Compressive Strength Optimization of Natural Polymer Modified Mortar with *Moringa oleifera* in Various Curing Medias

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Abstract* — Polymer modified concrete and polymer modified mortar are recommended for construction that built in aggressive environment such as seawater. This research wants to use Moringa oleifera as natural polymer for ingredient of modified mortar polymer because of its benefit and to find how natural polymer modified mortar with Moringa oleifera becomes durable in aggressive environment like in seawater and brackish water. This research conducted by experimental method. Several mortar cubes specimens with dimension 50 mm x 50 mm x 50 mm were produced with compressive strength design as f'_c = 30 MPa. Mortar mix composed by 1:1:0,6 (cement:sand:water). This research used Moringa oleifera powder as natural polymer, with and without skin. Total mix compositions for compressive test were 13 mixes (with one plain mortar mix as control specimens). Specimens were cured by plain water, seawater, and brakish water. The results of research note that: (1) natural polymer modified mortar with Moringa oleifera has advantage in improving its bonding mechanism, strength and its durability in seawater and brackish water; (2) The optimum composition of Natural polymer modified mortar with Moringa oleifera is achieved by M-I-TK-02 that contains Moringa oleifera as 0.2% of cement weight.

Key words – natural polymer modified mortar, Moringa oleifera , compressive strength, seawater, durability.

I. INTRODUCTION

In late decades, innovation of polymer concrete has been revealed. Polymer concrete is defined as composite material in which aggregates are bonded together with resins in a polymer matrix [1] that became the answer of the lack of conventional concrete mostly in durability performance. Polymer modified concrete and polymer modified mortar are the composites made by using polymer and cement and also aggregates, depend on the size of granule [2], [3]. Innovation of polymer modified concrete mainly aimed to get strength and durability performance, and also fast curing [4]. Polymer concrete is generally used to repair, strengthen, protect structure from corrosion, and also improves mechanical strength as well as chemical resistance and provides low permeability [5]. Chemical polymer generally used for polymer concrete ingredient while rubber latex and natural fiber generally used as organic polymers.

Due to the advantage of durability performance, polymer modified concrete and polymer modified mortar are recommended for construction that built in aggressive environment such as seawater. There is no doubt that concrete is the most durable materials for construction that built in seawater environment. Roman ancient seawater block concrete had proven excellent performance after submerged in Bay of Pozzuoli (*Baianus Sinus*), near Naples, for around 2000 years [6].

In order to achieve good performance of polymer modified mortar, a breakthrough is need. Therefore, this research wants to use *Moringa oleifera* as natural polymer for ingredient of modified mortar polymer because of its benefit. *Moringa oleifera* contains 4-alfa-4-rhamnosylosky-benzil-isothiocynate, myrosin, glyceride acid, palmitate acid, stearate oil, and bactericyde compounds [7], [8]. It has been investigated by [8] that *Moringa oleifera* can also work as coagulant that absorbs metallic ions in the water.

Therefore, it is very important to find how natural polymer modified mortar with *Moringa oleifera* becomes durable in aggressive environment like in seawater and brackish water. Hence, this research aimed to optimize the compressive performance of polymer modified mortar with *Moringa oleifera* in various curing medias that represent aggressive environment.

II. MATERIALS AND METHODS

Fig. 1 *Moringa oleifera* with skin

Fig. 2 *Moringa oleifera* without skin

This research conducted by experimental method. Several mortar cubes specimens with dimension 50 mm x 50 mm x 50 mm were produced with compressive strength design as f'_c = 30 MPa. Mortar mix composed by 1:1:0,6 (cement:sand:water). This research used *Moringa oleifera* powder as natural polymer, with and without skin (Fig 1 and 2), with dosages mentioned in Table 1. Total mix compositions were 13 mixes (with one plain mortar mix as control specimens, see Table 1).

All specimens were cured in 3 curing medias and then being tested for compressive strength at 7, 14, and 28 days referred to ASTM C-109. The curing medias were plain water, seawater, and brakish water.

TABLE I
MIX COMPOSITION OF NATURAL POLYMER MODIFIED MORTAR

Mix Code	% weight *Moringa oleifera* of cement	Number of samples in curing media (pcs)		
		Plain water	Seawater	Brakish water
M-I-TK*-0***	0	15	15	15
M-I-TK-01	0.1	15	15	15
M-I-TK-02	0.2	15	15	15
M-I-TK-03	0.5	15	15	15
M-I-TK-04	1	15	15	15
M-I-TK-05	2	15	15	15
M-I-TK-06	5	15	15	15
M-II-K**-01	0.1	15	15	15
M-II-K-02	0.2	15	15	15
M-II-K-03	0.5	15	15	15
M-II-K-04	1	15	15	15
M-II-K-05	2	15	15	15
M-II-K-06	5	15	15	15

