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The Assessment on the Acceptance of Waste Materials as a Partial Cement Replacement in Malaysian Construction Industry

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The Assessment on the Acceptance of Waste Materials as a Partial Cement Replacement in Malaysian Construction Industry

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Abstract. The numbers of Malaysia construction industry had been increasing in several years with the large construction building and infrastructures projects had been constructed. Therefore, these developments led to an increase of cement production. The production of cement causes a wider environmental implication such as air pollution, water pollution and soil pollution which are very dangerous for human health. This is due to the manufacturing of cement that release dust, toxic and carbon dioxide emissions, which is a significant contributor of greenhouse gases. To overcome this problem, several researches had been conducted for the past few decades to develop a new material to replace cement. Most of the materials selected are from waste materials that has similar chemical properties and mechanical properties. From the research, most of the results show a positive performance in concrete and suitable to be use as a cement replacement. Unfortunately, the research stops at the research stage where it is rarely seen that these waste materials had been used in construction, especially in Malaysia. Most of the developers did not corporate these waste materials as a cement replacement in their construction work due to unclear reasons. Therefore, this study had been conducted to investigate the factors of un-implementation of waste materials in construction industry especially in Malaysian construction. This can be achieved by intensive literature review on properties and performance of waste materials in concrete. An interview session with an expertise also had been conducted to design a questionnaire that later had been distributed to 140 respondents from construction site background especially registered contractor Class G1-G7 all around Peninsular Malaysia. The data had been analyzed and the factor contribute to un-implemented of waste materials in construction had been identified. From the data analysis, factors that contributes to the un-implemented are due to lack of awareness and knowledge about waste materials as a cement replacement. Thus, to overcome this problem, respondents suggest that the workshop need to be conducted to spread the awareness and give a knowledge regarding waste materials as a cement replacement.

1. Introduction

The Malaysian construction industry has approached a critical limit which is in several years, large construction building and infrastructures development projects had led to increasing in cement production. The production of cement itself will cause wider environmental implication [1]. This is due to the manufacturing of cement that cause major source of dust, toxic and carbon dioxide emissions, which is a significant contributor of greenhouse gases. An article from The Star [2] reported that on August 9 2014, Lafarge's cement production capacity was about 12.95 million tonnes, followed by YTL Cement at 5.95 million tonnes, CIMA at 3.4 million tonnes, Tasek Corp at 2.3 million tonnes and both Hume Cement and Holcim Malaysia at 2 million tonnes each year. From this data, the production of cement is huge as well as the impact of pollution to the environment. Generally, in cement production, carbon dioxide is emitted in a rotary kiln during the production of clinker which a cement component, calcium carbonate (CaCO3) was heated at high temperatures (1450°C to 1600°C) in order to induce a series of complex chemical reactions. Carbon dioxide is produced as a by-product during calcination process that occurs at temperature of 600°C to 900°C at the upper cooler end of the kiln or pre-calciner. This will have resulted in the conversion of carbonates into oxides [3]. The carbon dioxide will release to the atmosphere as the process goes on. With the huge production of cement stated, the emissions of carbon dioxide also will increase.

Thus, the problem related from cement production can be overcome by replacing cement with waste materials such as fly ash, coal bottom ash, rice husk ash (RHA), palm oil fuel ash (POFA) and eggshell in construction. Malaysia has been estimated to generate about 5.5 million tonnes of waste material in 2001 and only 5% of waste material were recycled. The remaining 95% is disposed of in overpopulated landfills in Malaysia [4]. By referring to a normal growth in population, the amount and type of waste materials had been increased accordingly. All non-decaying waste materials will remain in the environment for hundreds or perhaps thousands of years, which mean the non-decaying waste materials will cause a waste disposal crisis, thereby contributing to the environmental problems [5]. In order to reduce the amount of waste materials several studies on waste material as a cement replacement in construction industry had been carried out in the last few decades as there is a great potential of using it in construction industry [6]. According to Rindl [7], waste material had been widely used as a cement replacement in developed countries such as the United States, United Kingdom and other European countries.

As suggested by several researchers, waste materials could be used successfully in the construction industry and could meet the design specifications and requirements if and only if the materials are properly processed. Waste material such are fly ash, coal bottom ash, rice husk ash (RHA), palm oil fuel ash (POFA) and eggshell will act as pozzolans and could be used as supplement of cement in concrete production. There are several advantages of using these waste materials as cement replacement in concrete production such are durability of concrete can be improved as well as the porosity of concrete can be reduced, lower cement content required, the interface between aggregate can be improved, save energy and provide good improvement in concrete production [8]. Moreover, by additional of fly ash in as a cement replacement, the strength of concrete can be increased [9]. The presence of rice husk ash (RHA) and palm oil fuel ash (POFA) itself can help to improve the compressive strength of concrete and resistance against sulfate attack [10]. According to B. Chatveera [11], the contributions of waste materials in concrete production not only can decrease the amount of cement but also can improve the performance of concrete by improving its properties such are strength and durability.

