APPLICATION OF THE BUBBLE DECK SLAB TECHNOLOGY IN MALAYSIA

Dyg. Siti Quraisyah Abg. Adenan[1], Magcellia Berni[2], Kartini Kamaruddin[3] and Hamidah Mohd Saman[4]

[1,2]*Department of Civil Engineering and Construction, Faculty of Engineering, Science and Technology (FEST), Infrastructure University Kuala Lumpur (IUKL), 43000 Kajang, Selangor, MALAYSIA.*

[1,3,4]*Faculty of Civil Engineering, University Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, MALAYSIA.*

[1]*dyg_quraisyah@gmail.com,* [2]*maber6994@gmail.com,* [3]*kartini@uitm.edu.my,* [4]hamid929@salam.uitm.edu.my

ABSTRACT

The bubble deck slab is one of the successful attempts in biaxial technology where the amount of concrete in the slab is reduced due to the presence of grids made of recycled plastic hallow 'bubble' void formers. Generally, this newly invented slab is lightweight but still able to maintain similar load carrying capacity like the reinforced concrete slab. In Malaysia, most contractors prefer to use the conventional reinforced concrete slab compared to the bubble deck slab. This is because most contractors are not familiar with this new technology. The objectives of this research are to have a broader understanding of this technology applicability and the barriers of implementation in Malaysia. In addition, this study is able to determine the level of interest of the Malaysian construction personnel to apply this technology. This research was conducted in Selangor, Putrajaya and Kuala Lumpur only. The data collections intruments used to achieve the objectives of this research are a set of questionnaire and an interview protocol. A few barriers of implementation were identified and the majority of the respondents were interested to adopt this technology.

Keywords:

bubble deck slab technology, reinforced concrete slab, biaxial technology, plastic hallow

INTRODUCTION

The conventional concrete slab or reinforcement concrete slab is the most common concrete slab used in the construction industry. However, this conventional method is raising controversy regarding its negative impacts towards the environment and its inefficiency in some of the building structures. Not all reinforcement concrete slab in the structure has to perform carrying effect, which means the concrete usage in that building structure is a waste. The manufacturing process and transporting of cement are contributing to carbon dioxide emission, which is a bad impact toward the environment. Hence, many engineers and technologist attempt to create effective biaxial slab with hallow cavities for decades now.

The bubble deck slab is one of the successful attempts in biaxial technology where the amount of concrete in the slab is reduced due to the presence of grid of recycled plastic hallow 'bubble' void formers. Generally, this newly invented slab is lightweight but still able to maintain similar load carrying capacity like reinforced concrete slab. The first bubble deck slab technology was introduced in 1990s by German professor, Jorgen Bruening. The first structure that used this technology is Millennium Tower in Holland. Recycled plastic balls are locked side by side between layers of reinforcing welded steel wire and an internal lattice girder eliminates concrete that has no contribution to the structural performance of the slab. This new system also reduces the usage of formwork. The overall slabs are delivered partly pre-cast with a bottom layer of 70mm concrete providing permanent formwork into which is bedded the bottom layer of mesh reinforcement. Light reinforcement girders hold top mesh in place and trap into the sandwich the plastic ball void formers (Harding, 2004).

In Malaysia, most contractors prefer to use conventional reinforced concrete slab than bubble deck slab. This is because most contractors are not familiar with this new technology. According to

the Bubble Deck Construction Sdn Bhd (2017), this technology was introduced in Malaysia since 2011, however only 8 projects in Malaysia are using this technology for the past 6 years, such as WP Hotel, Maju-LinQ in Bandar Tasik Selatan, Rasa Factory in Ulu Selangor, Kawan Food Factory in Klang, The new PAM centre in Bangsar, Bunglow Car Porch in Bukit Jalil and one Bungalow in Bukit Gambir, Penang. Mostly the projects are located in Selangor and one in Penang.

In addition, this conventional construction method has been raising controversy relating to the manufacturing and transporting its materials. It also can be considered as wasting of materials such as usage of concrete in building structures that do not have any structural functions. All of these problems can be solved by using bubble deck slab technology as it helps to eliminate concrete usage in structures that do not have any structural functions and substitute it with recycled plastic balls. Thus, decreasing the dead weight of the structures which make it more desirable in seismic active regions. In order to solve this controversy, contractors and labour must be aware of its benefits and have a high level of understanding to conduct this technology to gain familiarity in the Malaysian construction industry. Furthermore, the application of this technology in Malaysia is one of the innovation technologies that can be implemented for the construction industry. This research gives the researchers a better understanding of the bubble deck slab system and how it can be an applicable system in Malaysia.

