Josef Hadipramana

Effect of various fibers and rice husk ash on the workability of self-compacting concrete

Quick Submit

Quick Submit

Universitas Muhammadiyah Sumatera Utara

Document Details

Submission ID

trn:oid:::1:3159434184

Submission Date

Feb 19, 2025, 7:49 AM GMT+7

Download Date

Feb 19, 2025, 8:27 AM GMT+7

File Name

syarat_khusus.pdf

File Size

1.7 MB

7 Pages

4,880 Words

23,569 Characters

7% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

- Small Matches (less than 28 words)

Exclusions

- 50 Excluded Sources

Match Groups

- **4** Not Cited or Quoted 3%
  Matches with neither in-text citation nor quotation marks
- **0** Missing Quotations 0%
  Matches that are still very similar to source material
- **5** Missing Citation 4%
  Matches that have quotation marks, but no in-text citation
- **0** Cited and Quoted 0%
  Matches with in-text citation present, but no quotation marks

Top Sources

3% Internet sources

5% Publications

4% Submitted works (Student Papers)

Integrity Flags

0 Integrity Flags for Review

No suspicious text manipulations found.

Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.

A Flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.

Match Groups

- **4** Not Cited or Quoted 3%
  Matches with neither in-text citation nor quotation marks
- **0** Missing Quotations 0%
  Matches that are still very similar to source material
- **5** Missing Citation 4%
  Matches that have quotation marks, but no in-text citation
- **0** Cited and Quoted 0%
  Matches with in-text citation present, but no quotation marks

Top Sources

3% Internet sources
5% Publications
4% Submitted works (Student Papers)

Top Sources

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	Student papers	IIT Delhi	<1%
2	Publication	Musa Adamu, Hani Alanazi, Yasser E. Ibrahim, Mohamed Abdellatief. "Mechanical...	<1%
3	Publication	Eva Marlina Ginting, Nurdin Bukit, Motlan Motlan, Ridwan Abdullah Sani. "Data e...	<1%
4	Publication	Negasi Gebremedhin, Gideon K. Rotich. "Manufacturing of Bathroom Wall Tile Co...	<1%
5	Publication	W. C. Tang, P. C. Ryan, H. Z. Cui, W. Liao. "Properties of Self-Compacting Concrete ...	<1%
6	Publication	Aneel Kumar, Rabinder Kumar, Vishan Das, Ashfaque Ahmed Jhatial, Tauha Hussa...	<1%
7	Internet	repository.unimilitar.edu.co	<1%
8	Internet	escholarship.org	<1%
9	Student papers	Napier University	<1%

AKADÉMIAI KIADÓ

Effect of various fibers and rice husk ash on the workability of self-compacting concrete

Josef Hadipramana[1], Fetra Venny Riza[2*], Ade Faisal[1], Bambang Hadibroto[2] and Shahrul Niza Mokhatar[3]

[1] Department of Civil Engineering, Faculty of Engineering, Universitas Muhammadiyah Sumatera Utara, Medan, Indonesia

[2] Department of Civil Engineering, Faculty of Engineering, Medan State University, Medan, Indonesia

[3] Structural Dynamic and Computational Engineering Focus Group, Faculty of Civil Engineering and Built Environment, University Tun Hussein Onn Malaysia, Johor, Malaysia

Pollack Periodica • An International Journal for Engineering and Information Sciences

DOI:
10.1556/606.2024.00943

Received: September 6, 2023 • Revised manuscript received: January 4, 2024 • Accepted: January 26, 2024

ORIGINAL RESEARCH PAPER

ABSTRACT

The study aims to investigate and find natural fiber as concrete reinforcement using the self-compacting concrete method. Methods of adding fiber and self-compacting concrete methods are exciting because these two methods have different characteristics and advantages. Therefore, the performance of the fresh-state flow capability of the self-compacting concrete method, which contains various fibers, was observed. Coconut fiber, pineapple leaf fiber, ijuk sugar palm fiber, and artificial polypropylene fiber were used with varying compositions of 0.3, 0.5, and 0.7% by mass of binder. The results show that coconut and pineapple fiber concrete met the European Guidelines for Self-Compacting Concrete standards. The coconut and pineapple fiber concrete performed admirably in all tests.

