International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 24 (2017) pp. 14687-14692
© Research India Publications. http://www.ripublication.com

Performance of Self-Curing Concrete Using Baby Diapers Polymer

Daud Mohamad[1]*, Salmia Beddu[1], Siti Nabihah Sadon[1], Nur Liyana Mohd Kamal[1], Zarina Itam[1], Agusril Syamsir[1], Khodrulnadiah Mohamad[1], Wani Mohd Sapuan[2]

[1]Civil Engineering Department, College of Engineering, Universiti Tenaga Nasional, Jln IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia.
[2] Civil Engineering Department, Infrastucture University Kuala Lumpur, Jln IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia.

Abstract

The advances in construction industry have contributed tremendously for the new developments in construction chemicals. The use of various chemicals in concrete alters the properties of strength and durability. Due to the vast construction activities, different grades of concrete with natural and artificial ingredients are in use. It is observed during construction even though supervision is given importance proper care is not taken in the curing and other operations. As an alternative to water curing, different other methods are also available including membrane curing, polymer curing etc. The water absorbed by the self-curing agent will be gradually released to maximize the heat of hydration and also improve the quality of concrete compare to conventional curing. Therefore, the objective of the research is to determine the effect of waste diapers polymer as a self-curing agent. There are several papers studied on internal curing agent and effect to the concrete. In this research, it will be analyzed by investigating the workability, compressive strength, weight loss and water absorption impact to the concrete. Design Mix with size of cube 100 x 100 x 100mm has been testing day 3, 7, 28 and 90 days with the ratio from 0% as a control and 1%, 2%, 3%, 5% and 10%. From the result that had obtained, 1% of diapers polymers can conclude that the internal curing process can help to improve the hydration process. When the hydration process occurs, the polymer can transfer the water to all part of the concrete and to the hydration point it results the early age cracking can be preventing and promotes maximization of cement hydration, potentially contributing to increase the strength and the fluid transport coefficients can be reduced.

Keywords: compressive strength; diapers polymer; self-curing concrete; water absorption; weight loss; workability

INTRODUCTION

Quality of the construction project is very crucial issue nowadays. Problem with the distance of work carried with water access or shortage of water will affect the curing process. There are several papers studied on internal curing agent and effect to the concrete such as from Polyethylene. Glycol (PEG400), ceramic and Super Absorbent Polymer that make them beneficial for engineering and construction applications. Statistic of waste disposable diapers 2008 for accounted for 3.7 million tons out of 166 million tons. In this research, we will use used disposable diapers as a self-curing agent that make from sodium polyacrylate. Sodium polyacrylate known as a super absorbent polymer (SAP) and the properties is becoming a gel-like substance when wet and absorb to the water. Normally diapers usage is for infants and baby who are not yet potty trained. Due to the massive construction activities, application of different grades of concrete with natural and artificial ingredients are in use. It is observed during construction even though supervision is given importance proper care is not taken in the curing and other operations. As an alternative to water curing, different other methods are also available including membrane curing, polymer curing etc. Curing is the process of avoid moisture content loss from concrete during the hydration process. Desired strength of concrete can only achieve by a proper curing technique. In the actual construction sites, improper curing techniques occasionally occur due to difficult or far places, some inaccessible, where curing cannot be properly supervised. These factors may lead to the lower performance of concrete. Recently, a lot of waste are being utilized to replace the commercially available materials such as coal bottom ash (CBA), fly ash, used engine oil and etc.

