IOP Conference Series: Materials Science and Engineering

PAPER • **OPEN ACCESS**

Analysis of the effect of using wire mesh layers on hot asphalt mixtures with modulus of elasticity

To cite this article: R Ismy *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1087** 012018

IOP Conf. Series: Materials Science and Engineering 1087 (2021) 012018 doi:10.1088/1757-899X/1087/1/012018

Analysis of the effect of using wire mesh layers on hot asphalt mixtures with modulus of elasticity

R Ismy[1,2], Husaini[3,*], S M Saleh[4], M Isya[4]
[1]Doctoral School of Engineering Science, Universitas Syiah Kuala, Banda Aceh, Indonesia
[2]Department of Civil Engineering, Universitas Almuslim, Matang Glumpang Dua, Indonesia
[3]Department of Mechanical Engineering, Universitas Syiah Kuala, Banda Aceh, Indonesia
[4]Department of Civil Engineering, Universitas Syiah Kuala, Banda Aceh, Indonesia

*Email: husainiftm@unsyiah.ac.id

Abstract. The value of the modulus of elasticity is very important to know for analyzing the strength of a hot asphalt mixture because the increase in the modulus of elasticity indicates an increase in the ability of a mixture to withstand loads by itself. The use of the wire mesh layer as reinforcement in hot asphalt mixture is considered capable of increasing the modulus of elasticity. The aim of this study was to analyze the relationship between the use of wire mesh layers in the hot asphalt mixture with the modulus of elasticity. The research was conducted using the three-point flexural test apparatus. Based on experiment methode, it was found that hot asphalt mixture with a layer of wire mesh laying 30 mm from the surface of the specimen was the best type of specimen modeling with a bending resistance value of 291.85 KN. The higher the flexural resistance value that can be withheld, the higher the modulus of elasticity, namely 3,800.13 MPa. The best asphalt mixtures are characterized by a high modulus of elasticity, high stress, and low strain.

1. Introduction

In general, road constructions in Indonesia use hot mix asphalt as the surface course for the pavement. The application of asphalt as the main material in pavement construction is classified as a flexible pavement [1-5]. Flexible pavement has several courses, which are-; surface, base course, and subbase course located on subgrade [6,7]. Strength dependency of flexible pavement in base course and subgrade causes this pavement type becomes strongly not recommended to apply on unstable soil conditions [5-6, 8-11]. The flexural strength is a common treatment for rigid pavement. The flexural strength of concrete is the capability of a concrete beam located on two laying to hold force with perpendicular axis of test specimen which is given until the test specimen is broken and stated in Mega pascal (Mpa) force per unit area [12-15].

In application of rigid pavement, wire mesh is used as cracked and pumping controller due to the controlling of stress and deflection values that increase service index [2, 7, 16-18]. Stiffness owned by wire mesh is also considerably capable to increase modulus of elasticity value [16-18]. Wire mesh is kind of reinforcements of supporting that commonly used in rigid pavement [13, 16]. Using reinforcement considerably can make the flexible pavement less dependent to the foundation course and base soil so it can be applied on the unstable soil [16-19]. High modulus of elasticity in a pavement will cause structure strength placed in its pavement [1, 16–18]. Several previous studies regarding to the method used to control the crack and hold pull force implemented checkered pattern which are available in a pavement [20].

Based on the maximum load gained by using flexural test tool with three points, this study develops the analysis the distributions of stress, strain and moment to the maximum load transpiring in hot mix asphalt with variation of Wire mesh; 20 mm from the surface of test specimen, 20 mm laying from the base of test specimen, from the centre or 30 mm from the surface of test specimen with high of test specimen is 60 mm [21]. The aims of this study was to analyze the effect of using wire mesh layers on the modulus of elasticity.

The test specimen used is Marshall Test to gain optimum asphalt content, while to analyse the flexural strength, flexural test tool with three points is used for this study [22-23]. To facilitate data analysis in order to get the required result, several parameters such as Marshall Characteristic and flexure performance in the form of maximum load values and deflection or deformation are used [2, 7, 16, 24, 25].

This study is conducted by applying experimental and empirical methods using wire mesh as reinforcement material. [26]. The test specimen used are hot mix with mixed aggregate and asphalt as well as Wire mesh. The specification of used wire mesh is Wire mesh M4 with 4 mm diameter and its hole size is 150 mm. Total amount of test specimens are 32; 24 of test specimens for obtaining Optimum Asphalt Content with Marshall Characteristic analysis and 8 test specimens for analysing the flexural strength value of hot mix asphalt in wire mesh course as reinforcement.

