Using Baking Powder as Additional Concrete Material

FK Budi Nugroho¹, S Sumarni¹, AG Thamrin¹, Roemintoyo¹, FD Isnantyo¹
¹Department of Civil Engineering Education, Faculty of Teacher Training and Education, Sebelas Maret University
Sebelas Maret University, Jl. Ir. Sutami 36A Surakarta 57126 Indonesia

E-mail: Fajarkus09@gmail.com
Srisumarni@staff.uns.ac.id
Agthamrin2@yahoo.com
Roemintoyo@staff.uns.ac.id
Isnantyo@staff.uns.ac.id

Abstract. Baking Powder is a useful ingredient for developing which basically used in increasing food volume. It is made from alkaline sodium bicarbonate elements, acid salts and corn starch. Baking powder is a chemical compound consisting of NaHCO₃ formula. This compound belongs to the salt group and has been used for a long time. The main added ingredients of retarders are divided into several categories according to their chemical composition, including: 1) Lignosulphonic Acid and other salts, ie., Na, Ca or NH₄, 2) Hydro-carboxylic acids and their salts. In this study we used baking powder as an added ingredient. This study aims at determining the setting time, compressive strength and the freshness of concrete with variations in the addition baking powder are 0.00%; 0.15%; 0.30%; 0.45% of the weight of cement. This is an experimental research. Test samples for compressive strength in the form of a concrete cylinder. The results showed that maximum value of compressive strength of concrete is in the addition of 0.45% baking powder with an increase in compressive strength of 6.43% of the nominal concrete.

1. Introduction
Concrete is one of the materials used for construction such as building structures, highways, piers, and various other structures. The development of concrete requires an increase in quality. To obtain a qualified concrete, there are several factors to be considered, among others: material, mixture proportions and work processes. Among the materials that can improve the quality of concrete include: additives from chemicals, materials with high density, silica-containing materials, and others. Among the materials used to improve the quality of concrete have been previously studied. [1-15].

[16] one of the additive ingredients to improve the quality of concrete is water - Reducing Admixtures need ingredients can reduce the need for water mixture to produce a highly consistence concrete, Water - Reducing Admixture is, therefore, used among others to avoid reducing the cement content and slump value from producing concrete with a comparative value or a low cement water factor ratio, all of which will increase the concrete compressive strength.

Material used for reducing water may be in the forms of both organic or inorganic ingredients for non-air-entrained concrete or with air in reducing the mixed water content. In addition, this added material can be used to modify the time of binding of concrete or mortar as a result of changes in the...
cement water factor. The mixed composition of these added ingredients is generally distinguished into 5 classes: 1. Lignosulfonic acid and the content of salts, 2. Modification and derivatives of lignosulfonic acid and salts. 3. Hydroxylated carboxylic acids and their salt content. 4. Modification of hydroxylated carboxylic acids and their salt content. 5. Other materials such as: Inorganic materials such as zinc, salts, barrack, phosphates, chlorides; Amino acids and their derivatives: Carbonic acid, polysaccharin and acid sugar; Polymer mixtures, such as ethers, melamine, naptan, silicon, hydrocarbon-sulfate derivatives. Baking powder is a chemical compound comprising of NaHCO₃ formula, the mention of which is frequently abbreviated as dense. This compound belongs to the salt group and has been used for a long period of time. This compound is also called baking soda, sodium bicarbonate, sodium hydrogen carbonate, and others.

In addition to concrete quality, setting time considerably needs attention. One of the jobs which demands slowing down the initial cement binding is the transportation process. The fresh concrete with a long distance from the batching plant to the concrete casting location while maintaining its workability. The initial cement binding is the time required for the cement paste to change its properties from liquid into solid. To cope with this problem, we need additional substances that function to slow the binding of cement (retarder admixture). Retarder mixtures are chemical aids that function to slow down the initial binding time (time setting), i.e., due to hot weather conditions or prolong of the hardening time intended to avoid cold connections, which enables the mixture work for longer periods. Additives that can be used as inhibitors include sugar, sucrose, sodium gluconate, glucose, citric acid and tartaric acid.[17]

Baking powder is sodium bicarbonate mixed with other substances of slightly acid. By referring to building materials and civil engineering No. 22 / SE / M / 2015 concerning guidelines for the use of chemical additives in concrete, baking powder (NaHCO₃) is a chemical containing salt, which is Sodium (Na). Thus, it enables to be used as additional material in concrete, for the Na includes an example of Lignosulphonic Acid.

