# EFFECT OF PROCESSED SPENT BLEACHING EARTH AND KENAF FIBER TOWARDS HEAT OF HYDRATION AND STRENGTH OF FOAMED CONCRETE

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# ABSTRAK

Bahan-bahan pozzolanik seperti Processed Spent Bleaching Earth (PSBE) telah digunakan secara meluas sebagai bahan pengganti simen separa dalam pembinaan konkrit kerana sifat pozzolannya. PSBE adalah sisa pepejal yang dihasilkan daripada proses pelunturan dalam industri minyak sawit dengan menggunakan pengekstrakan pelarut minyak mentah. Dalam kajian ini, kesan PSBE dan serat kenaf pada kebolehkerjaan, haba penghidratan dan kekuatan mampatan konkrit berbuih telah disiasat. Ini adalah tiga campuran yang telah disediakan iaitu konkrit berbuih (FC), 30% PSBE (PFC) dan 30% PSBE + serat kenaf (PKC). Semua campuran telah diuji dengan ujian kebolehkerjaan terlebih dahulu. Dari eksperimen ini, didapati PKC mempunyai aliran aliran terendah, iaitu sekitar 8% lebih rendah berbanding dengan FC. Untuk haba ujian penghidratan, keputusan telah membuktikan bahawa PKC menghasilkan konkrit berbuih yang mempunyai suhu puncak terendah, iaitu 7% dan 25% lebih rendah daripada FC untuk 150x150x150mm dan 300x300x300mm saiz kubus. Selain itu, diperhatikan bahawa PKC menggunakan masa terpanjang untuk mencapai suhu puncaknya berbanding dengan FC sebanyak 30% dan 45% lebih lama untuk saiz kiub 150x150x150mm dan 300x300x300mm. Akhir sekali, bagi ujian mampatan, ia menunjukkan bahawa PFC mempunyai kekuatan mampatan tertinggi selama 7, 28 dan 60 hari berbanding yang lain. Ringkasnya, berdasarkan pemerhatian dan keputusan yang diperolehi oleh kajian ini, dapat disimpulkan bahawa kehadiran PSBE yang bertindak sebagai pengganti simen separa adalah bermanfaat, terutamanya untuk pengeluaran konkrit berbuih.

# ABSTRACT

Pozzolanic materials such as Processed Spent Bleaching Earth (PSBE) have been widely used as a partial cement replacement material in concrete construction due to its pozzolanic properties. PSBE is solid waste generated from the bleaching process in the palm oil industry by using solvent extraction of crude oil. In this study, the effects of PSBE and kenaf fiber on workability, the heat of hydration and compressive strength of foamed concrete investigated. These are three mixtures that have prepared, namely foamed concrete (FC), 30% PSBE (PFC) and 30% PSBE + kenaf fiber (PKC). All the mixtures have been tested with the workability test first. From the experiment, it found that PKC has the lowest flowability, which is about 8% lower compared with FC. For the heat of hydration test, the results have proved that PKC produced foamed concrete that has the lowest peak temperature, which is 7% and 25% lower than FC for 150x150x150mm and 300x300x300mm cube sizes. Other than that, it observed that PKC consumed the longest time taken to achieve its peak temperature compared with FC by 30% and 45% longer for 150x150x150mm and 300x300x300mm cube sizes. Lastly, for the compression test, it shown that PFC has the highest compressive strength for 7, 28 and 60 days compared to others. In a nutshell, based on observations and results obtained by this study, it can be concluded that the presence of PSBE that act as partial cement replacement is a beneficial, especially for the production of foamed concrete.

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# LIST OF SYMBOLS

| | |
|---|---|
| % | Percentage |
| g | Gram |
| $^0C$ | Degree Celcius |
| $kg/m^3$ | Kilogram Per Meter Cube |
| MPa | Mega Pascal |
| L | Litre |
| $m^3$ | Meter cube |
| kg | Kilogram |

# LIST OF ABBREVIATIONS

| | |
|---|---|
| Sdn. Bhd. | Sendirian Berhad |
| SBE | Spent Bleaching Earth |
| PSBE | Processed Spent Bleaching Earth |
| OPC | Ordinary Portland Cement |
| ASTM | American Society for Testing and Materials |
| BS | British Standard |
| FC | Foamed Concrete |
| PFC | Foamed Concrete with PSBE |
| PKC | Foamed Concrete with PSBE and Kenaf Fibre |
| w/c | Water per cement |
| UMP | University Malaysia Pahang |
| $CO_2$ | Carbon Dioxide |
| $C_3S$ | Tricalcium Silicate |
| $C_2S$ | Dicalcium Silicate |
| $C_3A$ | Tricalcium Aluminate |
| $C_4AH$ | Calcium Aluminate Hydrate |
| $SiO_2$ | Silicon Dioxide |
| $CaCO_3$ | Calcium Carbonate |
| $Ca(OH)_2$ | Calcium Hydroxide |
| C-S-H | Calcium Silicate Hydrate |
| $H_2O$ | Water |
| $Al_2O_3$ | Aluminium Oxide |
| $kg/m^3$ | Kilogram per meter cube |
| MPa | Mega Pascal |
| L | Litre |
| $m^3$ | Meter cube |
| kg | Kilogram |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

Nowadays, foamed concrete commonly used for the construction of large lightweight component such as beams and partitions rather than using the normal concrete because of its advantages. Foamed concrete consists of random air voids caused by the air bubbles created from the mixture of foaming agents in a mortar (Amran, Farzadnia, & Ali, 2015). The foaming agent used during the mixing process of foamed concrete must produce air bubbles that can withstand with a high level of stability and can resists to the physical and chemical from the mixing, placing and hardening process of foamed concrete.

Foamed concrete has unique properties such as low density which can help to reduce the structural dead loads. Furthermore, the low density of this concrete can reduce the labour cost as only a small amount of workers needed to manage and handle the construction. In addition, the transportation cost can be saved too. The lightweight properties of foamed concrete make the transportation cost of precast structure from the factory to the construction site cheaper because only smaller lorries or trailers needed to transport them compared with the structure made up of normal concrete. Besides, it enhances the fire resistance, thermal conductivity and sound absorbance due to its textural surface and microstructural cells. Other than that, foamed concrete also have high flowability, which they can compact themselves significantly, and reduce the dependency towards the usage of the vibrator.

Thus, this study will describe the results of a laboratory-based finding on temperature profiles that may arise in foamed concrete due to hydration of cement and their effect towards the cube strength. The use of processed spent bleaching earth also was investigated to reduce the temperature rises. Furthermore, this study will consider whether the temperature profiles and strengths can be estimated.

## 1.2 Problem of Statement

The more excessive construction that uses normal concrete rather than foamed concrete will lead the cutting of landfills activities happened continuously to produce the aggregates. Cutting of landfills will cause the destruction of the environment and disturbance towards the wildlife and aquatic ecosystem. Besides, cutting of landfills also may lead greenhouse effect to occur at the surrounding area where the development took place as trees and landfills will be cut down to get the construction materials from under the ground, which is the aggregates. The ecosystems of aquatic life also will be disrupted and the water quality at the river located near to the construction area become worse because of the flow of muddy water from the cut of landfills area will flow into the river.

Other than that, the cost of production of normal concrete is more expensive compared with foamed concrete. This happened because the production of normal concrete required aggregates, which not necessary for the production of foamed concrete. The labour cost to produce the normal concrete also higher than the labour cost for the production of foamed concrete as more workers needed to construct the structure using normal concrete because of high-density behaviour. Finally, high density of normal concrete cause the cost of the transportation for normal concrete is more expensive than the foamed concrete too as the precast structure made up by using normal concrete required larger size of transportation in order to be transported from the factory to the construction site compared with the structure made up of foamed concrete (Amran et al., 2015).

Besides, the production of concrete will produce carbon dioxide ($CO_2$) gaseous. The $CO_2$ produced due to the chemical effect that took place when the cement added with the water during the mixing and curing process. The $CO_2$ released towards the atmosphere. Abundant $CO_2$ will cause greenhouse effect happened. The more the construction occurs, the more the $CO_2$ gaseous released.

Lastly, cracking of concrete usually occurred at large structures due to some factors such as heat of hydration. The heat of hydration can be defined as a chemical reaction in which the major compounds in cement form chemical bonds with water molecules and become hydrates or hydration products. The larger the surface of a structure, the higher the heat of hydration. This is why cracking usually occur at large massive structure.

## 1.3 Objectives

The objectives of this study are:

i. To identify the flow values due to the presence of kenaf and processed spent bleaching earth (PSBE) on foamed concrete workability.
ii. To determine the effect of kenaf and processed spent bleaching earth (PSBE) on foamed concrete compressive strength.
iii. To determine the effect of kenaf and processed spent bleaching earth (PSBE) on the hydration of foamed concrete.

## 1.4 Scope of Research

This research was done to determine the workability of fresh, foamed concrete. Other than that, this research also was carried out to determine the compressive strength and heat of hydration of foamed concrete too. The workability test was carried out first before the concrete poured into the moulds according to ASTM C230/C230M Standard – Standard Specification for Flow Table for Use in Tests of Hydraulic Cement. The cube beams with a dimension of 150mm x 150mm x 150mm and 300mm x 300mm x 300mm were used for the heat of hydration test as followed to ASTM C186-17 – Standard Test Method for Heat of Hydration of Hydraulic Cement. Besides, the cube beams with a dimension of 150mm x 150mm x 150mm were used for compressive strength test as referred to ASTM C109 Standard-Standard Test Method for Compressive Strength of Hydraulic Cement Mortars.

## 1.5 Significant of Research

Processed Spent Bleaching Earth (PSBE) that used as a partial cement replacement was improved the strength of the foamed concrete. Other than that, the greenhouse effect can be sustained as PSBE act as partial cement replacement. By using a smaller amount of cement, the amount of carbon dioxide ($CO_2$) released to the atmosphere became lower. Besides, the heat of hydration also can be reduced by using a smaller amount of cement. Next, the presence of the kenaf fibre can prevent cracking of foamed concrete. Lastly, environmental pollution also can be reduced as the foamed concrete is a lightweight concrete that does not require aggregates to be mixed.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

A lot of researches (Munir et al., 2015)(Lim, Tan, Lim, & Lee, 2013)(Jitchaiyaphum, Sinsiri, & Chindaprasirt, 2011) done to investigate and analyse the composition and behaviours of pozzolanic materials towards the performances of foamed concrete. Nevertheless, there is still a lack of research and also published literature about the effect of processed spent bleaching earth (PSBE). Same goes to kenaf fiber, where quite a lot of investigations had been handled to investigate their properties but lack of researches done to study their effect towards foamed concrete. Thus, this research is done, where the objective of this thesis is to investigate the effect of processed spent bleaching earth and kenaf fiber as partial replacement of cement on the heat of hydration of foamed concrete, workability of foamed concrete and the compressive strength of foamed concrete.

This chapter discussed the applications of foamed concrete in the construction field. Then, the discussion was continued by discussing the details about the composition of foamed concrete such as Portland cement, sand, water and foaming agent and followed by the advantages of processed spent bleaching earth and kenaf fiber. Lastly, the review continued with laboratory testing for workability, the heat of hydration and compression test.

## 2.2 Foamed Concrete

Foamed concrete, or also known as foamcrete, lightweight cellular concrete or low-density concrete, is one of the lightweight concrete with a density of 400–1850 kg/m$^3$

(Farzadnia et al., 2015). Generally, no coarse aggregate consumed for the production of foamed concrete. During past a few years ago, lightweight concrete, which is foamed concrete that was good in thermal insulating behaviour have been widely used as exterior wall materials and explored by lots of researchers (Ma & Chen, 2016).

Besides, foamed concrete is good in fire resistant (Amran et al., 2015). It can withstand in the fire for a longer period compared to normal concrete. Previous research had shown that foamed concrete with a density of 950 $kg/m^3$ and 1200 $kg/m^3$ can withstand to fire resistant for 2 hours and 3.5 hours (Amran et al., 2015). Other than that, foamed concrete also good in thermal insulation properties. According to Amran, Fardzania and Ali, foamed concrete consists of closed cell structure that has a thermal conductivity of up to 0.66 W/mK at 1600 $kg/m^3$ density compared with a normal concrete that has a thermal conductivity of 1.6 W/mK at 2200 $kg/m^3$ (Farzadnia et al., 2015). Another previous study made by Jones and McCarthy (Jones et al., 2006) has shown that the value for thermal conductivity of foamed concrete with dry density range between 1000 to 1200 $kg/m^3$ are 0.23 and 0.42 W/mK. Some studies also have come out saying that the degree of thermal insulation depends on the mix proportions of the foamed concrete itself (Amran et al., 2015). Lastly, foamed concrete are high flowability and self-compacting concrete, that ease the mixing process of it.

