Improving Mortar Properties in Saline Environment

by University Of Mataram

ISBN 979-587-621-1

SICEST PROCEEDINGS
SRIWIJAYA INTERNATIONAL CONFERENCE ON ENGINEERING, SCIENCE & TECHNOLOGY

Improving Mortar Properties in Saline Environment

Jauhar Fajrin*, Pathurahman and Lalu Gita Pratama
Department of Civil Engineering, Faculty of Engineering, Mataram University, Mataram-Lombok 83125, Indonesia,

Abstract: Buildings in coastal settlement are severely subjected to the effect of saline environment. Brick wall, which consists of brick and mortar, is the most affected component degraded by such environment. There are several methods reported in literatures for reducing the effect of aggressive environments to mortar. Most of the previous studies concentrate on introducing additional materials that might increase the overall building cost. This paper discusses the possibility of reducing the negative impact of saline environment by just increasing the proportion of cement in mortar mixes. The study was divided in two subsequent experimental stages. The first experiment was designed to select the most optimum mortar composition by varying the cement content. The research parameters includes compressive strength, water absorption and PH value of the mortar. Having obtained the most effective mortar composition through the first experiment, it was also investigated the possibility of using silica fume as a partial replacement for cement in further experimental stage. The study has proved that the cement content plays an important role in the quality of mortar. The increasing of cement content has considerably improved the compressive strength of mortar up to 370%. The optimum composition was mortar with the ratio of cement/sand of 30:70. The selected mixes has also significantly reduced water absorption by around 65%. The partial replacement of cement content with silica fume to the selected proportion further improved the properties of mortar. The compressive strength was enhanced by approximately 13%, while water absorption was reduced by 35%. The PH value seems not significantly affected by both treatments as the first experiment only increases the PH value up to 6% and further treatment decreases the PH value by only 2.5%.

Keywords: Improvement method; mortar properties; saline environment; mortar mixes.

e-mail: jauhar.fajrin@unram.ac.id*

1. INTRODUCTION

The knowledge of using proper material for housing is relatively less particularly for people who lives in rural areas. Building materials are often selected based on common practices which may lead to build less durable houses. It is also frequently observed as common practice that concrete or mortar mixes for building in normal condition is also employed for housing along a sea front. Crisman [1] stated that climate has to be considered as the most important factors in selecting and assembling of material. It is well understood that durability of homes in coastal areas relies on the type of materials used in building the construction. Masonry is a common material used for building construction in coastal settlement as it exhibits excellent long-term performance. The durability of masonry structures is influenced by both masonry units and the mortars [2]. It is therefore, mortar plays a significant contribution to the overall durability of a masonry or brick structure. Early damages to structures in saline environment are unavoidable and therefore preventive efforts have to be included in design and during the construction process. Bates [3] stated there is a strong correlation between damage and salinity level. The durability of mortar exposed to saline environment has been a topic of interest to researchers for long time. As pointed in [2], there are several factors that significantly affects the performance of mortar includes; mortar class, cement, sand, joint finish, masonry unit and period of exposure.

A lot of ideas and solutions have been discussed and revealed some important findings. However, it remains challenging for further study and research. Ganjian and Pouya [4] used silica fume as a cement replacement to enhance the performance of cement paste and concrete mixes in Persian gulf water. Rahman et al. [5] suggested the use of epoxy-based masonry mortar in building infrastructure as it showed excellent resistance to corrosive environment. In addition, modifying mortar by adding polyethylene terephthalate (PET) was reported in [6]. It was found that the modified mortar performed better against chemical attack by various acid. Most of the previous reported works in this topic tried to introduce additional materials in enhancing the performance of mortar under saline environment. This paper presents the results of experimental works on improving the performance of mortars in saline water by just increasing the cement content in mortar mixes. The research was motivated by the work of Wegian [7] who stated that the cement content has a significant influence on improving the strength and durability of concrete. Concrete with higher cement content more durable and stronger than normal concrete. More specifically, the current research uses inferential statistical analysis to obtain more accurate findings. Also, the proposed method has the advantage of being easy to be conducted by less-skill workers.

2. EXPERIMENTAL DETAILS

In this study, three different mortar compositions were prepared and assessed. With the inclusion of a control specimen that consists of a standard or normal mortar with 20% cement and 80% sand, the experiment was carried out to test four levels of a factor. The specimens were prepared and tested in accordance with SNI 03-6825-2002 standard [8]. For compressive test, the specimens were shaped into the size of 50 x 50 x 50 mm and the specimen was replicated 5 times. While the specimen for water absorption and PH value test were replicated 3 times. All specimens were exposed to aggressive environment by submerging them in saline water for 28 days. The samples preparation and testing process are presented in Fig.1. The experimental investigation was divided into two subsequent works; first and second experiments. The first experiment was designed to select the most optimum mortar compositions by varying the cement content. The selected mortar composition obtained from the first experiment was then used as the control specimen in further experiment in the second stage, where some amount of cement were partially replaced with silica fume.