KEYWORDS

fiber, workability, dilatancy, segregation, rice-husk-ash

1. INTRODUCTION

Porosity in concrete is often found in concrete due to a lack of compaction during moulding and air trapped in the concrete. The Self Compacting Concrete (SCC) method is believed to overcome the porous problem because SCC is concrete that can compact itself with a relatively high flow capability value and has an empirical distribution [1]. The results of the previous discussion stated that SCC is a type of concrete that is more liquid than conventional concrete mixtures. Concrete with the SCC method should be able to flow through the gaps between the bars of the reinforcement without segregation or separation of the material [2]. EFNARC [3] stated that the fresh state condition of the SCC must meet several conditions to achieve good SCC conditions, namely flowability, viscosity, and passing ability. However, this condition provides several options, depending on some construction purposes or the use of the materials, especially the size of the coarse aggregate, so that the test equipment and the magnitude of the test value can be adjusted. The water/cement (w/c) ratio in the SCC method dramatically affects the performance of SCC flowability and the mechanical properties of concrete in a fresh state and hardened conditions, regardless of how the concrete uses added materials or substitutes [4, 5]. In fresh state conditions, the w/c ratio provides the effect of destiny and bonding between the material interfaces in the concrete matrix when it hardens, thus affecting the strength of the concrete [6]. The SCC method correlates the w/c ratio and concrete strength. The strength of the concrete reduces as the w/c ratio increases. Although the w/c ratio is not the only one affecting the strength of concrete, this influence is dominant [7]. On the other hand, concrete is a material that has the

*Corresponding author.
E-mail: fetra@umsu.ac.id

AKJournals

advantage of compressive strength but is weak against tensile strength. So, to overcome these weaknesses, reinforcement is added in the concrete form of fiber [8, 9], both artificial and natural fibers. The superior physical and mechanical properties of Coconut Fiber (CF), PineApple Leaf Fiber (PALF), Ijuk Sugar Palm Fiber (ISPF), and PolyPropylene Fiber (PPF) have been reported by several studies [10, 11]. Adding fiber as reinforcement will provide an opportunity for other problems to occur. The presence of fiber is related to the segregation in concrete and affects the moisture content, affecting workability [12]. In addition, fibrillation produced by the fibers in the concrete mixture [13] will attract the substantial material into small lumps, thereby affecting workability. Nevertheless, mixing the fiber method in concrete with SCC has become a concern. The results of bending tests in controlled deflection confirm that the positive contribution of fibers in the mechanical behavior of SCC indicates the possibility of better fiber-matrix bonding [14]. Using fiber in the SCC method shows that the fibers are distributed more evenly on the specimen fracture surface [15]. In achieving the objectives of this study, it is necessary to study that the w/c ratio and the way of mixing fibers in concrete play an essential role in workability. In addition, the factor of adding other materials is cementitious materials, providing an opportunity to improve the performance of SCC flow capability [16, 17]. Using cementitious supplementary materials can increase eco-efficiency in SCC [18]. So combining fiber with cementitious materials like Rice Husk Ash (RHA) may show concrete with better results and eco-friendly [19], so the combination is enough to provide an opportunity for use in the SCC method. The chemical composition of RHA comes from repeated open burning to produce a composition like fly ash, which has been reported [13]. Using RHA as a cement substitute optimally can improve the mechanical characteristics of concrete [20]. Apart from that, the presence of cementing material can influence the density of the concrete matrix's interfacial zone, thereby increasing the strength of the concrete [21, 22]. Fiber concrete has different characteristics from normal concrete, especially in the fresh state. Studies on fibrous concrete using the SCC method are very limited. Therefore, this research aims to investigate the characteristics of concrete containing various types of fibers when using the SCC method. Starting from various fresh state tests based on EFNARC to the compressive strength results.

9

2. MATERIALS AND METHODS

2.1. Fibers and rice husk ash

Besides using fibers, the RHA is added as a binder in concrete mixtures to improve substantial performance [23]. PALF is produced manually [24], which is obtained by separating the leaves' fibers from the leaves' outermost layer. Then, the fibers are dried, and the result can be seen in Fig. 1a. CF and ISPF (Fig. 1b and c) are already available without a process, and PPF is available on the market (Fig. 1d). All fibers are 2 cm long with compositional variations of 0.3%, 0.5%, and 0.7% by mass of binder into the concrete mixture. The diameter of RHA is 0.075 mm or passed sieve number 200, which was abundantly available from the rice milling directly put into the concrete mix without process. RHA is obtained by open burning in a rice mill without being controlled and burned repeatedly, thus producing a lot of Silica.