TK* : without skin
K** : with skin
*** : control specimens

III. RESULTS AND DISCUSSION

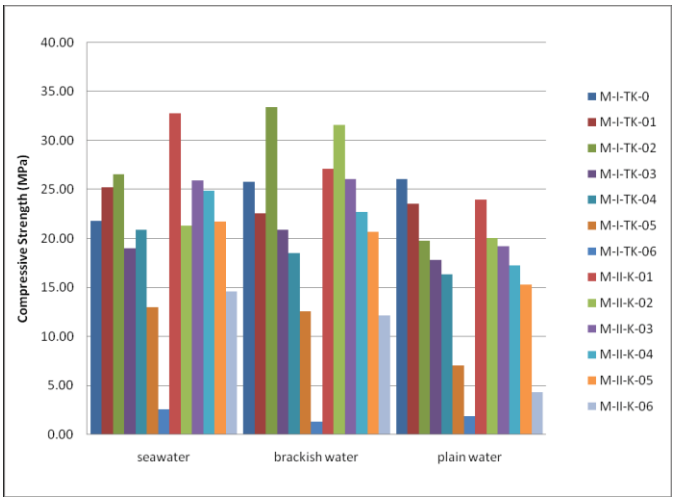

Fig. 3 Compressive strength of natural polymer modified mortar with *Moringa oleifera* at age 7 days (modified from [9], [10])

The compressive test has shown results as described by Figure 3, 4, and 5 [9], [10]. It is interesting that at the age 7 days, the compressive strength of some specimens (M-I-TK-01, M-I-TK-02, M-II-K-01) cured by seawater and brackish water were higher compared to the ones cured by plain water (Figure 3).

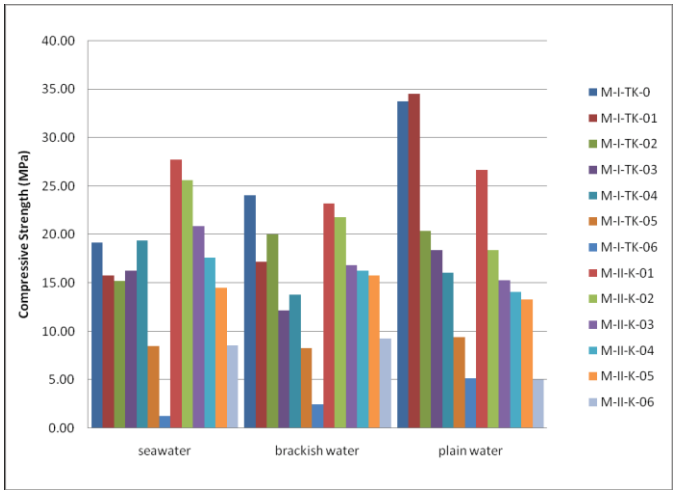

Fig. 4 Compressive strength of natural polymer modified mortar with *Moringa oleifera* at age 14 days (modified from [9], [10])

At the age 14 days, some specimens (M-I-TK-0 and M-I-TK-1) had higher compressive strength compared to the others cured by plain water. But it should be noted that the control specimens had lower compressive strength compared to M-II-K-01 and M-II-K-02 that cured by seawater (Figure 4).

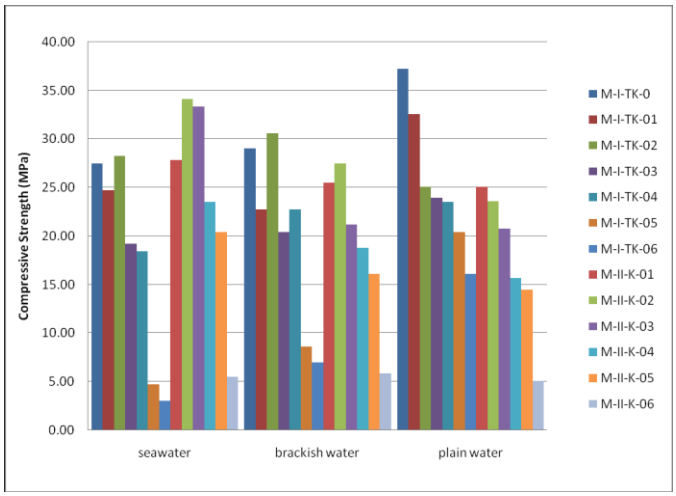

Fig. 5 Compressive strength of natural polymer modified mortar with *Moringa oleifera* at age 28 days (modified from [9], [10])

The control specimens had higher compressive strength compared to others that cured by plain water at age 28 days, but when the specimens cured by seawater and brackish water, the control specimens had lower compressive strength (Figure 5). Specimens M-I-TK-02, M-I-K-02, M-I-K-03 that cured by seawater had higher compressive strength compared to control specimens.