Potassium bitartate in case reacted with sodium bicarbonate will establish a compound called baking powder. Under controlled conditions, this reaction will produce sodium potassium bitartate salt, which is often referred to as rochelle salt of class A. A. [18]

Among the researches on setting time of concrete, among others: the addition of sodium silicate delayed the hydration of tricalcium aluminate and thus prolonged the setting process of oil-well cement.[19] that polymer latexes perform good water-reduction effect and delayed setting behavior on CSA cement mortar. [20]. The accelerating-retarding effect of triethanolamine on the initial setting time is caused by the different intensity of formed ettringite, which is governed by the triethanolamine dosage. This finding provides information about the role of triethanolamine and ettringite formation in the initial setting. [21]

In this research we use baking powder as an additive to determine the time of adjustment, compressive strength and freshness of concrete.

2. Theoretical Underpinnings
2.1. Cement Setting Time (Vicat Test)

The initial binding time of cement is the time needed to harden, calculated from the reaction of the cement with water and becoming cement paste. So that the cement is stiff enough to hold the load. Setting time occurs when the hardening or binding of the cement fibers. The initial binding of cement according to the standard is a minimum of 45 minutes. The initial binding of this cement must occur / proceed slowly. It is intended that there is a gap between stirring with other construction installations so that the workmanship has no difficulty in working. Final binding of cement according to the standard after 8 hours. After the cement is attached to the construction it should not be affected by interference, because it will damage the construction bond. If it is disturbed, it is better if the construction is torn down. [22]. The initial binding time can be determined when the vicat needle gets penetration as deep as 25 millimeters, and the final binding time, when the vicat needle cannot penetrate. [23]
2.2. Slump Test
Concrete slump is a decrease in height at the center of the upper surface of the concrete measured immediately after the slump test mold is removed. Slump test is an empirical test/method used to determine the consistency/stiffness (easy to do or workable) of a mixture of fresh concrete (fresh concrete). Rigidity in a concrete mixture shows how much water is used. Slump value is proportional to the value of the concrete mixture's moisture content, but inversely proportional to the strength of the concrete. In a concrete mixture/mix, water content is very important because it determines the level of workability. Concrete mixture that is too liquid will cause low concrete quality, and long to dry. While the concrete mixture that is too dry causes the mixture to be uneven and difficult to print. [24]

2.3. Compressive Strength of Concrete
Concrete compressive strength identifies the quality of a structure. The higher the level of structural strength desired, the higher the quality of the concrete needed.

3. Experiments
3.1 Materials
Materials used in this study include:
Portland cement. The cement used is semen gresik with 40 kg packaging. The coarse aggregate used is broken stone with a maximum size of 20 mm taken from PT Pancadarma Puspawira, Solo, Central Java. Has fulfilled the requirements of the Indonesian National Standard [25]. Fine aggregate used is using sand from Kaliworo River, Klaten, Central Java. Has fulfilled the requirements of the Indonesian National Standard [26-27]. The water used in the clean water is in the PTB FKIP UNS laboratory.
The added retarder used in this research is baking powder produced by PT Gunacipta Multirasa, Tangerang, Indonesia.

Experimental Procedure
Examination of Material
The material tested was fine aggregate (sand) and course aggregate (gravel) which had to meet the prescribed requirements of Indonesia standard. which included, among others:
Fine Aggregate testing include:
   a) Testing of sludge levels.
   b) Testing levels of organic substances.
   c) Testing specific gravity.
   d) Grading testing.
   e) Testing the water content.
Course aggregate testing.
   a) Testing for abrasion.
   b) Grading testing.
   c) Testing specific gravity.