2.2. Cement and aggregates

The cement used is Ordinary Portland Cement (OPC) available in the market, and the aggregate has passed several tests with the result presented in Table 1. Testing aggregate properties is significant for the SCC method because the mix of designs is highly dependent on these properties. Knowing the content and absorption of water is very important in determining the amount of water in the mix design. It is also

Table 1. Aggregate test results

Testing	Values
Density of Coarse Aggregate	2.16 g cm^{-3}
Density of Fine Aggregate	2.57 g cm^{-3}
Mud Content Coarse Aggregate	0.77%
Mud Content Fine Aggregate	3.30%
Bulk Density of Coarse Aggregate	1.32 g cm^{-3}
Bulk Density of Fine Aggregate	1.49 g cm^{-3}
Fine Modulus of Coarse Aggregate	7.09
Fine Modulus of Fine Aggregate	2.78
Water Content of Coarse Aggregate	0.60%
Water Content of Fine Aggregate	2.15%
Water Absorption of Coarse Aggregate	0.75%
Water Absorption of Fine Aggregate	1.73%
Maximum Diameter of Aggregate	20.00 mm


a) b) c) d)

Fig. 1. The fibers used in the study: a) PALF, b) CF, c) ISPF, d) PPF

essential to decide on the content of the sludge in the aggregate because the sludge will absorb a lot of water.

2.3. Mix design method

This SCC design mix applies previous research that designs with simple design steps for SCCs presented by Su et al. [25]. In the mixing method, each fiber is soaked in water for 15 min and drained for 30 min so that the water in the fiber comes out and the fiber is only moist to taste. The fibers are put into the concrete mixture in the mixer by spreading gradually and slowly so that clumping does not occur. This process takes place during a 3-min rotating mixer. Previously, all concrete mixtures, namely coarse aggregate, sand, cement, RHA, water, and super-plasticizer, were mixed in a mixer that was rotated for 3 min. Next, the concrete is poured into molds and in maintenance control in water at room temperature for 28 days. The composition of the SCC forming material is presented in Table 2. The w/c ratio used is 0.40 and 0.45. Concrete samples containing CF, PALF, ISPF, and PPF are given the codes FSK, FSN, FSI, and FSP, respectively.

2.4. Workability test

Consistency classification according to the provisions of EFNARC [3] and BS EN 12350-9:2010 British standard [26] is based on three kinds of tests to determine flowability, viscosity, and passing ability. Thus, this study used slump flow, V-funnel, and L-Box test instruments for each parameter test to determine the concrete's compressive strength using universal testing machine. The slum flow value describes the flowability of a fresh state under undefined conditions. The slump flow is a sensitive test usually determined for all SCCs. This test uses visual observation as the primary check to asess the consistency of fresh-state concrete that meets specifications. Timing testing T_{500} on slump flow was not recommended in this study, as the time value was relatively up and down when the fresh concrete reached a diameter of 500 mm, which was carried out repeatedly. For this reason, it is enough to use the V-funnel test following the provision for the viscosity test [3]. The L-Box method represents the ability of fresh concrete to flow through confined and narrow spaces, like in the reinforcement areas. In defining passing capability, it is necessary to consider the geometry and density of reinforcement and the maximum aggregate size so the fresh concrete can flow through the reinforcement bars. This study used the minimum passing ability specifications with gaps of 60–80 mm [3].

3. RESULT AND DISCUSSIONS

3.1. Fresh state testing

The fresh state SCC test results of all fiber variations show each character with a different value, involve slump flow, viscosity, and passing ability. Slump flow examination is carried out at each variation and w/c ratio so that the relationship between the compressive strength of the sample

Table 2. The material composition of SCC

Sample code	Fibers (%) *wt* of binder	*w/c*	Sp. (%) *wt* of binder	RHA (%) *wt* of cement	Coarse Aggr. (kg m^{-3})	Fine Aggr. (kg m^{-3})	Cement (kg m^{-3})	Water (Lt m^{-3})
FSK-1	0.3	0.40	0.9	10	592.61	998.10	450	198.00
FSK-2	0.5	0.40	0.9	10	592.61	998.10	450	198.00
FSK-3	0.7	0.40	0.9	10	592.61	998.10	450	198.00
FSK-4	0.3	0.45	0.9	10	592.61	998.10	450	222.75
FSK-5	0.5	0.45	0.9	10	592.61	998.10	450	222.75
FSK-6	0.7	0.45	0.9	10	592.61	998.10	450	222.75
FSN-1	0.3	0.40	0.9	10	592.61	998.10	450	198.00
FSN-2	0.5	0.40	0.9	10	592.61	998.10	450	198.00
FSN-3	0.7	0.40	0.9	10	592.61	998.10	450	198.00
FSN-4	0.3	0.45	0.9	10	592.61	998.10	450	222.75
FSN-5	0.5	0.45	0.9	10	592.61	998.10	450	222.75
FSN-6	0.7	0.45	0.9	10	592.61	998.10	450	222.75
FSI-1	0.3	0.40	0.9	10	592.61	998.10	450	198.00
FSI-2	0.5	0.40	0.9	10	592.61	998.10	450	198.00
FSI-3	0.7	0.40	0.9	10	592.61	998.10	450	198.00
FSI-4	0.3	0.45	0.9	10	592.61	998.10	450	222.75
FSI-5	0.5	0.45	0.9	10	592.61	998.10	450	222.75
FSI-6	0.7	0.45	0.9	10	592.61	998.10	450	222.75
FSP-1	0.3	0.40	0.9	10	592.61	998.10	450	198.00
FSP-2	0.5	0.40	0.9	10	592.61	998.10	450	198.00
FSP-3	0.7	0.40	0.9	10	592.61	998.10	450	198.00
FSP-4	0.3	0.45	0.9	10	592.61	998.10	450	222.75
FSP-5	0.5	0.45	0.9	10	592.61	998.10	450	222.75
FSP-6	0.7	0.45	0.9	10	592.61	998.10	450	222.75