Despite of several advantages of using waste materials as a cement replacement, there are still a problem of unimplemented of waste materials as a partial cement replacement. This study presents a result from an interview session with expertise and a questionnaire survey from construction site background respondent especially registered contractor Class G1-G7, consultant, supplier and local authority. A comprehensive review of data from previous researchers including the usage and advantages of using waste materials as a cement replacement are presented accordingly. This study also focuses on industrial waste sector and composite waste sectors including Fly Ash, Coal Bottom

Ash (CBA) and Rice Husk Ash (RHA), Palm Oil Fuel Ash (POFA) and Egg shell. The main objective of this study is to investigate the acceptance of waste materials as a partial cement replacement in Malaysian construction industry.

2. Literature review

The properties of waste materials

2.1. Fly ash

Fly ash can be categorized as one of the residues from a burning chamber from the coal in electrical power plant and contains the fine particles that rise with the flue gases. About 30% to 40% of fly ash can be produced from a tonne of pulverized coal, [12]. Fly ash is a spherical fine glass
powder with a particles size estimated in a range from 0.5 to 100μm and it is ordinarily finer than cement [13]. Hence, the spherical shape of fly ash will improve the workability since it is called as 'ball bearing impact' [14]. The first break-out in the use of fly ash in concrete was the construction of Hungry Horse Dam in 1948 with the using of 120,000 metric tonnes of fly ash [13]. The usage of fly ash has increased in the last 20 years, but less than 20% of fly ash collected was used in the cement and concrete industries [15]. This is due to its differences in the coal source which affect the chemical and physical properties of fly ash. It is vary depending on thermal plant collected [12]. According to Adam [16], "the price of fly ash concrete is equal to or less than the price of mixes with only Portland cement". Even so, nowadays, the production and properties of fly ash from each thermal plant similar with each other. Therefore, many research was conducted using fly ash as a partial or fully cement replacement.

Fly ash can be classified into two types which are fly ash class F and fly ash class C. The classification of fly ash based on the chemical composition. The main difference between fly ash Class F and C is the amount of calcium (Ca) content where fly ash Class F has less than 10% of calcium (Ca) content, while calcium (Ca) content in fly ash Class C is higher than 10% [17]. Table 1 shows chemical properties of fly ash Class F and C investigated by previous researcher. From the table, the amount of silica content in fly ash Class F is higher and similar with one in cement. Therefore, it is suitable to be a cement replacement in construction.

Table 1. Chemical properties of fly ash Class F and fly ash Class C.
Source. Comparison Study of Class F and Class C Fly Ashes as Cement Replacement Material on Strength Development of Non-Cement Mortar [18].

Chemical properties of fly ash Class F and C									
Materials	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	TiO_2	Mn_2O_3	SO_3
Fly ash Class F	65.43	23.14	1.46	2.09	0.00	1.04	1.35	0.07	0.69
Fly ash Class C	4.75	17.89	59.11	12.65	0.00	0.65	0.92	0.55	0.86

2.2. Coal bottom ash (CBA)

Coal bottom ash is also a residue from coal power plant. It is coarse material which drops into the bottom of the furnace in latest large combustion of coal thermal power plants. Basically, coal is black in color and made of decomposed plants and consists of large carbon [19]. In Malaysia, coal can be found at three geographical provinces which in Sarawak, Sabah and Peninsular Malaysia [20]. According to Hamzah [21], there are four established electrical power stations in Malaysia which composed of 80.1% of fly ash and 19.9% of coal bottom ash which is at Tanjung Bin, Johor (2,100MW), Jimah, Negeri Sembilan (1,400MW), Sultan Salahuddin Abdul Aziz/Kapar, Selangor (2,420 MW) and Sultan Azlan Shah/Mahjung, Perak (2100MW). The annual production of coal bottom ash in United State is 14 million tons, Europe 4 million tons, India about 25 million tons and Malaysia are around 1.7 million tons [22]. Table 2 shows the chemical composition of coal bottom ash studied by previous researches. It is approximately 70% of silicon oxide, aluminum oxide and iron oxide in coal bottom ash. According with ASTM C618, the percentage of loss of ignition required to max is 10% [23]. The main composed of coal bottom ash are silica, ferric oxide and alumina, with minor quantities of calcium oxide, sodium oxide, magnesium oxide and sulfur oxide. It has been endorsed by Jaturapitakkul and Cheerarot [24], that the coal bottom ash holds a well pozzolanic properties which could enhance the strength and durability performances of concrete.

