

Increasing Compressive Strength of Natural Polymer Modified Mortar with Honey and *Gracilaria Sp.*

Rr. M. I. Retno Susilorini^{1,*}, VG. Sri Rejeki², Budi Santosa¹, Andi Theo Haryanto¹, Ferdi Pangestu¹

¹Department of Civil Engineering, Soegijapranata Catholic University, Semarang, Indonesia

²Department of Civil Engineering, Soegijapranata Catholic University, Semarang, Indonesia

*susilorini@unika.ac.id

Abstract—Polymer modified mortar has been implemented to prolong lifetime of concrete and to increase its performance. Previous researches have proven that using *Gracilaria Sp.* will increase mortar and concrete compressive strength. Since sugar based admixture contributes great bonding mechanism, honey becomes alternative for compressive strength increase. This research wants to investigate the compressive strength of natural polymer modified mortar and concrete using honey and *Gracilaria Sp.* The compressive strength design is 20 MPa. There are two steps in the research, pre-experiment and main experiment. Results of pre-experiments used and developed to be implemented in main experiment. Main experiment found that the natural polymer modified mortar and concrete using honey and *Gracilaria Sp.* increase the compressive strength as 29.19% compare to the control specimens. Optimum composition for natural polymer modified mortar is using honey and *Gracilaria Sp.* as 0.03% and 0.1% of cement weight, while for natural polymer modified concrete is using honey and *Gracilaria Sp.* as 0.03% and 0.05% of cement weight.

Keywords—Compressive strength, natural, polymer modified mortar, honey, *Gracilaria Sp.*

I. INTRODUCTION

Polymer modified mortar has been implemented to prolong lifetime of concrete and to increase its performance. Previous researches [1,2,3] have proven that using *Gracilaria Sp.* will increase mortar and concrete compressive strength. Since sugar based admixture contributes great bonding mechanism, honey becomes alternative for compressive strength increase.

Natural honey contains 80–85% carbohydrate (mainly glucose and fructose), 15–17% water, 0.1–0.4% protein, 0.2% ash and minor quantities of amino acids, enzymes and vitamins [4]. It is sticky and viscous solutions. Honey contains great number of glucose and fructose that may improve bonding mechanism in mortar and concrete mix.

Gracilaria Sp. is also polysaccharide which contains agarose and agaropectin that make strong gel [5]. Hence, the addition of honey will also improve bonding mechanism in mortar and concrete mix, as proved by [1,2,3].

According to the advantage of honey and *Gracilaria Sp.*, this research wants to investigate the compressive strength of natural polymer modified mortar and concrete using honey and *Gracilaria Sp.*

II. METHOD

This research conducted by pre-experiment and main experiment stages. Results of pre-experiments have been used and developed to be implemented in main experiment. There are 21 Pre-experiment compositions shown by Table 1 and 2 while main experiment consists of 20 compositions as described by Figure 3 and 4. In pre-experiment stage, mortar cube specimens were produced while in main experiment both mortar and cylinder specimens were produced. Mortar cube specimen dimension is 5 mm x 5 mm x 5 mm while cylinder dimension is 10 mm in diameter and 20 in height. *Gracilaria Sp.* powder is used as natural polymer while honey is used as admixture. Mortar composition is of weight ratio of cement : sand : water = 1 : 1 : 0.6. Natural polymer modified mortar and concrete have compressive strength design of $f'_c = 20$ MPa (for mortar cured by plain water). All specimens were tested for compressive strength at age 7, 14, and 28 days.

Table 1. Composition of natural polymer modified mortar with honey and *Gracilaria Sp.* for pre-experiment (modified from [6])

| Specimen Code | Honey | <i>Gracilaria Sp.</i> | Number of specimens |
|---------------|-------------------|-----------------------|---------------------|
| | (% cement weight) | (% cement weight) | |
| A | 0.03 | 0.1 | @ 5 pcs |
| B | | 0.2 | |
| C | | 0.5 | |
| D | | 1 | |
| E | | 2 | |
| F | | 5 | |
| G | 0.3 | 0.1 | |
| H | | 0.2 | |
| I | | 0.5 | |
| J | | 1 | |
| K | | 2 | |
| L | | 5 | |

