidelines	0.63	2	Significant
	Clause K - Dispute Resolution			
	Negative implication:			
910	Lead to delay in resolving the disputes, e.g. lack of guidelines on what the Dispute Resolution Committee could do and cannot do	0.72	2	Significant
920	Lead to disputes	0.74	1	Significant
	Clause L - Occupational Safety and Health Requirements			
	Negative implication:			
930	Lack in the implementation of safe work culture	0.65	2	Significant
940	Sub-standard compliance with the safety and health requirement (safety and health element is not taken into consideration in their cost estimation during tendering)	0.66	1	Significant
950	Unable to refer to any related clause, in the event, there is an accident/incident	0.65	2	Significant

[1] All items and responses obtained from both rounds' MD were coded in an increasing number of 10 (i.e. 10, 20, 30, etc.). Coding presented in this paper is as in the author's PhD dissertation [8].

The results from both rounds MD had identified and assessed 56 implications of the incomplete clause. Interestingly, the incomplete clause could have both positive and negative implication as shown above for Clause Condition Precedent, Clause Concession Charges, Clause Design and Construction of the Project, Clause Asset Management Services, and

others. Among the positive implications identified, most of them are regarding the flexibility of the incomplete clause to deal with future change and opportunity to renegotiate. This is similar with the findings by Athias & Saussier (2010) where IC is preferred because of its flexibility to deal with the uncertainty of traffic flow.

On the other hand, most negative implications are concerning delay, disputes, and risk of opportunistic behavior. The finding is consistent with previous scholars i.e. Ho & Tsui (2009), Robinson & Scott (2009) and Domingues & Sarmento (2016). Based on the findings above, it has been confirmed that the presence of IC in PFI projects in Malaysia could have both positive and negative implications.

CONCLUSIONS

This study has successfully identified and assessed 56 implications of IC in PFI projects in Malaysia with specific reference to each incomplete clause. Most of the positive implications are concerning flexibility to deal with future change and opportunity to renegotiate. While, negative implications are mostly regarding the delay, disputes, and risk of opportunistic behavior.

Although IC cause positive implication, the fact that negative implication could also occur, PFI stakeholders cannot take the matter lightly and they should be ready with strategies to minimize or eliminate the negative implication. Besides, strategies to improve or maintain the status quo of the positive implication is also important to ensure the smoothness of the project's implementation.

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METHODOLOGY TO INVESTIGATE THE QUALITY OF COST DATA AS INPUTS FOR LCC ANALYSIS OF NEW FLEXIBLE PAVEMENT CONSTRUCTION IN THE MALAYSIAN CONSTRUCTION INDUSTRY

Nor Khalisah Bidi[1], Mohd Fairullazi Ayob[1], Khairuddin Abdul Rashid[1], Faizul Azli Mohd Rahim[2], and Haryati Yaacob[3]

[1]Department of Quantity Surveying, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, 50728 Kuala Lumpur, Malaysia

[2]Centre for Building, Construction & Tropical Architecture (BuCTA), Faculty of Built Environment, University of Malaya, 50603 Kuala Lumpur, Malaysia.

[3]School of Civil Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, Skudai, 81310 Johor.

Abstract

In the face of high cost of new road construction and maintenance, a large amount of money was required over the years by the Malaysia Government to spend on building new road and maintaining the quality of existing road pavements throughout the anticipated service lifespan. Many commentators pointed out that it is crucial to the road owners or clients, and related government agencies to give greater emphasize on optimising the total ownership cost on the new road pavement construction from the very early stage of the project life cycle. Life Cycle Cost (LCC) is a an economic assessment technique that is applied to calculate the total ownership cost of an asset, which can produce useful cost information to the clients and cost estimators in facilitating them to achieve the best value for money decision making on the investment of new road construction throughout the anticipated design lifespan. LCC compares the overall long-term economic efficiency between the competing road design alternatives over the anticipated lifetime to identify potential cost savings. The process of LCC estimation is divided into three main phases; i.e. data inputs, conversion, and outputs. However, the quality of data used in LCC analysis is significant to ensure the LCC estimation process can produce correct and reliable outputs to the clients and cost estimators. This paper presents the proposed methodology to investigate the quality of data used as inputs for LCC analysis of new flexible pavement construction. There are two types of road pavements, which are flexible and rigid pavements. The methodology proposed for the study is a qualitative research strategy that comprises of literature review and semi-structured interview. This paper is prepared as part of a two-year master programme of research undertaken by the first author to investigate the quality and readiness of the cost data as inputs for LCC analysis of new flexible pavement construction in the Malaysian construction industry.

Keywords: *Methodology; Life Cycle Cost; New Flexible Pavement Construction; Quality; Cost Data Inputs*

INTRODUCTION

Road infrastructures are very important assets in trade and transportation system, which act as an enabler to generate excellent growth to the economic and social to the country (Nasradeen and Zulkiple, 2013; Zarabizan et al., 2013; Nurul, 2010). The road infrastructures have become the most important means for 96% of transported goods and passengers (Sufiyan & Zulakmal, 2009 as cited by Putera Zal Hafizin, 2015). In Malaysia, the government has spent a large amount of money in the construction of new road networks and in the maintenance of existing road networks throughout the entire lifespan (Nasradeen and Zulkiple, 2013, Nurul, 2010; Zarabizan et al., 2013). For example, the Government of Malaysia has spent RM9,803.34 million between January 2017 and June 2017 for the

construction of infrastructure projects as stated in the Construction Quarterly Statistical Bulletin 2017, (CIDB, 2017). In Malaysia, there are two types of road pavements, which are flexible and rigid pavements (The Constructor, 2015; Wan Omar, 2015; Haritsehrawat, 2012; Mathew & Rao, 2007). The flexible pavement is constructed in five layers, which comprise of subgrade, sub-base, road base, base course and wearing course (The Constructor, 2014; PWD, 2013). While, the rigid pavement is constructed in three layers, which comprise of subgrade, base or sub-base, and concrete slab (The Constructor, 2014; PWD, 2013). The flexible pavement is well known for having lower initial capital cost, but higher maintenance cost as compared to rigid pavement (Wan Imran, 2015). The study carried by the authors focuses only on the investigation of quality and readiness of cost data used as inputs for LCC analysis of new flexible pavement construction in the Malaysian construction industry. This paper is prepared to present the proposed methodology to investigate the quality of cost data used as inputs for LCC analysis of new flexible pavement construction.

REVIEW OF LIFE CYCLE COST ANALYSIS OF FLEXIBLE PAVEMENT IN MALAYSIA

Most of the flexible pavement constructions in Malaysia are designed with a lifespan between ten and fifteen years (Zakaria & Hassan, 2005 as cited by Wan Imran, 2015). The main factors affecting the design life of flexible pavement are quality of materials, traffic loading, technology and thickness of flexible pavement layers (Vasudevan & Hidayu, 2014). For example, the flexible pavement structure will be deteriorated before the end of its design life when the thickness of each flexible pavement layer is designed thin. Hence, a major road maintenance work is required to rehabilitate this deteriorated road pavement (Vasudevan & Hidayu, 2014). It is not a misconception to state that the selection of design alternatives and construction methods during planning and design stage of the road pavement will give impact to the future operation and maintenance cost (Vasudevan & Hidayu, 2014; Wennstrom, 2014). Therefore, it is very important to connect initial capital cost with future costs such as maintenance and rehabilitation cost as well as salvage cost in the investment decision-making process at the very early stage of the project life cycle to achieve the best value for money over the investment.

LCC analysis is an economic assessment technique that can be applied to estimate the total ownership cost and to compare the overall long-term economic efficiency between the available competing alternatives in identifying potential significant cost savings (Boussabaine & Kirkham, 2006, BS ISO 15686-5, 2008, Davis Langdon, 2010, Davis Langdon Management Consulting, 2006, as cited by Mohd Fairullazi, 2014). LCC analysis provides cost information that can assist clients to achieve the most cost-effective on the investment made on a new construction of flexible pavement (Transportation Equity Act for the 21st Century, 2011 as cited by Ross, 2012; Khairani, 2009).

Based on a comprehensive review of literature on the current state of LCC practice in the Malaysian construction industry, it was observed that the Government of Malaysia has encouraged the adoption of life cycle cost practice in the procurement process to assist the government and clients to achieve the best value for money on investment made in building and infrastructure projects in the 10th Malaysia Plan (2011-2015) (Economic Planning Unit, 2010). In the current 11th Malaysia Plan (2016-2020), the Government of Malaysia has asserted again that LCC should be practised in the Malaysian construction industry,

specifically in the maintenance of road and rail infrastructure networks to maintain good working performance condition over the maximum service lifespan (Economic Planning Unit, 2015). Hence, it is not a misconception to state that the LCC analysis has become a chosen economic assessment technique to facilitate the Malaysian Government in designing the best value for money procurement strategies to achieve the most cost-effectiveness on public investment, particularly in building, road and rail infrastructure networks in Malaysia.

A technical agency of the government, the Public Work Department (PWD) has published an LCC guideline that entitled "Garis Panduan Kos Kitaran Hayat (2012)" [Guideline of Life Cycle Cost (2012)]. The objective of this guideline is to provide procedures and methodology that can facilitate the cost estimators to carry out LCC analysis for the new construction of public building and road projects in the Malaysian construction industry. This guideline also helps the clients and cost practitioners in making the best and cost-effective decision to achieve the most optimum life cycle cost of the investment made on building and road projects. The guideline provides fundamental LCC methodology and application, however, there is no explanation given on the methodology and procedures to identify and collect a comprehensive and quality cost data that required to be used as input for producing a complete and reliable LCC analysis with specific reference to the new flexible pavement construction.