Table 2: Chemical and physical properties of Coal Bottom Ash (CBA)
Source: Potential Use of Coal Bottom Ash as a Supplementary Cementing Material in Sustainable Concrete Construction [25].

Chemical properties of Coal Bottom Ash (CBA)								
Constitutes (Weight,%)	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	SO_3	LOI
[24]	48.12	23.47	10.55	11.65	3.45	0.07	1.76	4.02
[26]	42.7	23.0	17.0	9.8	1.54	0.29	1.22	-
[22]	45.3	18.1	19.48	8.7	0.969	-	0.352	-

2.3. Rice husk ash (RHA)
Rice husk ash is an agriculture waste material that produce in millions of tons per year by burning of rice husk either through open field burning or under incineration conditions in which temperature and duration are controlled [27]. This is because, the particle size and surface area of rice husk ash are depending on the controlled temperature and burning environment which is a highly reactive rice husk ash is obtained [28]. Rice husk contains 75-90% of organic matter such are cellulose, lignin and other mineral components such are silica, alkali and trace element [29]. Rice husk is unusually high in ash compared to other biomass fuels in the range of 10-20%. The ash contains 87-97% of silica which is highly porous and light weight, with a very high external surface area [30]. The presence of high amount of silica makes it a valuable material for use in industrial application [31]. About 20kg of rice husk ash produce from 100kg of rice husk and it is estimated around 20% of rice husk become rice husk ash [32]. Rice husk ash is the outer shell of rice grain [33]. According to Zhang [34], rice husk ash could be a suitable partly replacement for Portland cement because it contains non-crystalline silica. Table 3 shows the chemical and physical properties of rice husk ash based on the previous research which is rice husk ash contains approximately 85-90% of amorphous silica and it showed an environmentally friendly behaviour with cement as a supplementary cementing material in concrete [35], [36], [37], and [38].

Table 3: Chemical and physical properties of Rice Husk Ash (RHA).
Source: Study on Concrete with Rice Husk Ash [39].

Chemical properties of Rice Husk Ash (RHA)								
Constituent	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	LOI
[35]	88.32	0.46	0.67	0.67	0.44	-	2.91	5.81
[36]	86.49	0.01	0.91	0.50	0.13	0.05	2.70	8.83
[37]	92.95	0.31	0.26	0.53	0.55	0.08	2.06	1.97
[38]	87.32	0.22	0.28	0.48	0.28	1.02	3.14	2.1

2.4. Palm oil fuel ash (POFA)

The most studied waste material as cement replacement is Palm Oil Fuel Ash (POFA). POFA is one of the waste materials that generated from palm industry and due to its properties, it can be used as a cement replacement [40]. The expansion in the plantation of palm oil tress in Malaysia, Malaysia had been named as one of the main contributors in the palm oil industry and the production continues with the increase of time [41]. According to Malaysian Palm Oil Board (MPOB) (2015), Malaysia is the second largest of palm oil producer in the world after Indonesia. The plantation of palm oil has increase with the increasing demand of palm oil products which is from 400 ha in 1920 to more than 4.5 million ha in 2008 [42]. However, during the production of palm oil, large quantities of waste materials are generated such are palm oil shell, palm oil clinker and empty fruits bunch. These wastes are used as the key source of energy at the palm oil mill and the by-product which constitutes about 5% of the total weight of the waste is called POFA [43]. Table 4 shows chemical and physical composition of POFA by previous research. It is reported that the chemical composition of silica makes the highest proportion in all cases which plays an important role for a good pozzolanic property [41]. The particle size of ground POFA is smaller than the particle size of ordinary Portland cement, while the particle size of ordinary Portland cement is smaller than the particle size of unground POFA [44].

Table 4: Chemical and physical properties of Palm Oil Fuel Ash (POFA).
Source: Properties of fresh and hardened sustainable concrete due to the use of palm oil fuel ash as cement replacement [41].

Chemical properties of Palm Oil Fuel Ash (POFA)									
Constituent	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	LOI
[45]	67.09	6.12	5.92	5.58	3.06	0.11	5.45	-	2.20
[46]	60.42	4.26	3.34	11.00	5.31	0.18	5.03	0.45	2.55
[47]	67.72	3.71	4.71	5.57	4.04	0.16	7.67	1.07	6.20

2.5. Egg shell

Another waste material used for cement replacement is eggshell. Generally, the shell of egg is referred to as the eggshell, is one of the waste materials and around 2.8 million of eggs are consumed daily in Malaysia [48]. According to the Department of Veterinary Services (DVS) Malaysia, in 2016, the consumption of eggs is around 11906 million and it is being estimated the consumption of eggs will be increase to 12235 million in 2017 (DVS, 2018). The waste generated from egg are eggshell. Eggshells are composed of three layers which are, the outer eggshell, the outer shell membrane and the inner shell membrane [49]. The outer eggshell consists of calcium carbonate (CaCO3), which is covered with tiny pores [50]. Eggshell also consists of a thin outermost coating called the cuticle, which is the thickest component of eggshell and keratin is composed of the outer and inner shell membrane [49]. Shells of egg is roughly about 11% of the total weight of the egg [51]. Table 5 shows the chemical composition of eggshell by previous researchers. In addition, as reported by [52], eggshells contain high amount of calcium carbonate which is very similar to cement. Calcium carbonate in eggshell will act as a filler and fill pores in concrete as a result the porosity of concrete will decreased, and the strength will increase [53].