Nevertheless, foamed concrete also has their weakness too, such as longer time is taken for the mixing process. Other than that, the presence of water in the mixed material will make the foamed concrete more sensitive and the increase in density causes the compressive strength and flexural strength decreases.

### 2.2.1 Application of Foamed Concrete

Currently, foamed concrete has many applications in civil and structural engineering field due to its advantages. The high compressive strength of foamed concrete with pozzolanic materials allows foamed concrete to be used for structural applications or load-bearing capacity (Harith, 2018). Besides, foamed concrete also utilized to construct lightweight blocks and pre-cast panels, fire insulation, thermal and acoustic insulation, road sub-base, trench reinstatement, soil stabilization and shock absorbing barriers for airports and regular traffic (Amran et al., 2015).

In Canada, foamed concrete commonly used for tunnel annulus grouting. Meanwhile, in the United Kingdom, the annual market size of foamed concrete was estimated around 250,000 to 300,000$m^{3,}$ including an extensive mine stabilization project. Other than that, about 250,000 $mm^3$ foamed concrete also frequently used to construct a floor heating system. In the Middle East, the behaviors of foamed concrete such as lightweight and thermal insulation made it being chosen to be the construction materials to overcome the impact of earthquake and changes of temperature. In Holland, foamed concrete had used to construct the road sub-base because the amount of load to be carried is low. Foamed concrete also had been used to build bridge abutments due to its low density and the cheaper cost for repairing and rehabilitation cost.

## 2.3 Composition of Foamed Concrete

### 2.3.1 Cement

Cement is a fine, soft and powdery-type substance that acts as a binder. Cement hardened when it is mixed with water. Generally, Portland cement is one of the most common type of cement used for the production of concrete in the construction industry. It is a fine powder, produced by the heating of limestone with clay minerals that form clinker. Then, the clinker will be grinded and added with 2 to 3 percent of gypsum. Portland cement also act as a binder that sets and hardens when it is mixed with water through a hydration process, that produced calcium silicate hydrate gel (Odler & Dörr, 1979). Previous studies also proved that the foamed concrete with densities of 1500 $kg/m^3$, produced an increment of compressive strength started from 7 days and continue to increase as the age of the concrete increases (Ngo, S.H.; Le, T.T.T.; Huynh, 2017).

Portland cement is made up of several materials such as lime, silica, alumina and iron oxide. The specific chemical composition of Portland cement  shown in Table 2.1.

Table 2.1 Chemical Composition of Portland Cement

| Parameters | OPC (%) |
|---|---|
| CaO | 55.49 |
| $SiO_2$ | 26.49 |
| $Al_2O_3$ | 9.81 |
| $Fe_2O_3$ | 3.90 |
| MgO | 0.80 |
| $SO_3$ | 4.72 |

(Source: (Loh et al., 2013) )

### 2.3.2 Sand

Sand is a granular material made up of rock and mineral particles. The principal component of sand is the mineral quartz, which is composed of silica with a density of 1000kg/$m^3$ to 1800kg/$m^3$ (Ahmed & Abdelrahman, 2013). Sand with particularly high silica level referred to as silica sand or industrial sand. Sand categorized as smaller aggregates as the size of the sand is normally smaller than 4.75mm. Sand is one of the important ingredients for the production of concrete. Normally, the ratio of cement to sand used during casting of concrete is one to three. Different types of sand will affect different strength of concrete. Other than that, different sand to cement ratio will produce concrete with different strength too. This is because of the effect of hydration of cement as cement is good with thermal insulation properties. The higher the amount of cement used, the higher the heat of hydration.

### 2.3.3 Water

As we know, our earth was covered up by 99% of water. This means water can be found easily, but water with good quality is a little bit harder to be found. In the construction area, good quality of water is necessarily needed to produce good performance concrete during the hydration process. Without water, the hydration process of cement cannot occur and concrete cannot be formed. Water must react with cement chemically to produce C-S-H gel and carbon dioxide for the strength development of concrete (Abbas & Majdi, 2017). Besides, the production of good concrete also required adequate water to cement ratio (Zuo, Hong, Xiong, Wang, & Song, 2018). Previous research (Fathilah, N. N. F. M. & Tan, n.d.) has proved that the range of water to cement ratio of foamed concrete lies between 0.36 to 0.38. Regularly, a mixture of 100 kilograms of cement will only consume around 40-45 litres of water. The lower amount of water will cause the concrete's workability to become lower and can reduce the amount of foam produced for foamed concrete. Meanwhile, if the amount of water used for casting concrete is higher, the number of air voids produced will be more significant and this can affect the strength of the concrete.

### 2.3.4 Foaming Agent

Commonly, there are various types of a foaming agent such as saponin, detergent and hydrolysed proteins. First of all, the foaming agent is a material that helps to accelerate the production of foam to produce foamed concrete. Besides, the foaming agent also helps to increase the stability and strength of the bubble foam. Until now, many types of research had been done regarding the foaming agent. The previous study revealed that a lower concentration of foaming agent increases the stability of the foams in the foamed concrete (Kuzielová, Pach, & Palou, 2016). Besides, the foam performance can affect the pore structure in the foamed concrete, too (Hilal, Thom, & Dawson, 2015). Furthermore, (Falliano, Domenico, Ricciardi, & Gugliandolo, 2018) states that the type of foaming agent effects the compressive strength of the foamed concrete and also the thermal resistance of normal concrete. It found that the increase of the compressive strength of foamed concrete occurs with the presence of protein foaming agents in the mix design. Another previous study had been carried out and states that pore structure produced by different foaming agent affect the properties of the foamed concrete such as strength, water absorption and drying shrinkage (Nambiar & Ramamurthy, 2007).

## 2.4 Processed Spent Bleaching Earth

### 2.4.1 Spent Bleaching Earth

Spent Bleaching Earth (SBE) comes from an edible oil refinery that has treated. Spent bleaching earth contains about up to 30% of residual oil that rapidly oxidizes and produces unpleasant odours (Mana, Ouali, de Menorval, Zajac, & Charnay, 2011). Spent bleaching earth can be disposed of through several processes such as incineration, inclusion in animal feeds, landfilling method, or concrete manufacturing. Currently, in Malaysia, the most commonly practiced method is disposal at the landfills, that may cause fire and pollution hazards due to the degradation of the residual oil in it. Furthermore, it also may associate greenhouse gas emissions upon its disposal (Loh et al., 2013). Meanwhile, in Japan, spent bleaching earth has been incinerated for cement manufacturing, but there is difficulty in maintaining good cement quality because of the high concentration of oil in spent bleaching earth.

### 2.4.2 Processed Spent Bleaching Earth

A greater amount of spent bleaching earth is formed as waste material by the process of refining crude edible soil. Then, the spent bleaching earth undergoes bleaching method to produce processed spent bleaching earth. Nowadays, processed spent bleaching earth widely used as to be the partial replacement of cement to reduce the heat produced during the hydration process that may affect the properties and strength of the concrete (Rokiah, Khairunisa, Youventharan, & Arif, 2019). Table 2.2 shows the chemical composition of the processed spent bleaching earth.

Table 2.2 Chemical Composition of Processed Spent Bleaching Earth

| Parameters | PSBE (%) |
|---|---|
| $CaO$ | 6.60 |
| $SiO_2$ | 55.82 |
| $Al_2O_3$ | 13.48 |
| $Fe_2O_3$ | 8.24 |
| $MgO$ | 5.94 |
| $SO_3$ | 1.05 |

(Source: (Loh et al., 2013) )

## 2.5 Fiber

Fibers usually used in concrete to control cracking due to plastic shrinkage and drying shrinkage. There are various types of fibers such as steel fibers, asbestos fibers, synthetic fibers, natural organic fibers and glass fibers (Kaur & Talwar, 2017). Kenaf fibers are one of the natural organic fibers. Kenaf fibers are made up of Hibiscus Cannabinus. It can be got easily in Southern Asia, though its exact origin is unknown. There are many advantages of kenaf fibers, such as reduce the bleeding and improves the cohesion of a concrete mix. Kenaf fibers also have disadvantages such as the mix is harder to be compacted and lower the workability of the concrete due to the presence of fibers. Previous researches have proved that kenaf fibers could improve properties of normal and foamed concrete. Based on a study conducted by (Kaur & Talwar, 2017), the mechanical properties of concrete such as the compressive strength, compressive modulus and splitting tensile strength could be improved by adding kenaf fibers into the mixtures. Another study that focuses on foamed concrete conducted by (Falliano, De Domenico, Ricciardi, & Gugliandolo, 2019) supported that the presence of kenaf fibers in the mixtures of foamed concrete could improve the compressive and the flexural strength of the foamed concrete.

## 2.6 Workability

### 2.6.1 Flow Table Test

Flow table test is one of the workability tests. It is practiced to determine the consistency of concrete by measuring the diameter of the flow of the concrete. The consistency of the concrete may be affected by several factors such as water to cement ratio, mixing rate, type of mixer, type and dosages of mineral addition and chemical admixtures (Senff et al., 2009).

Figure 2.1 Flow Table Test

The first mixture workability device designed by Marvillet and Bought in 1978 that have been used to determine the resistance of the mixture to mixing via a spring and potentiometer (C. Wang, Hao, Ruan, Zhang, & Adhikari, 2013). Historically, the workability of the concrete mixtures was verified based on the experience of the people that conduct the workability test(Cook, Ley, & Ghaeezadah, 2014). Generally, an adequate mixture of concrete must be ensured to get a good quality of concrete. A workability test is done to offer a standard measurement that evaluates the performance of a mixture based on their application to be used later. If the workability of a mixture is not enough, it is typical to add cement and water content of the mixture, that will increase the cost but lower the sustainability and durability of the concrete. The workability test usually is done when fresh concrete is delivered to the site by a truck mixer, to check its consistency before it is poured into the mould.

### 2.7 Heat of Hydration

The heat of hydration happened during the curing process of the concrete. Usually, the heat of hydration of concrete will take place only for the first several days of the curing process, depending on the type of concrete used. The quality of the mixing and curing water for the concrete are important because theoretically, water plays an important role to determine the mechanical behaviours during hydration of concrete (Lu et al., 2018). Usually, clear fresh water is used during mixing and curing of the concrete to control the heat of hydration, since excess dissolves ions rarely presence in fresh water. According to Lu, various types of the dissolved ions present in the sea water solution such as chloride ion ($Cl^-$) and sulphate ion ($SO_4^{2-}$), that can stimulate the physical and chemical reactions in concrete. This causes the hydration process of the cement that uses seawater will demonstrate differently from the ordinary hydration cement that uses fresh water (J. Wang, Liu, & Li, 2018). However, sometimes, it is quite challenging to obtain fresh water. To preserve the heat of hydration of concrete that has to use sea water, sufficient information and solution on the seawater need to be provided, or else, the concrete will be severely affected.

Other than that, high volume to surface area ratio also can affect the rise of core temperature due to the heat of hydration of concrete (Jones & Mccarthy, 2006). If the core or surface thermal gradients are large enough, cracking of the concrete may occur that also causes the concrete performance being affected. The cracking of concrete occurred when the concrete surface shows a temperature drop to ensure the thermal balance with the air temperature. The differences in the degree of temperature between the center and at the surface of the concrete will cause the concrete to expand and contract through tensile stress that causes the thermal crack to occur (Khan et al., 2014). In more tremendous cases, it also may lead to dehydration of the plastic concrete. Core temperature also may last longer in foamed concrete compare to normal concrete.

Based on history, (Jones & Mccarthy, 2006) have conducted several laboratory testing to investigate more on the heat of hydration of foamed concrete. Firstly, the study on the effect of cement content on the temperature profiles. The result from this testing concluded that lower cement content would lower the peak temperature achieved by the foamed concrete. Furthermore, the lower cement content mixes demonstrated much slower rates of temperature rise. Next, study on the effect of cement combinations towards the rate of temperature rise. The research also proved that the mixture of cement with sand also could lower the peak temperature and slows the rate of temperature rises.

## 2.8 Strength of Foamed Concrete

Strength of concrete is the ability of concrete to withstand the stress yielded by external forces without failure. Performance of concrete can be assessed from the mechanical properties or the structural behaviour of the concrete itself. Several tests can be done to test the strength and determine the properties of the concrete. For this research, the test that was carried out to test the concrete strength is the compressive strength test.