In the context of education in Malaysia, LCC has been thought as one of the topics in economic subject of undergraduate studies at the tertiary institutions; i.e. Bachelor of Quantity Surveying (Mohd Fairullazi, 2014). LCC also has been thought as one of the subjects in postgraduate studies of certain local universities to provide knowledge and skills on the application of LCC analysis of maintenance during the in-use phases of assets and facilities (Mohd Fairullazi, 2014).

Although LCC has been increasingly recognized as an important economic assessment technique to provide cost information that can facilitate the clients to achieve the best value for money decision making, however many commentators pointed out that most of the clients and cost practitioners rarely practice LCC analysis even though they aware of the concept and significant practice of LCC technique (Mazlan, 2010; Mohamed, Karim, Nor & Kho, 2007 as cited by Wan et al., 2014; Mohd Fairullazi et al., 2017; Mohd Fairullazi, 2014; Mohd Fairullazi & Khairuddin, 2016, 2015, 2013, 2011a , 2011b). Besides, there is no evidence found from the literature study that can be proved true the cost data in the Malaysian construction industry are quality, complete and ready enough to be used as inputs for producing a comprehensive and reliable LCC analysis of new pavement construction. The following questions are used to resolve this research problem:

i. What is the state of LCC practice in the construction stage of new flexible pavement in the Malaysian construction industry?
ii. What is the mathematical cost model that can be applied in LCC analysis of new flexible pavement construction?
iii. What are the requirements of cost data that are required for producing a comprehensive LCC analysis of new flexible pavement construction?
iv. What is the state of quality of cost data as inputs for LCC analysis of new flexible pavement construction in the Malaysian construction industry?
v. What are the appropriate strategies that can be recommended to improve the quality of cost data for LCC analysis of new flexible pavement construction?

OBJECTIVE OF THE PAPER

The objective of this paper is to present a proposed methodology to investigate the quality of cost data as inputs for LCC analysis of flexible pavement over an anticipated study life. This paper is prepared as part of a two-year master programme of research that undertaken by the first author to investigate the quality and readiness of cost data as inputs for the estimation of the total cost of new flexible pavement construction in the Malaysian construction industry. The research mainly focuses on the quality of cost data used as inputs in LCC analysis of new flexible pavement construction. A methodology of data collection is designed and proposed for the study to achieve the research aim and to answer the following research objectives:

i. To determine the state of LCC practice in the construction stages of new flexible pavement in the Malaysian construction industry.
ii. To identify the mathematical cost model that can be applied in LCC analysis of new flexible pavement construction.
iii. To identify the cost data requirements required for a comprehensive LCC analysis of new flexible pavement construction.
iv. To determine the quality of cost data as inputs for LCC analysis of new flexible pavement construction in the Malaysian construction industry.
v. To identify the appropriate strategies that can be recommended to improve the quality of cost data for LCC analysis of new flexible pavement construction.

COST DATA INPUTS FOR LCC ESTIMATION OF NEW FLEXIBLE PAVEMENT CONSTRUCTION

The literature study has established three phases in the estimation process of LCC analysis; i.e. data inputs, conversion and outputs (BS ISO 15686-5, 2008; Rist, 2011; Kelly and Hunter, 2009; NATO Research and Technology Organisation, 2009, as cited by Mohd Fairullazi, 2014). However, cost data is the most important inputs for LCC analysis that have to be identified and collected in the early design stage of the project (Schade, 2007; NATO Research and Technology Organisation, 2009; Dhillon, 2010; Mohd Fairullazi & Khairuddin, 2011a, 2011b; Mohd Fairullazi, 2014). In order to estimate the total cost of new flexible pavement construction, three categories of cost components of LCC analysis of new flexible pavement construction have been identified; i.e. agency cost, road user cost and financial cost as illustrated in Figure 1 (Tinni, 2013; Dutta, 2014; Hallin et al., 2011; State of California, 2010, 2013).

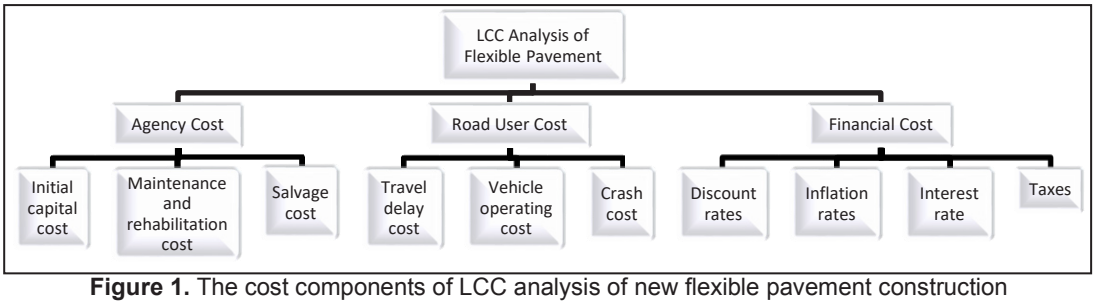

Figure 1. The cost components of LCC analysis of new flexible pavement construction (Adapted from British Standard Publication: Guide for life cycle costing of maintenance during the in-use phases of buildings (p. 34), by BS 8544, 2013 Copyright 2013 by BSI Standards Limited)

The agency cost is the cost incurred by the agency that includes the initial capital cost, maintenance, and rehabilitation cost as well as the salvage cost (Tinni, 2013; Dutta, 2014). The road user cost is the cost incurred by travelling public that includes travel delay cost, vehicle operating cost and crash cost. While, the financial cost is the cost and other charges involved in the borrowing money or purchasing assets, which comprises of discount rates, interest rates, inflation rates and taxes comprising (International Financial Reporting Tool, n.d.). Table 1 presents the description of each category of cost components for LCC analysis of flexible pavement.

Table 1. Cost components for LCC analysis of flexible pavement

Cost component		Description
Agency cost	Initial capital cost	-Initial capital cost is defined as a total investment towards completion including decommissioning by the end use of the road pavement.
	Maintenance and rehabilitation cost	Maintenance and rehabilitation cost of road pavement is the cost associated with the activity to return roadways that exhibit minor and major structural distress, to a good condition which produces a substantial extension in service life.
	Salvage cost	Salvage cost refers to the projected resale value of flexible pavement at the close of its useful life.
Road user cost	Travel delay cost	Travel delay cost is the cost incurred by the road users due to reduced speed and/or the use of alternate routes.
	Vehicle operating cost	Vehicle operating cost is the cost incurred by the vehicle owner due to blockage caused by maintenance of road structures
	Crash cost	Crash cost is the cost to bear any damage to the users and other vehicles, as well as public or private property and injuries.
Financial cost	Discount rates	The discount rate is the parameter used to represent the time value of money that depends on the inflation cost of capital, investment opportunities and personal consumption preferences.
	Interest rates	Interest rate is the certain percentage of a sum of money charged by the financial company in borrowing money
	Inflation rates	Inflation refers to an increase in the general price level that reflecting a decline in the purchasing power of money due to the economic activities
	Taxes	Taxes are the charges as the contribution to the state's revenue, imposed by the government on certain items such as property, income, expenditure, etc.

(Dutta, 2014, Alberto Torres & Carlos Bustamante, n.d, Langdon, 2010, Singh et al., 2003, Kristic & Marenjak, 2012, Fuller, 2009, International Financial Reporting Tool, 2015, Nor & Zainal, 2012, Matrixlab-Examples.com, 2009, Scheving, 2011, Mohd Fairullazi, 2014, Tinni, 2013, Hallin et al., 2011, BSI ISO 15686-5, 2008, Federal Highway Administration, 2015, Institute for Road Safety Research, 2014)

The data required for the estimation of LCC analysis are varieties and complex (Woodward, 1997; Wyton, 2008; Khairani, 2009 as cited by Mohd Fairullazi, 2014; Mohd Fairullazi & Khairuddin, 2011a, 2011b). However, the LCC estimators have to ensure cost data that are identified and collected are quality enough to be used as inputs for producing a comprehensive and reliable LCC analysis of new flexible pavement construction. The literature study has established the following key quality of data input requirements of LCC analysis in generating the comprehensive and reliable LCC analysis of new flexible pavement construction (Mohd Fairullazi et al., 2017; Mohd Fairullazi, 2014; Mohd Fairullazi and Khairuddin, 2016, 2015, 2013, 2011a, 2011b):

i. **Availability** of cost data indicates the level of data certainty (Gross and AEA, 2008; NATO Research and Technology Organisation, 2009; BS ISO 15686-5, 2008; BSI, 2008; Goh et al., 2010; Davis Langdon Management Consulting, 2007, as cited by Mohd Fairullazi et al., 2017; Mohd Fairullazi, 2014; Mohd Fairullazi and Khairuddin, 2016, 2015, 2013, 2011a, 2011b).
ii. **Accessibility** of cost data is defined as the ease of access to obtain cost data from data sources or suppliers within known background (NATO Research and Technology Organisation, 2009, as cited by Mohd Fairullazi et al., 2017; Mohd Fairullazi, 2014; Mohd Fairullazi and Khairuddin, 2016, 2015, 2013, 2011a, 2011b).
iii. **Current** data means as the most recent and advanced data that are updated on monthly basis or yearly basis (Free Dictionary, 2015, Khairani, 2009, as cited by Mohd Fairullazi et al., 2017; Mohd Fairullazi, 2014; Mohd Fairullazi and Khairuddin, 2016, 2015, 2013, 2011a, 2011b).
iv. **Reliability** of cost data refers to the consistency of data which implies how comparable the data to the actual value that arrived from similar and repetitive methods under the same research situation (Creswell & Clark, 2007, Neuman, 2003, Ashworth, 2004, Mohd Fairullazi et al., 2017; Mohd Fairullazi, 2014; Mohd Fairullazi and Khairuddin, 2016, 2015, 2013, 2011a, 2011b).