Table 5: Chemical Composition of Egg Shell.
Source: Green and Sustainable Concrete – The Potential Utilization of Rice Husk Ash and Egg Shells [54].

Chemical properties of Egg Shell									
Constituent	CaO	SiO_2	Al_2O_3	MgO	Na_2O	SO_3	P_2O_5	K_2O	Fe_2O_3
[55]	63.8	21.4	5.1	0.36	0.14	3.38	-	1.88	2.6
[56]	60.1	21.8	6.6	2.1	0.4	2.2	-	0.4	4.1
[57]	64.34	19.9	4.3	2.04	0.31	2.88	0.13	1.05	4.24

3. Methodology

The extensive literature review had been conducted to gather all the properties of waste materials. From here, waste materials that had been widely studied had been selected to present in this paper. Besides, a face-to-face interview with expert parties and questionnaire survey also conducted to seek an opinion as well as consultations on research area. For extensive literature review, all the general information such are types of waste materials available, properties of waste materials and the advantages are gathered to achieve the objectives of this study. The literature review has been gathered from several resources such are books, journals, articles and electronic resources like e- journal, websites, news and other online materials. The main focus of the literature review is to allow a general understanding of waste materials as a cement replacement in construction industry. Meanwhile, face-to-face interview session was conducted in structured form and all the questions are presented in the same order to all interviewees. Face-to-face interview is one of the best collecting data method because from this method, both interviewee and interviewers can express their viewpoints, in private, without a framework imposed by the researcher. In this study, interview sessions are carried on with ten (10) respondents from private and government sector especially with the registered contractor from class G1 – G7, contractor, Jabatan Kerja Raya (JKR), consultant and supplier who has related in construction industry. The last method in this study is questionnaire design. For this study, one hundred and forty (140) sets of the questionnaire was distributed to all respondents from both private and government sector who has related in construction industry all around Peninsular Malaysia. The questionnaire survey was distributed to determine the factors and causes that contributed to the stated problem and the most important thing is to identify general knowledge and understanding of the related parties regarding waste materials as a partial cement replacement in construction industry. In this questionnaire survey, five ordered response level were used. The format of five (5) level Likert scale used was of ascending order which are: (1) Strongly Agree, (2) Agree, (3) Neutral, (4) Disagree, (5) Strongly Disagree and this questionnaire survey consists of four (4) sections which are: (1) Section A; Respondent personal background, (2) Section B; Type of waste materials and its properties, (3) Section C; Benefits and impacts from the usage or production of waste materials as a partial cement replacement, (4) Section D; Factors of unimplemented of waste materials as a partial cement replacement and its solution and recommendation in overcome the problem. Figure 1 shows a flowchart of research methodology for this study.