and the slum flow value can be known. Following EFNARC [3], the slump flow value ranges from 550 to 850 mm according to the purpose of using concrete material in building construction. However, it uses a condition of 600–750 mm for all standard concrete applications. As for viscosity with the V-funnel test method, the recommended value is 6–12 s, and passing ability testing with the L-Box method must have a blocking ratio of 0.8–1.0.

3.2. Flowability

The results of the flowability test in Fig. 2 show that concrete with a w/c ratio of 0.40 reinforced all CF compositions (FSKl - FSK3). They have stable slump flow values to the required slump flow value. Only concrete reinforcement with PALF, with compositions of 0.3% and 0.5% (FSN 1 and FSN 2), is eligible, while a composition of 0.7% (FSN-3) has a slightly under qualified value.

These results show that increasing the PALF content in the concrete mixture decreases the concrete flow. Likewise, all concrete compositions with ISPF and PPF variation give problems to the flow rate. These two fibers provide early bonding with the concrete in the fresh state. The fiber's initial biding occurs due to the moisture content factor in the concrete mixture. Figure 3 shows that the increase in moisture content, namely at a water-cement ratio of 0.45, gives influence and space to the concrete mix to flow, which is seen in concrete reinforced by ISPF, which has a higher slump flow value than ISPF with a water-cement ratio 0.40. However, PPF-reinforced concrete has a low value when the w/c ratio is higher, which is 0.45. PPF artificial material has a higher fibrillation value when mixed in a concrete mixture and is more flexible, so the initial binding with the aggregate occurs faster. Then, in this condition, the clumping concrete fraction will inhibit the flow of concrete and affect the strength of concrete when it hardens [27, 28].

3.3. Viscosity

Figures 4 and 5 show the character of each concrete with the increased sum of fibers, and the w/c ratio in the V-funnel test. In this study, the role of all fibers with a content of 0.3% in concrete did not give a problem to the viscosity value. All variations of fiber met the viscosity rate speed requirements with a w/c ratio of 0.40 or 0.45. The CF character shows that a w/c ratio of 0.4 with a composition of 0.7% cannot meet the requirements of EFNARC [3]. At a w/c ratio, 0.45 gives free space to CF to bind the concrete, but no clumping occurs, and it flows smoothly at the appropriate time. The observations show that conversely, a stiffer ISPF and a slippery surface are not a problem for a low w/c ratio and will be an obstacle when the w/c ratio is high. A high w/c

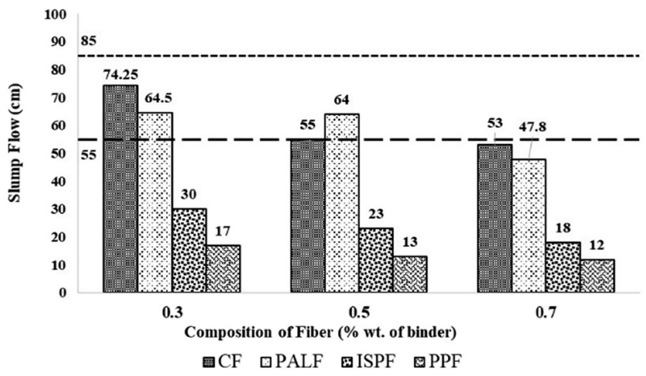

Fig. 2. Flowability set by EFNARC against SCC incorporating various fibers with w/c ratio 0.40