To analyse the flexural strength values on the test specimen, flexure test tool with three points is implemented with four types of wire mesh course placement, they are:

a. Hot mix asphalt without wire mesh as comparison
b. Hot mix asphalt with wire mesh placed 20 mm from the surface of test specimen
c. Hot mix asphalt with wire mesh placed 30 mm from the surface of test specimen
d. Hot mix asphalt with wire mesh placed 20 mm from the base of test specimen

2. Literature review and theory

2.1 Flexible pavement

Flexible pavement is a pavement course consists of subgrade, subbase course, base course dan surface [7, 27], as Figure 1 illustrates. Hot mix asphalt is a course in a road construction composed from the mixing of asphalt cement and well graded aggregate, it is mixed, overlaid and compacted while it is hot in certain temperature [7, 9, 27]. The material of the aggregate consists of coarse aggregate, fine aggregate and well graded filler mixed with asphalt [3-5, 25, 27].

In asphalt mixing, asphalt works as binder or adhesive between aggregate particles and the aggregate works as supporting. The mechanism characteristics of asphalt in asphalt mixing are obtained from friction and cohesion from its forming materials [3-5, 7].

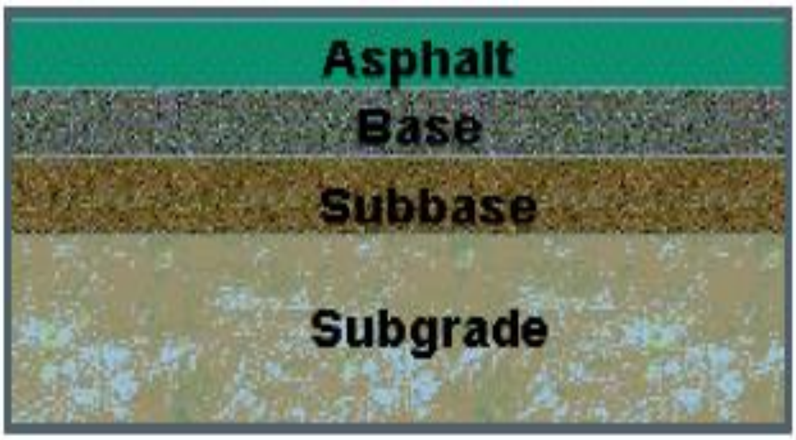

Figure 1. Composition of flexible pavement components.

IOP Conf. Series: Materials Science and Engineering 1087 (2021) 012018 doi:10.1088/1757-899X/1087/1/012018

2.2 Wire mesh
Wire mesh is a type of reinforcement from supporting pattern which commonly used in Rigid Pavement [13, 16]. In rigid pavement, the use of wire mesh is also used as crack control and pumping control due to the control of stress and deflection values so as to increase the service index with increasing the value of the modulus of elasticity [16, 28]. Wire mesh or usually called as woven wire is the iron chains resemble iron net that usually used to reinforce roof concrete. Wire mesh look like iron boxes that in each connection is glued together [13, 16], as shown in Figure 2.

Figure 2. Wire mesh.

2.3 Marshall test
Marshall Test, displayed in Figure 3, is the important stage in determining the characteristic of asphalt mixing. Marshall parameters used for this stage are stability, durability, flow, density, Marshall Quotient, void in mix, void in mineral aggregate and void filled with asphalt (VFA). Using Marshall test as well as analysing Marshall characteristic will obtain the optimum asphalt content [6, 9, 10, 25, 29, 30].

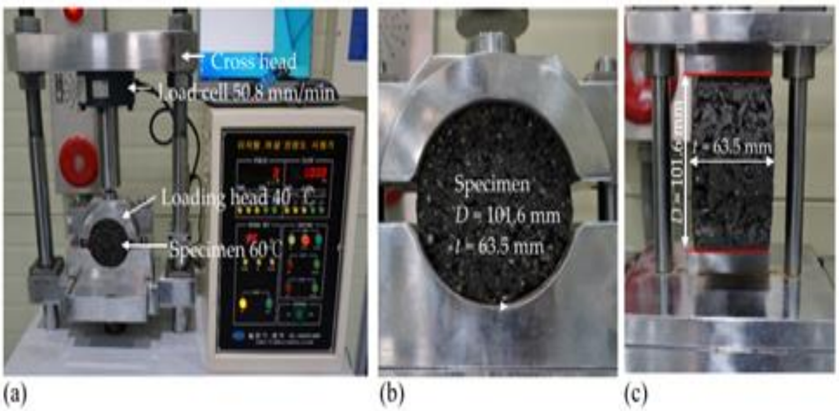

Figure 3. Marshall test.