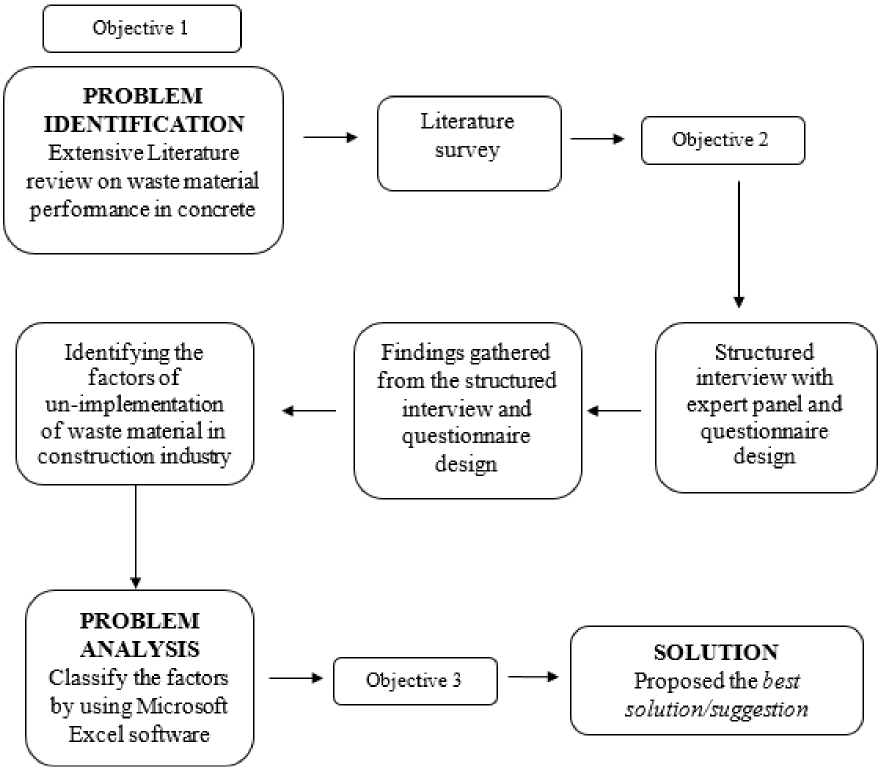

Figure 1. Research methodology method.

4. Results and discussion

The face-to-face interview session was conducted with ten (10) respondents which is an expert party and one hundred and forty (140) sets of questionnaire survey was distributed to all respondents from both private and government sector who has related in construction industry all around Peninsular Malaysia. Figure 2 shows the percentage of each types of company surveyed. The results show that 88.4% and 11.6% respondent are from private sector and government sector, respectively. From all the respondent, only 20.5% respondent are familiar in using waste materials as a partial cement replacement and the remaining 79.5% respondent are unfamiliar in using waste material in concrete production. Apart from that, only 16.1% company that received inquiries in using waste materials as a material for partial cement replacement and 83.9% respondent never experienced in using waste materials as a material in cement replacement. Figure 3 shows the percentage of company that familiar in using waste materials as a partial cement replacement and Figure 4 shows the percentage of company that received inquiries in using waste materials in cement for construction industry.

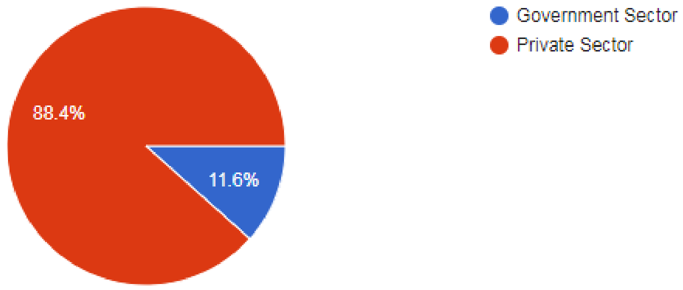

Figure 2. The percentage of each type of company surveyed.

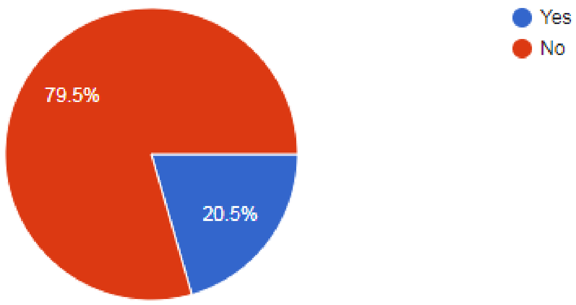

Figure 3. The percentage of company that familiar in using waste materials as a partial cement replacement.

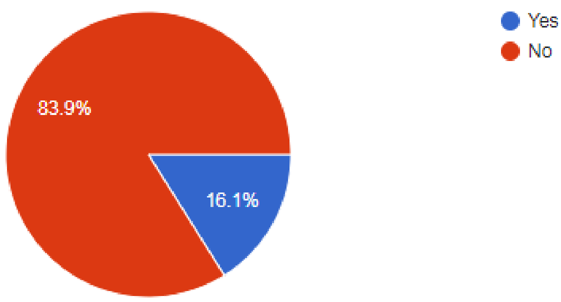

Figure 4. The percentage of company that received inquiries in using waste materials in cement for construction industry.

From the interview session and questionnaire design, 51.8% respondent have heard that fly ash can be used as a partial cement replacement, followed by 45.6% respondent have heard that egg shell can be one of the material for partial cement replacement, 37.5% respondent have heard that POFA can be used as a partial cement replacement, 31.2% respondent have heard that CBA can be one of the material for partial cement replacement and only 30.4% respondent have heard that RHA can be used as a partial cement replacement. It can be concluded that Fly Ash is the most commonly known waste materials compared to other waste materials. Thus, more research and data regarding other waste materials as a partial cement replacement should be done. Figure 5 shows percentage of the most common waste materials that respondents have heard.