There are two categories of data sources for LCC analysis; i.e. internal data and external data (Dooling & Overgaard, 2015; Mohd Fairullazi, 2014; Hooda, 2013; Khairani, 2009). Table 2 describes the two categories of data sources for LCC analysis.

Table 2. The categories of data sources for LCC analysis

Internal data	External data
The data are strictly recorded by the companies or organisations from the projects with known backgrounds and not publicly published (Khairani, 2009; Barron dictionary, n.d). The data is controlled by the firms to maintain professional image and integrity of their works to the clients (Khairani, 2009).	The data are published by the manufacturers, clients, suppliers, consultants, contractors, etc. for public use into published sources i.e. technical books and price data (Khairani, 2009; RTO-SAS-069, 2009). The data users can subscribe the data from the counter or access online on the corporate website. For example, the data users have to purchase published cost data from the counter of Board of Architects Malaysia at cost of RM18.00 to obtain cost data for professional fees. Besides that, the data users can access online through the official website of PWD to obtain cost data for construction cost for flexible pavement at the following address (http://ratol.jkr.gov.my/ search#). The followings are the list of examples data producers in Malaysian construction industry (Khairani, 2009): i. Public Work Department (PWD) ii. Construction Industry Development Board (CIDB) iii. Department of Statistics (DSM) iv. David Langdon & Seah Sdn Bhd in collaboration with Juru Ukur Bahan Malaysia & JUBM Sdn Bhd v. KPK Quantity Surveyors Sdn Bhd

REVIEW OF RESEARCH METHODOLOGY

The literature study has identified three types of research strategies, which include quantitative, qualitative and mixed methods research (Fellows & Liu, 2008; Naoum, 2007, 2003; Creswell and Clark, 2007; Axinn, 2006 as cited by Mohd Fairullazi, 2014). The key differences between these three research strategies are shown in Table 3.

Table 3. The quantitative, qualitative, and mixed method research strategies

Research Strategy	Definition
Quantitative research	It refers to the type of research in which the researcher generates numerical data by using statistical analysis (Wyse, 2016).
Qualitative research	It refers to exploratory research, where the researcher gains an understanding a social or human problem based on the respondents' opinions, views, and perceptions (Wyse, 2016; Creswell & Clark, 2007, Royse, 2008 as cited by Mohd Fairullazi, 2014).
Mixed methods research	It refers to the type of research that involves the quantitative and qualitative researches as purpose to complement the strength and overcome the weakness of a single research method (Biddix, 2016; Fellows & Liu, 2008, Kinight & Ruddock, 2008, Creswell & Clark, 2007 as cited by Mohd Fairullazi, 2014)

In this study, the qualitative research is chosen as the most preferred research strategy rather than quantitative and mixed method research due to the following reasons:

1. The research of LCC data input is subjective in nature (Mohd Fairullazi & Khairuddin, 2016, 2011b; Mohd Fairullazi, 2014). This is because the study requires the researchers to investigate the present practice of LCC analysis of flexible pavement and the state of quality of cost data as inputs for the estimation of the total cost of new flexible pavement construction on the basis of data availability, accessibility, currency, and reliability pavement.
2. Due to limited availability of data, the qualitative strategy helps the researcher to obtain data by getting views and opinions from the cost practitioners that have knowledge, skills or experience in LCC of road pavement (Mohd Fairullazi & Khairuddin, 2016, 2011b, Mohd Fairullazi, 2014).
3. The literature review has identified several past types of researches that have chosen qualitative research strategy to study the concepts and practice of LCC analysis. These include Wan Imran (2015), Mohd Fairullazi & Khairuddin (2016, 2011b), Mohd Fairullazi (2014), Mohd Faris & Arazi (2010), Anurag Shankar, Mohamed A. El-Gafy & Tariq Sami (2010), Langdon, 2010, Goh and Yang (2009). For example, Wan Imran (2015) has used qualitative research strategy (i.e. case study) for his study to investigate the comparison between reconstruction and Cold-In-Place Recycling (CIPR) methods.

In selecting the most appropriate approach for the chosen qualitative research strategy, a comprehensive literature review was carried out to assess the strengths and weaknesses of primary research approaches. Table 4 shows the outcomes of a comparative review of the primary research approaches. As referred to Table 4, the interview has been identified as the most appropriate approach to achieve the following research objectives:

i. To identify the mathematical cost model that can be applied in LCC analysis of new flexible pavement construction.
ii. To identify the cost data requirements required for a comprehensive LCC analysis of new flexible pavement construction.
iii. To determine the quality of cost data as inputs for LCC analysis of new flexible pavement construction in the Malaysian construction industry.
iv. To identify the appropriate strategies that can be recommended to improve the quality of cost data for LCC analysis of new flexible pavement construction.

Table 4. The outcome of the review of primary research approaches

Approaches	Reasons
Survey	Survey is not appropriate for this study because it requires a large number of respondents to provide response that meeting the required response rate (Sincero, 2012). Because of the limited number of people that have knowledge/skills/ experience in LCC analysis of flexible pavement in Malaysia, it is not a misconception to that it is impossible to obtain a sufficient number of respondents required for the study.
Case studies	Case studies are rejected for this study because there is no information revealed that LCC has been used in flexible pavement project in the past. Plus, the application of LCC in Malaysia is still new and at infancy stage (Mohd Fairullazi & Khairuddin, 2016, 2011b).
Interview	Interview is chosen as the most appropriate primary research approach to answer the research objectives. This approach facilitates the researcher to obtain **rich qualitative data** (Stuckey, 2013)**.** The researcher can pursue in-depth information on research area from respondents that have knowledge/skills' experiences in LCC field.
Focus group discussion (FGD)	Focus Group Discussion (FGD) can assist the researcher to **gather data more efficiently in terms of time** (Ayob, 2014). The FGD also can facilitate the researcher to **attain high levels of consistency and accuracy** due to its high face validity than other typical research approaches (e.g. surveys, case studies, action research) (Boatong, 2012, Lasch et al., 2012 as cited by Mohd Fairullazi, 2014). However, a significant limitation of this approach is that the researcher has difficulties **to get mutual agreement** from all FGD respondents to meet at a specified time and venue due to their tight schedules in effort to possess face to face discussion (Mohd Fairullazi, 2014).

METHODOLOGY PROPOSED FOR THE STUDY

The qualitative research strategy designed for the study comprises of literature review (theoretical approach) and semi-structured interview (fieldwork approach) with people that have knowledge, skills or experience in the field of LCC analysis of flexible pavement. The designed schematic flow of research methodology that is proposed for the study is presented in Figure 2.

The data obtained from the literature review will provide a basis for the implementation of interview approach. There are three types of interview approach; i.e. structured interview, semi-structured interview and unstructured interview (Stuckey, 2013; Gill et al., 2008). Table 5 shows the key comparison between the three different types of interview approaches.

The semi-structured interview has been identified as more appropriate primary research approach rather than other types of interview approach to achieve the research objectives. In addition, the following are the key reasons as to why the semi-structured interview is chosen as the primary research approach for the study:

1. The semi-structured interview approach helps the interviewee to **understand in details** the subject matter because it provides **clear instruction to the interviewee** on how to respond to questions in the semi-structured questionnaire (Woods, 2011; Harrell & Bradley, 2009; Gill et al., 2008; Stuckey, 2013, LAFOREST, 2009).
2. Several researchers claimed that this approach can help the researcher to obtain **rich qualitative data** and deep information because it comprises a balance between the flexibility of open-ended questions and closed-ended questions (Stuckey, 2013).