### 2.8.1 Compressive Strength

A compression test is one of the essential laboratory testings that test the compressive properties of concrete. Theoretically, compressive strength is the ability of the concrete to sustain the compressive load applied without any fracture that is measured in the unit of Pascal (Pa) or pound in a square inch (psi). Normally, the compressive strength test is conducted right after the curing process took place. The compressive test can be done at 7, 28 and 60 days after curing process took place. The normal samples used for the compressive strength test are cube and cylinder in shape.

Many factors can affect the compressive strength of concrete. Previous research had shown that the compressive strength of concrete depends on the mix design and the types of curing that took place on that concrete (Kupaei, Alengaram, Jumaat, & Nikraz, 2013). Other factors that also may affect the compressive strength of concrete are the quality of raw materials, water/cement ratio, temperature, relative humidity, compaction of concrete, age of concrete and the type of curing that the concrete undergoes (Lim et al., 2013). In general, the value of the compressive strength for the foamed concrete with a density of 400kg/m$^3$ to 600kg/m$^3$ is 0.13MPa to 14MPa (Tanveer, Jagdeesh, & Ahmed, 2017). Other research also is done to investigate the best curing method that can generate good compressive strength of foamed concrete. Based on the study conducted by (Ogah, 2016), a conclusion can be made about the best curing method that can generate good strength of normal concrete. The best curing method that can develop good compressive strength is air curing.


Figure 2.2 Compression Test

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

Throughout this chapter, the preparation of materials, specimens and the laboratory tests that involved in this research described. All the preparation for the materials and specimens and also the laboratory tests were carried out at the Concrete Laboratory, Faculty of Civil Engineering and Earth Resources, Universiti Malaysia Pahang. Figure 3.1 showed the flowchart of this research. The flow begins with the preparation of materials, casting of specimens and laboratory tests. Lastly, the tabulation of the data that have gathered from the laboratory testings.

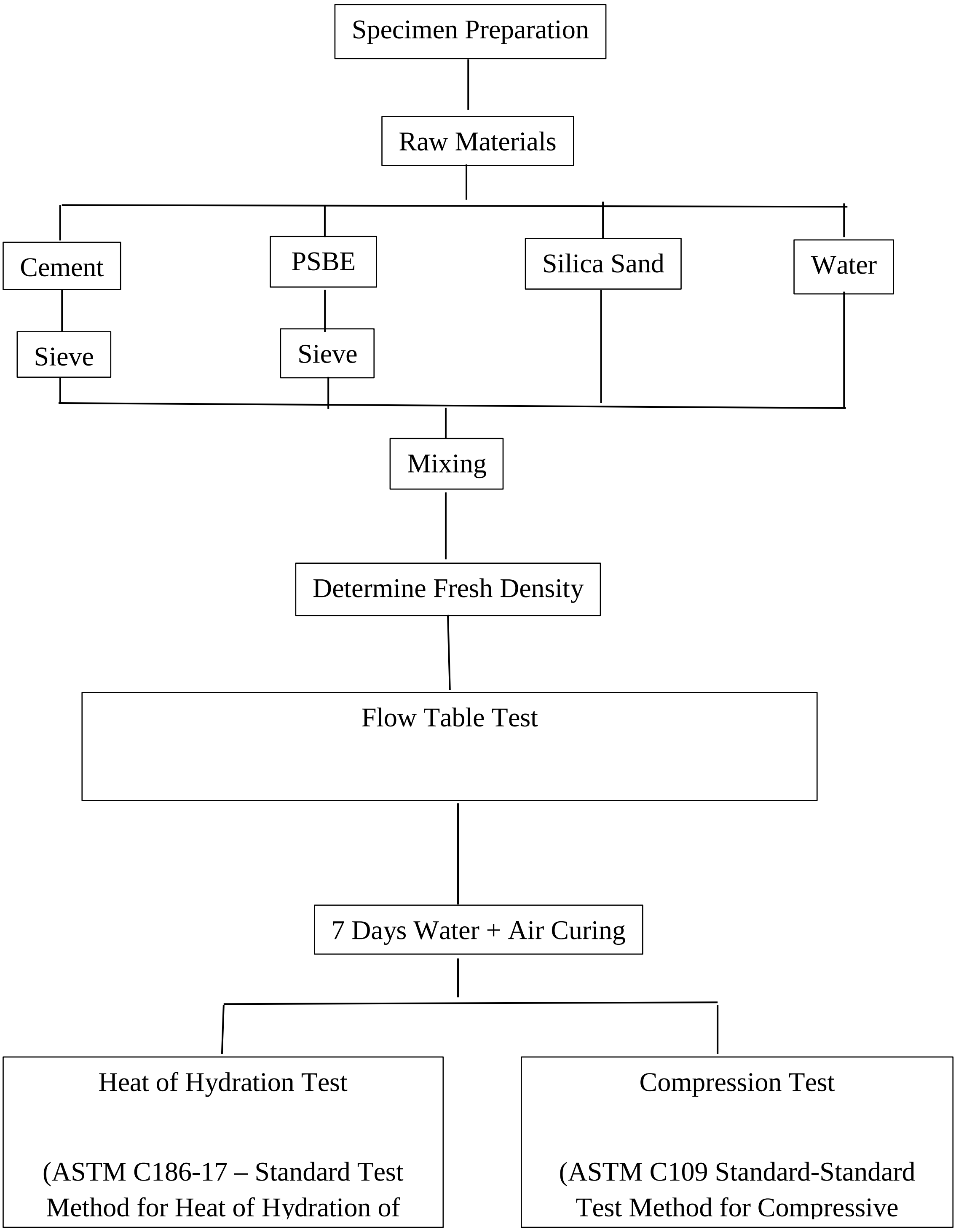


Figure 3.1 Flowchart of Study

### 3.2 Preparation of Materials

#### 3.2.1 Portland Cement

Ordinary Portland Cement, Type I cement has been used in this study to produce foamed concrete. The type of cement used in accordance with ASTM C150 (2012). It is known as "Orang Kuat" and was produced by YTL Cement Sdn. Bhd. The grade of the concrete is C30. Figure 3.2 shows the cement used for this study and Table 3.1 shows the chemical composition of Ordinary Portland Cement.


Figure 3.2 Ordinary Portland Cement

Table 3.1 Chemical Composition of Ordinary Portland Cement

| **Parameters** | **OPC (%)** |
|---|---|
| CaO | 55.49 |
| $SiO_2$ | 26.49 |
| $Al_2O_3$ | 9.81 |
| $Fe_2O_3$ | 3.90 |
| MgO | 0.80 |
| $SO_3$ | 4.72 |

### 3.2.2 Sand

The type of sand used was silica sand manufactured by Johor Silica Industries. The size of the silica sand is 425µm. Figure 3.3 shows the sand used throughout this study.


Figure 3.3 Silica Sand

### 3.2.3 Water

Water plays an essential role during the production of concrete to ensure the hydration and curing processes does not be affected by the quality of water. Impurities contain in water might influence the chemical reaction between cement and water to produce the C-S-H gel. Clean tap water used in this study.

### 3.2.4 Foaming Agent

The foaming agent is needed to produce foams for the production of foamed concrete. For this study, protein synthetic foaming agent has been used to produce preformed foam. The preformed foamed produced by diluting 1 liter of the foaming agent into 25 liters of water. The density of the preformed foam in this study is in the range between 50kg/m$^3$ to 60kg/m$^3$ by following to the standard ASTM C697. Figure 3.4 shows the foaming agent and Figure 3.5 shows the preformed foam.


Figure 3.4 Protein Foaming Agent

Figure 3.5 Pre-foamed Foam

### 3.2.5 Processed Spent Bleaching Earth

Processed Spent Bleaching Earth (PSBE) classified as Class N Natural Pozzolan in accordance with ASTM C618-12. PSBE used for this study was provided by Eco-Innovation Sdn. Bhd. The PSBE was dried under the sun for two days and sieved passing size 300µm before being mix with the cement. Figure 3.6 shows the sieve machine that has been used to sieve the PSBE and Figure 3.7 shows the PSBE that has passed the 300µm sieve.

Figure 3.6 Sieve Machine

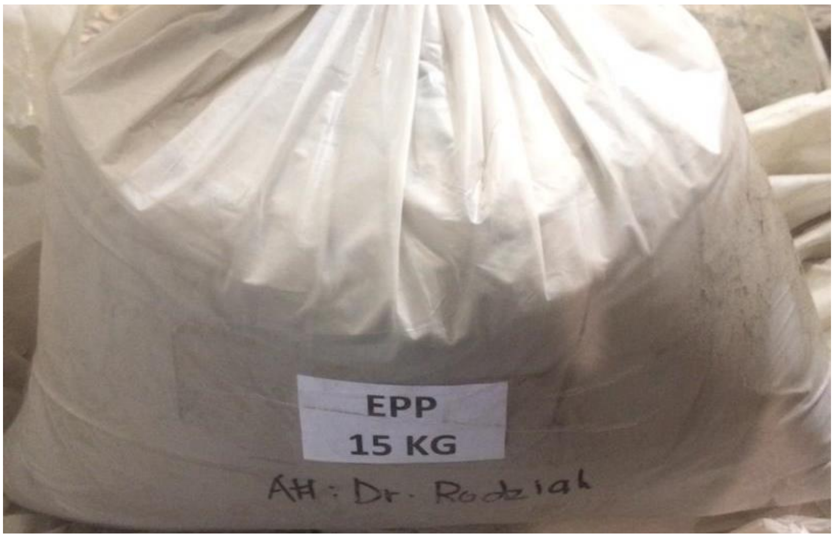


Figure 3.7 Processed Spent Bleaching Earth

### 3.2.6 Fiber

The fiber used for this study is kenaf fiber. The 5cm cut the kenaf fiber and treated in a sodium hydroxide solution for 24 hours before being used for mixing. Table 3.2 shows the proportion of kenaf fiber; Figure 3.8 shows kenaf fiber and sodium hydroxide used for this study.

Table 3.2 Proportion of Kenaf Fibre

| Parameters | Kenaf Fiber |
|---|---|
| Cellulose % | 70.00 |
| Hemicellulose % | 19.00 |
| Lignin % | 3.00 |
| Ash % | 1.3 |


Figure 3.8 Kenaf Fibre and Sodium Hydroxide

## 3.3 Mix Proportion of Foamed Concrete

For this study, three types of mixtures were prepared namely foamed concrete only (FC), that act as a controlled mixture, a combination of foamed concrete with 30% processed spent bleaching earth (PFC) and mix of foamed concrete with 30% processed spent bleaching earth and 0.5% kenaf fiber (PKC). Table 3.3 shows the mix proportion of the foamed concrete for this study.

Table 3.3 Mix Proportion of Foamed Concrete

| Mixture | Density ($kg/m^3$) | Cement (kg) | PSBE (kg) | Kenaf (kg) | Sand (kg) | Water (L) | Volume ($m^3$) |
|---|---|---|---|---|---|---|---|
| FC | 1600 | 69.7 | - | - | 104.5 | 34.8 | 0.13 |
| PFC | 1600 | 48.8 | 20.9 | - | 104.5 | 28.3 | 0.13 |
| PKC | 1600 | 48.8 | 20.9 | 0.24 | 104.5 | 28.3 | 0.13 |

## 3.4 Production of Foamed Concrete

### 3.4.1 Mixing Process

For this study, foamed concrete prepared by mixing of cement, silica sand, water, PSBE, kenaf fiber and preformed foamed by referring to ASTM C796. Firstly, the preformed foamed produced by diluting 1 liter of foaming agent for every 25 liters of water into the foam machine. Then, the density of the foamed was measured and it was ensured that the density was in the range between 50 to 60 $kg/m^3$. Later, the preformed foam was mix with the cement paste continuously until the mix was mix consistently. After that, 1 liter of the fresh foamed concrete taken and weight to confirm the density of the fresh foamed concrete was 1600$kg/m^3$. Next, the fresh foamed concrete's workability was tested by doing a flow table test according to ASTM C230/C230M to check the flowability of the fresh foamed concrete. The fresh foamed concrete is then poured into the cube specimens and cured with air. Figure 3.9 shows the fresh foamed concrete.

Figure 3.9 Fresh Foamed Concrete

### 3.4.2 Preparation of Specimens

In this study, nine cubes with size 300mm x 300mm x 300mm and 27 cubes of size 150mm x 150mm x 150mm prepared for each mixing type according to ASTM C796. Figure 3.10 and Figure 3.11 shows the specimens used, while Table 3.4 shows the details about the specimens used.