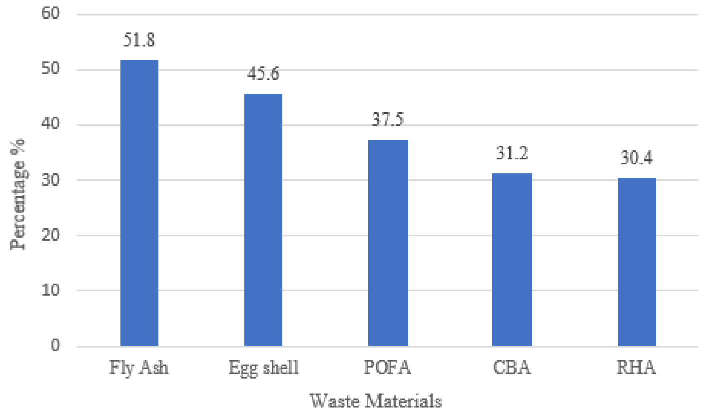

Figure 5. Percentage of the most common waste materials that respondents have heard.

Although the respondent is not familiar in using waste materials as a partial cement replacement, the respondents are still aware with the benefits and impacts from its usage in the production of concrete. Figure 6 shows the percentage of the respondent that aware with the implementation of waste materials in cement can reserve natural resources. From the chart, 32.1% and 44.6% respondent are strongly agreed and agreed that waste materials can help to reserve natural resources and 3.6% respondent that disagreed and strongly disagreed, and the remaining 16.1% respondent are neutral with the statement. Besides that, 25.9% and 40.2% respondent are strongly agreed and agreed that the consumption of non-renewable materials will influence on global warming and climate change and only 4.5% and 1.8% respondent that disagreed and strongly disagreed and the remaining 27.7% respondent are neutral with the statement. Figure 7 shows the percentage of respondent that aware with the consumption of non-renewable materials will influence on global warming and climate change. Other than that, 26.8% and 35.7% respondent are strongly agreed and agreed that the use of waste material can help with the landfill problem and only 5.4% and 2.7% respondent are disagreed and strongly disagreed, and the remaining 29.5% respondent are neutral with the statement. Figure 8 shows the percentage of respondent that aware with the use of waste material can help with the landfill problem.

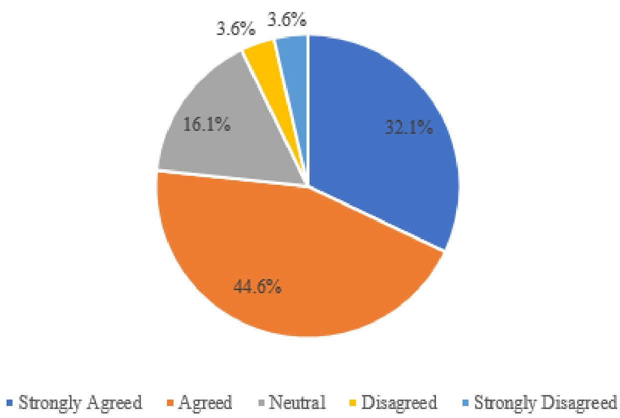

Figure 6. Percentage of the respondent that aware with the implementation of waste materials in cement can reserve natural resources.

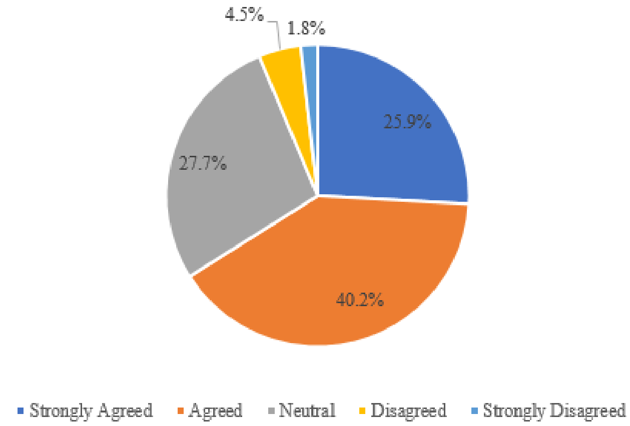

Figure 7. Percentage of respondent that aware with the consumption of non-renewable materials will influence on global warming and climate change.

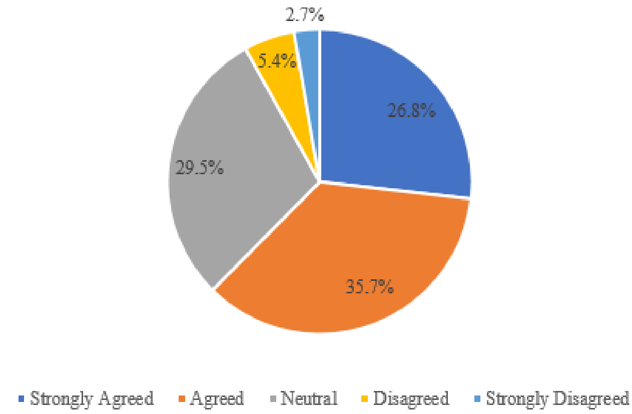

Figure 8. Percentage of respondent that aware with the use of waste material can help with the landfill problem.