ISBN 979-587-621-1
SICEST PROCEEDINGS
SRIWIJAYA INTERNATIONAL CONFERENCE ON ENGINEERING, SCIENCE & TECHNOLOGY

Fig.1. Samples and testing program

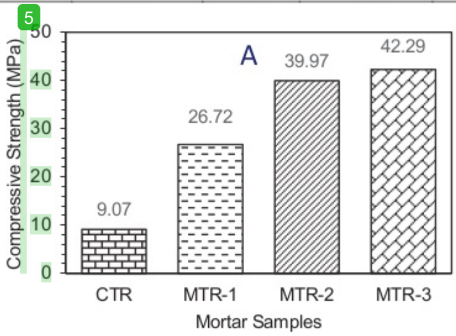
3. RESULTS AND DISCUSSIONS

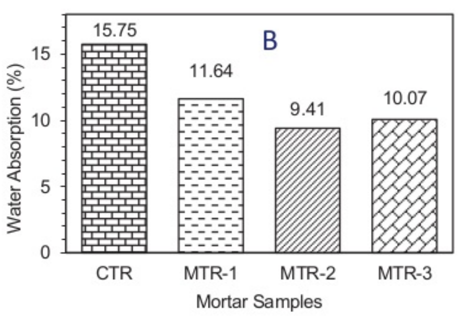
A. First Experiment

The mix design of mortar for the first experimental work is presented in Table I. As seen in the table, three different mortar compositions; MTR-1, MTR-2 and MTR-3 were compared to a control (CTR) specimens. The discussions were focused on three parameters; compressive strength, water absorption and PH value, that represented the physical and mechanical properties of mortar. The testing results are presented in Fig. 2.

TABLE I. MORTAR MIX DESIGN FOR THE FIRST EXPERIMENTAL WORK

Mortar Category	Percentage of material		Weight of material (gr)	
	Cement (%)	Sand (%)	Cement (g)	Sand (g)
CTR	20	80	400	1600
MTR-1	25	75	500	1500
MTR-2	30	70	600	1400
MTR-3	35	65	700	1300





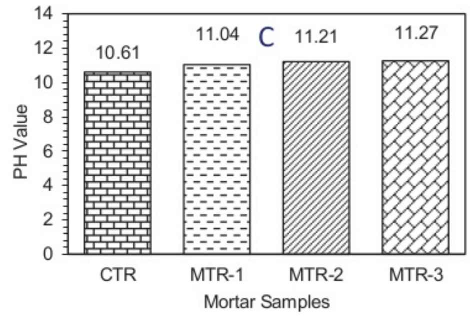


Fig.2. Results of the first experiment

The compressive strength, water absorption and PH value were plotted against the mortar categories. It is clearly demonstrated in the Fig. 2(A) that the increasing of cement content produces mortar with notably high in compressive strength. The range of improvement given is around 190% to 370%. Mortar MTR-1 with cement/sand ratio of 1:4 has the average compressive strength of 26.76 MPa, which is about 194.5% higher than such value of standard or normal mortar (CTR). Increasing the cement content by 30% and 35% further enhanced the compressive strength to 39.97 MPa (MTR-2) and 42.29 MPa (MTR-3), respectively. The enhancement provided was about 340.6% for MTR-2 and 366.2% for MTR-3. The result is comparable to the finding of Wegian [7] who previously stated that the cement content has a strong effect to the strength and durability of concrete. It is also confirmed the results of other previous study reported in Reference [2]; the higher cement content the lower scratch index which representing the durability of mortar. The report also noted that mortar with higher class provides better durability.

However, when a comparison is made between MTR-2 and MTR-3, the average compressive strength of these two levels differs by what seems to be a modest amount. In that case, the difference is perhaps due to difference in sample preparation or testing. This also indicated that the optimum cement content is approximately around 30%. Beyond that point, the improvement is no longer significant. The improvement of compressive strength is perhaps due to the enhancement of binding mechanism within mortar mixes. As the cement content increases, the surface area of sand is covered thoroughly by the cement matrix creating a good bonding between sand in contact. When the cement content exceeded the needs, the amount of sand as the reinforcement decreases and produces mortar with equal or even lower strength.