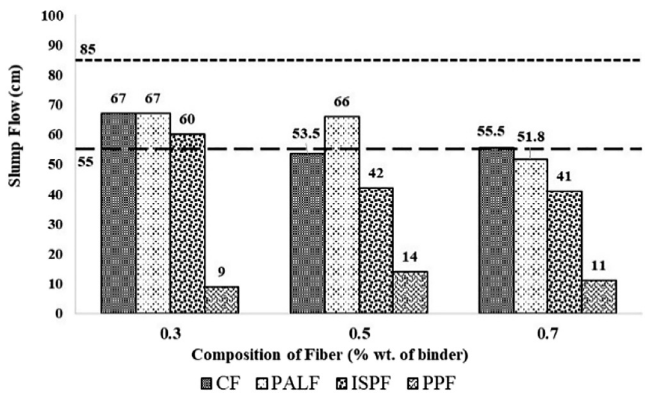

Fig. 3. Flowability for w/c ratio 0.45 and flow-ability limits set by EFNARC

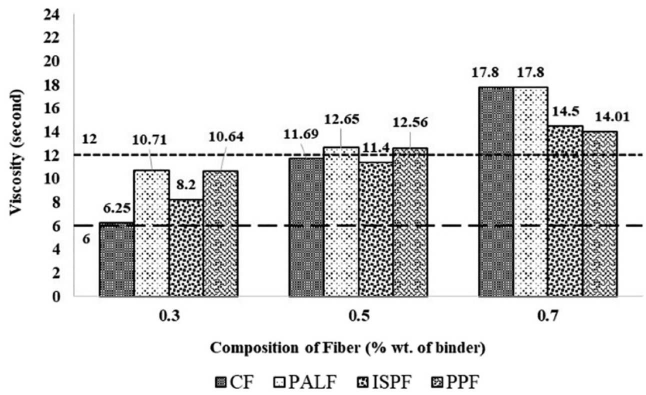

Fig. 4. Viscosity limitation determined by EFNARC againt SCC incorporating various fibers at w/c ratio 0.40

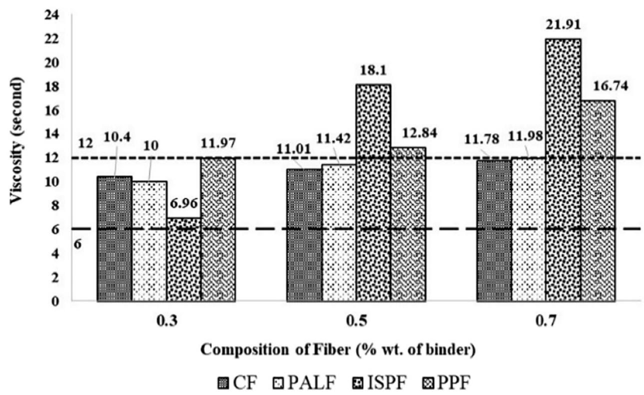

Fig. 5. The viscosity of SCC with various fibers at a w/c ratio of 0.45

ratio provides space for ISPF to bind itself into a lump. The character of ISPF is similar to PALF fiber but has a rather rough text than ISPF.

For the viscosity test of concrete containing PPF, clumping occurs in the concrete mixture related to the amount. The higher the amount of fiber in the concrete, the more jetting in the V-funnel test takes a lot of time. Exciting here is the promising result of observing the use of CF-related to viscosity. All composition quantities (0.3, 0.5, and 0.7%) at a w/c ratio of 0.45 meet the range specified by EFNARC [3] (Fig. 5). Even for the w/c ratio of 0.4, only 0.7% of the composition exceeds the EFNARC [3] range (Fig. 4) due to the amount of fiber causing a delay in the flow time of the V-funnel pad. But this also happens with all fibers with a composition of 0.7%.

3.4. Passing ability

In reality, passing ability depends on the fresh concrete's volume. Often, the paste flows ahead of the coarse aggregate particles behind, so the coarse aggregate that "loses" the paste blocks the flow of the concrete [29]. Fibers in the concrete can bind the concrete between the paste and the coarse aggregate particles, making dilatancy easy. This condition is a challenge in the flowability of fresh concrete because the fibers can bind the concrete and form small lumps so that they can get stuck in the bars on the L-Box. When the pressure is significant, or the w/c ratio is higher, the clots of concrete bonds can pass through the bars in small groups. The CF and ISPF fibrous concrete at w/c ratio 0.4 with a composition of 0.3% can flow on the bars on the L-Box in the passing ratio range of 0.8–1, but segregation occurs in the composition of 0.5% and 0.7% (Fig. 6).