3.2. Mix design concrete
At the calculation stage the planning is to mix concrete with or design a concrete mixture adding baking powder with additional variations of 0%, 0.15%, 0.30%, 0.45% of the weight of cement. The concrete mix plan calculation was carried out to determine the need for gravel, sand, cement and water. The mixed method used in this study applied a standard Indonesian mixed design method [28].

3.3. Setting time test
Testing step of the initial cement setting time used the Vicat apparatuses test. This test is carried out using American standard. [29] The following is Vicat Apperature or Vicat Tool used to know the time of binding of cement.
The compressive strength was calculated by using equation as follows:

\[ \sigma = \frac{P}{A} \]  

where \( \sigma \) = compressive strength, \( P \) = load, \( A \) = area of specimen

### Table 1. Properties of fine agregat (Sand)

| Properties         | Values  |
|--------------------|---------|
| Water Content      | 0.53 %  |
| Specific Gravity   | 2.573   |
| Fineness Modulus   | 3.063   |
| Zone               | 1       |
| Absorption         | 1.091 % |

Based on the results of fine aggregate (sand) testing, the values of sludge, organic matter and bulk specific gravity have met the standard requirements.

### Table 2. Properties of course agregate (Gravel)

| Properties         | Values  |
|--------------------|---------|
| Abration           | 9.32 %  |
| Specific Gravity   | 2.55    |
| Fineness Modulus   | 3.385   |
| Zone               | 2       |
| Absorption         | 1.07 %  |

Based on the results of course rough aggregate testing (gravel), the value of gradation, specific gravity, and abrasion tests have met the standard requirements [31]. The data of the results of initial setting time test is shown in Figure 1.
Based on the results of setting time testing, concrete by adding baking powder with a percentage, among others: 0.00%; 0.15%; 0.30%; 0.45% of the weight of the cement affects the bonding time of the concrete and forms a linear equation $Y = 600X + 230$, with variable $X$ being the variation of baking powder percentage and $Y$ variable is the binding time of the concrete. The regression value is 0.91.

The graph shows that the greater the addition of baking powder, the higher the binding time of the cement, which means that the more baking powder percentage added to the concrete the longer the drying process. This shows that baking powder has chemical contents that inhibit the interaction process between cement and water. The increase in concrete binding time for each variation of baking powder addition compared to normal concrete binding time without the addition of baking powder is shown as in Figure 2.

![Figure 2. The increased binding time from binding time without baking powder addition.](image)

In figure 2, the binding time in the variation of baking powder 0.45% cement increase 140% of the cement without any additional baking powder.

Concrete slump test data results are shown as in Figure 3.

![Figure 3. Slump Test](image)

Based on the results of slum testing, concrete by adding baking powder with a percentage include: 0.00%; 0.15%; 0.30%; 0.45% of the weight of the cement affects the nature of the dilution (workability) and forms a linear equation that is $Y = 1.1333X + 9.02$, with the variable $X$ is the variation in the percentage of baking powder and the variable $Y$ is the workability. The regression value is 0.98.
The graph shows that the greater the addition of baking powder, the higher the workability, which means that the more baking powder percentage is added, the concrete will be thinner. This shows that baking powder when mixed with water and cement becomes runny. The increase in the value of slum for each variation of baking powder added compared to concrete slump without the addition of baking powder is shown as shown in Figure 4.

![Graph showing increasing slump value with baking powder addition](image)

**Figure 4.** Increasing the slump value of the slump value without the addition of baking powder.

From the results of an increase in the slump value with a variation of the addition of baking powder results in a small increase, this shows that the interaction between baking powder and water has no effect of dilution. Referring to the observations during the slump test, the slump test is carried out shortly after the concrete is finished mixed, and does not wait any longer, it is possible to increase the slump value if the test is carried out by giving a time lag of testing for the concrete constituent reacting especially water, cement and baking powder.