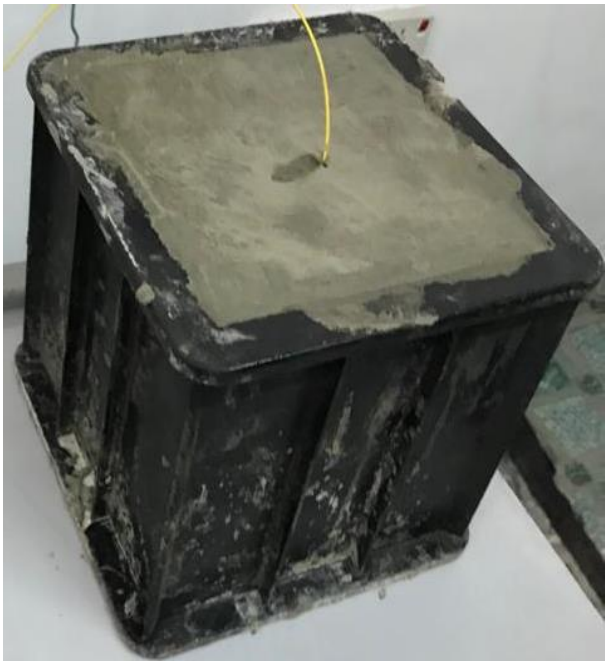

Figure 3.10 150mm x 150mm x 150mm cube

Figure 3.11 300mm x 300mm x 300mm cube

Table 3.4 Specimens Preparation

| SPECIMENS | TESTINGS | FC | | | PFC | | | PKC | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 7d | 28d | 60d | 7d | 28d | 60d | 7d | 28d | 60d |
| 150 x 150 x 150 mm | Heat of Hydration | 3 | - | - | 3 | - | - | 3 | - | - |
| | Compression Test | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 300 x 300 x 300 mm | Heat of Hydration Test | 3 | - | - | 3 | - | - | 3 | - | - |

### 3.5 Experimental Testing

For this research, the test that was carried out is workability, the heat of hydration and compression test.

#### 3.5.1 Workability Test

In this study, the flow table test conducted to check the workability of the foamed concrete by measuring the flowability of the concrete following to ASTM C230/ C230M standard. A flow table with a diameter of 255mm and flow mold with a diameter of 100mm used to conduct this test. Before the workability test started, the flow table and flow mold were ensured to be clean and in dry condition. Firstly, the flow table and flow mold were wiped gently to ensure it is clean and dry. After that, the flow mold placed at the center of the flow table. Later, the foamed concrete poured into the flow mold for the first layer, which is about 25mm thick. The concrete then tamped for 20 times by using the tamping rod to ensure the foamed concrete fills the flow mold uniformly. Next, the foamed concrete was poured again for the second layer and was tamped for 20 times too by using the tamping rod. Then, the overfilled foamed concrete was struck off to ensure a flat and smooth surface on top of the flow mold. After that, the flow mold lifted properly and the table was dropped immediately after 1 minute for 25 times in 15 seconds. Lastly, the diameter of the flow of the foamed concrete measured by using the measuring tape. According to previous research, the result of the flow table test should be in the range of 180-200mm. Figure 3.12 shows the flow table test.

Figure 3.12 Flow Table Test

### 3.5.2 Heat of Hydration Test

In this study, the heat of hydration test conducted by using thermocouples and a data logger, following ASTM C186-17 Standards. The thermocouples placed at the middle on the surface of the specimens and they were connected to the data logger as shown in Figure 3.12. The duration of this test was seven days. The data collected from the data logger on the 7$^{th}$ day. The cube specimens with dimension 300mm x 300mm x 300mm and 150mm x 150mm x 150mm were tested and evaluated. Figure 3.13 shows the specimens used for this testing and Figure 3.14 shows the testing set up for this study.

Figure 3.13 Preapartion of Specimens of Heat of Hydration


Figure 3.14 Heat of Hydration Setup

### 3.5.3 Compression Test

Firstly, the size of the mould used for the compression test in this study was 150mm x 150mm x 150mm. The concrete was filled into the moulds and was left to harden within three days. Then, the process continued by air curing. After that, the compression test was conducted for the concrete age of 7 days, 28 days and 60 days. The hydraulic Mechanic machine used for the compression test. The compressive strength of the foamed concrete was measured by observed and recorded the maximum load that the specimens can carry. Before that, the specimens that prepared was firstly placed at the center of the bearing plate and the upper and lower plain surfaces were correctly positioned as shown in Figure 3.15. This test carried in accordance with ASTM C109 Standards.


Figure 3.15 Hydraulic Mechanic Machine

# CHAPTER 4

# RESULTS AND DISCUSSION

## 4.1 Introduction

This study is performed to investigate the enhancement on the performance of the foamed concrete with the inclusion of partial replacement of cement using Processed Spent Bleaching Earth (PSBE), added with kenaf fiber. In this study, the main objective for the inclusion of PSBE and kenaf fiber into the mixture of the foamed concrete is to identify the internal temperature of the foamed concrete. The foamed concrete consists replacement of cement with PSBE and inclusion of kenaf fiber prepared. With this modification, three objectives aimed that is to study the effect of PSBE and kenaf fiber towards workability, the heat of hydration and compressive strength of foamed concrete.

Low flowability of fresh foamed concrete, a reduction on foamed concrete's heat of hydration and an increase in compressive strength expected from this study for better concrete performance, thus increase its concrete strength and durability. In this chapter, the results obtained from the experiment were carried out based on the research methodology. The results for all the laboratory testing conducted compared. After comparing all the results, the determination has been made to conclude on the effect of PSBE and kenaf fiber towards workability, the heat of hydration and compressive strength of foamed concrete. The suitability for the presence of PSBE and kenaf fiber into the foamed concrete analysed and recommendation has been made.

## 4.2 Workability

Figure 4.1 has shown that inclusion of PSBE and kenaf fiber has flow table values that lie within 180 to 195mm. From the bar chart, it can be seen that the addition of PSBE and kenaf fiber into the foamed concrete lowered the flowability of the fresh foamed concrete. It can be seen that FC produce the highest flowability of fresh foamed concrete with flow table value of 195mm, followed by PFC with flow table value of 185mm and the lowest flowability, PKC with flow table value of 180mm.

This happened due to the reduction in fineness modulus of cementitious materials. Both PSBE and kenaf fiber have a finer particle size, compared to OPC. Therefore, both PSBE and kenaf fiber has a larger surface area in the concrete and will need a higher amount of water to make the concrete more workable. However, the amount of fresh water used during the casting process is the same for all of the mixtures. Hence, that is the reason why the workability of the fresh foamed concrete becomes lower with the inclusion of PSBE and kenaf fiber.

The workability of the fresh foamed concrete with the inclusion of PSBE and kenaf fiber could be improved by adding superplasticizer. Superplasticizer, also known as a high range water reducer which could be categorized as chemical admixture, that could improve the flow characteristics of a foamed concrete. A similar trend of result reported by Azmi in 2016 through his finding on the strength of processed spent bleaching earth as partial replacement of cement in foamed concrete that has proved that presence of PSBE as partial cement replacement could reduce the workability of fresh foamed concrete.

Table 4.1 Flow table values for different mixtures

| Mixture | Flow table values (mm) |
|---|---|
| **FC** | 195 |
| **PFC** | 185 |
| **PKC** | 180 |

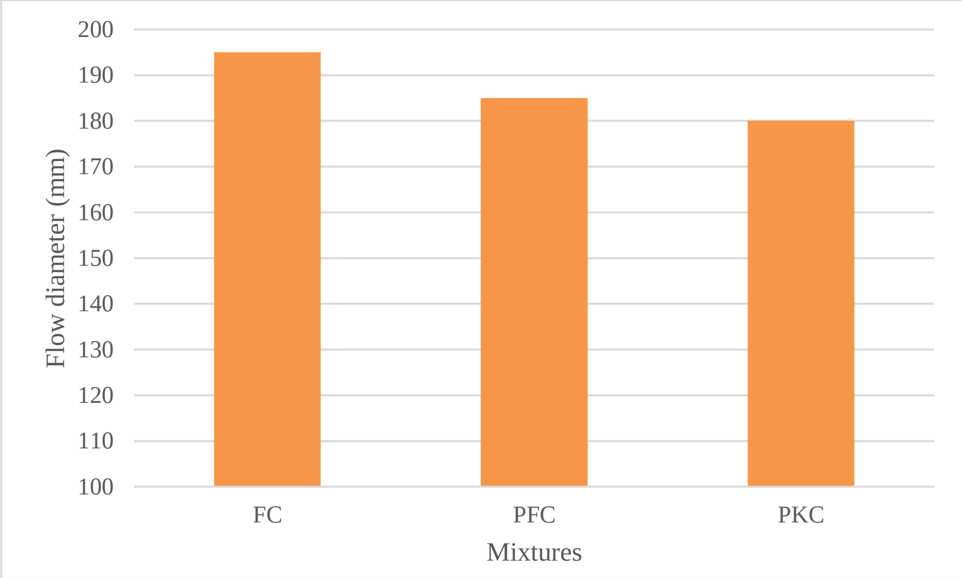


Figure 4.1 Comparison of flow table values

## 4.3 The heat of the Hydration

Figure 4.2 showed the internal temperature of the specimens that took place during the heat of hydration test that was carried out for seven days. Based on the graph, it can be concluded that FC has the highest internal temperature for both 150x150x150mm and 300x300x300mm sample sizes, followed by PFC and PKC. The heat of hydration happened due to the hydration process, a reaction between cement and water that evolved the heat, that is called heat of hydration. So, this study has proved that the presence of PSBE that act as partial cement replacement can reduce the heat generated during the hydration process.

Also, it showed that the longest time consumed for PKC to achieve the peak temperature followed by PFC and FC, for both 150x150x150mm and 300x300x300mm cubes. Therefore, it has discovered that the inclusion of the PSBE can help to increase the time taken for the concrete to achieve the peak temperature. Overall, PKC is the best mixture that can be lowered and decreased the time taken for the foamed concrete to achieve the peak temperature.

Other than that, the size of specimens also affected the heat of hydration of the foamed concrete. Based on the graph, it can be seen that the internal temperature of the specimens with dimension 300x300x300mm is higher than the internal temperature of the specimens with size 150x150x150mm. So, it concluded that the larger the size of the specimens, the higher the heat of hydration of the foamed concrete. This happened due to the higher volume to surface area ratio of the larger specimen size.

In conclusion, the presence of PSBE as partial cement replacement and kenaf fiber have help to improve the heat of hydration process by lowering the peak temperature of hydration other than delay the time taken for the concrete to achieve the peak temperature. So, the cracking problem also can be prevented with the presence of PSBE that act as partial cement replacement. Besides, the bigger size of specimens will produce higher heat of hydration that occurs during the curing period of the foamed concrete.

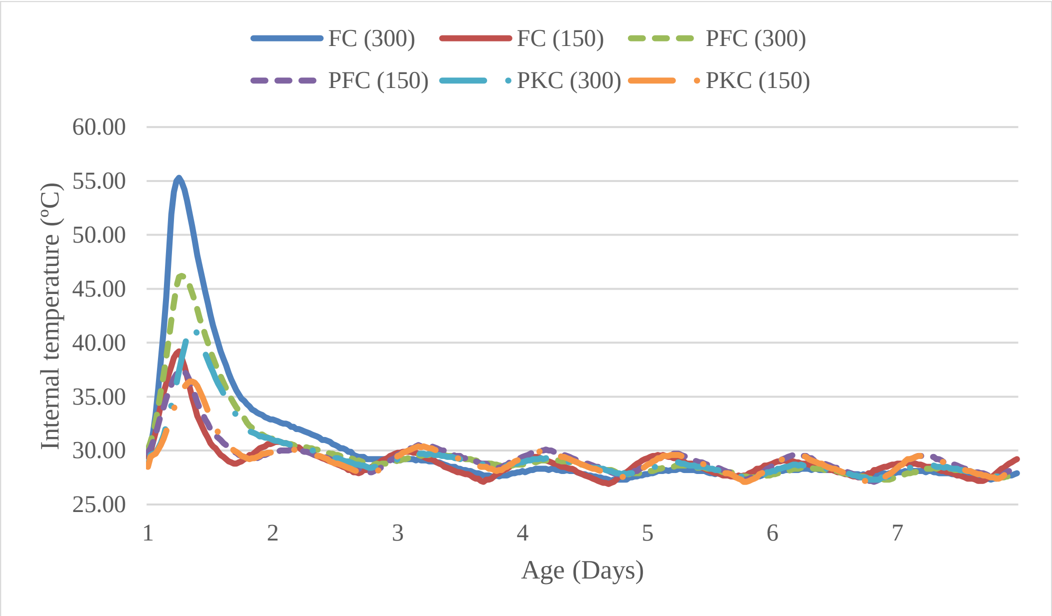


Figure 4.2 Comparison of internal temperature

## 4.4 Compression Strength

Table 4.2 and Figure 4.3 showed the result of the compressive strength of the foamed concrete at the age of 7, 28 and 60 days. Based on the results, it can be seen that PFC has the highest compressive strength at 28 days, followed by PKC and FC. The compressive strength gained by PFC at 28 days is 6.042MPa, which is about 37% greater than the compressive strength of the control mixture, FC. It also can be seen that the compressive strength of PFC is the highest at the age of 60 days with a value of 9.018MPa.