All PALF and PPF fiber variations do not meet at a w/c ratio 0.4. In contrast, for a w/c ratio of 0.45 (Fig. 7), all fibers have a passing ability ratio outside the EFNARC [3] range except PPF 0.3% and ISPFs 0.5% and 0.7%. In this test, it is challenging for fibrous concrete to achieve the specified conditions since all fibers apply the initial binding on the mortar into clots in fresh-state concrete. In this test, it is complicated for fibrous concrete to achieve the specified conditions since all fibers apply the initial binding on the

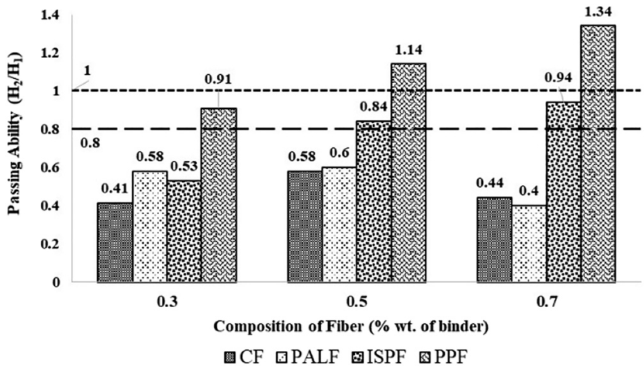

Fig. 7. Passing ability of SCC with various fibers at w/c ratio 0.45

concrete into clots in fresh-state concrete. This condition causes dilatancy and an increase in the density of fresh state or wet packing density of concrete, which makes it difficult for them to flow through the bars [30]. However, the results showed that wet compaction in ISPF and PPF with a composition of 0.5% and 0.7%, w/c ratio of 0.45, pulled concrete lumps to pass through the iron bars simultaneously. This condition increases the volume of concrete in the horizontal part of the L-Box. It increases the height of H_2, thereby increasing the value of the passing ability ratio and segregation.

3.5. Compressive strength

Figure 8 shows the relationship between compressive strength and fiber variations with two w/c ratios (i.e., 0.4 and 0.45). The strength of concrete is the expected result of developing concrete. The design mix prepared in this study refers to the SCC concrete manufactured by Su et al. [25] with the characteristic compressive strength of concrete was 20 MPa. The strength of concrete increases with several fibers, showing the fiber influences the strength of concrete. However, some compositions give the result of counter plans. ISPF fibrous concrete (FSI-1) can offset these results at a w/c ratio of 0.40. The results of concrete strength testing show the advantages of concrete with fiber variations at a w/c ratio of 0.40 rather than a w/c ratio of 0.45. A significant

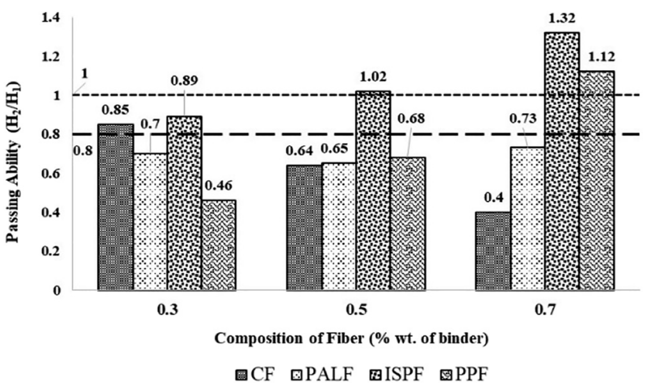

Fig. 6. Passing ability set by EFNARC on SCC with various fibers at w/c 0.40

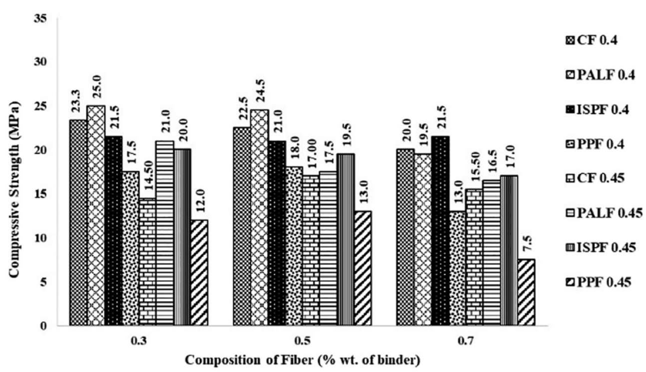

Fig. 8. Compressive strength of some fiber variations at w/c ratios 0.40 and 0.45

difference occurs in CF fibrous concrete, where the w/c ratio of 0.45 (FSK-4, FSK-5, and FSK-6) is much lower than the strength of CF fibrous concrete with a w/c ratio of 0.40 (FSK-1, FSK-2, and FSK-3).