Table 2. Composition of natural polymer modified mortar with honey for pre-experiment (modified from [6])

| Specimen Code | Honey | Number of specimens |
|---------------|-------------------|---------------------|
| | (% cement weight) | |
| M | 0.01 | @ 5 pcs |
| N | 0.02 | |
| O | 0.03 | |
| P | 0.04 | |
| Q | 0.05 | |
| R | 0.1 | |
| S | 0.2 | |
| T | 0.3 | |
| U | 0.4 | |
| V | 0.5 | |

Table 3. Composition of natural polymer modified mortar with honey and *Gracilaria Sp.* for main experiment (modified from [6])

| Specimen Code | Honey | <i>Gracilaria Sp.</i> |
|------------------|-------------------|-----------------------|
| | (% cement weight) | (% cement weight) |
| KT-M-K | 0 | 0 |
| KT-M-M0,03-G0,05 | 0.03 | 0.05 |
| KT-M-M0,03-G0,1 | 0.03 | 0.1 |
| KT-M-M0,03-G0,2 | 0.03 | 0.2 |
| KT-M-M0,03-G1 | 0.03 | 1 |
| KT-M-M0,03-G1,5 | 0.03 | 1.5 |

Table 4. Composition of natural polymer modified concrete with honey and *Gracilaria Sp.* for main experiment (modified from [6])

| Specimen Code | Honey | <i>Gracilaria Sp.</i> |
|------------------|-------------------|-----------------------|
| | (% cement weight) | (% cement weight) |
| KT-B-K | 0 | 0 |
| KT-B-M0,03-G0,05 | 0.03 | 0.05 |
| KT-B-M0,03-G0,1 | 0.03 | 0.1 |
| KT-B-M0,03-G0,2 | 0.03 | 0.2 |
| KT-B-M0,03-G1 | 0.03 | 1 |
| KT-B-M0,03-G1,5 | 0.03 | 1.5 |

III. RESULTS AND DISCUSSION

Pre-experiment found some optimum composition as shown by Table 3 and 4. Those compositions then implemented and developed in main experiment. Figure 1 describes compressive strength of natural polymer modified mortar at age 28 days, 5 compositions of main experiment which are consist of 5 specimens of each composition, while for natural polymer modified concrete shown by Figure 2. The results of main experiment found that KT-M-M0,03-G0,05 compressive strength has increased gradually from age 7 days to 28 days (Figure 3). It isn't happened to other compositions of natural polymer modified mortar. The phenomenon isn't happened to natural polymer modified concrete that has gradual increase of compressive strength (Figure 4). The specimen KT-B-M0,03-G1 has optimum increase of 29.19% (27.39 MPa) compared to control specimens (Table 5).

This research has proven that addition of honey and *Gracilaria Sp.* increase ‘double’ bonding mechanism, from honey and from *Gracilaria Sp.* The bonding mechanism gets the mortar and concrete highly compacted and strong that will increase the compressive strength. Hence, it is proved that natural polymer modified mortar and concrete with honey and *Gracilaria Sp.* have better compressive strength compared to the one without honey and *Gracilaria Sp.*

Table 5. Compressive strength increase of natural polymer modified concrete with honey and *Gracilaria Sp.* for main experiment (modified from [6])

| Specimen Code | % Δ_{7-28} days | % Δ_{14-28} days |
|------------------|------------------------|-------------------------|
| KT-B-K | 17,15% | 20,32% |
| KT-B-M0,03-G0,05 | 43,77% | 11,66% |
| KT-B-M0,03-G0,1 | 63,94% | 31,96% |
| KT-B-M0,03-G0,2 | 28,69% | 17,04% |
| KT-B-M0,03-G1 | 16,85% | 4,9% |
| KT-B-M0,03-G1,5 | 38,48% | 11,79% |