However, regarding the strength performance of concrete using waste materials as a partial cement replacement, most of the respondents are neutral or uncertain about it. Figure 9 shows the percentage of respondent regarding concrete from waste materials can improve workability of concrete. From the chart shows, 52.7% respondent are neutral with workability of concrete after using waste materials and 12.5% and 26.8% respondent are strongly agreed and disagreed with the statement. Other than workability of concrete using waste materials as a partial cement replacement, about 58% respondent are neutral with the use of waste materials can improve the performances of concrete. However, 11.6% and 24.1% respondent are strongly agreed and agreed, while the remaining 5.4% and 0.9% respondent are disagreed and strongly agreed with the statement. Figure 10 shows the percentage of respondent regarding the performances of concrete using waste materials as a partial cement replacement.

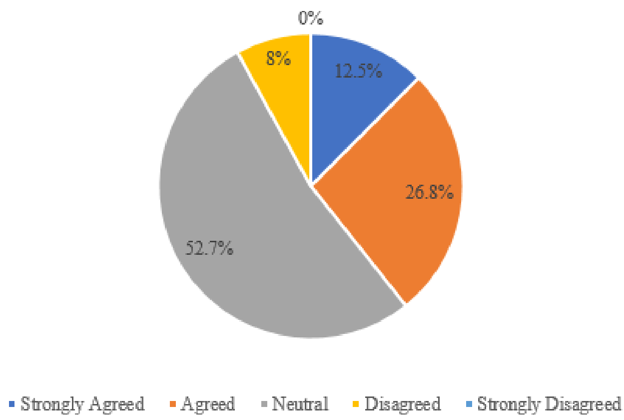

Figure 9. The percentage of respondent regarding concrete from waste materials can improve workability of concrete.

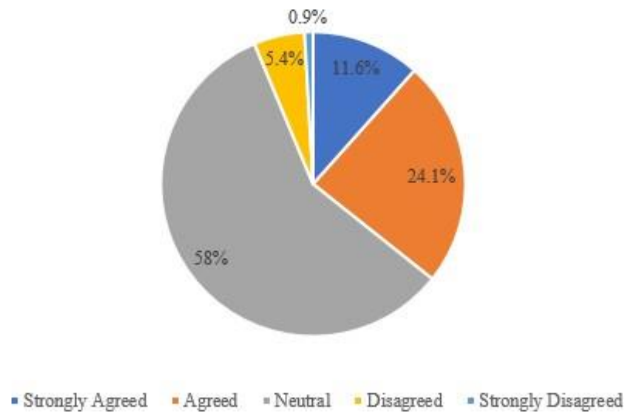

Figure 10. The percentage of respondent regarding the performances of concrete using waste materials as a partial cement replacement.

With further interview session with the expert parties, the uncertainly respondents regarding the performance of concrete using waste materials as a result of un-implementation of waste materials as a partial cement replacement are because of several factors. The factors of un-implementation of waste materials as a material for partial cement replacement are summarized in the figure below. From the graph, the first factors of un-implemented of waste materials in concrete production are because of lack of quantitative data on properties of concrete using waste materials and company itself not sure with the acceptance of client or end users regarding the concrete using waste materials. The percentage for both factors are 63.4%. The second factors of un-implemented of waste materials is company, client and end user itself unfamiliar on the type of waste materials that can be used as a partial cement replacement. The percentage of this factors is 62.5%. Next is fear of product failure or service life of construction that using waste materials as a material in cement replacement is the third factors with percentage of 60.8% followed by 60.7% percentage with the fourth factors which is fear with quality of product that using waste materials are not same as quality of product of Ordinary Portland cement (OPC). The fifth and sixth factors of unimplemented of waste materials as a partial cement replacement are lack of general knowledge regarding the usage and benefits of waste materials and company does not have special permits or regulations in order to use waste materials as a partial cement replacement. The percentage for both factors is 60.7% and 59.8%, respectively. Besides that, because of lack of equipment for processing waste materials, lack of market to buy waste materials and extra space is needed to store and keep waste materials in order to use in partial cement replacement are make it in the seventh, eighth and ninth factors of unimplemented of waste materials in concrete production. The percentage for each of the factors are 58.9%, 58% and 57.1% respectively. Finally, the last factors of unimplemented waste materials in cement for concrete production with the percentage of 48.2% is due to financial and time constraint in processing of waste materials for cement replacement. Figure 11 shows the summarized graph for factors of unimplemented of waste materials a partial cement replacement.