Figure 2. The schematic flow of the research methodology

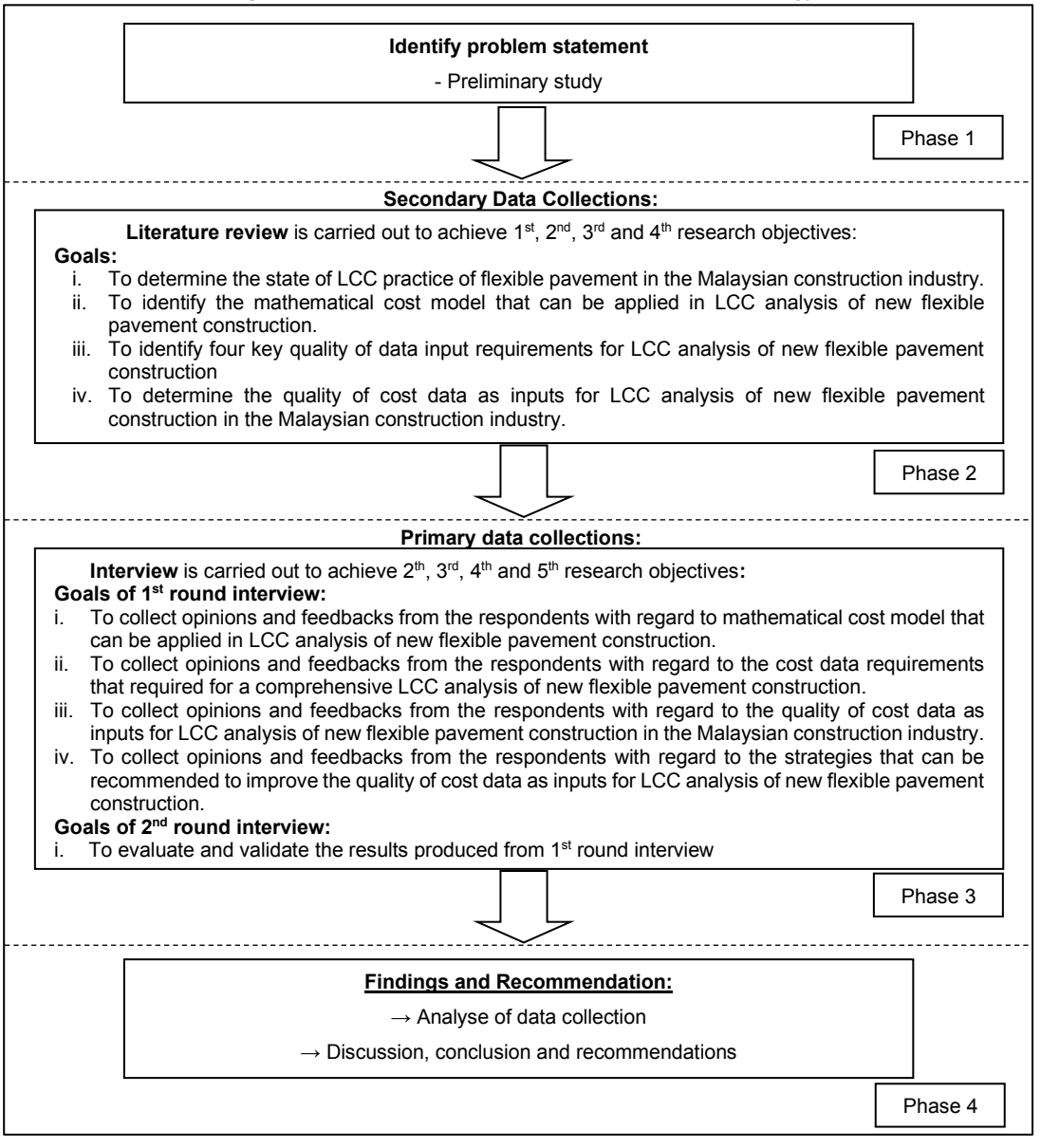

Table 5. Types of interview

Types of interview	Description
Structured interview	• It refers to an interview that is structured by the interviewer because the interviewer predefined and pre-planning all questions. • The researcher provides a set of questionnaires that comprises close-ended questions.
Semi-structured interview	• It refers to the sequence of the interview process can be changed. • The researcher provides a set of questionnaires that comprises open-ended questions and closed-ended questions.
Unstructured interview	• It refers to open and free discussions that provide little guidance to talk on the predefined topic or subject area. • It comprises open-ended questions.

(Sources: Stuckey, 2013; Woods, 2011; Gill et al., 2008)

In order to improve the reliability and validity of the outcomes of the semi-structured interview in the study, two-rounds of interview questionnaires are decided to be carried out with a group of respondents that have knowledge, skills or experiences in the field of LCC analysis of flexible pavement. A set of criteria is established to select suitable people to become interview respondents in the study. The respondents for the interview questionnaire will be selected based on the following criteria:

1. The respondents should have at least the degree holder in the construction industry
2. The respondents have knowledge, skills or experience in LCC analysis of flexible road pavement, e.g. facility manager, quantity surveyor, engineer, architect, value management manager and others.
3. The respondents are easily available and enthusiastic to commit in the interview session.
4. The respondents are able to understand the aim and objectives of the research.
5. The respondents should competent in making a judgement with regard to flexible pavement construction and maintenance.

First-round interview questionnaire

The main objective of carrying out the first-round interview questionnaire is to collect responses from the respondents with regard to LCC analysis of new flexible pavement construction. The questionnaire is designed to guide the implementation of semi-structured interview approach to attain views and opinions from selected respondents regarding the research areas with regard to the topic and to ensure the research objectives can be achieved. The questions are structured in open-ended and close-ended questions (McLeod, 2014; Fluidsurveys Team, 2013). Open-ended questions are the exploratory questions, whilst the close-ended questions require respondents to choose from a list of options. The first-round interview questionnaire consists of two sections which are Section A and Section B. The purpose of designing the Section A (profile information of the respondents) is to ensure only suitable people who have knowledge, skills, and experiences in LCC analysis of flexible pavement can be chosen to become respondents in the study. The potential respondents who are not fulfilling the criteria required will be advised to discontinue the subsequent questions and to recommend their colleague(s) who have knowledge, skills, and experiences in LCC analysis of flexible pavement construction that can assist the researcher in the study. Section B is designed to obtain a valuable opinion from the respondents regarding the quality of cost data that can be used as inputs for LCC analysis of new flexible pavement construction in terms of data availability, accessibility, currency, and reliability, and to identify strategies that are appropriate to improve the quality of cost data for the LCC analysis of new flexible pavement construction. In Section B, the respondents will be required to tick their answers in the appropriate boxes to indicate the state of cost data in terms of data availability, accessibility, currency, and reliability that can be used as inputs for producing the comprehensive and reliable LCC analysis of new flexible pavement in the Malaysian construction industry. If the respondents believe that the cost data is current, the respondents are required to specify the year of the latest edition of the cost data. This question also requires the respondents to specify data sources for each category cost component of LCC analysis of new flexible pavement construction.

The researcher will carry out the first-round questionnaire through face to face interview. By carrying out the face to face interview, it helps the researcher to provide adequate information and to provide additional explanation about the scope and the objectives of the research (Sincero, 2012). In order to ensure the questionnaire is answerable and easily understood, a pilot study will be carried out with a supervisor and academician that have knowledge in LCC field and postgraduate students (peers) to identify mistakes, inappropriate language, and wordings of the questions that can cause confusion to the readers or respondents. The researcher will then review and revise the questionnaire based on the comments given to improve the quality of the questionnaire. The responses obtained from the first-round interview will be transcribed, analysed and coded for producing second-round questionnaire.

Second-round interview questionnaire

In order to validate the results obtained from the first-round questionnaire, the second-round interview questionnaire will be carried out by evaluating the level of agreement reached among the respondents based on 5-point Likert scale by using standard deviation score. The second-round questionnaire will be distributed to respondents that have completed the first-round questionnaire.

The second-round questionnaire is designed in a form of 5-point Likert scale *(1. Strongly disagree 2. Disagree 3. Neither disagree nor agree 4. Agree and 5. Strongly agree)*. The respondents will be required to rate their degree of agreement on each item response. Moreover, the respondents will also be given opportunities to provide comments concerning the data inputs of LCC of new flexible pavement construction if they think the responses collected from the first-round questionnaire are incomplete. The item responses of each question that collected from the second-round questionnaire will be ranked in descending order according to the frequency of agreement based on the outcomes of the first-round interview questionnaire.

The researcher will carry out the second-round questionnaire through face to face interview to increase the response rate as well as to provide adequate information and further clarification on some subject matters. SMS and WhatsApp reminders are sent regularly to the respondents to ensure the respondents are able to complete the questionnaires before the timeline. The results obtained from the second-round questionnaire will be analysed using descriptive group statistical analysis techniques, i.e. mean and standard deviation in order to rank the most important items as perceived by the overall respondents in the set of questions and to determine the level of consensus achieved in the group of respondents (Grobbelear, 2007; Shah & Tillman, 2011 as cited by Mohd Fairullazi, 2014).

Reliability and validity of the semi-structured interview questionnaire

Reliability refers to consistency, stability, or dependability of the data where reliable measurement is carried out at the second-round interview to achieve consistency of the results with the previous round interview (Shuttleworth, 2017). In order to ensure the reliability of the results, the responses obtained from the first-round interview will be analysed by measuring the frequencies and percentages of each item response. Then, each of the item responses collected from the first-round interview will be coded and presented in the second-

round interview questionnaire. All item responses collected for each question in the second-round questionnaire will be ranked in descending order according to the frequency of agreement based on the outcomes of the first-round of interview questionnaire. The results obtained from the second-round interview questionnaire will be analysed by using the descriptive statistical analysis techniques, i.e. mean and standard deviation to measure the group mean score and to determine the level of consensus reached amongst the respondents in the study, where the lower values of standard deviation scores are indicated as the higher level of consensus achieved and vice versa (Park et al., 2006; Al-Mabrouk & Soar, 2009 as cited by Nur Syaimasyaza, 2017; Mohd Fairullazi, 2014). Validity refers as a measurement to test the truthfulness of the results (King, 2007; Mohd Fairullazi, 2014 as cited by Nur Syaimasyaza, 2017). The first and second-round interview questionnaires will be piloted with the research supervisor and academicians in order to improve the validity of the semi-structured questionnaires. This procedure allowed the researcher to identify mistakes in the questionnaire and to ensure that each question is answerable (Gordon, 1994; Sarantakos, 2005; King, 2007; Skulmoski & Hartman, 2007; Wentholt & Fewer, 2010; Naoum, 2013; Fong et al., 2013 as cited by Nur Syaimasyaza, 2017). Besides that, a list of criteria is designed to identify suitable respondents who have knowledge, skills, and experiences in LCC analysis of flexible pavement construction that can help to increase the validity of the data collected from the semi-structured interview approach in the study (Goodman, 1987 as cited by Hasson et al., 2000; Bulger, 2004, Nur Syaimasyaza, 2017).

However, the literature study has identified the following as the key limitations that can hinder the implementation of the semi-structured interview in primary data collection:

1. **Prone to possible bias**. The respondents give the answers that please the interviewer rather than what the respondents feel (Correa, 2014).
2. **Time-consuming to analyse data**. The researcher takes time to analyse data because the questionnaire consists of the open-ended and closed-ended question. The responses collected from open-ended questions have to be coded according to the categories (Correa, 2014; Hoyos & Barnes, 2012; Sincero, 2012).

The aforementioned limitations above show that the identification of appropriate mitigation strategies is required to be undertaken in the study to improve the reliability and validity of the semi-structured interview.