The impact of waste from disposable diapers on the environment has been over-looked. Concerning about the current environment issues, solid waste from disposable diapers produce 1.5%. This amount has been increased over the year [1]. Surveyed conducted estimated between 5 to 40 percent that disposable diapers occupied somewhere of landfill space [2]. Disposable diapers contain of dioxin and dyes which is one of cancer agent that it will be danger if released into the environment. That toxin can accumulate in humans and animals [3]. Avoid from effect to environment, few studies have been done which involved of Super-Absorbent Polymer with concrete. Once the initial free water has been consumed, the water absorbed by the self-curing agent will be gradually released to maximize the heat of hydration and also improve the quality of concrete compare to conventional curing. To avoid concrete not achieved the

maximum strength, improper curing or dry-air curing should be seriously concern because designed strength is not achieved by this method [4]. In disposable pampers, one of the material is super-absorbent gel to absorb wetness and keep baby dry. Those materials also help baby feel comforts, avoid diapers rash and keep baby skins healthy. According to the U.S. Environmental Protection Agency (EPA) (2015), about 20 billion disposable diapers are dumped in landfills each year, accounting for more than 3.5 million tons of waste [5]. From that data show that, waste diapers also contribute impact to dump area and that numbers increase year by year. Although the way to decompose disposable diapers need to be exposed to oxygen and sunlight, they do not degrade well in a landfill. Actually, to decompose disposable diapers need to take about 500 years.

Curing function is to avoid from moisture content loss or hydration of the cement. Curing process is a control of temperature and moisture movement from concrete and into the concrete [6]. Strength and impermeability of concrete will not achieve if Improper curing process [7]. Effect from curing has a strong influence on the properties of hardened concrete such as will increase the durability, strength, volume stability, abrasion resistance, impermeability and resistance to freezing and thawing [8]. The function of Internal curing agent is to serve as internal storage for curing water. For this reason, internal curing agents are usually very porous materials with weak mechanical properties. The effects of Internal curing on the mechanical properties and durability of concrete are to minimize these effects remain the subject of research interest [9]. The main application of internal curing agent will help to improve concrete strength with high risk of early age cracking. Several methods have been proposed to mitigate autogenous shrinkage and the internal stress that might be induced. Expansive additives (EXA) based on calcium sulfoaluminate or free lime [10,11], drying shrinkage-reducing admixtures (SRA) [11–12] super- absorbent polymer particles inclusions [13], as well as high belite or lowheat Portland cement [10,11] have been successfully and extensively used in mitigating shrinkage. According to [3] result Self-Consolidating Lightweight Concrete at 7 and 28 days ages when incorporating with SAP show that reducing the compressive strength. The coarser SAP resulted, however, in slightly lower reduction than the fine SAP. With the advantages it brings in extreme weather conditions as well as its reduction in water usage on sites, this makes Internal curing a topic which will garner more attention as water usage shoots upwards in the construction industry [15].

According to A. Assmann et. al. [18], polymer used is a gel polymerized type of SAP. It was a development product supplied by BASF Construction Chemicals, Germany. Gel polymerized SAP is typically crushed from larger pieces and has an irregular shape. The median diameter of the dry particles ranges between 60 and 125 μm. The fluid absorption capacity was 24 g/g. It should be noted that the SAP was “salt insensitive” which means that it was developed for the special use in high alkaline environment such as cementitious suspensions. The concrete was chosen such that should maintain 60 to 70 MPA after 28 days. The specimen was divided into three groups to simulate different situations which are first group could dry from day 1 used for shrinkage measurements and they were not loaded, second group of specimen were wrapped in polyethylene (PE) foil which were loaded after 28 days and third group were sealed by an aluminum barrier foil where some of them tested in sealed condition and the rest unsealed and loaded. There may be some results drawn from the experimental investigation on concretes with two water-to-cement ratios. Two mixes were compared which had the same water content whereby one contained entrained water by SAP. The strength for both mixtures was almost the same after 28 days. Mixture with SAP showed a significantly less autogenous shrinkage. SAP modified concrete had approximately 50% less tensile creep. Also the tensile creep of SAP modified concrete had different strengths and different paste volumes. While in [19] research the study on pre-soaked SAP effect, show the properties of self- consolidating lightweight concrete. From result, the mixture contained of commercially ASTM type II cement will improve workability by use silica fume and a polycarboxylate- based on superplasticizer.