Every cement goes through the hydration process, as shown in Equation 1.1. The OPC will react with water to form Calcium-Silicate-Hydrate (CSH) gel and Calcium Hydroxide, $Ca(OH)_2$. For the increasing of compressive strength with the presence of PSBE, this is because of the reaction that took place between $Ca(OH)_2$ with silica in the pozzolanic materials that formed secondary CSH gel as shown in Eq. 2. This reaction is called a pozzolanic reaction. A higher denser foamed concrete with higher compressive strength can be obtained through this process.

$$\text{Cement} + H_2O \longrightarrow CSH + Ca(OH)_2 \qquad \text{(Eq. 1)}$$

$$\text{Pozzolans} + Ca(OH)_2 \longrightarrow CSH \qquad \text{(Eq. 2)}$$

But the inclusion of kenaf fiber is insignificance to improve the compressive strength of the foamed concrete. Theoretically, kenaf fiber only helps to improve the flexural strength but not for compressive strength.

In conclusion, the presence of PSBE that act as partial cement replacement of cement is beneficial to produce foamed concrete with higher compressive strength. Sharba has reported a similar trend of the result, Leman, Sultan, Ishak and Azmah Hanim through their findings on partial replacement of glass fiber by woven kenaf in hybrid composites and its effect on monotonic and fatigue properties that also shows that the compressive strength increases over age with the inclusion of partial cement replacement materials.

Table 4.2 Compressive strength values for different mixtures

| Mixtures | Average Compressive Strength (MPa) | | |
|---|---|---|---|
| | 7 days | 28 days | 60 days |
| FC | 2.437 | 4.414 | 5.326 |
| PFC | 3.584 | 6.042 | 9.018 |
| PKC | 3.247 | 5.424 | 6.785 |

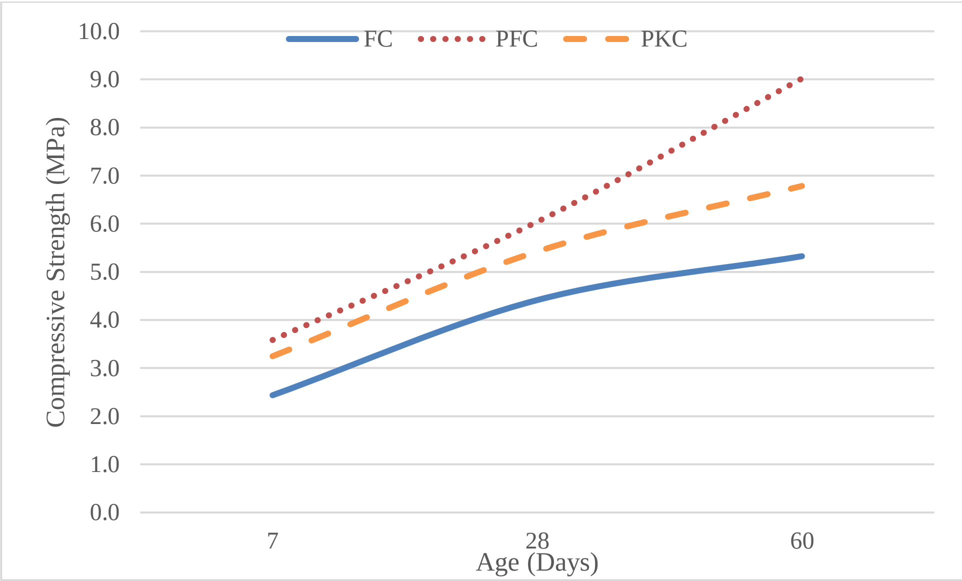


Figure 4.3 Comparison for compressive strength at the age of 7, 28 and 60 days

# CHAPTER 5

# CONCLUSION AND RECOMMENDATION

## 5.1 Introduction

In this research, the application of PSBE as partial replacement material of cement and kenaf fiber in foamed concrete was carried out to evaluate the performance and strength of the foamed concrete. The data that have collected presented that the inclusion of PSBE and kenaf fiber into the mixture lead to positive influence on foamed concrete properties. This chapter highlighted several conclusions drawn from the research conducted.

## 5.2 Conclusion

In this research, the application of PSBE as partial replacement material of cement and kenaf fiber in foamed concrete was carried out to evaluate the performance and strength of the foamed concrete. The data that have collected presented that the inclusion of PSBE and kenaf fiber into the mixture leads to a positive influence on foamed concrete properties. This chapter highlighted several conclusions drawn from the research that was conducted.

As a conclusion, the results from the tests that have conducted have shown that the inclusion of PSBE and kenaf fiber into the foamed concrete mixture is satisfactory. From the experimental results, the conclusion of this study can be summarized as follows:

1 The workability of foamed concrete has shown to be decreasing with the inclusion of PSBE and kenaf fiber. PSBE have been used as pozzolanic materials, that act

as partial cement replacement while kenaf has used as fiber. Both PSBE and kenaf fiber have finer particles compared to OPC. This means that PSBE and kenaf fiber has a larger surface area than OPC. A larger surface area indicates to have a higher amount of water to make the fresh foamed concrete more workable. Thus, the inclusion of PSBE and kenaf fiber will decrease the workability of the fresh foamed concrete. To improve the flow properties of the concrete, superplasticizer was recommended to be used.

2 PSBE and kenaf fiber also have given a positive impact on the heat of hydration test. It is shown that PKC has the lowest temperature, followed by PFC and FC for both 150x 150x 150mm and 300x 300x 300mm cubes size. It also is shown that longest time delay consumed by PKC, followed by PFC and PKC for both 150x 150x 150mm and 300x 300x 300mm cubes size. This happened due to the inclusion of PSBE as partial cement replacement and kenaf fiber that helps to improve the heat of hydration process by lowering the peak temperature of hydration other than delay the time taken for the concrete to achieve the peak temperature. This study also has revealed that the size of specimens also affects the heat of hydration. The result of this study has proved that a smaller size of specimens produced lower internal peak temperature for the heat of hydration.

3 For the compression test, the result has shown that PFC has the highest compressive strength, followed by PKC and FC. This happened because a higher density of foamed concrete with higher compressive strength can be obtained through the hydration process that involves pozzolanic materials with $Ca(OH)_2$ only. But the inclusion of kenaf fiber is insignificance to improve the compressive strength of the foamed concrete. It has been proved by the previous study that concluded kenaf fiber help to enhance the flexural strength only but not for compressive strength.

## 5.3 Recommendation

This study mainly focuses on the performance of PSBE and kenaf fiber towards the workability, heat of hydration and compressive strength of foamed concrete. The utilization of PSBE and kenaf fiber into the foamed concrete is strongly recommended based on the results achieved. However, several improvements need to be done for better future work. Below are some recommendation for further studying in the future:

- Use a wide range of data series collection for curing ages. For example, cure the concrete for one year to get more accurate data for this study.
- Use PSBE with more fineness to improve the performance of the foamed concrete. A finer particle of PSBE believes in enhancing the compressive strength of foamed concrete.
- The used of superplasticizer could improve the compressive strength of the foamed concrete.
- Use admixture such as Palm Oil Fuel Ash as replacement of sand and fine aggregates to reduce the heat of hydration effect further.
- Use larger size of specimens such as beams for more precise effect on the heat of hydration.

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## APPENDIX A
## RESULT FOR HEAT OF HYDRATION

| TIME | | FC (300) | FC (150) | PFC (300) | PFC (150) | PKC (300) | PKC (150) |
|---|---|---|---|---|---|---|---|
| Day 1 | 19-02-21 15:32 | 29.70 | 29.70 | 29.90 | 29.70 | 28.50 | 28.50 |
| | 19-02-21 16:02 | 29.60 | 29.40 | 30.10 | 29.80 | 28.60 | 28.50 |
| | 19-02-21 16:32 | 30.40 | 29.90 | 30.80 | 30.20 | 29.60 | 29.40 |
| | 19-02-21 17:02 | 31.70 | 30.80 | 31.60 | 30.80 | 29.70 | 29.60 |
| | 19-02-21 17:32 | 33.40 | 31.70 | 32.70 | 31.50 | 29.80 | 29.70 |
| | 19-02-21 18:02 | 35.70 | 33.10 | 34.00 | 32.40 | 30.20 | 30.10 |
| | 19-02-21 18:32 | 38.30 | 34.20 | 35.50 | 33.30 | 30.70 | 30.50 |
| | 19-02-21 19:02 | 41.20 | 35.40 | 37.00 | 34.00 | 31.40 | 31.10 |
| | 19-02-21 19:32 | 44.20 | 36.20 | 38.60 | 34.80 | 32.30 | 31.80 |
| | 19-02-21 20:02 | 48.10 | 37.10 | 40.30 | 35.50 | 33.20 | 32.50 |
| | 19-02-21 20:32 | 51.90 | 37.80 | 42.10 | 36.10 | 34.20 | 33.20 |
| | 19-02-21 21:02 | 54.00 | 38.60 | 43.70 | 36.70 | 35.20 | 33.90 |
| | 19-02-21 21:32 | 55.00 | 39.00 | 45.20 | 37.10 | 36.20 | 34.40 |
| | 19-02-21 22:02 | 55.30 | 39.20 | 46.10 | 37.40 | 37.40 | 35.00 |
| | 19-02-21 22:32 | 54.90 | 38.60 | 46.20 | 37.50 | 38.50 | 35.50 |
| | 19-02-21 23:02 | 54.20 | 37.80 | 46.10 | 37.30 | 39.60 | 35.90 |
| | 19-02-21 23:32 | 53.20 | 36.90 | 45.80 | 37.00 | 40.60 | 36.20 |
| | 20-02-21 0:02 | 52.00 | 35.90 | 45.30 | 36.50 | 41.30 | 36.40 |
| | 20-02-21 0:32 | 50.80 | 34.90 | 44.60 | 35.80 | 41.50 | 36.40 |
| | 20-02-21 1:02 | 49.50 | 34.10 | 43.90 | 35.20 | 41.30 | 36.30 |
| | 20-02-21 1:32 | 48.10 | 33.20 | 43.10 | 34.50 | 40.80 | 36.00 |
| | 20-02-21 2:02 | 47.00 | 32.70 | 42.20 | 33.90 | 40.20 | 35.50 |
| | 20-02-21 2:32 | 45.80 | 32.10 | 41.50 | 33.40 | 39.70 | 34.90 |
| | 20-02-21 3:02 | 44.70 | 31.60 | 40.70 | 32.90 | 39.00 | 34.30 |
| | 20-02-21 3:32 | 43.70 | 31.20 | 40.00 | 32.50 | 38.40 | 33.70 |
| | 20-02-21 4:02 | 42.60 | 30.70 | 39.20 | 32.00 | 37.80 | 33.10 |
| | 20-02-21 4:32 | 41.60 | 30.40 | 38.60 | 31.80 | 37.30 | 32.60 |
| | 20-02-21 5:02 | 40.80 | 30.20 | 38.00 | 31.40 | 36.70 | 32.10 |
| | 20-02-21 5:32 | 40.00 | 29.90 | 37.40 | 31.20 | 36.20 | 31.70 |
| | 20-02-21 6:02 | 39.20 | 29.60 | 36.90 | 31.00 | 35.80 | 31.40 |
| | 20-02-21 6:32 | 38.50 | 29.40 | 36.30 | 30.70 | 35.30 | 31.00 |
| | 20-02-21 7:02 | 37.90 | 29.20 | 35.80 | 30.50 | 34.80 | 30.80 |
| | 20-02-21 7:32 | 37.20 | 29.00 | 35.30 | 30.30 | 34.40 | 30.50 |
| | 20-02-21 8:02 | 36.60 | 28.90 | 34.80 | 30.10 | 34.00 | 30.30 |
| | 20-02-21 8:32 | 36.10 | 28.80 | 34.40 | 29.90 | 33.60 | 30.00 |
| | 20-02-21 9:02 | 35.60 | 28.80 | 34.00 | 29.80 | 33.30 | 29.90 |
| | 20-02-21 9:32 | 35.20 | 28.90 | 33.70 | 29.60 | 32.90 | 29.70 |
| | 20-02-21 10:02 | 34.80 | 29.00 | 33.30 | 29.50 | 32.50 | 29.50 |
| | 20-02-21 10:32 | 34.60 | 29.20 | 33.00 | 29.40 | 32.30 | 29.40 |