The bubble deck slab systems pledge a high level of experience through the industry from contractors, engineers, and architects. Efficacious and prosperity implementation of bubble deck slab technology in the Malaysia construction industry will present diverse advantages and interests compared to the conventional method. As 1 kg of plastic is capable of replacing 100 kg of concrete, the company can reduce significant carbon emissions which is used in manufacturing and transporting concrete. Further, the recycled plastic hollow balls used for the bubble deck slab is reusable and recyclable which shows its sustainability potential (Ali & Kumar, M. 2017). Finally, this research is part of an on-going study which will enhance the practicing and implementation of the bubble deck slab technology in Malaysia.

The aim of this research is to achieve these objectives:

1. To examine the applicability of the bubble deck slab technology in Malaysia.
2. To identify the barriers of implementing bubble deck slab technology in Malaysia.
3. To determine the interest of construction personnel towards application of the bubble deck slab technology in Malaysia.

LITERATURE REVIEW

Background Study

In 1848, the first reinforced concrete was introduced by Jean-Louis Lambot. Lambot used iron in 1995, German professor, Mr. Jorgen Bruening introduced bubble deck slab system in the construction industry. The bubble deck slab technology is a system where the concrete usage in the area that has no structural effect is substituted with 100% recycled plastic balls. This system comprises bubble void formers, concrete and two form of steel which are reinforcement mesh for lateral support and diagonal girders for vertical support of the bubbles. The bubble voids are positioned in between top and bottom reinforcement mesh and joined together with vertical lattice girders. The reinforcement mesh and diagonal girders lock and distribute the plastic balls in exact positions. The bubble deck slab system is based on the patented integration technique - the direct way of linking air and steel (Shetkar & Hanche, 2015; Tiwari & Zafar, 2016).

The main disadvantage of concrete construction is the construction of the horizontal slab where a section of the concrete has no structural function, adds unnecessary self-weight to the

concrete structure which contributes to significant stress applied to the structure, and limits the span of the concrete. It also contributes to material wastage and energy consumption (Teja, 2016).

The bubble deck slab comprises of 3 main materials, which are concrete, steel reinforcement and the most important material, plastic balls. The main material in the bubble deck slab is the hollow sphere that is made from recycled high density polyethylene (HDPE). This material does not react chemically with concrete and reinforcement steel, has no porosity and has enough rigidity and strength to carry the maximum load, for example, the load from pouring concrete. The plastic balls can be recycled and reused to ensure its sustainability in the construction industry. This system uses the common type of cement, which is standard Portland cement, where no plasticizer is needed in this technology and the minimum grade is M30. The aggregate used should not be more than 20mm. For the precast layer, common concrete or self-compacting concrete can be used (Ali & Kumar, 2017).

The steel reinforcement in this system needs two types of reinforcement steel. First is reinforcement mesh layers for lateral supports and diagonal girders for vertical support for the bubbles. Only steel reinforcement with grade Fe60 strength or higher is used in this system. The function of this reinforcement is to lock the plastic balls into its positions. Technically the plastic balls are 'sandwiched' between bottom and top reinforcement mesh layers. These reinforcement meshes are then welded with diagonal short length bars (Joseph, 2016).

There are 3 versions or types of bubble deck slab reinforcement modules, filigree elements and finished plank. Reinforcement Modules of bubble deck slab consists of a pre-fabricated bubble deck slab where the plastic balls are well-positioned between reinforcement steels, as shown in Figure 1. These components are then transported to the site, placed on traditional formwork linked with additional reinforcement before pouring concrete mix using conventional method. The advantage of this type is that, it is suitable for small construction areas as the components can be stacked in the sites before installing these components. Filigree Elements is a combination of pre-cast and in-situ constructions, where 60mm thick of bottom concrete layer is pre-casted and transported on to the site with the plastic balls and reinforcement steels unattached. Then these elements are casted on site, as shown in Figure 2. For casting the plastic balls on the top of the concrete layer, temporary stands are used to hold the plastic balls. This type might need additional steel depending on the design of the building. This type is suitable for new constructions, where the designer has the freedom to position the plastic balls and the reinforcement steels. This type is the best to apply for slab that has opening, such as opening for stairs. Finished plank is where the whole material is pre-fabricated to its finish form by the manufacturer. Then the final product is transported to the site, as shown in Figure 3. However, this type has disadvantages compared to other types because it requires support beams or load bearing wall. This type of bubble deck slab is suitable for short spans and fast construction (Mahalakshmi et al., 2017).

