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Research paper

The utilization of concrete sludge of batching plant (CSBP) as a partial cement replacement in concrete

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Abstract

Key players of construction industries prefer to use ready-mix concrete as one of the supplied materials for their projects. In conjunction with this, production of fresh concrete from batching plants is increasing consistently as the development of construction industries. Unfortunately, more than 8 tons of fresh concrete waste can be obtained and return to the batching plants. In addition, most of the batching plants dispose the concrete waste on the ground or discharging them at the landfill. Thus, this research aims in correlating the strength response to the contribution of Concrete Sludge of Batching Plant (CSBP) as recycled materials and additives in the manufacturing of concrete. In this study, two different replacement levels in percentage of CSBP which are 10% and 20% to cement weight were adopted. The compressive strength of concrete specimens was performed in accordance with the BS EN 12390: 2009. The result revealed that the compressive strength of the CSBP concrete with 20% cement replacement is observed to gain the strength comparable than those of control sample by the value of 41.6 N/mm2 while the control sample achieved 42.6 N/mm2 at 28 days of age. It can be said that CSBP can be used as the potential of recycled material in the conventional concrete to support the green and sustainable approach in construction industries and to solve the issues of overloaded concrete sludge produce by batching plant.

Keywords: *Batching Plant; Concrete Sludge; Construction Waste; Recycled Material; Strength Performance.*

1. Introduction

As approaching to a developed country, construction industry in Malaysia is now moving rapidly. The growth of new buildings and infrastructures in this country also supported the growth of manufacturing factory to supply the need of materials for such construction projects. The production of fresh concrete from batching plants is in line with the increasing of construction development activities in this country.

Batching plant of ready-mix concrete does give the advantage to the construction projects as the concrete don't have to cast in-situ, but there are about 8-10 tons of fresh concrete can be returned to the batching plant because of two factors which are (i) over-ordered concrete and (ii) leftover concrete [1]. The returned concrete can be considered as wasted concrete which correspond to 0.4-0.5% of the total production for a daily output of 1000 m^3 of concrete [2]. If the batching plants does not have any proper system to manage the returned concrete, it will keep increasing the amount of fresh concrete waste which is considered as concrete sludge.

As the fresh concrete waste has a high potential to damage the environment, thus reuse of this concrete could help generate a reduction in landfill usage, less exploitation of natural resources and reduced transportation costs. Furthermore, there are also beneficial reasons for improving the quality of materials which help to extend the life of recycled materials, especially in terms of reducing the greenhouse effect [3].

On the other hand, [4] were studying about the current methods for utilization of the fresh concrete waste returned to batching plants. They have concluded that there are nine methods to benefiting the returned concrete in batching plants which as listed (i) matching with suitable customers, (ii) blending with next matches, (iii) discharging into settling basin, (iv) discharging onto the ground, (v) producing pre-cast concrete components, (vi) recycling mechanically, (vii) using the hardened slurry cake in concrete, (viii) using the hardened slurry cake in partition wall blocks, (ix) using hydration stabilizer admixtures, and (x) using superabsorbent polymer. Above all the methods, discharging to the ground are the most used method by the batching plants [4]. The waste concrete is discharge at a certain location in the plant or at the selected dumping area until it hardened. This was not a proper way to treat the environment as the hardened concrete could be piled up until the area of dumping is full and caused overload [5]. Plus, the massive amount of waste can damage the environment, and this is the important problem that the construction industry must overcome [6].

One of the methods that can be used to solve the hardened concrete is by crushing it and produce recycled aggregates [7]. 42% of the aggregates can be recycled from concrete waste to produce recycled concrete [8]. Study in 2015 shows that concrete that contain 15-30% of recycled fresh concrete waste is ideal for producing normal strength concrete [9]. In this study, 10-20% of CSBP will be replaced as the recycled materials and the strength will be compare with the normal concrete [10].

The manufacturing of CSBP concrete has been subjected to the inclusion of waste materials following intensive research work in recent years. The purpose of this research is to study the effects of the addition of CSBP on the standard properties of concrete mixes by considering the performance of the concrete that contains different percentage of CSBP. Very few researches have been conducted on the use of CSBP in concrete. The use of CSBP in structural concrete could be economical and profitable for reducing the concrete sludge at the batching plant. CSBP could be a valuable recycled material in construction and helps to decrease the environmental issue and as well as it is in line with the sustainable approaches in construction industries.

2. Methodology

This study will determine the compressive strength of the concrete when 10-20% of CSBP is added to replace the cement. The proportional of the replacement is based on the previous study conducted by [3] which they were replacing the cement from 5-15% and the results shows that 5% of cement replacement has the potential to achieve the required compressive strength. The concrete mix also is designed as a conventional concrete which to be achieved 30 N/mm^2 of compressive strength at the age of 28 days because through the comparison that will be made, it can show the potential of the recycled concrete to be use in any of the civil engineering construction industries as a green and sustainable concept [11]. By conducting this study, it will help the batching plant to reduce or to eliminate the concrete sludge from discharging to the landfill and yet to improve the management of construction waste.