2.4 Three points flexure test
Flexural test with three points is accordingly conducted to standardization of measuring flexural performance of concrete asphalt in temperature 10° C, when the asphalt mixing is susceptible to crack [31]. Loading rate is controlled in 50 mm/minute. Spesimen and test setting are illustrated in Figure 4.

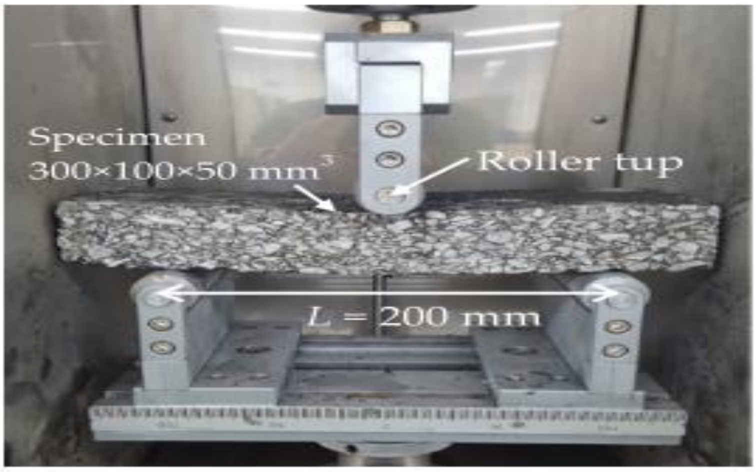

Figure 4. Three points flexure test.

3. Result and discussion

3.1 *The optimum asphalt content*
The first step of the study in hot mix is determining the Optimum Asphalt Content (OAC). After physical control of the aggregate and asphalt, then it is continued by preparing specimen test to analyse Marshall Characteristic. Based on the evaluation of Marshall characteristic in test specimen using Marshall test, it is found that OAC value is 5,75%.

3.2 *Correlation between loading and placement model of wire mesh*
The analysis of correlation between loading and placement model of wire mesh gained by hot mix asphalt is conducted by using flexural test tool with three points. The specimen test used is hot mix asphalt in Optimum Asphalt Content (OAC) that is obtained from Marshall characteristic test which is 5,75%. The test specimen is made with four types of wire mesh M4 placement in hot mix asphalt, as shown in Table 1.

Table 1. Asphalt mixed flexural testing results.

Number Of Test Object	Average KN	Loas (P) N	Deflection mm	Stress Mpa	Strain	Modulus Of Elasticity Mpa	Poison Ratio
1	188,5	188.500	9,5	78,54	0,038	2.066,89	0,15-0,45
2	197,7	197.700	9	82,38	0,036	2.288,19	0,15-0,45
3	291,85	291.850	8	121,60	0,032	3.800,13	0,15-0,45
4	251,3	251.300	8	104,71	0,032	3.272,14	0,15-0,45

Note:
Type of test object:
1. *Hot asphalt mixture without wire mesh layer (as comparison standard);*
2. *Hot asphalt mixture by laying 20 mm wire mesh layer from the surface of the test object;*
3. *Hot asphalt mixture by laying 30 mm wire mesh layer from the surface of the test object;*
4. *Hot asphalt mixture by laying 20 mm wire mesh layer from the base of the test object;*

Based on the result of the study, it is found that the highest loading which can be hold by hot mix asphalt is in test specimen type no. 3 where the hot mix with wire mesh course placed 30 mm from the surface of test specimen is 291,85 KN. The value of deflection occurs is 8 mm.

3.3 Stress, strain and modulus of elasticity
Looking at the relationship between loading and stress, strain and modulus of elasticity will be presented in a graphic form which is the result of the exposure from Table 1.

3.3.1 Stress
Stress is a reaction that occurs in all parts of the specimen in order to withstand a given load [18, 32, 33]. The description of the relationship between loading and stress is illustrated in Figure 5.