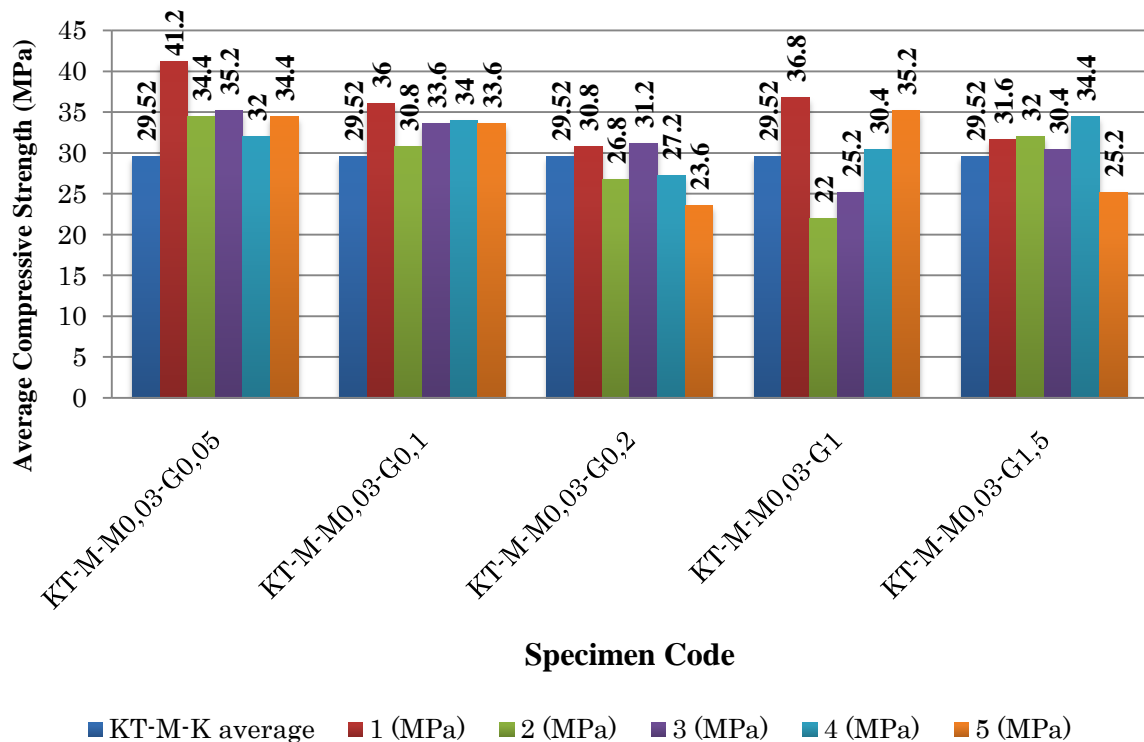


Figure 1. Compressive strength of natural polymer modified mortar with honey and *Gracilaria Sp.* at 28 days for main experiment (modified from [6])

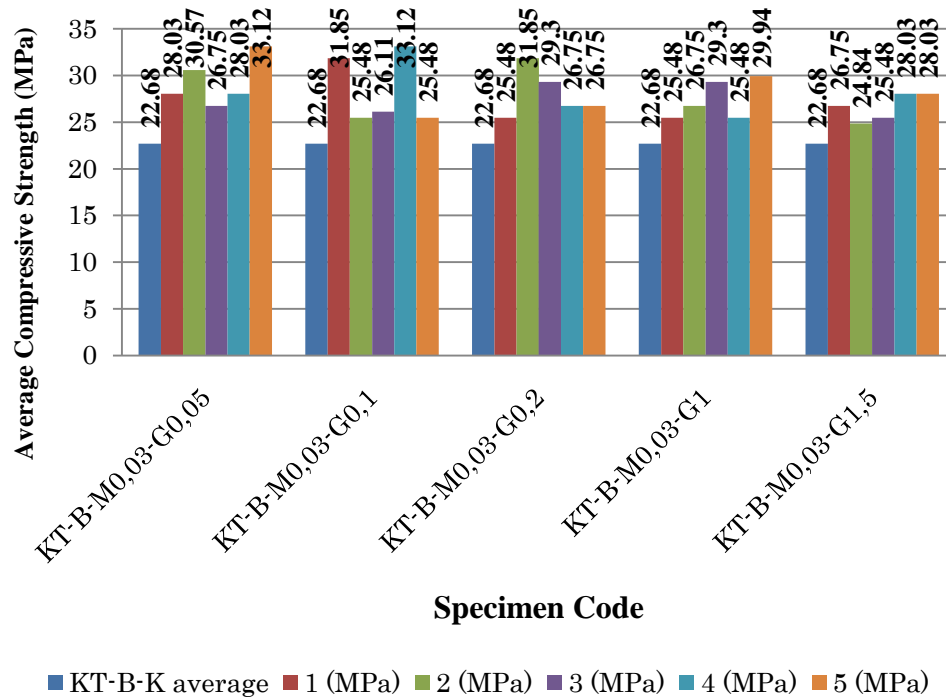


Figure 2. Compressive strength of natural polymer modified concrete with honey and *Gracilaria Sp.* at 28 days for main experiment (modified from [6])