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|---|---|---|---|---|---|---|---|
| | 20-02-21 11:02 | 34.30 | 29.30 | 32.60 | 29.30 | 32.00 | 29.30 |
| | 20-02-21 11:32 | 34.10 | 29.60 | 32.30 | 29.20 | 31.80 | 29.20 |
| | 20-02-21 12:02 | 33.80 | 29.60 | 32.10 | 29.30 | 31.70 | 29.30 |
| | 20-02-21 12:32 | 33.70 | 29.80 | 31.90 | 29.30 | 31.60 | 29.30 |
| | 20-02-21 13:02 | 33.50 | 30.00 | 31.70 | 29.30 | 31.50 | 29.40 |
| | 20-02-21 13:32 | 33.40 | 30.20 | 31.50 | 29.40 | 31.30 | 29.50 |
| | 20-02-21 14:02 | 33.30 | 30.30 | 31.50 | 29.60 | 31.30 | 29.70 |
| | 20-02-21 14:32 | 33.10 | 30.40 | 31.30 | 29.60 | 31.20 | 29.70 |
| | 20-02-21 15:02 | 33.00 | 30.60 | 31.20 | 29.70 | 31.20 | 29.80 |
| Day 2 | 20-02-21 15:32 | 32.90 | 30.60 | 31.10 | 29.80 | 31.10 | 29.80 |
| | 20-02-21 16:02 | 32.90 | 30.70 | 31.10 | 29.80 | 31.00 | 29.90 |
| | 20-02-21 16:32 | 32.80 | 30.80 | 30.90 | 29.80 | 30.90 | 29.90 |
| | 20-02-21 17:02 | 32.70 | 30.80 | 30.90 | 29.90 | 30.90 | 30.00 |
| | 20-02-21 17:32 | 32.60 | 30.80 | 30.80 | 30.00 | 30.80 | 30.00 |
| | 20-02-21 18:02 | 32.50 | 30.70 | 30.70 | 30.00 | 30.70 | 30.00 |
| | 20-02-21 18:32 | 32.50 | 30.70 | 30.70 | 30.00 | 30.70 | 30.00 |
| | 20-02-21 19:02 | 32.40 | 30.60 | 30.60 | 30.00 | 30.60 | 30.10 |
| | 20-02-21 19:32 | 32.20 | 30.50 | 30.60 | 30.10 | 30.50 | 30.10 |
| | 20-02-21 20:02 | 32.20 | 30.50 | 30.50 | 30.10 | 30.50 | 30.10 |
| | 20-02-21 20:32 | 32.00 | 30.30 | 30.40 | 30.00 | 30.40 | 30.00 |
| | 20-02-21 21:02 | 32.00 | 30.30 | 30.40 | 30.00 | 30.40 | 30.00 |
| | 20-02-21 21:32 | 31.90 | 30.10 | 30.40 | 30.00 | 30.30 | 30.00 |
| | 20-02-21 22:02 | 31.80 | 30.00 | 30.30 | 29.90 | 30.30 | 29.90 |
| | 20-02-21 22:32 | 31.70 | 30.00 | 30.30 | 29.90 | 30.20 | 29.90 |
| | 20-02-21 23:02 | 31.60 | 29.90 | 30.20 | 29.80 | 30.10 | 29.80 |
| | 20-02-21 23:32 | 31.50 | 29.70 | 30.20 | 29.70 | 30.00 | 29.70 |
| | 21-02-21 0:02 | 31.40 | 29.60 | 30.10 | 29.60 | 30.00 | 29.60 |
| | 21-02-21 0:32 | 31.30 | 29.50 | 30.10 | 29.60 | 29.90 | 29.50 |
| | 21-02-21 1:02 | 31.20 | 29.40 | 30.00 | 29.50 | 29.90 | 29.50 |
| | 21-02-21 1:32 | 31.00 | 29.30 | 29.90 | 29.50 | 29.80 | 29.40 |
| | 21-02-21 2:02 | 31.00 | 29.20 | 29.90 | 29.40 | 29.70 | 29.30 |
| | 21-02-21 2:32 | 30.90 | 29.10 | 29.80 | 29.30 | 29.60 | 29.20 |
| | 21-02-21 3:02 | 30.80 | 29.00 | 29.70 | 29.20 | 29.50 | 29.00 |
| | 21-02-21 3:32 | 30.60 | 28.90 | 29.70 | 29.10 | 29.40 | 28.90 |
| | 21-02-21 4:02 | 30.50 | 28.80 | 29.60 | 29.00 | 29.30 | 28.80 |
| | 21-02-21 4:32 | 30.40 | 28.70 | 29.60 | 28.90 | 29.30 | 28.80 |
| | 21-02-21 5:02 | 30.20 | 28.60 | 29.50 | 28.90 | 29.20 | 28.70 |
| | 21-02-21 5:32 | 30.20 | 28.50 | 29.40 | 28.70 | 29.10 | 28.60 |
| | 21-02-21 6:02 | 30.10 | 28.40 | 29.30 | 28.60 | 29.00 | 28.50 |
| | 21-02-21 6:32 | 29.90 | 28.20 | 29.30 | 28.60 | 29.00 | 28.40 |
| | 21-02-21 7:02 | 29.90 | 28.20 | 29.30 | 28.50 | 28.90 | 28.30 |
| | 21-02-21 7:32 | 29.60 | 28.00 | 29.20 | 28.40 | 28.80 | 28.20 |
| | 21-02-21 8:02 | 29.50 | 28.00 | 29.00 | 28.30 | 28.70 | 28.10 |
| | 21-02-21 8:32 | 29.40 | 27.90 | 29.10 | 28.30 | 28.70 | 28.10 |

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| | 21-02-21 9:02 | 29.40 | 28.00 | 29.00 | 28.30 | 28.60 | 28.10 |
| | 21-02-21 9:32 | 29.40 | 28.20 | 28.90 | 28.20 | 28.60 | 28.00 |
| | 21-02-21 10:02 | 29.20 | 28.20 | 28.80 | 28.10 | 28.50 | 27.90 |
| | 21-02-21 10:32 | 29.20 | 28.30 | 28.80 | 28.00 | 28.40 | 27.90 |
| | 21-02-21 11:02 | 29.20 | 28.50 | 28.70 | 28.00 | 28.40 | 27.80 |
| | 21-02-21 11:32 | 29.20 | 28.60 | 28.70 | 28.10 | 28.50 | 27.90 |
| | 21-02-21 12:02 | 29.20 | 28.80 | 28.80 | 28.30 | 28.50 | 28.10 |
| | 21-02-21 12:32 | 29.20 | 28.90 | 28.70 | 28.30 | 28.50 | 28.20 |
| | 21-02-21 13:02 | 29.20 | 29.10 | 28.80 | 28.50 | 28.60 | 28.40 |
| | 21-02-21 13:32 | 29.20 | 29.20 | 28.80 | 28.70 | 28.70 | 28.50 |
| | 21-02-21 14:02 | 29.10 | 29.30 | 28.80 | 28.80 | 28.80 | 28.70 |
| | 21-02-21 14:32 | 29.20 | 29.50 | 28.90 | 29.10 | 29.00 | 29.00 |
| | 21-02-21 15:02 | 29.20 | 29.60 | 28.90 | 29.20 | 29.00 | 29.10 |
| Day 3 | 21-02-21 15:32 | 29.10 | 29.70 | 28.90 | 29.30 | 29.00 | 29.20 |
| | 21-02-21 16:02 | 29.10 | 29.80 | 29.10 | 29.60 | 29.20 | 29.50 |
| | 21-02-21 16:32 | 29.10 | 29.80 | 29.10 | 29.70 | 29.20 | 29.60 |
| | 21-02-21 17:02 | 29.20 | 29.90 | 29.20 | 29.80 | 29.30 | 29.80 |
| | 21-02-21 17:32 | 29.20 | 29.90 | 29.20 | 30.00 | 29.40 | 29.90 |
| | 21-02-21 18:02 | 29.20 | 29.90 | 29.30 | 30.10 | 29.50 | 30.00 |
| | 21-02-21 18:32 | 29.20 | 29.90 | 29.30 | 30.20 | 29.50 | 30.10 |
| | 21-02-21 19:02 | 29.20 | 29.80 | 29.30 | 30.20 | 29.50 | 30.20 |
| | 21-02-21 19:32 | 29.10 | 29.80 | 29.50 | 30.40 | 29.70 | 30.30 |
| | 21-02-21 20:02 | 29.20 | 29.70 | 29.60 | 30.50 | 29.70 | 30.40 |
| | 21-02-21 20:32 | 29.10 | 29.50 | 29.50 | 30.40 | 29.70 | 30.30 |
| | 21-02-21 21:02 | 29.10 | 29.40 | 29.60 | 30.50 | 29.70 | 30.40 |
| | 21-02-21 21:32 | 29.10 | 29.30 | 29.60 | 30.40 | 29.60 | 30.30 |
| | 21-02-21 22:02 | 29.00 | 29.20 | 29.60 | 30.40 | 29.70 | 30.20 |
| | 21-02-21 22:32 | 29.00 | 29.20 | 29.70 | 30.40 | 29.70 | 30.20 |
| | 21-02-21 23:02 | 29.00 | 29.10 | 29.60 | 30.30 | 29.60 | 30.10 |
| | 21-02-21 23:32 | 28.90 | 28.90 | 29.60 | 30.20 | 29.60 | 30.00 |
| | 22-02-21 0:02 | 28.90 | 28.80 | 29.60 | 30.10 | 29.60 | 29.90 |
| | 22-02-21 0:32 | 28.80 | 28.70 | 29.60 | 30.00 | 29.50 | 29.80 |
| | 22-02-21 1:02 | 28.70 | 28.50 | 29.60 | 30.00 | 29.50 | 29.70 |
| | 22-02-21 1:32 | 28.60 | 28.40 | 29.50 | 29.80 | 29.40 | 29.60 |
| | 22-02-21 2:02 | 28.50 | 28.30 | 29.50 | 29.80 | 29.40 | 29.50 |
| | 22-02-21 2:32 | 28.50 | 28.20 | 29.50 | 29.70 | 29.40 | 29.40 |
| | 22-02-21 3:02 | 28.50 | 28.10 | 29.40 | 29.50 | 29.30 | 29.30 |
| | 22-02-21 3:32 | 28.30 | 28.00 | 29.40 | 29.50 | 29.30 | 29.30 |
| | 22-02-21 4:02 | 28.30 | 28.00 | 29.40 | 29.50 | 29.20 | 29.20 |
| | 22-02-21 4:32 | 28.20 | 27.90 | 29.30 | 29.30 | 29.20 | 29.10 |
| | 22-02-21 5:02 | 28.20 | 27.80 | 29.20 | 29.30 | 29.10 | 29.00 |
| | 22-02-21 5:32 | 28.10 | 27.80 | 29.20 | 29.20 | 29.00 | 28.90 |
| | 22-02-21 6:02 | 28.10 | 27.70 | 29.20 | 29.20 | 29.10 | 28.90 |
| | 22-02-21 6:32 | 28.00 | 27.50 | 29.10 | 29.00 | 28.90 | 28.70 |