CONCLUSION AND RECOMMENDATION

This paper has presented the methodology proposed for the study to investigate the quality of cost data as inputs for the estimation of total cost of flexible pavement. The qualitative research has been proposed as the most appropriate research strategy for the study that comprises:

1. Literature review (theoretical approach and as secondary data collection)
2. Semi-structured interview (fieldwork approach)

The semi-structured interview has been identified as the most appropriate fieldwork approach to help the researchers to obtain data that are subjective in nature by procuring view, opinions, and ideas from people that have knowledge, skills or experiences in the field of

LCC analysis of flexible pavement. Two rounds of the semi-structured interview will be carried out to collect responses from the respondents with regard to LCC analysis of new flexible pavement construction, and to validate the outcomes obtained from the first responses collected. However, the study has identified several limitations that can hinder the implementation of the semi-structured interview in the study. Therefore, further research is encouraged as a second part of the study to identify appropriate strategies that can mitigate the aforementioned limitations of the proposed research methodology.

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ASSESSING COMPANY READINESS LEVEL TOWARDS THE IMPLEMENTATION OF BUILDING INFORMATION MODELLING (BIM) IN INDONESIA

Jati Utomo Dwi Hatmoko, Frida Kistiani and Riqi Radian Khasani
Faculty of Civil Engineering, Diponegoro University, Indonesia.

Abstract
While the use of Building Information Modelling (BIM) is becoming more widespread in developed countries, it is still relatively new in Indonesia. Many companies are still not aware of BIM and the benefits of it. The aim of this research is to assess the company readiness level towards BIM implementation in Indonesia. For this purpose, company readiness index (CRI) was developed to measure the company readiness, followed by a gap analysis. Four main elements of readiness include organizational process, management, people, and technology, which are further broken down into 11 categories of variables and 28 readiness criteria. Data was obtained through questionnaire surveys and interviews with 37 respondents from four companies consisting of contractors, engineering consultants, and EPCI (Engineering, Procurement, Construction and Installation), which have implemented BIM in their operation. The results show on average CRI value of 76.19%, meaning that basically they are ready for BIM implementation. Coordination between BIM and CAD, process redesign, implementation plan, new roles empowerment is among the highest readiness level, while perceived benefit, and risk management are among the least ready. These findings give valuable insights of readiness level of companies towards BIM implementation and areas for improvement in Indonesia.

Keywords: *Building Information Modelling (BIM); Company Readiness Index; Indonesia.*

INTRODUCTION

Building Information Modelling (BIM) as one of the latest technological development has increasingly been popular and widespread in many developed countries. International BIM Report 2016 reveals the use of BIM in the following countries, i.e. UK (48%), Canada (67%), Denmark (78%) and Japan (46%), which is expected to rise significantly along with the increasing awareness of BIM and its benefits. This report also discloses the high awareness of BIM in those countries, i.e. UK (95%), Canada (98%), Denmark (96%) and Japan (92%). In North America, 50% of companies engaged in the construction sector are already implementing BIM and 20% of companies that have not implemented, will implement BIM within a period of 2 years (Arayici et al., 2009).

BIM can be defined broadly as an information technology development which shorten the lifecycle of the building to provide security and a more productive environment for its users, reducing the environmental impact of the existing building and improve operational efficiency during the building lifecycle (Arayici and Aouad 2011; Liu et al., 2015; Ustinovičius et al., 2015). It can also be interpreted into physical and functional representation of buildings and facilities as a source of information to determine a decision during the lifecycle of the building. BIM can be seen as a system that integrates diverse information on a project, which is very useful for the Architect, Engineer, Construction (AEC) industry to design, implement and manage projects more efficiently and cost-effective. Its application covers all phases in the project life cycle, i.e. planning (preconstruction), design, construction and after-construction phase (operation and maintenance). BIM can be used for the following purposes, i.e. visualization, fabrication / shop drawing, code review, cost estimating,

construction sequencing, early detection of conflicts, interferences and collisions, forensic analysis, and facilities management (Azhar et al., 2011).

BIM method allows a virtual information model to be handed from the planning team at design stage to the main contractor and subcontractors, and then to the project owner who can later make a decision to construct an efficient building with respect to time, quality and cost (Bryde et al., 2013; Fazli et al., 2014).

To speed up BIM adoption, some countries mandate BIM adoption. The UK government has mandated BIM level 2 adoption of government funded projects since April 2016 (Ganah and John, 2013). Singapore, one of the countries which is very BIM visionary, also mandates BIM e-submissions for building projects greater than 5000 square meters (Building and Construction Authority 2016). It also launches a guidebook use of BIM for the construction industry to change the paradigm in the AEC industry (Zakaria et al., 2013). In Indonesia, the implementation of BIM in AEC industry is still known very little, with only little research has been started, e.g. (Chandra et al., 2017). Therefore, research on the company readiness level is paramount to explore more BIM implementation in Indonesia. The aim of this research is to assess the company readiness level towards BIM implementation in Indonesia.

ROLES, BENEFITS, CHALLENGES AND RISKS OF BIM

The role of BIM in the planning stage of the construction work is to build a virtual building before it is built physically (Smith and Tardif, 2009; Chandra et al., 2017). This is done to reproduce problems which are likely to occur and simulate and analyse their impact. The use of BIM is strongly influenced from the early models issued by the planning team so that the model can be easily communicated to other parties and can reduce design errors (Kiviniemi et al., 2008). BIM also reduces demand for information and design change, thus increasing productivity in preparing working drawings, specifications and monitoring tools and materials. The productivity improvement of a drawing with detailed structural reinforcement can reach 21% up to 59%, depending on the size, complexity and repetition of the structure (Kaner et al., 2008; Lee et al., 2012).

Exploration of BIM implementation in 35 construction projects has found the following benefits, i.e. cost reduction, time reduction, communication improvement, coordination improvement, quality increase, reduction of negative risks, better scope clarity, and organization improvement (bride et al., 2013). This is in line with a report from the Centre for Integrated Facilities Engineering (CIFE) that the BIM implementation in 32 projects shows elimination of the unbudgeted changes of up to 40%, increase accuracy, cost estimate within 3%, time reduction up to 80% to produce a cost estimate, 10% savings of the contract value by detecting clashes, and 7% reduction of project duration (Azhar et al., 2011). BIM also reduces the risk of employment, greater predictability, and reduce waste (Takim et al., 2013; Masood et. al, 2014; Irizarry et. al, 2013). Investigation on 10 projects in the US have found an average return on investment on BIM of 634%, which clearly shows a very high economic return (Azhar et al., 2011).

Besides the benefits, BIM implementation also poses risks related to technical, managerial, environmental, financial and legal aspects (Chien et al., 2014). They can be broken down into 13 risk factors, i.e. inadequate project experience, lack of software compatibility, model management difficulties, inefficient data interoperability, management

process change difficulties, inadequate top management commitment, workflow transition difficulties, lack of skilled personnel, increase in short-term workload, rise in short-term costs, additional expenditures, lack of BIM standards, and unclear legal liability. In addition, there are also other risks related to the lack of determination of BIM data ownership and copyright law (Azhar et al., 2011), licensed in the production (Thomson and Miner, 2006), and ownership contract documents (Miettinen and Paavola, 2014).

READINESS ASSESSMENT TOWARD BIM IMPLEMENTATION

Readiness assessment basically evaluating the current capability of an organization as compared to a certain level of target performance (Alshawi, 2007). Two elements in the assessment typically include evaluation criteria and the target of the system implementation. Typically, the main factors related to the implementation of IT system are people, process and technology (Kunz and Fischer, 2012; Smith and Tardif, 2009). In relation to BIM, Haron (2013) added the importance of management to these three factors as the main elements in the framework to measure readiness towards BIM implementation, i.e. process, management, people and technology. These four elements of management, process, people and technology of BIM implementation were also adopted in architectural practices (Hanafi et al., 2016), while Zahrizan et al. (2013) considered organizational culture, people, technology and recognition from the government. The theoretical framework of the company readiness toward BIM implementation is shown in Figure 1 and summarized in Table 1.

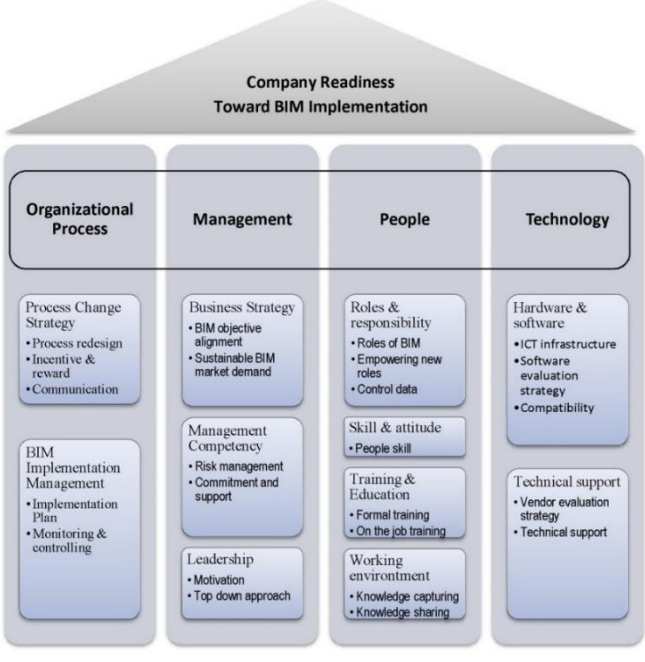

Figure 1. Theoretical Framework of Company Readiness toward BIM implementation (Adapted from Haron, 2013; Hanafi et al., 2016; Zahrizan et al., 2013; Paper, 2012)

The implementation of BIM changes the business process flow so that it requires process change strategies and management to support the BIM implementation (Smith and Tardif, 2009; Eastman et al., 2008; Kaner et al., 2008). In this case, the organizational process consists of process change strategy, implementation management and policy. Organizational readiness

becomes critical in determining the value of investments required to adopt BIM that can affect a company's business strategy. Management's ability to commit, support and motivate employees also can make sustainable BIM market demand after implementation BIM process (Smith and Tardif, 2009), therefore management aspects consist of business strategy, management competency, leadership.