METHODOLOGY

Materials

In this research, Baby Diapers Polymer brand ‘Mamy Poko’ was selected. The priced consider medium ranged and selected because it is familiar and easy to get in Malaysia market. Cement that used is Ordinary Portland cement brand crocodile. Superplasticizer we used brand Sika ViscoCrete-2088. Sika ViscoCrete-2088 is a chloride free, high range water reducing admixture for promoting high ultimate and early strengths.

Mix proportion

The workability and compressive strength of the self-curing concrete after 90 days due to the additive added as a self-curing agent in the concrete mixture determined by conducted some testing. The procedures to produce the concrete sample for the tests are explained sequentially in order to achieve the objective of this study. Self-curing process conducted in Laboratory with room temperature 250 Celcius to 270 Celcius. Self-curing implemented by using room temperature. The optimum self- curing agent using disposable diapers was determined by using six (6) mixes for each type of curing with one mix as a control. All the sample prepared for testing concrete fulfilled the standard requirement which is BS1881: Part 116:1983. This standard is method for determination of compressive strength of concrete cubes. The dosage was referring Table 1 by weight of the cement.

Table 1: Mix Proportion

Mix	Mix Proportion					
	OPC (kg/m^3)	***W/C (%)***	***SP (%)***	***Self-Curing Agent (Disposable Diapers Polymer) (%)***	***Coarse agg. (kg/m^3)***	***Fine agg. (kg/m^3)***
M1	400	30	2	0	1252	674
M2	400	30	2	1	1252	674
M3	400	30	2	2	1252	674
M4	400	30	2	3	1252	674
M5	400	30	2	5	1252	674
M6	400	30	2	10	1252	674

Slump test

Fresh concrete properties were determined by conduct a slump test. Slump test in this study was conducted according to BS EN 12350-2:2000. One of method to determine workability of concrete is a slump test. Slump test conduct to indicate water content that has been used in the mix and also shown the stiffness of the concrete. Function of stiffness in the concrete mix should be matched to the requirements for the finished product quality.

Compressive Strength test

This research, sample size 100 x 100 x 100mm was tested by destructive test on hardened concrete using compressive test machine to get the strength. Testing followed American Society for Testing Materials ASTM C39/C39M standard. Loading with maximum 3000KN and speed 2KN/sec. Three (3) sample per day (3, 7, 28 and 90 days) has been tested. Testing start from day 3 because from that, we can see the changes of strength due to hydration more accurately. Compressive strength unit in MPa will show the whether have an effect in term of strength while add a self-curing agent into a concrete mix.

RESULT AND DISCUSSION

Workability

Addition of Diapers Polymers in concrete mixture can have a considerable effect on concrete workability since it will absorb some of water content of the mixture. As a results of that (Fig. 1), there has an increase workability of concrete with self- curing agent Diapers Polymer. From this result, we can notice that the slump test value decreased by almost 70% when adding 0.4% relative to cement of Diapers Polymer to concrete mixture.