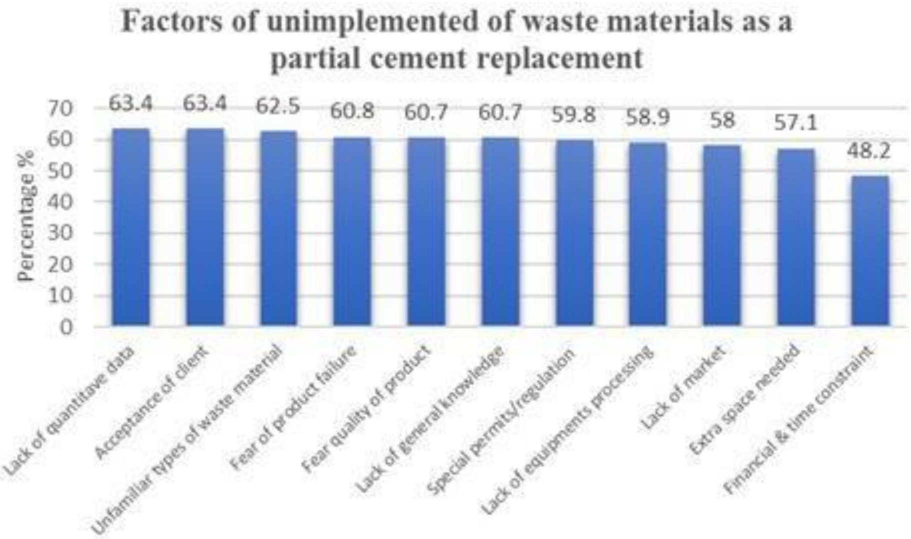

Figure 11. Factors of unimplemented of waste materials a partial cement replacement.

Despite of all the factors that contribute to un-implementation of waste materials as a partial cement replacement, there are several solutions and recommendations that can be derived from the interview session and questionnaire design in order to overcome the problem related to unimplemented waste materials in cement for concrete production. Figure 12 shows summarized of solutions and recommendations that can be make according to industrial perspective. From the interview session with expertise and questionnaire design that had been distributed, 71.5% respondent agreed that, more educational programme or conference should be done in the future in order to introduce the availability and applicability of waste materials as a partial cement replacement so that can help to encourage industry and spread awareness regarding the benefits of usage waste materials to the relevant and parties and society itself. Besides that, about 70.5% respondent are agreed more research, analysis and data regarding waste materials properties and benefits should be done before using in construction and can be as a reference for future development. Apart from that, 70.5% respondent also agreed that in order to implement waste materials as a material for partial cement replacement, industry itself should be more open and innovative in accepting this new technology. Other than that, 69.6% respondent agreed that university and industry should create a better connection in order to share knowledge regarding the usage of waste materials and their application in concrete production. Lastly, 62.5% respondent agreed if government can act regarding this matter which is the government should approve on include the usage of waste materials as a partial cement replacement for concrete production in clause so that can be used as a reference or guideline.

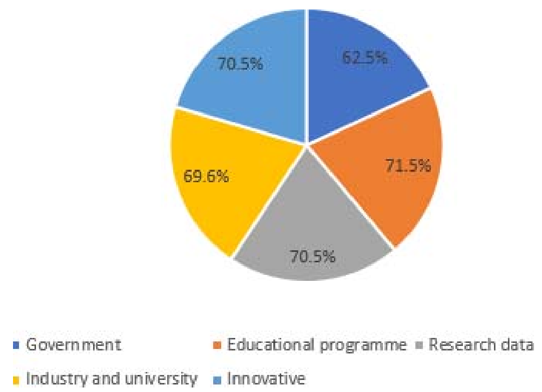

Figure 12. Summarized of solutions and recommendations that can be make according to industrial perspective.

5. Conclusion

Based on previous researchers, waste materials such are Fly Ash, Coal Bottom Ash (CBA), Rice Husk Ash (RHA), Palm Oil Fuel Ash (POFA) and Egg shell are suitable and can be used as a material cement replacement since these materials possess a good pozzolanic materials as cement itself. A good pozzolanic properties can be measure by referring the chemical compositions of one of the materials. Therefore, it is very important to gather all the data regarding properties of each of the waste materials from previous researcher so that can be a reference and guideline in future since industry itself has a little knowledge about waste materials as a partial cement replacement. Besides that, by implementing waste materials can help to saves energy, reduces wastes, saves natural resources, reduce air, soil and water pollution as well as can reduces greenhouse gases. In this study, an interview session with expert parties and questionnaire design are conducted in order to investigate the factors of unimplemented of waste materials as a partial cement replacement. With the results obtained the best solutions and recommendations have been made so that the problem regarding the unimplemented of waste materials in concrete production can be overcome.

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