4. CONCLUSION

This study has evaluated the workability behavior of SCCs containing several fiber variations and the use of RHA on the basis EFNARC requires. Clumping events caused by fiber fibrillation are inevitable, so dilatancy can quickly occur and reduce flow. Some of the types of fibers used in this experiment, CF and PALF with the appropriate composition, have good character in passing the test of ability, viscosity, and passing ability.

Combining fiber variations with the suitable w/c ratio composition, where the experiment results in a w/c ratio 0.40, can increase the projected concrete's strength. However, in this experiment, artificial PPF cannot increase the strength of concrete, and only natural fibers can play a role in the strength of concrete. In this study, the relationship between concrete strength and workability performance in SCCs using fiber variation and RHA can be estimated and follows EFNARC requirements. As a result, the utilization of natural fibers in concrete using the SCC method can be employed in settings similar to the findings of this study. Based on these findings, it is recommended that PALF and CF be used, as they produce the best results.

ACKNOWLEDGEMENT

The Authors expressed their gratitude and acknowledgement given by the Ministry of Education and Culture Research and Technology (Kemendikbud-Ristek) Republic of Indonesia for the PDUPT and Higher Education Service Institute – Region 1 (LLDIKTI-1) as well as the Institute of Research and Community Service – Universitas Muhammadiyah Sumatera Utara (LPPM-UMSU) and Department of Civil Engineering, Faculty of Engineering, UMSU, Medan Indonesia for research and staffing resources.

REFERENCES

[1] K. H. Khayat, "Workability, testing, and performance of self-consolidating," *ACI Mater. J.*, vol. 96, no. 3, pp. 346–353, 2015.

[2] O. S. Olafusi, A. P. Adewuyi, A. I. Otunla, and A. O. Babalola, "Evaluation of fresh and hardened properties of self-compacting concrete," *Open J. Civ. Eng.*, vol. 5, no. 1, pp. 1–7, 2015.

[3] EFNARC, "The European Guidelines for Self-Compacting Concrete," *Eur. Guidel. Self Compact. Concr.*, 2005.

[4] B. Felekoğlu, S. Türkel, and B. Baradan, "Effect of water/cement ratio on the fresh and hardened properties of self-compacting concrete," *Build. Environ.*, vol. 42, no. 4, pp. 1795–1802, 2007.

[5] M. H. A. Beygi, M. T. Kazemi, I. M. Nikbin, and J. V. Amiri, "The effect of water to cement ratio on fracture parameters and brittleness of self-compacting concrete," *Mater. Des.*, vol. 50, pp. 267–276, 2013.

[6] S. V. Hanafiah and K. N. Amalina, "The effect of w/c ratio on microstructure of Self-Compacting Concrete (SCC) with Sugar Cane Bagasse Ash (SCBA)," in *Proceedings of the 3rd International Conference on Construction and Building Engineering*, Palembang, Indonesia, August 14–17, 2017, pp. 050006-1–050006-10.

[7] I. M. Nikbin, M. H. A. Beygi, M. T. Kazemi, J. V. Amiri, S. Rabbanifar, E. Rahmani, and S. Rahimi, "A comprehensive investigation into the effect of water to cement ratio and powder content on mechanical properties of self-compacting concrete," *Constr. Build. Mater.*, vol. 57, pp. 69–80, 2014.

[8] N. F. Medina, G. Barluenga, and F. Hernández-Olivares, "Combined effect of Polypropylene fibers and Silica Fume to improve the durability of concrete with natural Pozzolans blended cement," *Constr. Build. Mater.*, vol. 96, pp. 556–566, 2015.

[9] V. Afroughsabet and T. Ozbakkaloglu, "Mechanical and durability properties of high-strength concrete containing steel and polypropylene fibers," *Constr. Build. Mater.*, vol. 94, pp. 73–82, 2015.

[10] W. Z. W. Zahari, R. N. R. L. Badri, H. Ardyananta, D. Kurniawan, and F. M. Nor, "Mechanical properties and water absorption behavior of polypropylene/ijuk fiber composite by using silane treatment," *Proced. Manuf*, vol. 2, pp. 573–578, 2015.

[11] S. S. Todkar and S. A. Patil, "Review on mechanical properties evaluation of pineapple leaf fibre (PALF) reinforced polymer composites," *Compos. Part B: Eng.*, vol. 174, 2019, Art no. 106927.

[12] S. Y. Ghanem, J. Bowling, and Z. Sun, "Mechanical properties of hybrid synthetic fiber reinforced self-consolidating concrete," *Compos. Part C: Open Access*, vol. 5, 2021, Art no. 100154.