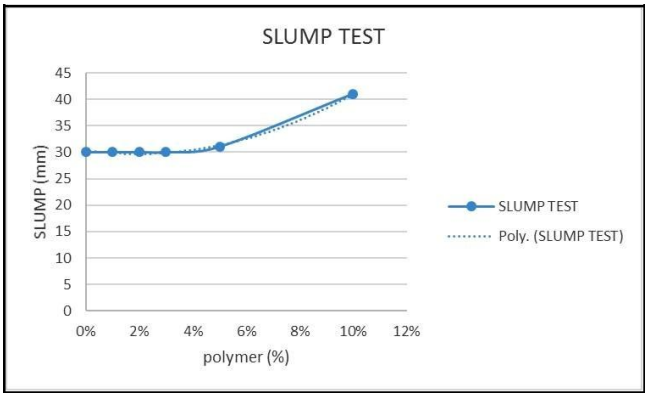

Figure 1: Workability of concrete

As shown in Fig. 1, all concrete mixes have slump value in the range of 10mm-40mm which indicates that the degree of workability is low. The control mix and mix concrete 1, mix concrete 2 and concrete mix 3 has the same slump which is 30mm. The concrete mix 4 had increased the slump that is 31mm and the concrete mix 5 has the more slumps that are 41. This might be due to the addition of Diapers Polymer into the concrete mix that increases the workability even though the water cement ratio is just the same. The concrete mix 5 has the higher percentages of using the polymer that are 10% the percentages had affect the slump test due to the mix be more loose and freely to move because it contains more liquid gel in it. This might be due to increment of the amount of Diapers Polymer as it acts as a self-curing agent that happen to be a water reservoir to the concrete and so it reduces the workability decreases, the addition of the Diapers Polymer in the low percentages does not affect the workability of the concrete when compare to the control mix. But from the result we can see the highest percentages helps the concrete cubes to have higher slump than the normal mix but still maintain in a low degree of workability which is fairly acceptable.

Compressive Strength Test

In general, addition of Diapers Polymer to the concrete mixture will be presented as a reduction in compressive strength of the concrete compared to a reference mixture without Diapers Polymer added which have been reported by most of publications especially at early ages of concrete. Reduction of compressive strength due to addition of Diapers Polymer can differ depends of their dosage and w/c ration used in the mixture. The higher dosage and water used, the higher reduction percentage in compressive strength compare to control mixture without Diapers Polymer added. In average, the result shows a 30% reduction in compressive strength with 1% of SAP added at age of 3 days, 20% reduction at age of 7 days, 15% reduction at age of 28 days (refer to Fig. 2).

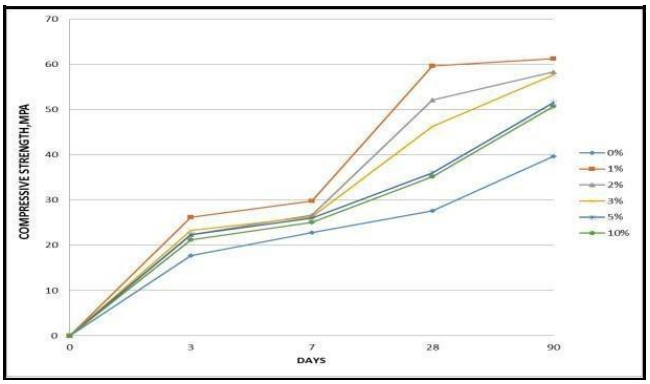

Figure 2: Compressive strength of control mix and polymer diapers concrete

3 days of concrete curing is to check the workability of the concrete and the strength of the concrete. The compression has been done with the concrete with the different ratio of Diapers polymer that had been added. Based on the results that had been gain, at the 3 days of concrete curing the strength are low because of the hydration process are not fully done. Refer on the results, we can see the compressive strength test had been increased on the 7 days of curing. The trend of the graph is uniformly for all the mix. The concrete mix with added of the polymer 1% has the highest strength development for the 7 days curing this is because the polymer can be water reservoir when the hydration process and because of the amount of polymer that had been added are not in large amount, the void in the concrete are less that affect the strength of the concrete. The strength for the concrete for all concrete mix still increase in the 28 days of curing. On the 28 days of curing, normally the design grade of the concrete had been obtained. The concrete mix with added of the polymer 1% also has the highest strength. Refer to the results of the compressive strength test, all the mix had achieved the design mix strength except the control mix and the concrete mix 4 and concrete mix 5. For the concrete mix 4 and concrete mix 5, this due to the void occurs in the concrete. The concrete mix 4 and concrete mix 5 has more void compare to others because of the highest percentage of use polymer. When the hydration process, the liquid in the polymer had been absorb and the polymer will shrinkage and it will leave a void between inside it and it affect the strength of the concrete. The concrete with a more void will give a less strength.