2.1. Materials

The concrete mix used in this study contains of cement, coarse aggregate, fine aggregate, CSBP and water. The Ordinary Portland Cement (OPC) Type I was used throughout this study in compliance with BS EN 197-1: 2000. CSBP used in this study as shown in Figure 1 was obtained from the batching plant owned by Lafarge Concrete Industries Sdn Bhd and was sieved through 90 µm to produce specific grain size similar with cement. Natural aggregates which consist of coarse aggregates having the size of 10 mm and 20 mm and fine aggregates passing 5 mm sieve was also used in this study.

Fig. 1: Concrete Sludge of Batching Plant (CSBP).

2.2. Mixture proportions

The mix proportions were prepared according to the British Department of Environment (DOE) to achieve 30 N/mm^2 of compressive strength at the age of 28 days. In this study, three cube specimens were casted with a size of 100 mm x 100 mm x 100 mm for each different replacement level at the age of 1, 7, 14 and 28 days. The proportions of the concrete mixtures were prepared in three different mixes as tabulated in Table 1. The water/binder ratios were set for all mixes at 0.5. The amount of CSBP added to each mixture as cement replacement was 10% and 20% respectively.

Table 1: Mix Proportions for All Concrete Mixtures

Material	Control (kg/m^3)	10% (kg/m^3)	20% (kg/m^3)
Cement	355	319	284
Coarse Aggregate	1200	1200	1200
Fine Aggregate	707	707	707
CSBP	-	36	71
Water	190	190	190

2.3. Compressive strength test

In this study, the compression strength test was performed by using a 1500 kN capacity concrete compression machine in accordance to BS EN 12390-3: 2009. In this experimental study, for each proportional of concrete with CSBP, three cubes were tested at 1, 7, 14, and 28 days of age. The strength of concrete is defined as maximum stress in can resist or the maximum load it can carry. Cubes are the usual type of compression test specimen used to determine the compressive strength of the concrete. The compressive strength is taken as the maximum compressive load it can carry per unit area. The procedures are the cubes been removing from curing tank and wipe it. The weight of the cubes must be taken before carrying the compression test. The bearing surface of the testing machine is been cleaned and the cubes is been placed centrally on the lower platen. Then the load is been apply and the maximum load, type of failure and crack patterns is recorded.

Fig. 2: Compressive Strength Test of Concrete Specimens

3. Results and discussion

3.1. Compressive strength

The development of the compressive strength of concrete mixtures containing different replacement level of CSBP concrete in tabulated in Table 2 and illustrated in Figure 3. On the day 1, the 10% CSBP concrete shows a positive increment of compressive strength compare to the 20% CSBP concrete. However, through days 7 until days 28, the compressive strength of 20% CSBP produces similar value compare to the control sample. In addition, 20% CSBP concrete has achieved its design compressive strength as early as days 7. The compressive strength at days 28 for 10% CSBP concrete was 37.3 N/mm^2 compare to the 20% CSBP concrete which was 41.6 N/mm^2.
The inclusion of 10% - 20% CSBP produces a significant development of strength and 20% CSBP attains the highest rate of compressive strength and comparable with control mix up to 28 days of curing by the value of 41.6 N/mm2. This result shows good performance for the incorporation of CSBP in concrete mixes that might be attributed to the high value of pozzolanic reactivity of CSBP. Meanwhile, it can be observed that 10% CSBP concrete contributes the reduction in strength with the range of 8–17% during curing time as compared with those of control specimens.

Table 2: Compressive Strength of CSBP Concrete

Specimen	Compressive strength at 1 day (N/mm^2)	Compressive strength at 7 days (N/mm^2)	Compressive strength at 21 days (N/mm^2)	Compressive strength at 28 days (N/mm^2)
Control	16.4	32.5	39.2	42.6
10% CSBP	13.5	29.9	35.4	37.3
20% CSBP	12.1	33.4	40.9	41.6

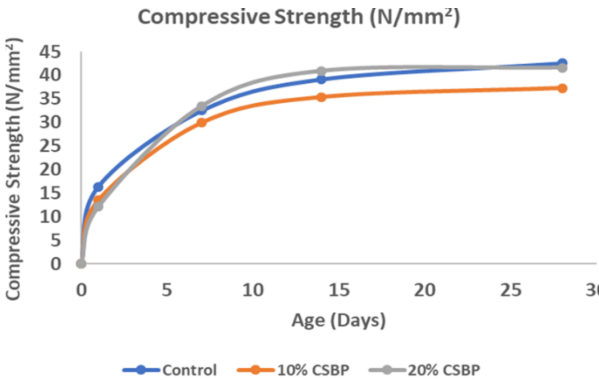

Fig. 3: The Compressive Strength Development of Concrete with CSBP Content.