The result of compression strength test of concrete is shown in Figure 5.

![Graph showing variations of baking powder versus compression strength](image)

**Figure 5.** Variations of baking powder versus compressive strength

Based on the results of the concrete compressive strength test that the concrete by adding baking powder with a percentage include: 0.00%; 0.15%; 0.30%; 0.45% of cement weight affects the compressive strength of concrete and forms a linear equation \( Y = 3.1133X + 21.652 \), with variable \( X \) is the variation of the baking powder percentage and \( Y \) variable is the compressive strength. The regression value is 0.99.
The graph shows that the greater the addition of baking powder the higher the compressive strength, which means that the more baking powder percentage is added, the stronger the concrete.

The increase in compressive strength value of each variation of the addition of baking powder compared to the compressive strength of concrete without the addition of baking powder is shown as shown in Figure 6.

![Figure 6. Increasing the compressive strength value of concrete from the compressive strength value of concrete without the addition of baking powder.](image)

The highest concrete compressive strength of 23.03 MPa, occurs in concrete with the addition of 0.45% baking powder, this value indicates that there is an increase in compressive strength of 6.43% of the concrete without the addition of baking powder. This shows that baking powder has properties as a superplasticizer which is an added material to increase the compressive strength of concrete. The highest compressive strength value of 23.03 MPa. Based on the Indonesian national standard, this concrete is still a normal type of concrete.

5. Conclusion

This study concludes that the greater addition of the baking powder used, the longer the hardening and working capacity are found to be slightly increased. The maximum value of concrete compressive strength is the application of 0.45 per cent baking powder with an improvement of 6.43 per cent of gross concrete compressive strength.

References

[1] Xiao, J., Ma, Z., Sui, T., Akbarnezhad, A., & Duan, Z. 2018. Mechanical properties of concrete mixed with recycled powder produced from construction and demolition waste, *Journal of Cleaner Production*, 188, pp.720-731.

[2] Mazloom, M., Ramezanianpour, A. A., & Brooks, J. J. 2004. Effect of silica fume on mechanical properties of high-strength concrete, *Cement and Concrete Composites*, 26, (4), pp. 347-357.

[3] Chen, S. D., Hwang, C. H., & Hsu, K. C. 1999. The effects of sulphonated phenolic resins on the properties of concrete. *Cement and concrete research*, 29, (2), pp.255-259.

[4] Ramachandran, V. S., & Malhotra, V. M. 1996. Superplasticizers. In *Concrete Admixtures Handbook William*, Andrew Publishing, pp. 410-517.

[5] Sitorus, L. R. 2018. Analisis Kuat Tekan Terhadap Umur Beton dengan Menggunakan Admixture Superplasticizer Viscocrete-3115 N.

[6] Janowska-Renkas, E. 2015. The influence of the chemical structure of polycarboxylic superplasticizers on their effectiveness in cement pastes. *Procedia Engineering*, 108, pp. 575-583.
[7] Irawan, I. 2017. Pengaruh Silica Fume Terhadap Beton Mutu Tinggi Self Compacting Concrete, Doctoral dissertation, Universitas Pendidikan Indonesia.

[8] Chen, H.J. and Wu, C.H. 2018. Influence of Aggregate Gradation on the Engineering Properties of Lightweight Aggregate Concrete, Appl. Sci. 2018, 8, 1324; doi:10.3390/app8081324.

[9] Síčaková, A. & Špek, M. 2019. The Efect of a High Amount of Micro-Fillers on the Long-Term Properties of Concrete, Materials 2019, 12, 3421; doi:10.3390/ma1203421.