Water Absorption Test

Water absorption test were tested at 28 days of curing for each mix including control mix. Water absorption for control mix is 4.6% while for 10% and 20% replacement of GCBA is similar to control mix however for 30% of GCBA replacement is higher compare to control mix. The water absorption for GCBA concrete are not exceeding the maximum percentage which is 20%. The result of water absorption was shown in Fig. 3.

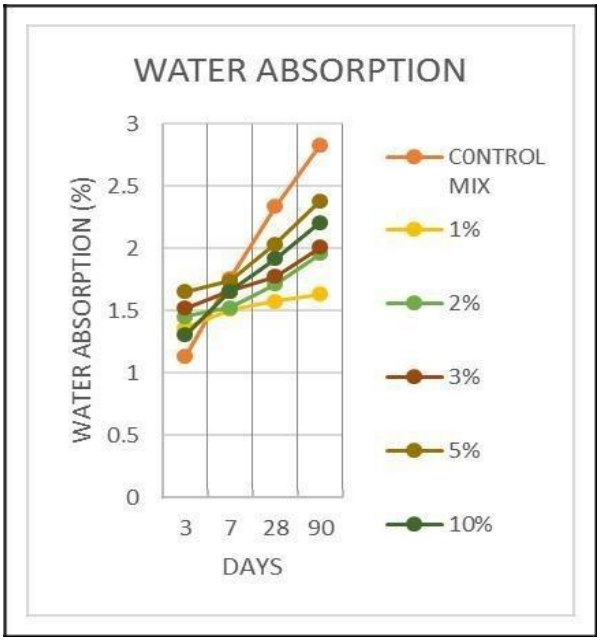

Figure 3: Water absorption against percentage of polymer replacement

From the results, water absorption for the control mix is the highest and it increase rapidly. This is due to the hydration process and the curing. The control mix had been curing outside the water curing tank without added of any self-curing agent because of that, it absorbs the large amount of water. For the small percentage of polymer that had been added, the water absorption also increases but in a small scale because the polymer in the concrete had retain sufficient amount of water for the concrete so will has less water loss and less water absorption compare to the concrete mix with the higher percentage of polymer. The concrete that have higher percentage of polymer had absorbed large amount of water compare to the less polymer due to the polymer inside the concrete. When the polymer reservoir the water inside it, the early age of the concrete will become faster and the water also will lose faster and it effect the water absorption. Refer to the figure below, we can conclude that the concrete mixture has the best durability because it not absorbs the large amount of water and it will give effect to the strength.

Weight Loss Test

By referring Fig.4, we can see the pattern of the weight loss. All the concrete mixture had decreased the weight loss because of the effect of the polymer inside the concrete. When the water that had been retained in the polymer had been used in the hydration process, the weight loss will be reduced because the concrete had been hydrated and the heat inside the concrete due to the chemical reaction when react with water had been over. For the concrete mix with the 1% of added polymer had achieved the minimum weight loss and started to be constant and it give the good characteristics of concrete

Figure 4: Weight Loss of concrete for 72 hours

CONCLUSION

The result that had obtained can conclude that the internal curing help to improve the hydration process. When the hydration process occurs, the polymer can transfer the water to all part of the concrete and to the hydration point it results the early age cracking can be preventing and promotes maximization of cement hydration, potentially contributing to increase the strength and the fluid transport coefficients can be reduced. Compared to the conventional curing, the water can penetrate only a few millimetres from outside into inside the concrete. But in the internal curing, the water in the polymers already inside the concrete and it make the water be more easily to penetrate into the concrete and transfer it uniformly. Once concrete sets, chemical shrinkage continues in the cement paste as hydration progresses and creates partially-filled pores within the microstructure of the concrete. These unfilled pores in the cement paste create capillary stress, which causes shrinkage. Internal curing provides readily available additional water throughout the concrete, so more of the pores remain water-filled, minimizing stress and strain development. Findings that concrete cube with added of the 1% of the baby diapers polymers has the optimum result. The hydrations for the internal curing increased and it gives the positive result and have a highest strength and a good durability.