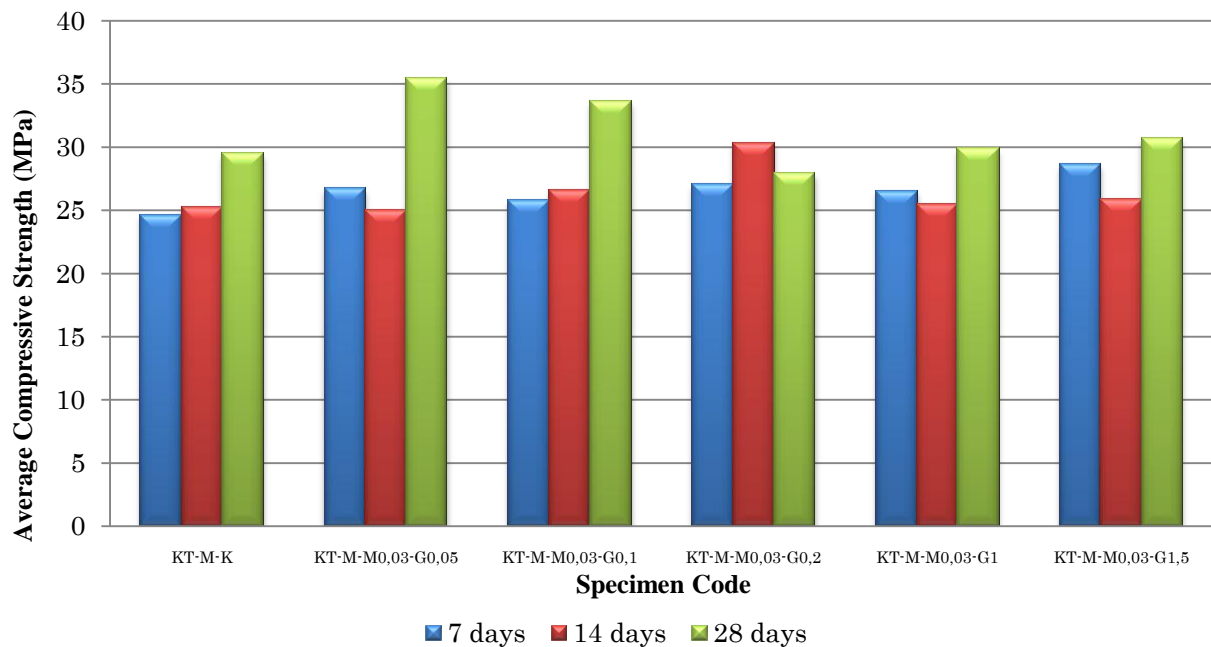


Figure 3. Compressive strength of natural polymer modified mortar with honey and *Gracilaria Sp.* at 7, 14, and 28 days for main experiment (modified from [6])