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| | 22-02-21 7:02 | 27.90 | 27.40 | 29.10 | 29.00 | 28.90 | 28.70 |
| | 22-02-21 7:32 | 27.90 | 27.40 | 29.00 | 28.90 | 28.90 | 28.60 |
| | 22-02-21 8:02 | 27.80 | 27.20 | 29.00 | 28.80 | 28.80 | 28.50 |
| | 22-02-21 8:32 | 27.70 | 27.10 | 28.90 | 28.80 | 28.70 | 28.50 |
| | 22-02-21 9:02 | 27.70 | 27.30 | 28.90 | 28.80 | 28.70 | 28.50 |
| | 22-02-21 9:32 | 27.70 | 27.30 | 28.80 | 28.60 | 28.60 | 28.30 |
| | 22-02-21 10:02 | 27.60 | 27.40 | 28.80 | 28.50 | 28.60 | 28.30 |
| | 22-02-21 10:32 | 27.60 | 27.60 | 28.70 | 28.50 | 28.50 | 28.20 |
| | 22-02-21 11:02 | 27.70 | 27.80 | 28.70 | 28.40 | 28.50 | 28.10 |
| | 22-02-21 11:32 | 27.60 | 27.90 | 28.60 | 28.40 | 28.50 | 28.20 |
| | 22-02-21 12:02 | 27.70 | 28.10 | 28.60 | 28.50 | 28.50 | 28.20 |
| | 22-02-21 12:32 | 27.70 | 28.20 | 28.50 | 28.60 | 28.50 | 28.40 |
| | 22-02-21 13:02 | 27.70 | 28.30 | 28.60 | 28.70 | 28.60 | 28.50 |
| | 22-02-21 13:32 | 27.80 | 28.50 | 28.60 | 28.90 | 28.70 | 28.70 |
| | 22-02-21 14:02 | 27.90 | 28.70 | 28.60 | 29.00 | 28.80 | 28.80 |
| | 22-02-21 14:32 | 27.90 | 28.90 | 28.70 | 29.10 | 28.80 | 29.00 |
| | 22-02-21 15:02 | 28.00 | 29.00 | 28.70 | 29.20 | 28.80 | 29.10 |
| Day 4 | 22-02-21 15:32 | 28.00 | 29.10 | 28.70 | 29.30 | 28.90 | 29.20 |
| | 22-02-21 16:02 | 28.10 | 29.30 | 28.70 | 29.40 | 28.90 | 29.30 |
| | 22-02-21 16:32 | 28.00 | 29.20 | 28.80 | 29.50 | 29.00 | 29.40 |
| | 22-02-21 17:02 | 28.10 | 29.40 | 28.80 | 29.60 | 29.10 | 29.50 |
| | 22-02-21 17:32 | 28.20 | 29.40 | 28.90 | 29.70 | 29.10 | 29.60 |
| | 22-02-21 18:02 | 28.20 | 29.40 | 29.00 | 29.90 | 29.20 | 29.80 |
| | 22-02-21 18:32 | 28.30 | 29.40 | 28.90 | 29.90 | 29.20 | 29.80 |
| | 22-02-21 19:02 | 28.30 | 29.40 | 29.00 | 30.00 | 29.20 | 29.80 |
| | 22-02-21 19:32 | 28.30 | 29.30 | 29.10 | 30.00 | 29.30 | 30.00 |
| | 22-02-21 20:02 | 28.30 | 29.20 | 29.10 | 30.00 | 29.20 | 29.90 |
| | 22-02-21 20:32 | 28.30 | 29.10 | 29.10 | 30.10 | 29.30 | 30.00 |
| | 22-02-21 21:02 | 28.20 | 29.00 | 29.10 | 30.00 | 29.30 | 29.90 |
| | 22-02-21 21:32 | 28.30 | 28.90 | 29.10 | 30.00 | 29.30 | 29.90 |
| | 22-02-21 22:02 | 28.30 | 28.80 | 29.10 | 29.90 | 29.20 | 29.70 |
| | 22-02-21 22:32 | 28.20 | 28.80 | 29.10 | 29.90 | 29.20 | 29.70 |
| | 22-02-21 23:02 | 28.20 | 28.60 | 29.10 | 29.80 | 29.20 | 29.60 |
| | 22-02-21 23:32 | 28.10 | 28.50 | 29.00 | 29.60 | 29.00 | 29.40 |
| | 23-02-21 0:02 | 28.10 | 28.50 | 29.00 | 29.60 | 29.10 | 29.40 |
| | 23-02-21 0:32 | 28.20 | 28.40 | 29.00 | 29.50 | 29.00 | 29.30 |
| | 23-02-21 1:02 | 28.10 | 28.30 | 28.90 | 29.40 | 28.90 | 29.20 |
| | 23-02-21 1:32 | 28.10 | 28.30 | 28.90 | 29.30 | 28.90 | 29.10 |
| | 23-02-21 2:02 | 28.10 | 28.20 | 28.80 | 29.20 | 28.90 | 29.00 |
| | 23-02-21 2:32 | 28.00 | 28.00 | 28.80 | 29.10 | 28.80 | 28.90 |
| | 23-02-21 3:02 | 27.90 | 27.90 | 28.70 | 29.00 | 28.70 | 28.80 |
| | 23-02-21 3:32 | 27.80 | 27.80 | 28.70 | 28.90 | 28.70 | 28.70 |
| | 23-02-21 4:02 | 27.80 | 27.70 | 28.60 | 28.80 | 28.60 | 28.60 |
| | 23-02-21 4:32 | 27.70 | 27.60 | 28.60 | 28.80 | 28.60 | 28.50 |

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| | 23-02-21 5:02 | 27.70 | 27.50 | 28.50 | 28.70 | 28.50 | 28.40 |
| | 23-02-21 5:32 | 27.60 | 27.40 | 28.50 | 28.60 | 28.40 | 28.30 |
| | 23-02-21 6:02 | 27.60 | 27.30 | 28.50 | 28.50 | 28.40 | 28.30 |
| | 23-02-21 6:32 | 27.50 | 27.20 | 28.50 | 28.50 | 28.40 | 28.20 |
| | 23-02-21 7:02 | 27.50 | 27.10 | 28.40 | 28.40 | 28.30 | 28.10 |
| | 23-02-21 7:32 | 27.40 | 27.00 | 28.30 | 28.30 | 28.30 | 28.10 |
| | 23-02-21 8:02 | 27.40 | 27.00 | 28.20 | 28.20 | 28.20 | 28.00 |
| | 23-02-21 8:32 | 27.30 | 26.90 | 28.20 | 28.10 | 28.10 | 27.90 |
| | 23-02-21 9:02 | 27.20 | 27.00 | 28.20 | 28.00 | 28.10 | 27.80 |
| | 23-02-21 9:32 | 27.30 | 27.10 | 28.10 | 27.90 | 28.00 | 27.70 |
| | 23-02-21 10:02 | 27.30 | 27.30 | 28.00 | 27.80 | 27.90 | 27.60 |
| | 23-02-21 10:32 | 27.30 | 27.60 | 28.00 | 27.80 | 27.90 | 27.50 |
| | 23-02-21 11:02 | 27.30 | 27.70 | 27.90 | 27.70 | 27.80 | 27.50 |
| | 23-02-21 11:32 | 27.30 | 27.90 | 27.90 | 27.80 | 27.90 | 27.60 |
| | 23-02-21 12:02 | 27.30 | 28.00 | 27.80 | 27.70 | 27.80 | 27.50 |
| | 23-02-21 12:32 | 27.50 | 28.20 | 27.80 | 27.80 | 27.90 | 27.60 |
| | 23-02-21 13:02 | 27.50 | 28.40 | 27.90 | 27.90 | 27.90 | 27.70 |
| | 23-02-21 13:32 | 27.60 | 28.60 | 27.90 | 28.10 | 28.00 | 27.90 |
| | 23-02-21 14:02 | 27.60 | 28.80 | 27.90 | 28.10 | 28.00 | 28.00 |
| | 23-02-21 14:32 | 27.70 | 28.90 | 27.90 | 28.30 | 28.10 | 28.20 |
| | 23-02-21 15:02 | 27.70 | 29.10 | 27.90 | 28.40 | 28.20 | 28.30 |
| Day 5 | 23-02-21 15:32 | 27.80 | 29.20 | 28.00 | 28.60 | 28.30 | 28.50 |
| | 23-02-21 16:02 | 27.80 | 29.30 | 28.10 | 28.70 | 28.40 | 28.70 |
| | 23-02-21 16:32 | 27.90 | 29.40 | 28.10 | 28.90 | 28.40 | 28.80 |
| | 23-02-21 17:02 | 27.90 | 29.50 | 28.10 | 29.00 | 28.50 | 29.00 |
| | 23-02-21 17:32 | 28.00 | 29.50 | 28.20 | 29.10 | 28.50 | 29.10 |
| | 23-02-21 18:02 | 28.10 | 29.60 | 28.30 | 29.30 | 28.60 | 29.30 |
| | 23-02-21 18:32 | 28.10 | 29.50 | 28.30 | 29.30 | 28.60 | 29.30 |
| | 23-02-21 19:02 | 28.10 | 29.60 | 28.40 | 29.50 | 28.70 | 29.50 |
| | 23-02-21 19:32 | 28.20 | 29.50 | 28.40 | 29.60 | 28.80 | 29.50 |
| | 23-02-21 20:02 | 28.10 | 29.40 | 28.40 | 29.60 | 28.80 | 29.50 |
| | 23-02-21 20:32 | 28.20 | 29.40 | 28.50 | 29.60 | 28.80 | 29.60 |
| | 23-02-21 21:02 | 28.20 | 29.30 | 28.50 | 29.70 | 28.90 | 29.60 |
| | 23-02-21 21:32 | 28.20 | 29.30 | 28.60 | 29.70 | 28.90 | 29.60 |
| | 23-02-21 22:02 | 28.30 | 29.20 | 28.60 | 29.70 | 28.90 | 29.60 |
| | 23-02-21 22:32 | 28.30 | 29.10 | 28.60 | 29.60 | 28.80 | 29.50 |
| | 23-02-21 23:02 | 28.20 | 29.00 | 28.60 | 29.50 | 28.80 | 29.40 |
| | 23-02-21 23:32 | 28.20 | 28.80 | 28.60 | 29.40 | 28.70 | 29.30 |
| | 24-02-21 0:02 | 28.20 | 28.80 | 28.50 | 29.30 | 28.60 | 29.10 |
| | 24-02-21 0:32 | 28.20 | 28.80 | 28.50 | 29.20 | 28.60 | 29.00 |
| | 24-02-21 1:02 | 28.20 | 28.70 | 28.50 | 29.10 | 28.60 | 28.90 |
| | 24-02-21 1:32 | 28.10 | 28.50 | 28.40 | 29.00 | 28.50 | 28.80 |
| | 24-02-21 2:02 | 28.10 | 28.50 | 28.40 | 28.90 | 28.50 | 28.70 |
| | 24-02-21 2:32 | 28.10 | 28.40 | 28.50 | 28.90 | 28.50 | 28.80 |