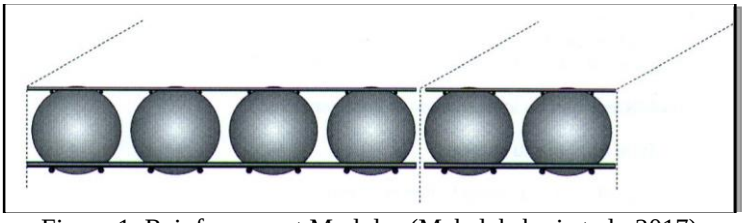

Figure 1: Reinforcement Modules (Mahalakshmi et al., 2017)

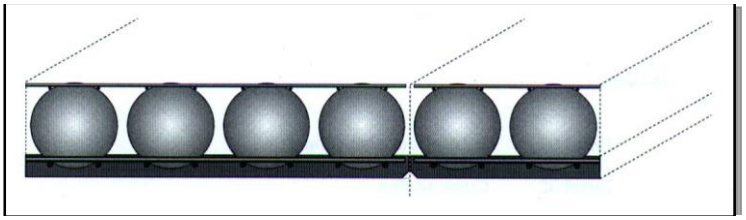

Figure 2: Filigree Elements (Mahalakshmi et al., 2017)

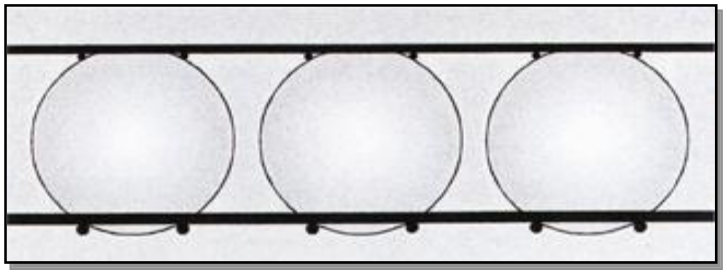

Figure 3: Finished plank (Mahalakshmi et al., 2017)

Advantages of the Bubble Deck Slab

Based on several studies and researches, there are many advantages for the construction industry to gain from bubble deck slab technology which are:

i. Superior Static

The bubble deck slab technology can be considered as a standard concrete flab slab due to its properties of lightweight. This technology can help to construct longer spans of slab, which have fewer columns, no beams or ribs under the ceiling is needed, and pillars have no capital.

ii. Production and Carrying Out

The slab has higher quality because of the automated and well-controlled production, the components produced are easy to erect, and requires less space for storage.

iii. Economical Approach

This technology saves up to 50% of materials; not just materials form the bubble deck slab itself, it also saves materials in constructing extra columns, beams, pillars and etc. In addition, decrease in weight and materials mean lower transportation costs, where it is easier to lift the components and does not require heavy lifting machineries.

iv. Eco-friendly Approach

The bubble deck slab is a suitable solution in construction when it comes to green approach. According to bubble deck UK, approximately 50% of concrete usage in construction is reduced. For every 5000m² of bubble deck slabs, the following can be saved: 1000m³ of site concrete, 166 trips of lorry to transport concrete ready mix, 1,798 tonnes of foundation load or less 19 piles, 1,745 GJ energy used in concrete production and haulage, and it can also save 278 tonnes of carbon dioxide emissions. In addition, the plastic balls can be recycled and reused to ensure the sustainability of the building. Accordingly, 1 kg of recycled plastic balls can replace 100kg of concrete (Shetkar & Hanche, 2015; Tiwari & Zafar, 2016; Ali & Kumar, 2017).