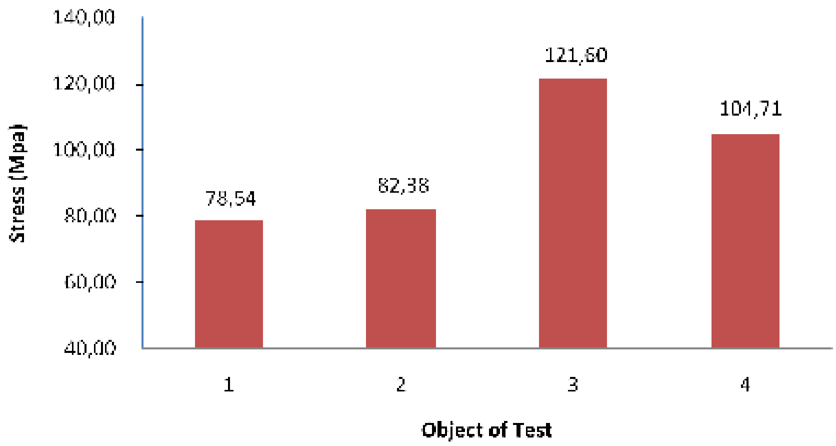

Figure 5. Graph of the relationship between test object loading and stress.

Based on Figure 5 the results obtained are:

a. The highest/maximum stress is 121.60 Mpa on the type 3 of the specimen, which is a hot asphalt mixture with a layer of wire mesh placed 30 mm from the surface of the specimen.
b. The lowest/minimum stress is 78.54 Mpa on the type 1 of the specimen, namely hot asphalt mixture without wire mesh layer.
c. The maximum stress that occurs between the type 1 and type 2 of the specimens has a value that is not much different, namely 78.54 Mpa and 82.38 Mpa.

3.3.2 Strain
Strain is a relative change in the size or shape of an object that is subjected to stress [18, 28, 33]. The magnitude of the strain value according to Table 1 that occurred is described in Figure 6.

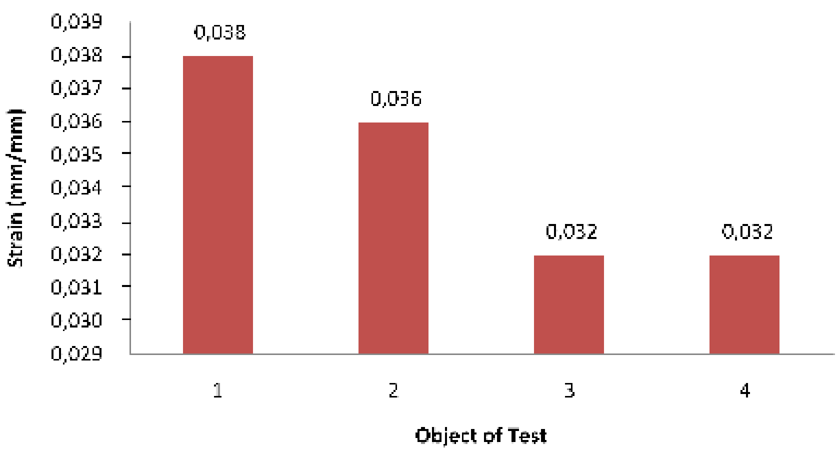

Figure 6. Graph of relationship between test object load and strain.

Figure 6 explains that the results obtained are:

a. The lowest/minimum strain is 0.032 mm/mm on the type 3 of the specimen, which is a hot asphalt mixture with a layer of wire mesh placed 30 mm from the surface of the specimen
b. The highest/maximum strain is 0.038 mm/mm in the type 1 of the specimen, namely hot asphalt mixture without wire mesh coating
c. The value of strain is very dependent on the amount of deflection that occurs
d. The maximum strain value that occurs between type 3 and type 4 of the specimens has the same value because they both have the same deflection amount of 8 mm

3.3.3 Modulus of elasticity

Modulus of elasticity is the ratio between the stress and strain of an object [18, 30]. The modulus of elasticity is also known as Young's modulus and is denoted by E.

$$E = \frac{\sigma}{\varepsilon} \tag{1}$$

E = Modulus of elasticity (MPa atau Psi),
τ = Stress (MPa), and
ε = Strain.

The modulus of elasticity is very important in analyzing the mixed strength of a construction. The high modulus of elasticity indicates that the ability of a mixture is good enough to withstand loads by itself.