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|---|---|---|---|---|---|---|---|
| | 24-02-21 3:02 | 28.10 | 28.30 | 28.40 | 28.80 | 28.50 | 28.70 |
| | 24-02-21 3:32 | 28.00 | 28.20 | 28.30 | 28.70 | 28.40 | 28.60 |
| | 24-02-21 4:02 | 27.90 | 28.10 | 28.30 | 28.60 | 28.30 | 28.40 |
| | 24-02-21 4:32 | 27.90 | 28.00 | 28.20 | 28.50 | 28.30 | 28.30 |
| | 24-02-21 5:02 | 27.80 | 27.90 | 28.20 | 28.40 | 28.20 | 28.20 |
| | 24-02-21 5:32 | 27.90 | 27.90 | 28.20 | 28.40 | 28.20 | 28.20 |
| | 24-02-21 6:02 | 27.80 | 27.80 | 28.10 | 28.30 | 28.10 | 28.10 |
| | 24-02-21 6:32 | 27.80 | 27.70 | 28.00 | 28.20 | 28.10 | 28.00 |
| | 24-02-21 7:02 | 27.70 | 27.70 | 28.00 | 28.10 | 28.00 | 27.90 |
| | 24-02-21 7:32 | 27.70 | 27.70 | 28.00 | 28.00 | 27.90 | 27.90 |
| | 24-02-21 8:02 | 27.70 | 27.60 | 28.00 | 28.00 | 27.90 | 27.80 |
| | 24-02-21 8:32 | 27.70 | 27.60 | 27.90 | 27.80 | 27.80 | 27.70 |
| | 24-02-21 9:02 | 27.60 | 27.50 | 27.80 | 27.70 | 27.70 | 27.50 |
| | 24-02-21 9:32 | 27.60 | 27.70 | 27.80 | 27.60 | 27.70 | 27.40 |
| | 24-02-21 10:02 | 27.50 | 27.60 | 27.70 | 27.50 | 27.60 | 27.30 |
| | 24-02-21 10:32 | 27.60 | 27.70 | 27.60 | 27.30 | 27.50 | 27.10 |
| | 24-02-21 11:02 | 27.50 | 27.70 | 27.60 | 27.30 | 27.50 | 27.10 |
| | 24-02-21 11:32 | 27.60 | 27.90 | 27.50 | 27.40 | 27.50 | 27.20 |
| | 24-02-21 12:02 | 27.60 | 28.00 | 27.50 | 27.50 | 27.50 | 27.30 |
| | 24-02-21 12:32 | 27.60 | 28.10 | 27.50 | 27.50 | 27.60 | 27.40 |
| | 24-02-21 13:02 | 27.70 | 28.30 | 27.50 | 27.60 | 27.60 | 27.50 |
| | 24-02-21 13:32 | 27.60 | 28.30 | 27.50 | 27.80 | 27.70 | 27.80 |
| | 24-02-21 14:02 | 27.70 | 28.40 | 27.50 | 27.90 | 27.70 | 27.90 |
| | 24-02-21 14:32 | 27.80 | 28.60 | 27.60 | 28.10 | 27.80 | 28.10 |
| | 24-02-21 15:02 | 27.80 | 28.60 | 27.70 | 28.30 | 28.00 | 28.30 |
| Day 6 | 24-02-21 15:32 | 27.90 | 28.70 | 27.70 | 28.40 | 28.00 | 28.40 |
| | 24-02-21 16:02 | 27.90 | 28.80 | 27.80 | 28.60 | 28.10 | 28.60 |
| | 24-02-21 16:32 | 27.90 | 28.90 | 27.80 | 28.70 | 28.10 | 28.70 |
| | 24-02-21 17:02 | 28.10 | 29.00 | 27.90 | 28.90 | 28.30 | 28.90 |
| | 24-02-21 17:32 | 28.10 | 29.00 | 27.90 | 29.10 | 28.30 | 29.10 |
| | 24-02-21 18:02 | 28.10 | 29.10 | 28.00 | 29.20 | 28.40 | 29.20 |
| | 24-02-21 18:32 | 28.20 | 29.10 | 28.00 | 29.30 | 28.50 | 29.30 |
| | 24-02-21 19:02 | 28.20 | 29.00 | 28.10 | 29.40 | 28.50 | 29.40 |
| | 24-02-21 19:32 | 28.20 | 29.10 | 28.20 | 29.50 | 28.60 | 29.50 |
| | 24-02-21 20:02 | 28.20 | 29.00 | 28.30 | 29.60 | 28.70 | 29.60 |
| | 24-02-21 20:32 | 28.20 | 28.90 | 28.30 | 29.60 | 28.70 | 29.60 |
| | 24-02-21 21:02 | 28.20 | 28.90 | 28.30 | 29.50 | 28.60 | 29.50 |
| | 24-02-21 21:32 | 28.30 | 28.80 | 28.40 | 29.60 | 28.70 | 29.50 |
| | 24-02-21 22:02 | 28.30 | 28.80 | 28.40 | 29.50 | 28.60 | 29.50 |
| | 24-02-21 22:32 | 28.30 | 28.80 | 28.40 | 29.50 | 28.60 | 29.40 |
| | 24-02-21 23:02 | 28.30 | 28.70 | 28.40 | 29.30 | 28.50 | 29.20 |
| | 24-02-21 23:32 | 28.20 | 28.60 | 28.40 | 29.30 | 28.50 | 29.10 |
| | 25-02-21 0:02 | 28.30 | 28.60 | 28.30 | 29.10 | 28.40 | 29.00 |
| | 25-02-21 0:32 | 28.30 | 28.50 | 28.30 | 29.10 | 28.50 | 28.90 |

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|---|---|---|---|---|---|---|---|
| | 25-02-21 1:02 | 28.20 | 28.40 | 28.30 | 29.00 | 28.40 | 28.80 |
| | 25-02-21 1:32 | 28.20 | 28.30 | 28.30 | 28.90 | 28.40 | 28.80 |
| | 25-02-21 2:02 | 28.20 | 28.30 | 28.20 | 28.80 | 28.30 | 28.60 |
| | 25-02-21 2:32 | 28.20 | 28.30 | 28.20 | 28.70 | 28.30 | 28.50 |
| | 25-02-21 3:02 | 28.20 | 28.20 | 28.10 | 28.60 | 28.20 | 28.40 |
| | 25-02-21 3:32 | 28.20 | 28.20 | 28.10 | 28.50 | 28.20 | 28.30 |
| | 25-02-21 4:02 | 28.10 | 28.10 | 28.10 | 28.40 | 28.10 | 28.30 |
| | 25-02-21 4:32 | 28.10 | 28.00 | 28.10 | 28.40 | 28.10 | 28.20 |
| | 25-02-21 5:02 | 28.00 | 28.00 | 28.00 | 28.30 | 28.10 | 28.10 |
| | 25-02-21 5:32 | 28.00 | 27.90 | 27.90 | 28.10 | 27.90 | 28.00 |
| | 25-02-21 6:02 | 27.90 | 27.80 | 27.90 | 28.10 | 28.00 | 28.00 |
| | 25-02-21 6:32 | 28.00 | 27.80 | 27.80 | 28.00 | 27.90 | 27.80 |
| | 25-02-21 7:02 | 27.90 | 27.70 | 27.80 | 27.90 | 27.80 | 27.70 |
| | 25-02-21 7:32 | 27.80 | 27.60 | 27.80 | 27.80 | 27.70 | 27.60 |
| | 25-02-21 8:02 | 27.80 | 27.60 | 27.70 | 27.70 | 27.70 | 27.50 |
| | 25-02-21 8:32 | 27.80 | 27.50 | 27.60 | 27.50 | 27.60 | 27.40 |
| | 25-02-21 9:02 | 27.70 | 27.50 | 27.60 | 27.50 | 27.50 | 27.30 |
| | 25-02-21 9:32 | 27.80 | 27.70 | 27.60 | 27.40 | 27.50 | 27.20 |
| | 25-02-21 10:02 | 27.70 | 27.70 | 27.50 | 27.30 | 27.50 | 27.20 |
| | 25-02-21 10:32 | 27.70 | 27.90 | 27.40 | 27.20 | 27.30 | 27.00 |
| | 25-02-21 11:02 | 27.70 | 27.90 | 27.40 | 27.20 | 27.30 | 27.00 |
| | 25-02-21 11:32 | 27.80 | 28.20 | 27.30 | 27.10 | 27.30 | 26.90 |
| | 25-02-21 12:02 | 27.80 | 28.20 | 27.30 | 27.20 | 27.30 | 27.10 |
| | 25-02-21 12:32 | 27.80 | 28.30 | 27.20 | 27.30 | 27.30 | 27.10 |
| | 25-02-21 13:02 | 27.90 | 28.40 | 27.40 | 27.50 | 27.50 | 27.40 |
| | 25-02-21 13:32 | 27.90 | 28.50 | 27.30 | 27.50 | 27.50 | 27.50 |
| | 25-02-21 14:02 | 27.80 | 28.50 | 27.30 | 27.70 | 27.60 | 27.70 |
| | 25-02-21 14:32 | 27.90 | 28.60 | 27.30 | 27.80 | 27.60 | 27.80 |
| | 25-02-21 15:02 | 27.90 | 28.70 | 27.40 | 28.00 | 27.70 | 28.00 |
| Day 7 | 25-02-21 15:32 | 27.90 | 28.70 | 27.50 | 28.20 | 27.80 | 28.20 |
| | 25-02-21 16:02 | 28.00 | 28.80 | 27.60 | 28.40 | 27.90 | 28.40 |
| | 25-02-21 16:32 | 28.00 | 28.80 | 27.70 | 28.60 | 28.10 | 28.60 |
| | 25-02-21 17:02 | 28.00 | 28.80 | 27.70 | 28.70 | 28.10 | 28.70 |
| | 25-02-21 17:32 | 28.10 | 28.90 | 27.80 | 28.90 | 28.30 | 29.00 |
| | 25-02-21 18:02 | 28.00 | 28.80 | 27.90 | 29.10 | 28.40 | 29.20 |
| | 25-02-21 18:32 | 28.10 | 28.80 | 27.90 | 29.20 | 28.40 | 29.20 |
| | 25-02-21 19:02 | 28.10 | 28.80 | 28.00 | 29.30 | 28.40 | 29.30 |
| | 25-02-21 19:32 | 28.10 | 28.80 | 28.00 | 29.40 | 28.50 | 29.40 |
| | 25-02-21 20:02 | 28.10 | 28.70 | 28.20 | 29.50 | 28.60 | 29.50 |
| | 25-02-21 20:32 | 28.10 | 28.70 | 28.20 | 29.50 | 28.60 | 29.50 |
| | 25-02-21 21:02 | 28.10 | 28.60 | 28.20 | 29.50 | 28.60 | 29.50 |
| | 25-02-21 21:32 | 28.00 | 28.50 | 28.30 | 29.50 | 28.60 | 29.50 |
| | 25-02-21 22:02 | 28.10 | 28.50 | 28.30 | 29.40 | 28.60 | 29.40 |
| | 25-02-21 22:32 | 28.10 | 28.50 | 28.30 | 29.40 | 28.60 | 29.40 |

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|---|---|---|---|---|---|---|---|
| | 25-02-21 23:02 | 28.00 | 28.40 | 28.40 | 29.40 | 28.60 | 29.30 |
| | 25-02-21 23:32 | 28.00 | 28.30 | 28.30 | 29.20 | 28.50 | 29.10 |
| | 26-02-21 0:02 | 27.90 | 28.20 | 28.40 | 29.20 | 28.50 | 29.10 |
| | 26-02-21 0:32 | 27.90 | 28.10 | 28.40 | 29.10 | 28.50 | 29.00 |
| | 26-02-21 1:02 | 27.90 | 28.10 | 28.30 | 28.90 | 28.40 | 28.90 |
| | 26-02-21 1:32 | 27.90 | 28.00 | 28.40 | 29.00 | 28.50 | 28.90 |
| | 26-02-21 2:02 | 27.90 | 28.00 | 28.30 | 28.90 | 28.40 | 28.70 |
| | 26-02-21 2:32 | 27.80 | 27.90 | 28.30 | 28.70 | 28.30 | 28.60 |
| | 26-02-21 3:02 | 27.80 | 27.80 | 28.20 | 28.70 | 28.30 | 28.60 |
| | 26-02-21 3:32 | 27.70 | 27.70 | 28.20 | 28.60 | 28.30 | 28.50 |
| | 26-02-21 4:02 | 27.80 | 27.70 | 28.20 | 28.50 | 28.20 | 28.40 |
| | 26-02-21 4:32 | 27.70 | 27.60 | 28.10 | 28.40 | 28.20 | 28.30 |
| | 26-02-21 5:02 | 27.60 | 27.50 | 28.00 | 28.30 | 28.10 | 28.20 |
| | 26-02-21 5:32 | 27.50 | 27.40 | 28.00 | 28.30 | 28.10 | 28.10 |
| | 26-02-21 6:02 | 27.60 | 27.40 | 28.00 | 28.20 | 28.10 | 28.10 |
| | 26-02-21 6:32 | 27.50 | 27.40 | 28.00 | 28.10 | 28.00 | 28.00 |
| | 26-02-21 7:02 | 27.50 | 27.30 | 27.90 | 28.00 | 27.90 | 27.90 |
| | 26-02-21 7:32 | 27.40 | 27.20 | 27.80 | 28.00 | 27.90 | 27.80 |
| | 26-02-21 8:02 | 27.30 | 27.20 | 27.90 | 27.90 | 27.90 | 27.80 |
| | 26-02-21 8:32 | 27.40 | 27.20 | 27.80 | 27.90 | 27.80 | 27.70 |
| | 26-02-21 9:02 | 27.40 | 27.30 | 27.80 | 27.80 | 27.80 | 27.70 |
| | 26-02-21 9:32 | 27.40 | 27.50 | 27.70 | 27.70 | 27.70 | 27.60 |
| | 26-02-21 10:02 | 27.30 | 27.50 | 27.70 | 27.60 | 27.60 | 27.50 |
| | 26-02-21 10:32 | 27.40 | 27.70 | 27.70 | 27.70 | 27.70 | 27.50 |
| | 26-02-21 11:02 | 27.40 | 27.90 | 27.60 | 27.50 | 27.60 | 27.40 |
| | 26-02-21 11:32 | 27.50 | 28.10 | 27.60 | 27.60 | 27.60 | 27.40 |
| | 26-02-21 12:02 | 27.60 | 28.30 | 27.50 | 27.60 | 27.60 | 27.50 |
| | 26-02-21 12:32 | 27.60 | 28.40 | 27.50 | 27.80 | 27.70 | 27.70 |
| | 26-02-21 13:02 | 27.60 | 28.60 | 27.60 | 28.00 | 27.80 | 27.90 |
| | 26-02-21 13:32 | 27.70 | 28.80 | 27.60 | 28.10 | 27.90 | 28.10 |
| | 26-02-21 14:02 | 27.70 | 28.90 | 27.70 | 28.30 | 28.00 | 28.30 |
| | 26-02-21 14:32 | 27.80 | 29.10 | 27.70 | 28.40 | 28.00 | 28.40 |
| | 26-02-21 15:02 | 27.90 | 29.20 | 27.80 | 28.60 | 28.10 | 28.70 |