METHODOLOGY

Introduction

Application of the bubble deck slab in Malaysia is selected as the topic of this study because it is the best solution for problems related to the use of concrete in the construction industry, such as wastage of concrete in conventional reinforced concrete slabs. This research presents the advantages of using bubble deck slab in Malaysia and to create a broader understanding about this innovative technology through collecting information that can provide an investigative perspective to a research problem. All primary quantitative data in this research were collected through a questionnaire and qualitative data through interviews. The qualitative data from interviews of respondents give an in-depth understanding of their opinions and experiences and quantitative data from the questionnaire give information based on facts and numbers. The qualitative and quantitative data enabled the researchers to investigate and achieve the research objectives. This research paper is divided into 5 main sections including introduction, literature review, methodology, data collection, and conclusion and recommendation.

Instrument

Two approaches were used to obtain data in this research. The researchers used questionnaire and interview to achieve the objectives. For objective number 1, the researchers conducted in-depth interviews with the four respondents. The questionnaire was divided into 4 sections: section A was general questions about respondent's background, Section B the respondents were equired to answer questions related to objective 2 using a Likert scale, and for section C the respondents were required to answer questions related to objective 3 using Yes/No responses. While in section D, respondents gave their recommendations and suggestions relating to the application of bubble deck slab technology in Malaysia. Figure 4 shows the chart of instruments used in this research.

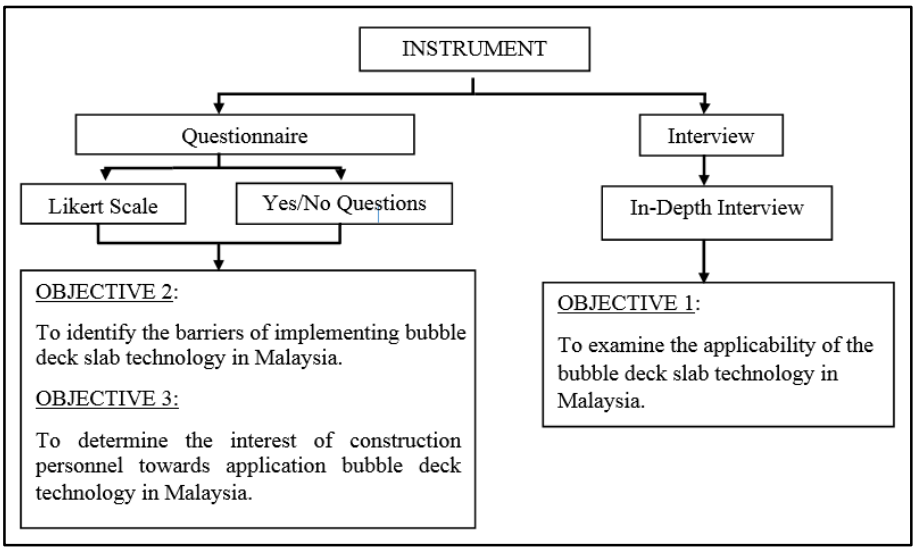

Figure 4: Instruments used in this research

Research Respondents and Sampling Method

The researchers conducted in-depth interviews with four personnel from Bubble Deck Construction Sdn Bhd to achieve the first objective. 100 sets of a questionnaire were distributed among contractors, engineers, project manager, architects, quantity surveyors and site supervisor in order to obtain second and third objectives. The questionnaire was distributed to respondents by using 2 ways, first a hardcopy was given directly to the selected respondents and second via google form where the link of the google form was sent to selected respondents. The link was sent via email, phone number and other social media; whichever was convenient for the respondents. Table 1 shows the list respondents for each methodology used.

Table 1: List of respondents for each methodology used

Method	Respondents	Objectives
In-depth Interview	Bubbledeck Construction Sdn Bhd	1. To examine the applicability of the bubble deck slab technology in Malaysia.
Questionnaire (close-ended)	Construction Personnel i. Contractors ii. Engineers iii. Project Manager iv. Quantity Surveyor v. Architects vi. Site Supervisor	2. To identify the barriers in implementing bubble deck slab technology in Malaysia 3. To determine the interest of construction personnel towards application of bubble deck technology in Malaysia

Data Analysis

Qualitative data obtained from the interview sessions with the four personnel from Bubble Deck Construction Sdn Bhd was analysed using manual comparative analysisto achieve objective number 1. While dta from the questionnaire was analysed using Microsoft Excel to achieve objectives number 2 and 3.