The average of water absorption also differs by a large amount when comparing each level to the control, as depicted in Fig. 2(B). It is clearly shown that mortar with high cement content absorb much less water compared to the normal mortar, which may lead to a more durable performance in long term. The range of improvement was approximately 35% to 67%. A proportion of 30:70 of cement/sand (MTR-2) has considerably improved the water absorption properties. The water absorption was reduced by approximately 67.37%, from 15.75% to only 9.41%. Increasing the proportion of cement by 5% (MTR-1) gives a moderate enhancement by 35.31% of the water absorption properties of mortar. In addition, the water absorption properties of MTR-3 was 10.07%, which is about 56.4% less than the control (CTR). The reason why mortar with higher cement content absorb less water is probably due to the presence of adequate cement matrix is not

ISBN 979-587-621-1

only improving the bonding between sand particles but also filling the pores within the mortar.

Fig. 2(C) shows the trend of the PH value which constantly to rise up slightly as the percentage of silica fume is increased. The difference only ranges between 4 to 6%. The addition of 15% more cement to the control increases the PH value by 6.2% (MTR-3). While the PH value of MTR-1 and MTR-2 is 11.04 and 11.21, respectively. The difference to the control was about 4.05% and 5.65% for MTR-1 and MTR-2, respectively. It is important to note that the PH value for all treatments is higher than 7 which means that all mortars are not in acid conditions. The PH value above 6.5 should be maintained to prevent material from degradation due to acid condition [9].

B. Second Experiment

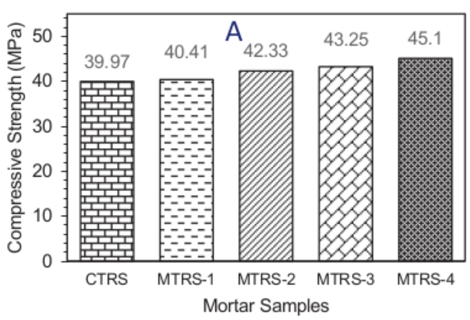
The mix design of mortar for the second experimental work is presented in Table II and Table III. As presented in the tables, the specimen label has been changed by adding a letter 'S' at the end which means 'Silica'. The mortar compositions; MTRS-1, MTRS-2, MTRS-3 and MTRS-4 were compared to a control (CTRS) specimens.

TABLE II. PERCENTAGE AND WEIGHT OF SILICA FUME AS A PARTIAL REPLACEMENT OF CEMENT

Mortar Category	Percentage of silica fume to cement (%)	Weight of Silica fume (g)	Weight of cement (g)	Percentage of silica fume to mortar mix design (%)
CTRS	0	0	600	0
MTRS-1	3	18	582	0.9
MTRS-2	5	30	570	1.5
MTRS-3	7	42	558	2.1
MTRS-4	10	60	540	3

TABLE III. MORTAR MIX DESIG OF THE SECOND EXPERIMENTAL WORK

Mortar Category	Weight of material (gr)		
	Cement (g)	Silica fume (g)	Sand (g)
CTRS	600	0	1400
MTRS-1	582	18	1400
MTRS-2	570	30	1400
MTRS-3	558	42	1400
MTRS-4	540	60	1400



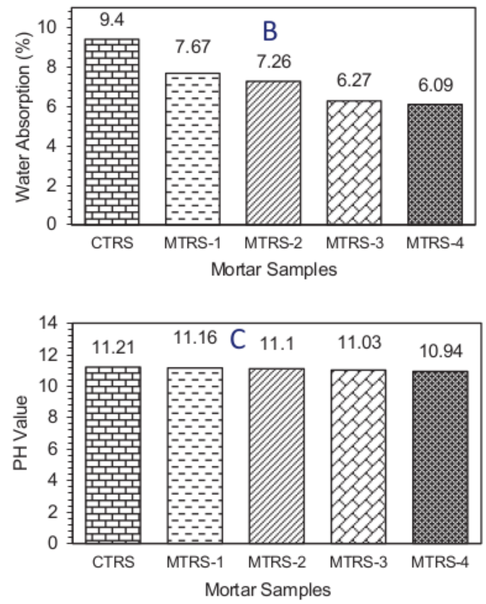


Fig.3. Results of the second experiment

Fig. 3 shows the results of experiment in the second stage. As mentioned previously, the second experiment was designed to investigate whether replacing some amount of cement with silica fume improves mortar properties or not. As it can be noticed in Fig. 3 (A), the average compressive strength of mortar with partially replacement of cement content with silica fume is 40.41 MPa (MTRS-1), 42.33 MPa (MTRS-2), 43.25 MPa (MTRS-3) and 45.1 MPa (MTRS-4). The range of improvement is only around 1% to 13%, which is much less compared to the results of the first experiment. Replacing cement with silica fume to about 10% increases the compressive strength by 12.84%. In addition, the replacement of 3%, 5% and 7% cement with silica fume improves the compressive strength by 1.1%, 5.9% and 8.2%, respectively. Overall, the results indicated that the further replacement of cement with silica fume may not provide significant improvement in compressive strength, especially when cost and workmanshipare taken into account.