The successful implementation of BIM requires people who concern and focus in BIM with new roles and responsibilities, a new skill and attitude set and training and education until they felt confident and comfortable (Mohd et al., 2017; Muhammad et al., 2017; Harris et al., 2014; Haron et al., 2015; Adi et al., 2016; Smith and Tardif, 2009; Eastman et al., 2008; Zahrizan et al., 2013; Merschbrock and Munkvold, 2015; Gu et al., 2008; Yusuf and Osman, 2008). The implementation of ICT in the construction industry is constrained against society and culture, some people in the organization feel anxious due to the application of new technology will take over their role (Heng Li et al., 2000; Davis and Songer, 2009). People element consists of roles and responsibility, skill and attitude, training and education, work environment.

The absence of strategic planning on the use of new technology can be a potential problem for many companies. Investing in technological advances requires the right strategy as there is a time lag between initial investment and income. The proper use of hardware and software in supporting the use of new technologies should be applied to companies and partners to support BIM implementation (Heng Li et al., 2000; Mui et al., 2003; Alshawi, 2007; Peppard et al., 2007). Technology element consists of choice of hardware and software and technical support.

In the construction industry there have been some examples of assessment of the readiness level using readiness index, e.g. Jaafar et al. (2007) used technology readiness index (TRI) to assess the readiness of construction firm managers in terms of technology in Malaysia, Ruikar et al. (2006) developed an e-readiness assessment prototype application for construction companies in terms of their management, people, processes and technology, etc. In this research a company readiness index is used to measure the company readiness level towards BIM implementation.

RESEARCH METHOD

A purposive sampling method has been adopted in this research. This method allows non-probability samples to be selected based on certain characteristics of a population to answer research questions. In this case, four Indonesian companies in EPCI and AEC industries which have implemented BIM in their operation were selected, consisting of a contractor, an engineering consultant, and two EPCI companies.

Data was obtained through questionnaire surveys and interviews with 37 respondents working for companies in EPCI and AEC industries, which consists of top management (32%) and middle level managers (68%), with nearly 60% having greater than 5 years working experience. The questionnaire basically asked the respondents against the importance level of the BIM readiness criteria and the readiness of companies in implementing BIM using a 1 to 5 Likert scale indicating a range from not ready to very ready.

Table 1. Readiness criteria and operational definition
(Adapted from (Haron, 2013; Hanafi et al., 2016; Zahrizan et al., 2013; Paper, 2012))

Elements	Category	Description	Criteria	Operational Definition
Organisational Process	Process change strategy	The methodology that the organization has developed to change its business processes	P01. Process redesign	The changing process of changing a set of activities by analyzing current business processes and identify changes required to incorporate BIM model-oriented processes
			P02. Incentives & reward	Incentives and rewards for motivating staff to change to the new process of BIM method.
			P03.Communication	Effective communication to explain the BIM at all levels and to all individuals within the company
	BIM Implementation Management	Combine BIM into business processes by establishing a good management system	P04.Implementation plan	Document plan to support the implementation of BIM by adapting guidelines and international standards.
			P05.Monitoring and controlling	Monitoring and controlling technique to ensure the successful implementation
			P06.Adequate resources	Adequate resources to facilitate and support the implementation of BIM, whether human resources or infrastructure
			P07. BIM & CAD coordination	BIM and Cad coordination to support effective business processes
			P08. BIM pilot project	Piloting some project to BIM implementation
			P09. Perceived benefit	Understanding the advantages of BIM from various references
Management	Business Strategy	BIM's implementation by identifying a profitable business strategy formula	M01.BIM objective alignment	The alignment of the objectives of BIM implementation in the further business
			M02.Sustainable BIM market demand	Create sustainable market demand after the implementation BIM process
	Management Competency	Use and implementation of BIM supported by management competence	M03. Risk management	Company skills to apply effective risk management system for BIM implementation
			M04.Commitment and support	Continuous commitment and support from management
	Leadership	Management leadership encourages the implementation of BIM	M05. Motivation	Management's ability to motivate individuals in implementing the process of BIM
			M06. Top down approach	A top down approach to encourage BIM implementation of the company
People	Roles & responsibility	Establishment of individual roles and responsibilities related to BIM implementation by the organization	S01. Roles of BIM	Roles and responsibilities of individuals as BIM administrator
			S02. Empowering new roles	Enterprise empowerment for all new roles as BIM executor
			S03. Control data	Control of data issued in each model as part of individual responsibility
	Skill & attitude	Skills and attitudes that individuals need to implement BIM	S04. People skill	Human resources with the appropriate skills that match the roles and responsibilities of the company
	Training & education	Training and educational programs needed to support the BIM implementation	S05. Formal training	Formal training to develop skill and knowledge of BIM processes and tools
			S06. On the job training	Continuing on the job training to enhance skills and confidence level
	Work environment	BIM implementation is supported by good work environment characteristics	S07. Knowledge capturing	Individuals who want to learn BIM and know how to learn it
			S08.Knowledge sharing	A work environment that supports learning and knowledge sharing on implementing BIM
Technology	Hardware & software	BIM implementation is supported by ICT hardware tools and infrastructure	T01. ICT infrastructure	ICT infrastructure (information and communication technology) to support the BIM implementation
			T02. Software evaluation strategy	A strategy to evaluate BIM software that combines business and company needs
			T03. Compatibility	BIM software compatibility with partners
	Technical support	BIM implementation is supported by software and hardware technical support	T04. Vendor evaluation strategy	The right way companies to evaluate the capabilities of the software vendors
			T05. Technical support	To support the company in BIM implementation

Company Readiness Index (CRI) is used to measure the company readiness level towards BIM implementation which consider all the readiness criteria for their importance and readiness. The mean important scores (MIS) were calculated using (Eq. 1), which later also were used to calculate the weighting factors (WF) by summing up the MIS, and express each one as a percentage of the total (Eq. 2). The mean readiness scores (MRS) were calculated using (Eq. 3), and were used to calculate the weighted scores (WS) by multiplying each mean readiness score (MRS) by its corresponding WF (Eq. 4). To calculate the CRI, the total weighted score (WS) was divided by 5 (the highest Likert scale), and multiplied by 100 (Eq. 5), resulting the CRI of 76.43%. The calculation process of the CRI is shown in table 3. The reliability coefficients (Cronbach's alphas) for importance and readiness factors of the returned questionnaires are all more acceptable (higher than 0.7). This indicates the consistency of the scale used in the study and suggests reliable data has been obtained. In addition, item-to-total correlation of each measure larger than 0.275 is considered to have criterion validity.

The Gap analysis method is used to evaluate the readiness level of each criteria by calculating the gap between the mean readiness score (MRS) and the mean importance score (MIS) of all readiness criteria. The ranks of the criteria are based on these gap values. The less gap values indicate the higher ranking of the readiness status. Table 2 shows the classification of readiness status for CRI and gap analysis.

(1) $MIS = \frac{\sum_{i=1}^{n} Yi}{n}$

(2) $WF = \frac{MIS}{\sum_{i=1}^{p} MIS} \times 100\%$

(3) $MRS = \frac{\sum_{i=1}^{n} Xi}{n}$

(4) $WS_i = WF_i \times MRS_i$

(5) $CRI = \frac{\sum_{i=1}^{n} WSI}{5} \times 100\%$

Table 2. Classification of readiness status

CRI value	Mean Gap Interval	Readiness Status
0% - 34,99%	0.650-0.757	Not ready
35% - 50,99%	0.542-0.649	Less Ready
51% - 65,9%	0.433-0.541	Quite ready
66% - 80,99%	0.325-0.432	Ready
81% - 100%	0.216-0.324	Very Ready

RESULT AND DISCUSSION

Figure 2 shows the CRI values for each company of 77.73%, 74.14%, 74.93%, 77.41%, respectively, and the average CRI value of 76,19%. All these CRI values fall into 'ready' category. It can be concluded that overall the companies have sufficient capabilities in all four elements of the organizational process, management, human resources and technology in their BIM implementation. Table 2 shows the status of readiness level for all 28 criteria which are calculated based on the gap between the mean values of importance and readiness. It can be seen that 4 criteria (14.3%) are 'very ready', 13 criteria (46.4%) are 'ready', 9 criteria (32.1%) are 'quite ready', 1 criteria (3.6%) are 'less ready', 1 criteria (3.6%) is 'not ready'. The top four rank criteria with 'very ready' status, include; BIM & CAD coordination (P07), process redesign (P01), implementation plan (P04), and empowering new roles (S02). While the bottom two criteria with 'less ready' and 'not ready' status include; perceived benefit (P09), and risk management (M03).