ACKNOWLEDGEMENT

This research was funded by UNITEN Internal Grant. The authors would like to extend their acknowledgement to University Tenaga Nasional for providing facilities to accomplishing the present research. Acknowledgements also to Technical Team Civil Engineering Laboratory, University Tenaga Nasional for their great contribution and assistance to complete this work.

REFERENCES

[1] Municipal Solid Waste in the United States; Facts and Figures for 2010, US EPA Office of Solid Waste, 2010

[2] Rathje, William L., and Cullen Murphy. Rubbish: the archaeology of garbage. University of Arizona Press, 2001.

[3] Allsopp, Michelle. Achieving Zero Dioxin: An emergency strategy for dioxin elimination. September 1994. Greenpeace. http://archive.greenpeace.org/toxics/reports/azd/azd.html

[4] Kholia, R., Vyas, B. A., Tank, T. G., Student, G., & College, L. D. E. (2014). Effect on Concrete by Different Curing Method and Efficiency of Curing Compounds – A Review. International Journal of Advanced Engineering Technology.

[5] Municipal Solid Waste in the United States: 2007 Facts and Figures by the Office of Solid Waste, EPA, November, 2008. Table 15 tracks a steady increase from 1960 through 2007.

[6] Neville, A.M., 1996. Properties of Concrete, Fourth and Final Edition. John Wiley and Sons, Inc., New York, USA.

[7] Fauzi, M., 1995. The Study on the Physical Properties of Surface Layer Concrete under the Influence of Medium Temperature Environments. Ph.D. Thesis, Kyushu University, Japan.

[8] Chapter 12 "Curing Concrete", University of Memphis http://www.ce.memphis.edu/1101/notes/concrete/PCA_manual/Chap12. pdf.

[9] Zhutovsky, S., & Kovler, K. (2012). Effect of internal curing on durability-related properties of high performance concrete. Cement and Concrete Research, 42(1), 20–26. http://doi.org/10.1016/j.cemconres.2011.07.012

[10] A. Hori, M. Marioka, E. Sakai, M. Daimon, Influence of expansive additives on autogenous shrinkage, in: E.I. Tazawa (Ed.), Autoge nous Shrinkage of Concrete, E. and F.N. Spon, London, 1999, pp. 93–104.

[11] H. Ito, I. Maruyama, M. Tanimura, R. Sato, Early age deformation and resultant induced stress in expensive high strength concrete, Journal of Advanced Concrete Technology 2 (2) (2004) 155–174.

[12] E.I. Tazawa, S. Miyazawa, Influence of constituent and composition on autogenous shrinkage of cementitous materials, Magazine of Concrete Research 49 (178) (1997) 15–22

[13] O.M. Jensen, P.F. Hansen,Water-entrained cement-based materials: I. Principle and theoretical background, Cement and Concrete Research 31 (4) (2001) 647–654

[14] AzariJafari, Hessam, et al. "Effects of pre-soaked super absorbent polymers on fresh and hardened properties of self- consolidating lightweight concrete." Construction and Building Materials 113 (2016): 215-220.Sequeira, K., Naik, R. H., Pai, B. H. V, & Naik, R. H. (2015). Use of Superabsorbent Polymers in Internally Cured Concrete- a Review, 1593–1595.

[15] Colon, J., Mestre-Montserrat, M., Puig-Ventosa, I., S? anchez, A., 2013. Performance of compostable baby used diapers in the composting process with the organic fraction of municipal solid waste. Waste Manag. 33, 1097e1103.

[16] H. Azarijafari, A. Kazemian, M. Rahimi, and A. Yahia, "Effects of pre- soaked super absorbent polymers on fresh and hardened properties of self- consolidating lightweight concrete," Constr. Build. Mater., vol. 113, pp. 215– 220, 2016.

[17] Bentz, Dale P., and W. Jason Weiss. Internal curing: a 2010 state-of- the-art review. US Department of Commerce, National Institute of Standards and Technology, 2011