A significant improvement provided by the partial replacement of cement content with silica fume might be seen through the water absorption parameter, as presented in Fig. 3(B). The reduction of water absorption ranges from 18.3% to a maximum of 35% for the replacement of cement by 10% silica fume, which is considered as significant. Meanwhile, the PH value seems not significantly affected by the replacement treatment. As seen in Fig. 3(C), the PH value for all specimen groups only differ slightly, where the PH value of CTRS is 11.2 and 10.9 for the highest silica fume content (MTRS-4). However, the pattern remains constant to decrease as the percentage of silica fume increased.

4. CONCLUSIONS

The study has proved that the cement content plays an important role in the quality of mortar. The increasing of cement content by 10%, from a normal mixes of 20:80 to 30:70, has considerably improved the compressive strength of mortar by around 340%. Although the cement content was also increased to 35:65 and resulted in further improvement by approximately 365%, the optimum mixes remains the mortar with the proportion of cement/sand of 30:70. The selected mixes also significantly reduced the water absorption by around 65%. The study has also confirmed that further treatment by partially replacing cement content with silica fume up to 10% to the selected mixes only improves the compressive strength by approximately 13%. The further treatment has, however, significantly reduced the water absorption up to 35%. The PH value seems not significantly affected by both treatments as the first experiment only increases the PH value by around 6% and further treatment in the second experiment decreases the PH value by a maximum value 2.5%.

ACKNOWLEDGMENTS:

We greatly appreciate the sponsorship from the Ministry of Research, Technology and Higher Education under the scheme of Hibah Bersaing 2015-2016 which made this research possible. A huge thank also we would like to offer to technician; Mr. Imam Hadiwijaya for his help during the testing.

REFERENCES

[1] P. Crisman. Materials. Accessed from: https://www.wbdg.org/ resorces/materials. php.

[2] Cement Concrete and Aggregates Australia. A technical note: Durability of masonry mortar, March (2007).

[3] S. J. Bates. A critical evaluation of salt weathering impacts on building materials at Jazirat al Hamra, UAE, Geoverse ISSN1758-3411 (online) (2010), accessed from: http://geoverse. brookes.ac.uk/article_resources/batesSJ.htm.

[4] E. Ganjian, H.S. Pouya. The effect of Persian Gulf tidal zone exposure on durability of mixes containing silica fume and blast furnace slag. Construction and Building Materials. 23(2) (2009) 644-652.

[5] M. M. Rahman, M. A. Islam, M. T. Uddin. Excellent durability of epoxy modified mortars in corrosive environments, Journal of Polymer Engineering. 36(1) (2015) 79-85.

[6] M. Omrane, M. Mouli, A.S. Benosman, Y. Senhadji. Deterioration of mortar composites in acidic environment, Advanced Material Research, 1064 (2015) 3-8.

[7] F. M. Wegian. Effect of seawater for mixing and curing on structural concrete, The IES Journal Part A: Civil and Structural Engineering, 3(4) (2010) 235-243.

[8] SNI 03-6825-2002 standard. Metode pengujian kekuatan mortar semen prortland untuk pekerjaan sipil.

[9] American Cement Manufacturers. Acid resistance, accessed from: http://www.cement.org/for-concrete-books-learning/concrete-technology/ durability/acid-resistance.

Improving Mortar Properties in Saline Environment

ORIGINALITY REPORT

9%	6%	4%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Helen Walkington. "Chapter 14 GEOverse: An Undergraduate Research Journal: Research Dissemination Within and Beyond the Curriculum", Springer Nature, 2014 Publication	1%
2	Sukanta Kumer Shill, Safat Al-Deen, Mahmud Ashraf, Wayne Hutchison, Muhammad Monowar Hossain. "Performance of amine cured epoxy and silica fume modified cement mortar under military airbase operating conditions", Construction and Building Materials, 2020 Publication	1%
3	raiith.iith.ac.in Internet Source	1%
4	www.coventry.ac.uk Internet Source	1%
5	www.irbnet.de Internet Source	1%

Submitted to Sriwijaya University

6	Student Paper	1%
7	www.scientific.net Internet Source	1%
8	epdf.pub Internet Source	1%
9	Submitted to Universiti Sains Malaysia Student Paper	1%
10	Submitted to College of Estate Management Student Paper	<1%
11	www.flypizza4.it Internet Source	<1%
12	Submitted to University of Newcastle Student Paper	<1%
13	mdpi.com Internet Source	<1%
14	Submitted to Victoria University College Student Paper	<1%
15	Ravindra K. Dhir, Jorge de Brito, Raman Mangabhai, Chao Qun Lye. "Production and Properties of Copper Slag", Elsevier BV, 2017 Publication	<1%

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		