3.2. Density

The relationship between compressive strength and density of CSBP concrete at 28 days of curing time is represented in Figure 4. Based on the result obtained, it reveals that the inclusion of both percentage of CSBP in concrete mixes attained the lower density compared with the control specimens. The trend of compressive strength and density had more favorable for concrete containing 20% CSBP. Although, the density of 20% CSBP concrete was lower than control sample, this mixture performed relatively beneficially to strength development than that of control concrete.

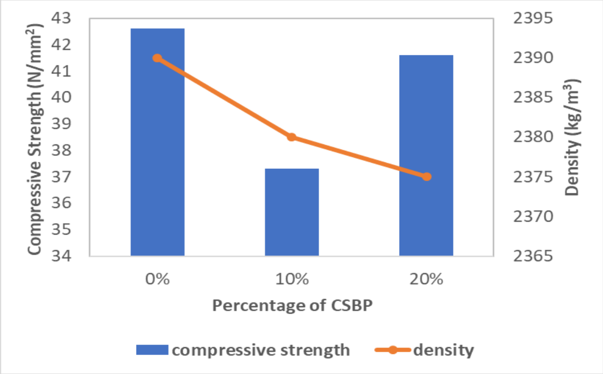

Fig. 4: The Compressive Strength of CSBP Concrete with Density at 28 Days.

4. Conclusion

In conclusion, the replacing proportion of cement with CSBP up to 20% is found to contribute towards compressive strength. By blending of CSBP, concrete mix exhibited favourable and equivalent compressive strength than those of control specimens. The density test showed that 20% CSBP had the lowest density than other concrete mixes by the reading of 2375 kg/m^3 at 28 days of curing time.

In addition, the CSBP can be use as the potential of recycled material in the conventional concrete to support the green and sustainable approach in construction industries. The selection of suitable methods of recycling the waste concrete sludge from batching plant can save and enhance the sustainability of the overall environment and affect society positively. This finding indicated that the production of the concrete mixed with CSBP could be a profitable disposal alternative for the batching plant in the future.

Eventually, the utilization of CSBP concrete as a potential alternative of construction material may attract the attention of industrial practitioners particularly ready mixed concrete sector to benefit from such wastes.

References

[1] Kou S., Zhan B., Poon C., (2012) *Feasibility study of using recycled fresh concrete waste as coarse aggregates in concrete*, Const. Build. Mater. 28, 549-556. https://doi.org/10.1016/j.conbuildmat.2011.08.027.

[2] CSI (Cement Sustainability Initiative), (2009) *Recycling Concrete, World Business Council for Sustainable Development*, Switzerland.

[3] Rosman M.S., Abas N.F., Othuman Mydin M.A., (2014), *Concrete Waste as a Cement Replacement Material in Concrete Blocks for Optimization of Thermal and Mechanical Properties*, Sustainable Built Environment Symposium (SBES 2014), Vol. 11, SHS Web of Conferences, 01013. https://doi.org/10.1051/shsconf/20141101013.

[4] Aynur K., Serdar U., (2016), *Current Methods for the Utilization of the Fresh Concrete Waste Returned to Batching Plants*, Procedia Engineering 161, 42 – 46. https://doi.org/10.1016/j.proeng.2016.08.495.

[5] Daniel A.L., Charles Z., (2016), *Use of contaminated sludge in concrete*, Procedia Engineering 145, 1201 – 1208. https://doi.org/10.1016/j.proeng.2016.04.155.

[6] Aynur K., Serdar U., Bayram E., Volkan A., Ahmet A., Murat A., (2015), *Fresh ready-mixed concrete waste in construction projects: a planning approach*, Procedia Engineering 123, 268 – 275. https://doi.org/10.1016/j.proeng.2015.10.088.

[7] Luiz B.P.V., Antonio D.F, (2015), *Evaluation of concrete recycling system efficiency for ready-mix concrete plants*, Waste Management 56, 337–351. https://doi.org/10.1016/j.wasman.2016.07.015.

[8] Vivian W.Y.T., Tam C.M., (2007) *Economic comparison of recycling over-ordered fresh concrete: a case study approach*, Res. Cons. Rec. 52, 208-218. https://doi.org/10.1016/j.resconrec.2006.12.005.

[9] Arunvivek G.K., Maheswaran G., Kumar S.S., Senthilkumar M., Bragadeeswaran T., (2015), *Experimental study on influence of recycled fresh concrete waste coarse aggregate on properties of concrete*, Int. J. App. Eng. Res. 10, 29809-29815.

[10] Valls S., Yagu¨e A., Va´zquez E., Mariscal C., (2004), *Physical and mechanical properties of concrete with added dry sludge from a sewage treatment plant*, Cement and Concrete Research 34, 2203–2208. https://doi.org/10.1016/j.cemconres.2004.02.004.

[11] Bhargav T., Pramit M.S., Parth B.P., (2017), *Effect of Partial Replacement of Sand with Wastage of Manufactured AAC Block in Concrete*, Materials Today: Proceedings 4, 9817–9821. https://doi.org/10.1016/j.matpr.2017.06.273.