Concrete and mortar performance exposed to seawater has been investigated for several decades. Seawater contains 78% NaCl, 10.5% $MgCl_2$, 5% $MgSO_4$, 3.9% $CaSO_4$, 2.3% K_2SO_4, and 0.3% KBr [11]. The presence of $MgSO_4$ takes important role in sulphate attack to concrete by crystallisation [12]. According to the research of [6] and [12], concrete that cured by seawater will have higher compressive strength compared to the one cured by plain water because the production of poorly crystalline calcium-aluminium-silicate-hydrate (C-A-S-H) binder by reaction of ash, lime, and seawater. Those facts have explained the results of this research that some specimens cured by seawater and brakish water have higher compressive strength compared the ones cured by plain water.

In order to keep durable, concrete should produced also by durable materials. In this research, specimens of natural polymer modified mortar with *Moringa oleifera* have shown higher compressive strength compared to the control specimens. *Moringa oleifera* contains glyceride. Glycerides are esters that formed by glycerol (or glycerine) and fatty acids. Glycerol (or glycerine) is potential to increase the compressive strength of concrete and mortar and also cement that were investigated by [13], [14]. The use of glycerine that was combined with litharge is very effective in improving workable and quick setting mortar to become strong and harder [13]. Another advantage of *Moringa oleifera* use in concrete and mortar is performing as corrosion inhibitor [15]. The experiment by [15] proved that the inhibitor molecules *Moringa oleifera* of can absorb on the mild steel surface. According to the explanation of *Moringa oleifera* advantages, it can be understood that the addition of *Moringa oleifera* has increased the performance of natural polymer modified mortar to become stronger and harder because its better bonding mechanism. The natural polymer modified mortar with also performed better compressive strength in seawater because the molecules of *Moringa oleifera* has absorbed the ions of chloride.

Among the 12 mix compositions of natural polymer modified mortar, there were 4 mix compositions should be optimized. They are M-I-TK-01, M-I-TK-02, M-I-K-01, and M-I-K-02 (Figure 6 and 7). Figure 6 has shown that compressive strength of M-I-TK-02 (*Moringa oleifera* without skin) in the three medias (plain water, seawater, and brackish water) increased, but compressive strength of M-I-TK-02 decreased.

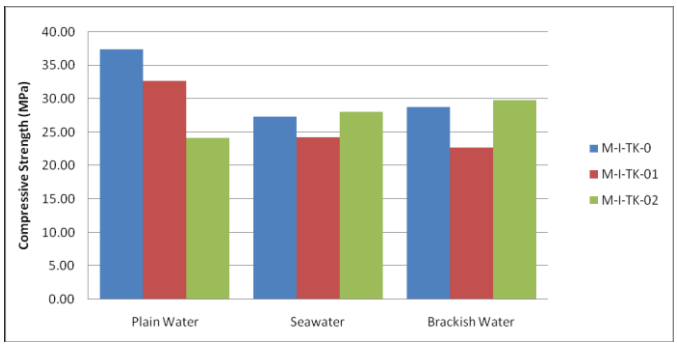

Fig. 6 Compressive strength of control specimens, M-I-TK-01, and M-I-TK-02 in various medias at age 28 days (modified from [9], [10])

It was also found that M-I-K-02 (*Moringa oleifera* with skin) has higher compressive strength compared to M-I-TK-01 that cured by seawater, slightly higher compared to the ones cured by brackish water, and slightly lower compared to the ones cured by plain water. According to the results shown by Figure 6 and 7, the optimum mix composition of natural polymer modified mortar is M-I-TK-02 that contains *Moringa oleifera* as 0.2% of cement weight.

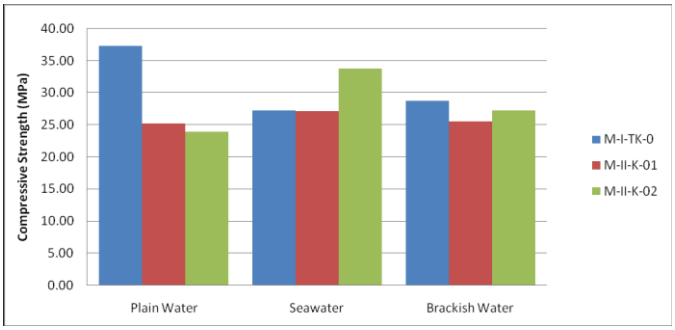

Fig. 7 Compressive strength of control specimens, M-I-K-01, and M-I-K-02 in various medias at age 28 days (modified from [9], [10])

IV. CONCLUSIONS

This research meets conclusions as follow:

1. Natural polymer modified mortar with *Moringa oleifera* has advantage in improving its bonding mechanism, strength and its durability in seawater and brackish water
2. The optimum composition of Natural polymer modified mortar with *Moringa oleifera* is achieved by M-I-TK-02 that contains *Moringa oleifera* as 0.2% of cement weight

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