[10] Zahiri, F., Eskandari-Naddaf, H. Optimizing the compressive strength of concrete containing micro-silica, nano-silica, and polypropylene fibers using extreme vertices mixture design. Front. Struct. Civ. Eng. 13, 821–830 (2019). https://doi.org/10.1007/s11709-019-0518-

[11] Wang Y, Hu S, He, Z.2019. Mechanical and Fracture Properties of Fly Ash Geopolymer Concrete Additive with Calcium Aluminate Cement. Materials (Basel, Switzerland), 15 Sep 2019, 12(18), DOI: 10.3390/m12182982

[12] Rajanna, S.K. Vinjamur, M. & Mukhopadhyay, M. 2017. Robust Silica Aerogel Microspheres from Rice Husk Ash to Enhance the Dissolution Rate of Poorly Water-Soluble Drugs, Chemical Engineering Communications, 204 (2); pp. 249-253, DOI: 10.1080/00986445.2016.1263618.

[13] Rasoni, Y., & Yuriisman, Y. 2014. Penelitian Pembuatan Beton Mutu Tinggi Dengan Semen PCC Menggunakan Sikafume dan Viscocrete-10 Sebagai Bahan Tambah. Abstract of Undergraduate Research, Faculty of Civil and Planning Engineering, Bung Hatta University, 1(2).

[14] Abolpoura, B., Mehdi Afsahia, M., Hosseini, S.G. 2015. Statistical analysis of the effective factors on the 28 days compressive strength and setting time of the concrete, Journal of Advanced Research, 6, (5), September 2015, pp. 699-709, DOI: https://doi.org/10.1016/j.jare.2014.03.005

[15] Alqadia, A.N.S., Bin Mustapha, K.N., Naganathan,S. & Al-Kadic, Q.N.S.(2013). Development of self-compacting concrete using contrast constant factorial design, Journal of King Saud University - Engineering Sciences, 25, (2), July 2013, pp.105-112, https://doi.org/10.1016/j.jksues.2012.06.002

[16] American standart ASTM. 1982. Standard Specification for Chemical Admixtire for Concrete Type F. American Society for Testing Materials, ASTM C 494-82, Philadelphia.

[17] Otunyo,A. W., Onwusiri, S. C. & Nwaiwu, N. (2015), Effect of Sugar Cane Juice on Slump Values, Setting Times and Strength Of Concrete, Nigerian Journal of Technology (NIJOTECH), 34, (2), April 2015, pp. 254 – 258, DOI: http://dx.doi.org/10.4314/njt.v34i2.6

[18] Ar, Indah. 2009. Persenayawaan dari Golongan I A, Natrium Bikarbonat dan Kalium Bitartart sebagai bahan baku pembuatan Garam Rochelle, Artikel dalam https://indongolz.files.wordpress.com/2010/06/garam-rochelle.pdf.

[19] Guo S, Zhang Y, Wang K, Bu Y, Wang C, Ma C, Liu H. 2019. Delaying the hydration of Portland cement by sodium silicate: Setting time and retarding mechanism. Construction and Building Materials, 205:543-8. https://doi.org/10.1016/j.conbuildmat.2017.08.168

[20] Li L, Wang R, Lu Q. 2018. Influence of polymer latex on the setting time, mechanical properties and durability of calcium sulfoaluminate cement mortar, Construction and Building Materials, 169:911-22. https://doi.org/10.1016/j.conbuildmat.2018.03.005

[21] Yaphary YL, Yu Z, Lam RH, Lau D. 2017. Effect of triethanolamine on cement hydration toward initial setting time, Construction and Building Materials, 141:94-103. https://doi.org/10.1016/j.conbuildmat.2017.02.072

[22] Indonesian product standardization SNI 03-6827-2002

[23] American standart ASTM C191-92

[24] Indonesian product standardization SNI 03-1972-2008

[25] Indonesian product standardization SNI S-04-1989-F

[26] Indonesian product standardization SNI 1969-2008

[27] Indonesian product standardization SNI 2417-2008

[28] Indonesian product standardization SNI 03-3449-2002
[29] Indonesian product standardization SNI 1969-2008
[30] Mulyono, Tri. 2004. *Concrete Technology*. Yogyakarta: Publisher Andi.
[31] American standard ASTM C187