[13] J. Hadipramana, F. V. Riza, I. A. Rahman, L. Y. Loon, S. H. Adnan, and A. M. A. Zaidi, "Pozzolanic characterization of waste Rice Husk Ash (RHA) from Muar, Malaysia," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 160, Art no. 012066.

[14] G. Pons, M. Mouret, M. Alcantara, and J. L. Granju, "Mechanical behavior of self-compacting concrete with hybrid fiber reinforcement," *Mater. Struct.*, vol. 40, pp. 201–210, 2007.

[15] M. G. Alberti, A. Enfedaque, and J. C. Gálvez, "Comparison between polyolefin fiber reinforced vibrated conventional concrete and self-compacting concrete," *Constr. Build. Mater.*, vol. 85, pp. 182–194, 2015.

[16] I. Ismail, N. Jamaluddin, and S. Shahidan, "A review on performance of waste materials in self-compacting concrete (SCC)," *J. Teknol.*, vol. 78, no. 5, pp. 29–35, 2016.

[17] A. Muhammad, N. Usman, and N. Gambo, "Effect of binary blended pozzolanic materials on properties of self-compacting concrete," *Int. J. Constr. Manag.*, vol. 22, no. 7, pp. 1323–1332, 2022.

[18] S. Kamaruddin, W. I. Goh, N. A. N. A. Mutalib, A. A. Jhatial, N. Mohamad, and A. F. Rahman, "Effect of combined supplementary cementitious materials on the fresh and mechanical properties of eco-efficient self-compacting concrete," *Arab. J. Sci. Eng.*, vol. 46, pp. 10953–10973, 2021.

[19] M. J. Memon, A. A. Jhatial, A. Murtaza, M. S. Raza, and K. B. Phulpoto, "Production of eco-friendly concrete incorporating rice husk ash and polypropylene fibers," *Environ. Sci. Pollut. Res.*, vol. 28, pp. 39168–39184, 2021.

[20] K. A. Tariq, M. Sohaib, and M. A. Baig, "Effect of partial replacement of cement with rice husk ash on concrete properties," *Pollack Period.*, vol. 16, no. 13, pp. 83–87, 2021.
[21] G. L. Thankam and N. T. Renganathan, "Ideal supplementary cementing material - Metakaolin: A review," *Int. Rev. Appl. Sci. Eng.*, vol. 11, no. 1, pp. 58–65, 2020.
[22] A. El Mir and S. G. Nehme, "Effect of air entraining admixture on the properties of self-compacting concrete incorporating supplementary cementitious materials," *Pollack Period.*, vol. 12, no. 3, pp. 85–98, 2017.
[23] G. Akeke, M. E. Ephraim, I. Z. S. Akobo, and J. O. Ukpata, "Structural properties of rice husk ash concrete," *Int. J. Adv. Eng. Sci. Appl. Math.*, vol. 3, no. 3, pp. 57–62, 8269, 2013.
[24] M. Asim, K. Abdan, M. Jawaid, M. Nasir, Z. Dashtizadeh, M. R. Ishak, and M. E. Hoque, "A review on pineapple leaves fiber and its composites," *Int. J. Polym. Sci.*, vol. 2015, 2015, Art no. 50567.
[25] N. Su, K. C. Hsu, and H. W. Chai, "A simple mix design method for self-compacting concrete," *Cem. Concr. Res.*, vol. 31, no. 12, pp. 1799–1807, 2001.
[26] *BS EN 12350-9:2010*, Testing fresh concrete self-compacting concrete. V-funnel test, Br. Stand., 2010.
[27] M. Amran, V. Lesovik, A. Tolstoy, R. Fediuk, N. Rusinova, D. N. Qader, K. Mohammed, and R. S. M. Rashid, "Properties and performance of polypropylene fibered high-strength concrete with an improved composite binders," *Case Stud. Constr. Mater.*, vol. 17, 2022, Art no. e01621.
[28] Y. I. A. Aisheh, D. S. Atrushi, M. H. Akeed, S. Qaidi, and B. A. Tayeh, "Influence of polypropylene and steel fibers on the mechanical properties of ultra-high-performance fiber-reinforced geopolymer concrete," *Case Stud. Constr. Mater.*, vol. 17, 2022, Art no. e01234.
[29] S. K. Ling and A. K. H. Kwan, "Adding ground sand to decrease paste volume, increase cohesiveness and improve passing ability of SCC," *Constr. Build. Mater.*, vol. 84, pp. 46–53, 2015.
[30] M. H. Lai, A. M. Griffith, L. Hanzic, Q. Wang, and J. C. M. Ho, "Interdependence of passing ability, dilatancy and wet packing density of concrete," *Constr. Build. Mater.*, vol. 270, 2021, Art no. 121440.