Based on Table 1, it will be drawn in Figure 7.

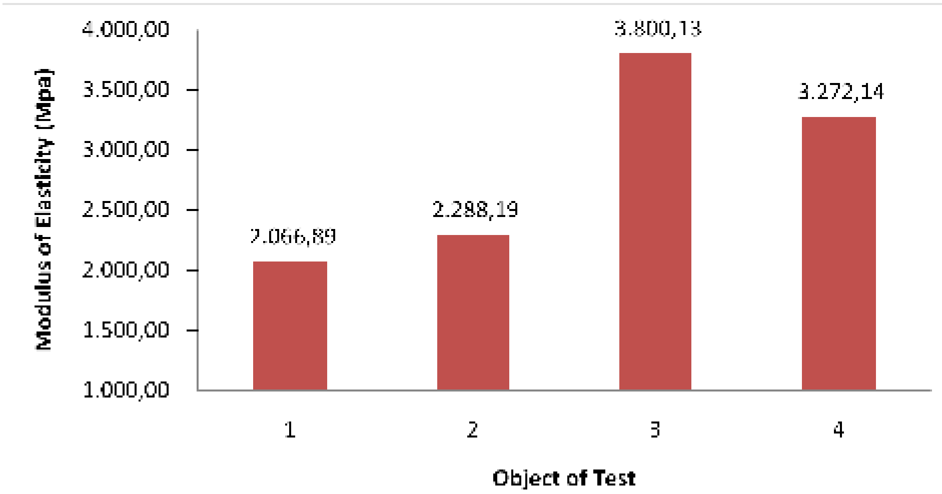

Figure 7. The relationship between test object loading and modulus of elasticity.

Figure 7 explains that the results obtained are:

a. The highest/maximum modulus of elasticity is 3,800.13 MPa in type 3 of the specimen, namely hot asphalt mixture with wire mesh layers placed 30 mm from the surface of the specimen
b. The lowest/minimum modulus of elasticity is 2,066.89 MPa in the type 1 of the specimen, namely hot asphalt mixture without wire mesh coating
c. The value of the modulus of elasticity is very dependent on the value of Stress and Strain
d. The value of the modulus of elasticity also depends on the placement of the wire mesh layers in the hot asphalt mixtures.

4. Conclusion

Based on the Marshall test and three-point bending test, several things can be concluded. The use of wire mesh layers in hot asphalt mixtures can increase the flexural resistance of the asphalt mixture.

The highest load that can be withheld as a flexural resistance value is obtained in the hot asphalt mixture with a layer of wire mesh placed 30 mm from the surface of the test object, namely 291.85 KN. The maximum stress is 121.6 Mpa, the minimum strain is 0.032 mm/mm, the maximum elastic modulus is 3,800.16 Mpa. The amount of deflection that occurs is between 8 mm

The value of the modulus of elasticity is very dependent on the value of Stress and Strain. The increase in voltage value depends on the increase in load held. The value of the strain depends on the amount of deflection that occurs

The modulus of elasticity is directly proportional to stress and inversely proportional to strain. Increasing the value of the modulus of elasticity indicates the high ability of a mixture to withstand loads by itself.