Table 3. Readiness Status and Rank of Criteria

Criteria	Cronbach's alphas		Item Total Correlation		Mean Importance	Weighted Factors	Mean Readiness	Weighted Score	Gap Score	Readiness Status	Rank
	Importance	Readiness	Importance	Readiness	(MIS)	(WF)	(MRS)	(WS)	MIS-MRS		
P01	0.76	0.77	0.40	0.33	3.86	3.26	3.54	11.53	0.32	very ready	2
P02	0.75	0.77	0.34	0.37	3.92	3.30	3.57	11.78	0.35	ready	5
P03	0.73	0.75	0.38	0.52	4.68	3.94	4.24	16.72	0.43	ready	16
P04	0.74	0.76	0.40	0.50	4.19	3.53	3.86	13.65	0.32	very ready	3
P05	0.73	0.77	0.37	0.35	4.49	3.78	4.08	15.43	0.41	ready	14
P06	0.74	0.76	0.43	0.33	4.86	4.10	4.49	18.41	0.37	ready	7
P07	0.73	0.76	0.39	0.36	4.00	3.37	3.78	12.76	0.22	very ready	1
P08	0.75	0.76	0.36	0.41	4.35	3.67	3.89	14.27	0.46	quite ready	19
P09	0.72	0.75	0.54	0.40	4.05	3.42	3.46	11.82	0.59	less ready	27
M01	0.73	0.77	0.48	0.36	3.89	3.28	3.49	11.44	0.41	ready	13
M02	0.72	0.76	0.53	0.44	4.14	3.49	3.62	12.62	0.51	quite ready	25
M03	0.74	0.76	0.46	0.33	4.32	3.64	3.57	13.00	0.76	not ready	28
M04	0.73	0.74	0.50	0.53	4.35	3.67	3.89	14.27	0.46	quite ready	20
M05	0.74	0.75	0.33	0.38	4.22	3.55	3.68	13.06	0.54	quite ready	26
M06	0.73	0.74	0.42	0.53	4.08	3.44	3.57	12.27	0.51	quite ready	24
S01	0.74	0.76	0.38	0.34	4.22	3.55	3.81	13.54	0.41	ready	10
S02	0.73	0.74	0.40	0.51	3.73	3.14	3.41	10.70	0.32	very ready	4
S03	0.74	0.77	0.41	0.36	4.57	3.85	4.14	15.92	0.43	ready	17
S04	0.76	0.76	0.39	0.38	4.32	3.64	3.97	14.48	0.35	ready	6
S05	0.74	0.75	0.38	0.42	4.38	3.69	4.00	14.76	0.38	ready	8
S06	0.72	0.74	0.52	0.59	4.35	3.67	3.86	14.17	0.49	quite ready	23
S07	0.74	0.75	0.41	0.38	3.92	3.30	3.51	11.60	0.41	ready	11
S08	0.74	0.76	0.41	0.38	4.24	3.58	3.84	13.73	0.41	ready	12
T01	0.75	0.76	0.40	0.37	4.49	3.78	4.08	15.43	0.41	ready	15
T02	0.73	0.74	0.32	0.58	4.32	3.64	3.86	14.09	0.46	quite ready	21
T03	0.74	0.77	0.39	0.41	4.43	3.74	3.95	14.74	0.49	quite ready	22
T04	0.73	0.75	0.43	0.41	3.97	3.35	3.51	11.77	0.46	quite ready	18
T05	0.73	0.76	0.38	0.33	4.30	3.62	3.92	14.19	0.38	ready	9
					$\overline{MIS}$= 4,24	∑WF= 100	$\overline{MRS}$= 3,81	CRI = ∑WS/5 = 76,43%			

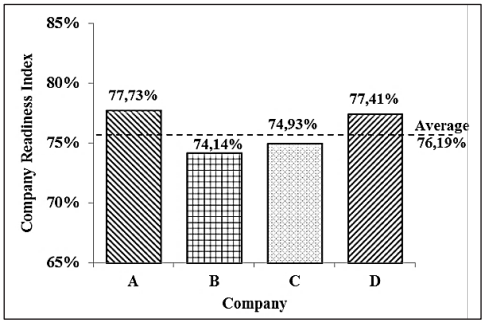

Figure 2. Company Readiness Index

Figure 3 shows the spider-web diagram for the four elements, from which comparison of the importance and readiness of each criteria can be examined. It can be seen the discrepancies between the values of readiness and importance, suggesting the improvement areas for each criteria. Figure 4 shows propositions and values of each element of the four companies. It can be seen that in general the values of the four elements ranging from 69.33% to 79.34%. The organizational process has the highest readiness level for companies A and D, while technology has highest the readiness level for companies' B and C. On the other hand, the management aspect has the lowest readiness level for company A, B, and C. To understand further the context, condition and challenges of BIM implementation of each company, Table 4 highlights the comparison between these 4 companies on 4 elements; process, management, people technology. It will be described briefly below.

Company A is a company engaged in the field of engineering consultants with some focus as on the design techniques on offshore oil and gas facilities in the process, design engineering in onshore oil and gas and terminal facilities, EPCI (Engineering, Procurement, Construction and Installation) project, engineering design, geothermal power plant, engineering design of buildings and civic buildings. It employs 300 people and has implemented BIM in the operation for about 10 years. This BIM implementation was originally started due to client's request as part of the tender requirement. The results show that organizational process element has the highest readiness level, while management has the lowest readiness level. Trainings were held regularly for the relevant staffs and considered as dummy projects. From technology elements, the hardware and software are updated regularly so it can always fulfill tender requirements and increase efficiency in the operation. Challenges for BIM implementation include communication, where during the BIM implementation, an effective communication is extremely required to work on a typical complex plan that consists of a wide range of multi-disciplinary of the process, electrical, piping, instruments, mechanical and structural require good communication to avoid design errors and waste of materials.

Company B is a company engaged in the oil and gas based EPCI which has a specialization in onshore, offshore and fabrication, and working with mostly international clients. It employs approximately 1000 employees and has implemented BIM for 10 years. It sees control, monitoring and coordination between BIM and CAD are one of the most important criteria within the organizational process element. In support of the business, the top management is committed to apply a comprehensive management strategy to manage risks and challenges associated with the BIM implementation process, as well as the provision of facilities and training for human resources. Regular update of BIM software has been done to facilitate the compatibility operation with partners and clients and to increase efficiency and effectiveness of the process.

Company C is a company engaged in steel fabrication, and most fabricates the oil and gas sector, is also a world-class EPCI company in Indonesia. It employs 1000 employees and has implemented BIM for 12 years. As this company deals with the fabrication process, which require high accuracy to produce precise dimensions, monitoring and control, and effective communication have been seen as one of the most important criteria, to avoid misunderstandings on the design, increase efficiency and create a sustainable market. The training and education are done regularly, including upgrading the BIM software and hardware following client demand as part of business strategy.

Company D is one of the State-Owned Enterprises (SOEs) which is engaged in the planning and construction of buildings (real estate). SOE's main business field is the implementation of building construction and civil, are also working on other related business fields, such as building management, property development and realty. Employing approximately 1700 employees, it has only recently implemented BIM for 3 years. To support the implementation, the top management is committed and has established a new department with roles and responsibilities focusing on BIM, including appointing new positions as BIM manager, BIM coordinator and BIM engineer. It also held regular training to improve the knowledge and skills of staffs. As the BIM implementation is relatively new, as well as its implementation of its construction projects, the technology element is the least ready among the other three elements.

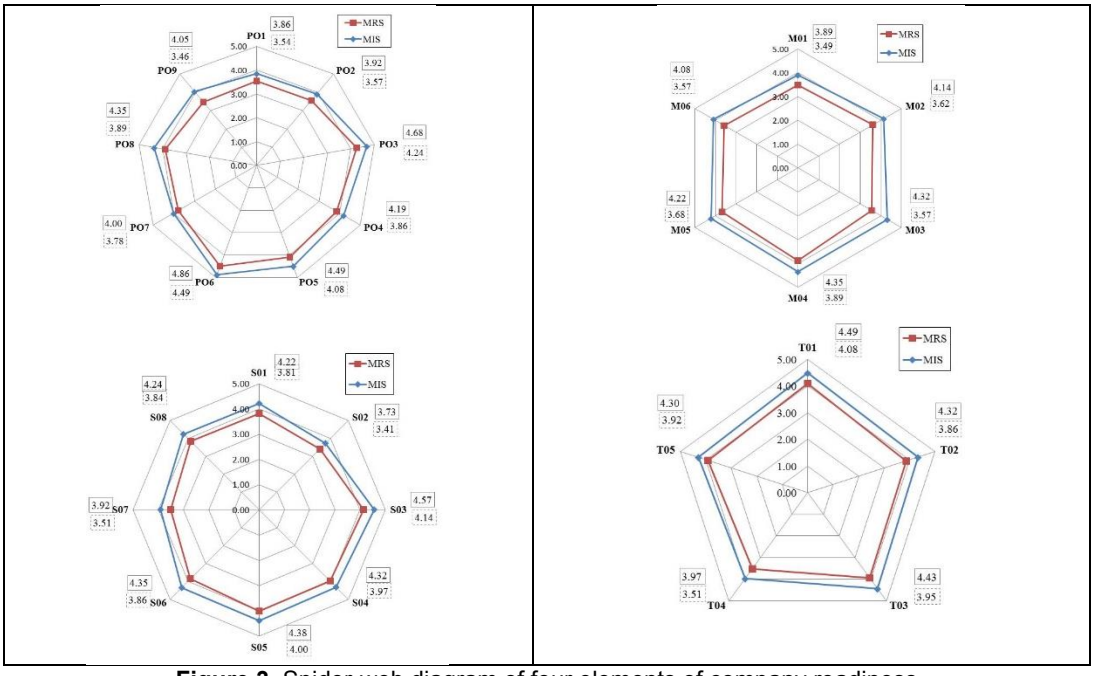

Figure 3. Spider-web diagram of four elements of company readiness

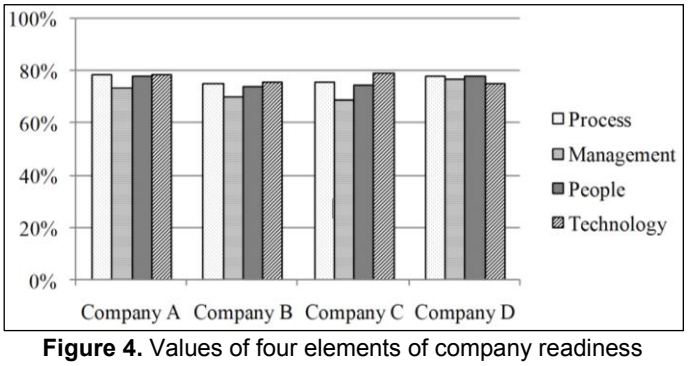

Figure 4. Values of four elements of company readiness

This research complements the findings of Chandra et al., (2017) which investigate the benefits and challenges on BIM implementation as perceived by practitioners in Indonesia AEC industry, as well as in other countries, e.g. (Chandra et al., 2017; Ghaffarianhoseini et al., 2017; Vass and Gustavsson, 2017). The findings of this research are also in line with and reinforce the findings of Jung and Lee (2015) which stated that in Asia, 43.9% and 22% of company respondents are considered early majority and early adopter of BIM, while the top three in terms of BIM usage in Asia are; design authoring (73%), 3D coordination (70.3%), and existing condition modelling (67.6%).