RESULTS AND DISCUSSION

Data collected from the questionnaire and interview sessions are analysed and discussed here. The interview sessions with the four personnel from Bubble Deck Construction Sdn, Bhd. were conducted in order to achieve objective 1 of this research. The questionnaire was developed and distributed to construction companies in Putrajaya, Kuala Lumpur and Selangor (Petaling Jaya, Subang Jaya, Bukit Jalil, Serdang) in order to achieve objectives 2 and 3. Table 2 shows the number of respondents for both data collection methods:

Table 2: Number of respondents

Description	Number
Number of questionnaires were distributed	100
Number of answered questionnaires were collected	75
Number of interview sessions were conducted	4

Interview Data Collection and Result

The selection of respondents are based on respondent's understanding and expertise in bubble deck slab technology. The interview sessions were conducted with four respondents from Bubbledeck Construction Sdn. Bhd. All four respondents' personal data such as their email addresses and phone numbers are kept strictly confidential in order to prevent any disputes or consequences that could emerge in the future. Table 3 shows the background of the respondents while Table 4 shows the responses gained from the interview sessions in order to examine the applicability of the bubble deck slab technology in Malaysia, which is the first objective of this research.

Table 3: Respondent's background

Company Name and Address	Respondent	Name	Position
Bubbledeck Construction Sdn. Bhd No. 59, Jalan Kampung Pandan, 55100 Kuala Lumpur	A	Abg. Abadullah Abg. Josmani	Senior Design Engineer
	B	Fatin Mumairah	Engineer
	C	Norazlina	Chief Quantity Surveyor
	D	Mohamand Safuan Shahbudin	Site Supervisor

Table 4: Responses gained from the interview sessions to examine the applicability of the bubble deck slab technology in Malaysia

Section	Question	Answer
Section 1: The quality of bubble deck slab compared to conventional slab	1. What is the difference between the bubble deck slab and the conventional slab?	The use of HDPE plastic balls to substitute the concrete in area of slab that does not carry any structural effect.
	2. Is the bubble deck slab as strong as the conventional slab?	Yes, the bubble deck slab has same strength as conventional slab.
	3. What are the physical properties of the bubble deck slab?	Bubble deck slab carries same physical properties as conventional slab, in term of weight, it is lighter than conventional slab, it is also fire proof, tested and certified by SIRIM. Lastly, it is can have seismic design upon request.
	4. Can it be used for landed house?	Yes, bubble deck slab system can be used for all type of building.
Section 2: The cost of the bubble deck slab technology compared to the conventional slab	1. How much is the cost of the bubble deck slab compared to the conventional slab	The cost of bubble deck is a bit higher than conventional slab. However, it can be fix in the future.
	2. How much is the cost of the bubble deck slab transportation and how is the bubble deck slab transported?	The cost of transportation can be vary; it is depending on the project location and number of client demand. It is transported by trailer.

Section 3: The comparison between the bubble deck slab technology and the conventional slab in terms of construction time	1. How long does it take to deliver the bubble deck slab to the project site?	It can be up to 8 weeks upon date of receipt of letter of award and down payment.
	2. Does the bubble deck slab construction work faster than the conventional slab?	Yes, bubble deck slab is faster than conventional slab because it is pre-fabricated, which help the construction work cut down the duration of concrete curing. It is also reduce the amount of beams and column for the building.
	3. What is the floor cycle for an area of 800m² of bubble deck slab system?	The floor cycle for 800m² can take up to 6 days, with project team of 6 members.
	4. How many days can the scaffolding allow to be dismantled for the bubble deck slab system?	Depending on the concrete condition, but mostly once the concrete achieved its characteristic design strength the scaffolding can be dismantle.

Questionnaire Data Collection and Result

Based on Table 5 all barriers are identified by the respondents. The highest ranked barrier is lack of awareness and knowledge among the construction community with a mean score of 4.23, 88% of the respondents are agree that this barrier is the highest barrier among all barriers, while 8% of the respondents show that it doesn't affect much the implementation of bubble deck slab technology. Whereas, 4% of respondents do not agree that this barrier will affect the implementation of the bubble deck slab technology. The lowest rank is easy accessible guidance on the bubble deck slab technology with a mean score of 3.87, which means it does not affect much the implementation of the bubble deck slab technology. Second to eighth ranked are the following: lack of marketing, low level of demand, lack of government support, lack of labour knowledge and skills, initial cost, and low awareness of benefits of the bubble deck slab technology.