References

[1] Behiry A E A E M 2012 *Ain Shams Eng. J.,* **3 (4)** 367-374.
[2] Suprapto T M 2006 *Bahan dan struktur jalan raya*. 3rd Edition. Yogyakarta: KMTS FT UGM. *(in Bahasa Indonesia).*
[3] Isnanda I, Saleh S M, Isya M 2018 *Jurnal Teknik Sipil,* **1(3)** 637-646. *(in Bahasa Indonesia).*
[4] Razuardi R, Saleh, S M, Isya M 2018 *Jurnal Teknik Sipil,* **1 (3)** 715-724. *(in Bahasa Indonesia).*
[5] Saleh S M, Anggraini R, Aquina H 2014 *Jurnal Teknik Sipil,* **21 (3)** 241-250. *(in Bahasa Indonesia).*
[6] Bukhari R A 2007 *Rekayasa bahan dan tebal perkerasan jalan raya*. Banda Aceh: Engineering Faculty of Universitas Syiah Kuala. *(in Bahasa Indonesia).*
[7] Sukirman S 2003 *Beton aspal campuran panas*. Jakarta: Yayasan Obor Indonesia. *(in Bahasa Indonesia).*
[8] Hassani A. Taghipoor M, Karimi M M 2020 *Constr. Build. Mater.*, **253** 119196.
[9] AASTHO 1990 *Standard specification for transportation materials and methods of sampling and testing.* 15th ed. Washington, DC: AASHTO.
[10] Ismy R, Saleh S M, Isya M, Husaini. 2020. *Int. J. Psycho. Rehab.,* **24 (2)** 502-509.
[11] Afonso M L, Dinis-Almeida M, Pereira-de-Oliveira L A, Castro-Gomes J, Zoorob S E 2016 *Constr. Build. Mater.,* **102** 155-161.
[12] Wikipedia 2019 Material Description list. Available at https://id.wikipedia.org/wiki/Kekuatan_tarik. *(in Bahasa Indonesia).*
[13] Huang Y H 1993 *Pavement analisys and design*. London: University of Ketucky.
[14] Huang Y H 2004 *Pavement analisys and design*. Vol. 2, 2nd Edition. New Jersey: Pearson Prentice Hall.
[15] Saputra E, Putra E, Rachman M 2019 *IOP Conf. Ser.: Mater. Sci. Eng.,* **523 (1)** 012073.
[16] Suryawan A 2005 *Perkerasan beton semen portland (rigid pavement).* Jakarta: Beta Offset. *(in Bahasa Indonesia).*
[17] Saleleubaja S, Warman M, Farni I 2015 *Perencanaan perkerasan kaku (rigid pavement) pada ruas jalan "batas Kota Padang–Simpang Haru*. Thesis, Universitas Bung Hatta, Indonesia. *(in Bahasa Indonesia).*
[18] Lubis A S, Muis Z A, Iskandar T D 2018 *IOP Conf. Ser.: Mater. Sci. Eng*., **309(1)** 012113.
[19] Elleboudy A M, Saleh N M, Salama A G 2017 *Alexandria Eng. J.,* **56 (3)** 319-326.
[20] Walubita L F, Nyamuhokya T P, Komb, J J, Tanvir H A, Souliman M I, Naik B 2018 *Constr. Build. Mater.,* **191** 726-735.
[21] Implementation Team 2019 *Laboratory Center for National Road Works II*. Medan.
[22] Kim M J, Kim S, Yoo D Y, Shin H O 2018 *Constr. Build. Mater.,* **178** 233-243.
[23] Sesaria D A 2018 P*engaruh gradasi crumb rubber pada karakteristik campuran aspal.* Universitas Sumatera (USU) Repocitory. *(in Bahasa Indonesia).*

[24] Widyantara I G N, Suparma L B, Muthohar I 2018 *Informasi dan Ekspose hasil Riset Teknik Sipil dan Arsitektur,* **14 (1)** 48-61. *(in Bahasa Indonesia).*
[25] Ismy R 2015 *Jurnal Variasi*, **3 (8)**. *(in Bahasa Indonesia).*
[26] The latest list of prices for goods in May 2019 2019 Available at: http://cekhargabahan.com/daftar-harga-bahan-bangunan-terbaru/. *(in Bahasa Indonesia).*
[27] National Standardization Body (BSN) 1989 *SNI 03-1732-1989 Tata cara perencanaan tebal perkerasan lentur jalan raya.* Jakarta: National Standardization Body (BSN). *(in Bahasa Indonesia).*
[28] Correia N S, Zornberg J G 2018 *Geotextiles and Geomembranes,* **46 (1)** 111-120.
[29] Direktorat Jendral Bina Marga 2014 *Spesifikasi Umum Direktorat Jenderal Bina Marga 2010.* Edition Revision 3 Division 6. Jakarta: Ministry of Public Works of Indonesia. *(in Bahasa Indonesia).*
[30] Widodo S, Setyaningsih I 2011 *Simposium Nasional RAPI X FT UMS.* S13-S18. *(in Bahasa Indonesia).*
[31] Wu S, Ye Q, Li N 2008 *Constr. Buildi. Mater.,* **22 (10)** 2111-2115.
[32] Husaini H, Yudha S B Z, Akhyar H 2018 *AIP Conference Proceedings,* **1983 (1)** 030001.
[33] Hasanuddin I, Husaini M, Akhyar H 2018 *IOP Conf. Ser.: Mater. Sci. Eng.,* **352** 1-7.