This research has contributed to enhancing the existing knowledge on BIM implementation in Indonesia. The context, condition and challenges of BIM implementation of four companies which have been described, can give insight and comprehensive understanding of company readiness level towards BIM implementation. These findings are beneficial for related industry, as well as policy makers in making decision on future direction of roadmap and strategy for BIM implementation in Indonesia.

Table 4. Comparison of readiness toward BIM implementation of four companies

Attributes	Company A	Company B	Company C	Company D
Company Status	**Private**	**Private**	**Private**	**State Owned Enterprise (SOE)**
Type of Industry	Offshore oil and gas, EPCI project, engineering design, geothermal power plant, engineering design of buildings and civil buildings.	Oil and gas based EPCI	Steel fabrication, and most fabricate the oil and gas sector, is also a world-class EPCI.	Construction of buildings (real estate) / AEC.
No of employees	300	1000	1000	1700
Duration of BIM implementation	10 years	10 years	12 years	3 years
Summary of elements				
• Organisational Process	The use of CAD is still required for fast track projects combined with BIM software, incentives are given to employees when they reach the target, communication is required for design planning involving multi-disciplinary background of knowledge.	Continuous control and monitoring and coordination between BIM and CAD are paramount; coordination between BIM and CAD needs to be strengthened, as the BIM design process is longer so they should use CAD as working drawings.	The use of BIM cuts the fabrication processes, resulting in fast and efficient production, precise dimensions, and waste reduction.	The collaboration of CAD and BIM software as a transition process from 2D to 3D. The incentive is given to employees who are able to improve their competencies. The company has a BIM roadmap.
• Management	The implementation of BIM was originally implemented as a result of the factors of the client, to participate in the tender.	The use of BIM to meet the requirements of tender qualification is in line with the company's business objectives.	The application of BIM in the fabrication process strongly supports business.	Top management is fully committed, aware and show good leadership in BIM implementation. BIM as business strategy to meet market demand and to compete with international companies.
• People	There are new roles and responsibilities, the BIM admin responsible for integrating accounting data in detail.	Not all HR knows BIM. Regular training is held to improve the skills. The management team did not add new employees, but only added job description according to project needs.	The training and education of the HR done regularly to fill new roles and responsibilities.	Regular training is held to enhance the establishment of skills and interactions in implementing BIM method. New roles and responsibilities are established accordingly.
• Technology	Regular upgrade on the hardware and software, particularly for tender. Vendors of the BIM software participate in providing training to employees.	Regular upgrade on the hardware and software to ensure compatibility with client requirements.	Regular update of licenses of software and machine for fabrication.	Upgrade hardware to support BIM software based on the project owner's request and the type of project.
CRI / Readiness status	77.74% / ready	74.14% / ready	74.93% / ready	77.41% / ready
• Highest readiness level	Organizational process	Technology	Technology	Organizational process
• Lowest readiness level	Management	Management	Management	Technology
Challenges of BIM implementation	Inter-organizational communication	Regular control and supervision to ensure the conformance of the actual work with BIM model.	Update technology for fabrication machine and BIM software integration	BIM support from company partners, e.g. subcontractor, supplier, etc.

CONCLUSION AND RECOMMENDATION

This research has developed readiness criteria and assessed readiness level of four companies which have implemented BIM in their operation. The four elements of readiness consist of organizational process, management, human resources and technology, of which further broken down into 11 categories of variables and 28 readiness criteria. The results show an average of the Company Readiness Index (CRI) of 76.19%, with CRI values for each company of 77,73%, 74,14%, 74,93%, 77,41%, respectively.

The readiness level for all 28 criteria which are calculated based on the gap between the mean values of importance and readiness, as follows; 4 criteria (14.3%) are 'very ready', 13 criteria (46.4%) are 'ready', 9 criteria (32.1%) are 'quite ready', 1 criteria (3.6%) is 'less ready', 1 criteria (3.6%) is 'not ready'. The top four rank criteria with 'very ready' status, include; BIM & CAD coordination, process redesign, implementation plan, and empowering new roles; while the bottom two criteria with 'less ready' and 'not ready' status include; perceived benefit, and risk management.

This research has a limitation on the number of companies being observed, nevertheless this research gives a significant contribution to understanding the readiness level toward BIM implementation in Indonesia, which otherwise may not be available. Further research can be done by observing a greater number of companies from both industries, including examining the roles of government to encourage BIM implementation policy for public project to increase the efficiency and value for money from taxpayer.

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GUIDE TO AUTHORS

Aims and Scope:

The Malaysian Construction Research Journal (MCRJ) is the journal dedicated to the documentation of R&D achievements and technological development relevant to the construction industry within Malaysia and elsewhere in the world. It is a collation of research papers and other academic publications produced by researchers, practitioners, industrialists, academicians, and all those involved in the construction industry. The papers cover a wide spectrum encompassing building technology, materials science, information technology, environment, quality, economics and many relevant disciplines that can contribute to the enhancement of knowledge in the construction field. The MCRJ aspire to become the premier communication media amongst knowledge professionals in the construction industry and shall hopefully, breach the knowledge gap currently prevalent between and amongst the knowledge producers and the construction practitioners.

Articles submitted will be reviewed and accepted on the understanding that they have not been published elsewhere. The authors have to fill the Declaration of the Authors form and return the form via fax to the secretariat. The length of articles should be between 3,500 and 8,000 words or approximately 8 – 15 printed pages (final version). The manuscripts should be written in English. The original manuscript should be typed one sided, single-spacing, single column with font of 11 point (Times New Roman). Paper size should be of Executive (18.42 cm x 26.67 cm) with 2 cm margins on the left, right and bottom and 3 cm for the top. Authors can submit the manuscript:

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CODIFICATION AND APPLICATION OF SEMI-LOOF ELEMENTS FOR COMPLEX STRUCTURES

Ahmad Abd Rahman[1,2], Maria Diyana Musa[2] and Sumiana Yusoff[2]
[1]Department of Quantity Surveying, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Sarawak, Malaysia
[2] Institute of Ocean and Earth Sciences (IOES), University of Malaya, Malaysia

Abstract (Arial Bold, 9pt. Left and right indent 0.64 cm.)
Damage assessment …… ……(it should be single paragraph of about 100 – 250 words.)

Keywords: *Finite element analysis; Modal analysis; Mode shape; Natural frequency; Plate structure*

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Heading 2 (Arial Bold + Lower Case, 11pt)

Heading 3 (Arial Italic + Lower Case, 11pt)

Body Text: Times New Roman, 11 pt. All paragraph must be differentiated by 0.64 cm tab.

Units: All units and abbreviations of dimensions should conform to SI standards.

Figures: Figures should be in box with line width 0.5pt. All illustrations and photographs must be numbered consecutively as it appears in the text and accompanied with appropriate captions below them.

Figures caption: Arial Bold + Arial, 9pt. should be written below the figures.

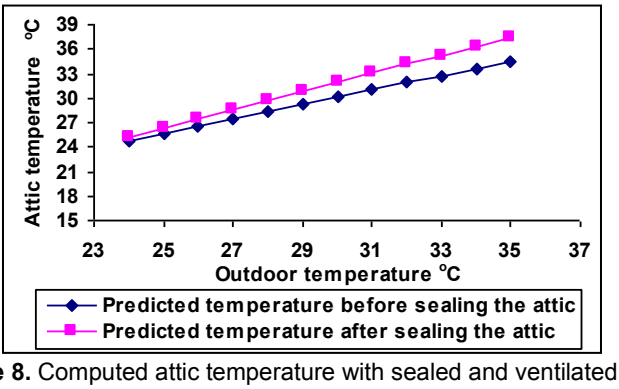

Figure 8. Computed attic temperature with sealed and ventilated attic

Tables: Arial, 8pt. Table should be incorporated in the text.

Table caption: Arial Bold + Arial, 9pt. Caption should be written above the table.

Table Line: 0.5pt.

Table 1. Recommended/Acceptable Physical water quality criteria

Parameter	Raw Water Quality	Drinking Water Quality
Total coliform (MPN/100ml)	500	0
Turbidity (NTU)	1000	5
Color (Hazen)	300	15
pH	5.5-9.0	6.5-9.0

(Source: Twort et al., 1985; MWA,1994)

Reference: Times New Roman, 11pt. Left indent 0.64 cm, first line left indent – 0.64 cm. **Reference should be cited in the text as follows:** "Berdahl and Bretz (1997) found…" or "(Bower et al., 1998)". References should be listed in alphabetical order, on separate sheets from the text. In the list of References, the titles of periodicals should be given in full, while for books should state the title, place of publication, name of publisher, and indication of edition.

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