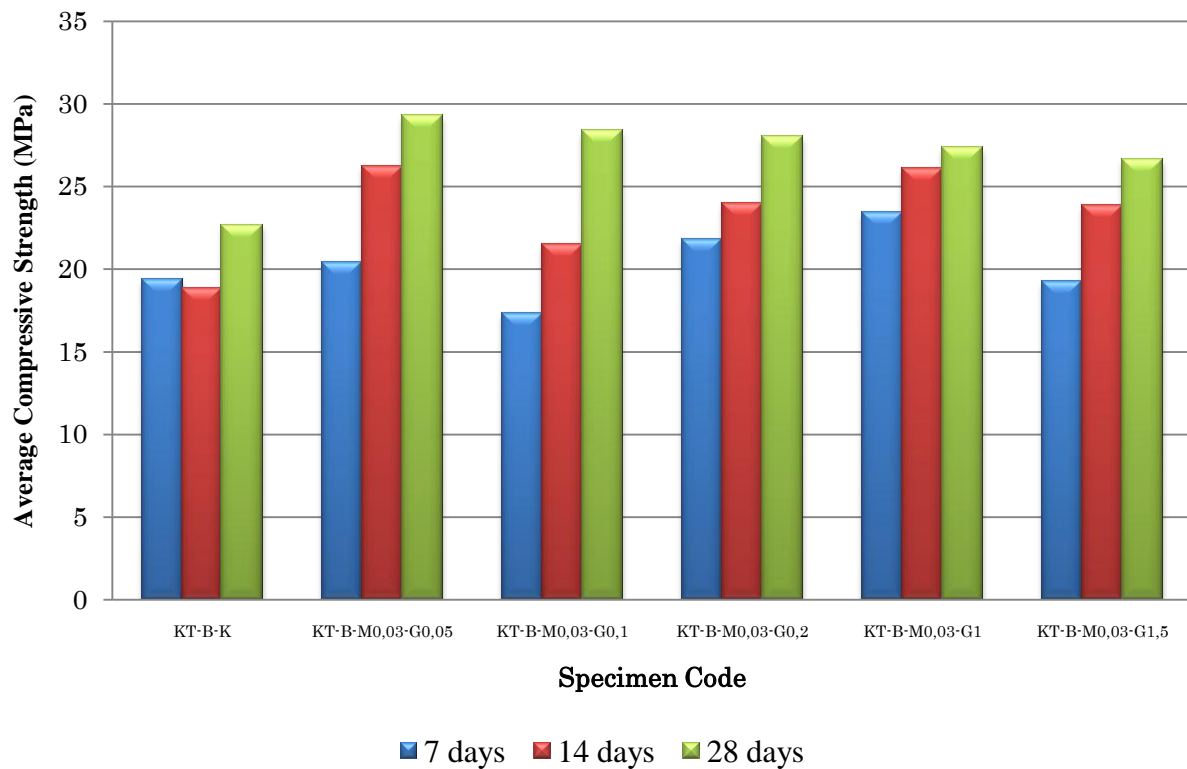


Figure 4. Compressive strength of natural polymer modified concrete with honey and *Gracilaria Sp.* at 7, 14, and 28 days for main experiment (modified from [6])

IV. CONCLUDING REMARKS

This research has found that honey and *Gracilaria Sp.* increased the compressive strength of natural polymer modified mortar and concrete of 29.19%. The performance of the natural polymer modified mortar and concrete was getting better because of ‘double’ bonding mechanism that makes its compressive strength getting higher. Optimum composition for natural polymer modified mortar is using honey and *Gracilaria Sp.* as 0.03% and 0.1% of cement weight, while for natural

polymer modified concrete is using honey and *Gracilaria Sp.* as 0.03% and 0.05% of cement weight.

ACKNOWLEDGMENT

This research is funded by Competency Grant 2014-2016 (Second Year), Contract No. 052/K6/KL/SP/Penelitian/2014), Directorate of Research and Community Service, Ministry of Research, Technology, and Higher Education.

REFERENCES

- [1] Susilorini, Rr. M.I. Retno., Hardjasaputra, H., Tudjono, S, Hapsari, G., Wahyu. S., Hadikusumo, G., and Sucipto, J. “The advantage of natural polymer modified mortar with seaweed: green construction material innovation for sustainable concrete”, *Procedia Engineering* Vol. 95, pp. 419-425, 2014.
- [2] Susilorini, Rr. M.I. Retno., Rejeki, VG. Sri., Santosa, Budi., Susanto, Agus., and Daniel Kurniawan, Daniel. “Increasing the Performance of Natural Polymer Modified Mortar with *Gracilaria Sp.* and *Moringa oleifera* in Aggressive Environment for Green Materials”, *Proceedings of ICCBL*, pp. 1-7, 2015.
- [3] Susilorini, Rr. M.I. Retno., Kusumawardaningsih, Yuliarti., Rejeki, VG. Sri., Santosa, Budi., Fani, Jena A., and Talubun, Valentina. “Promising Materials Innovation: Natural Polymer Modified Mortar with *Gracilaria Sp.* and *Moringa oleifera*”, submitted for 4th International Symposium on Ultra High Performance Concrete and High Performance Materials (Hipermat), Kassel, Germany, 2016.
- [4] Buba, Fatimah., Gidado, Abubakar, and Shugaba, Aliyu. “Analysis of Biochemical Composition of Honey Samples from North-East Nigeria”, *Biochemistry & Analytical Biochemistry*, 2(3), pp. 1-7, 2013.
- [5] Salamah, E., Erungan, AC., Retnowati, Y. “Pemanfaatan *Gracilaria Sp.* dalam pembuatan permen jelly”, *Buletin Teknologi Hasil Perikanan*, 9(1), pp. 38-46, 2006.
- [6] Haryanto, Andi Theo., and Pangestu, Ferdi. “Optimasi Campuran Mortar dan Beton dengan Polimer Alami *Gracilaria Sp.* dan Bahan Tambah Madu”, Undergraduate Thesis, Department of Civil Engineering, Faculty of Engineering, Soegijapranata Catholic University.