Table 5: Barriers in implementing the bubble deck slab technology in Malaysia

No	Barriers	Frequency						Mean	Scale	Ranking
		1	2	3	4	5	Total			
1	Does initial cost of the bubble deck slab technology affect implementation of this technology?	0	5	9	36	25	75	4.08	Agree	6
2	Does lack of labour knowledge and skills influence the implementation of the bubble deck slab technology?	0	0	17	32	26	75	4.12	Agree	5
3	Does awareness and knowledge among the	0	3	6	37	29	75	4.23	Agree	1

	construction community play an important role in implementing the bubble deck slab technology?									
4	Will awareness of benefits of the bubble deck slab technology give significant influence in implementing this technology?	0	3	15	33	24	75	4.04	Agree	7
5	Does the government provide support in implementing the bubble deck slab technology?	0	1	15	33	26	75	4.12	Agree	4
6	Does lack of marketing of the bubble deck slab Technology affect the implementation of this technology?	0	0	12	34	29	75	4.23	Agree	2
7	Is motivation and aspiration value on the bubble deck slab technology important for this technology?	0	2	17	35	21	75	4.00	Agree	8
8	Does easy accessible guidance on the bubble deck slab technology have significant influence on the success of this technology?	0	1	26	30	18	75	3.87	Agree	9
9	Does level of demand for the bubble deck slab technology and cultural change resistance have significant influence in the bubble deck slab technology implementation?	0	1	19	25	30	75	4.12	Agree	3

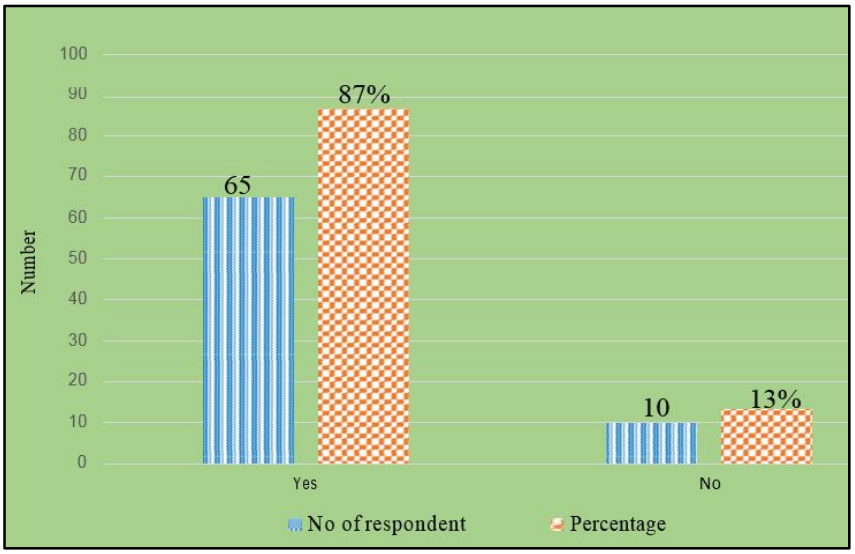

Figure 5: The frequency and percentage of interest level of the construction personnel's interest towards application bubble deck slab technology in Malaysia

Figure 5 shows that 87% of the respondents are interested to use the bubble deck slab technology on their next project, which is equivalent to 65 respondents out of 75 respondents. While 13% of the respondents are not interested to use this technology which is equivalent to 10 of the respondents.

CONCLUSION

The applicability of the the bubble deck slab technology in Malaysia was examined by conducting interview sessions. Other than that, the barriers in implementing the bubble deck slab technology in Malaysia and the interest of construction personnel's towards the application of this technology was identified and determined by distributing questionnaires. Based on the objectives of this research study, it can be concluded that the bubble deck slab technology is applicable to all types of buildings. Moreover, it also has the same physical properties as the conventional slab and in terms of weight, the bubble deck is lighter compared to the conventional slab. Many barriers of the bubble deck implementation in Malaysia were identified. The highest ranked barrier is lack of awareness and knowledge among construction community while the lowest ranked is lack of easy accessible guidance on the bubble deck slab technology. 87% of the respondents are interested to apply bubble deck slab for their next project. The areas covered in this study are Selangor, Kuala Lumpur and Putrajaya, and the researchers conclude that the majority of the construction personnel in this area are interested to apply this technology.

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