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IMPACTS OF VIETNAM REGION CLIMATE TO SOME PROPERTIES OF CONCRETE BRICKS INDIFFERENT MAINTENANCE REGIMES

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ABSTRACT: Vietnam’s Government has been driving the development of unburned building materials with an output of about 12 billion bricks/ year in 2020 in which concrete bricks are accounted for 70%. Curing is considered an important step to ensure stable product quality, reduce shrinkage, and reduce cracking when using concrete bricks in construction. This paper presents the results of research on climate impacts of the North Central and South of Vietnam to some properties of concrete bricks such as loss of mass, compressive strength, and shrinkage in different maintenance regimes. The results showed that loss of mass due to evaporated water about 3-4.2% and shrinkage 0.35÷0.6 mm/m during the first 14 days of curing. The test results strongly recommend that concrete bricks should be properly cured and the age and degree of shrinkage of concrete brick need to be concerned when putting into construction. That is very necessary during winter in the North and Central regions, and in the dry season in the South.

Keywords: Concrete brick, Curing regime, Climate, Shrinkage

1. INTRODUCTION

To promote the development of unburned building materials in Vietnam, the Government has issued many documents. In which, those remarkably are the Decision No 567QD-TTg dated 28/04/2010 on approving the Development program unburned building materials by the year 2020 [1]; and Decision No. 1469/ QD-TTg dated 22/8/2014 to approve the Master plan on development of Vietnam's construction materials up to 2020 and orientations to 2030 [2]. Accordingly, by the year 2020, Vietnam needs about 12 billion standard bricks of unburned building materials, in which Concrete Bricks (CB) are accounted for 70%. As reported by the Ministry of Construction, the production of concrete bricks in 2017 was 6.5 billion standard bricks with about 2200 production lines.

CB is made from an unworkable concrete mixture with common ingredients such as cement, grit, sand, blast-furnace slag, fly ash, mineral additives, water, etc. This type of brick is shaped by vibration, pressing, or both vibration and pressing. CB is commonly used for load-bearing walls, covering walls of construction works [3].

Although CB is widely produced and constructed, there is still the appearance of cracks and water permeability when used CB in construction. Some major causes of the appearance are given as quality of CB products, design works, and construction processes. In terms of quality products, three main influence factors are mentioned: 1) control of raw materials and mixing ratio, 2) raw material mixing process, and 3) curing process.

Vietnam is a country located in the tropical regions of the northern hemisphere. It has a climate of the tropical monsoon, with the basic characteristics being hot moist and seasonally distinctly deformed. Due to the country stretched from north to south, the climate also varies by region. The North has hot summers and cold winters. The climate of the South is the high temperature, little change in humidity, and rainfall regimes diverged markedly seasonal. According to the terrain, Vietnam can be divided into three climatic zones representing three regions: North, Central, and South. The central climate is influenced by both northern and southern climates. The Northern and Central climate can be divided into two distinct seasons of summer and winter. The Southern climates can be divided into two seasons: rainy and dry seasons. Data on Vietnam's climate shows quite large differences in seasonal weather conditions and by region [4]. These climatic characteristics can affect the production process and using concrete materials.

Many experts believe that the curing process is the most important of the three factors mentioned above for the quality of CB. Concrete brick factories currently use different curing processes such as spraying moisture in 1-2 days, soaking in water, maintaining in saturated steam generated from boilers, etc [5-9]. Therefore, the study identified the regime curing concrete bricks accordingly for each region weather, and each factory is significantly needed. This paper presents results on the impacts of the Vietnam region climate on some properties of concrete bricks in different maintenance regimes.

2. MATERIALS AND METHODS

2.1 Materials

In this study, raw materials and CB samples were from three factories in the North, Central, and South of Vietnam. Two group samples with different design compressive strength, namely: samples M15 and M20 of the North; samples M10 and M15 of the Central; and samples M5 and M7.5 of the South.

Fig.1 Concrete specimens

2.2 Methods

In the study, 3 different curing regimes were used, and 3 parameters of CB were identified, such as loss of mass (LOM), compressive strength, and shrinkage that described as following.

2.2.1 Curing regimes

- Natural maintenance (N) is that samples were naturally kept in the room environment after shaped.
- Plastic bag maintenance (B) is that samples were covered in a plastic bag and put in room environment after shaped.
- Curing (C) is that samples were maintained in a curing tunnel at about 50ºC and 85% of relative humidity [9]. This regime was only applied for samples from the southern factory.

2.2.2 Loss of Mass

LOM is the mean of loss of mass of 5 samples that is calculated by the following formula

$$LOM = \frac{m_0 - m_t}{m_0} \times 100\% \qquad (1)$$

In which: m_0- sample mass at the beginning; m_t- sample mass at the time t.

2.2.3 Compressive strength

Compressive strength is determined according to TCVN 6477: 2016 [10] with specimen sizes 220× 105× 65 mm.

Fig.2 Compressive test

2.2.4 Shrinkage

Shrinkage is determined on cylindrical samples with a size of 100 x 200 mm. The samples were manually shaped from a concrete mixture that had a density as the same as CB produced in the factory. The shrinkage was determined according to ASTM C157 [11].

Fig.3 Shrinkage test

2.2.5 Weather conditions

The experiments were conducted under weather conditions in three regions of North, Central, and South of Vietnam with the parameters listed in the Table 1.

Table 1 Weather parameters [12]

Season- region	Air temperature (ºC)	Relative humidity (%)	Wind speed (m/s)
Summer in the North and Central	28-35	65-85	1-2.5
Winter in North and Central	18-30	40-65	1-2.5
Dry season in the South	28 -40	40-65	1-2.5
Rainy season in the South	28-35	65-85	1-2.5

3. RESULTS AND DISCUSSION

3.1 Loss of Mass

3.1.1 LOM of CB in the North

Test results determining LOM of CB in the North in the winter and summer are presented in Table 2 and Fig.4. As shown in Fig.4, it is clear that the LOMs of the group samples in natural maintenance was significantly larger than that of the sample group in plastic bag maintenance. The LOMs were caused by water evaporation. In natural maintenance, the speed of evaporation of CB took place very quickly, especially during the first 7 days. At 7 days, LOM of CB was about 2.8% and 2.1% in the winter and summer. The evaporation at the age of 7 days accounted for about 83% of the water amount at the age of 56 days. In contrast, it was only about 0.14-0.4% with samples covered by plastic bags. Besides, LOMs in the summer were smaller than that in the winter. This can be explained by the higher temperatures accelerate hydration rate reduces the amount of free water evaporation.

Table 2 LOM of CB in the North in the winter (W) and summer (S) (%)

Days	1	3	7	14	21	28	56
M15-B.S	0.4	0.42	0.44	0.46	0.51	0.56	0.58
M15-N.S	0.82	1.55	1.97	2.25	2.4	2.46	2.49
M20-B.S	0.38	0.4	0.41	0.46	0.49	0.57	0.64
M20-N.S	1.33	1.64	2.4	2.61	2.71	2.71	2.75
M15-B.W		0.03	0.17	0.23		0.32	0.73
M15-N.W		2.21	2.71	2.79		3.1	3.26
M20-B.W		0.05	0.11	0.17		0.3	0.63
M20-N.W		2.37	2.91	3.02		3.37	3.59

3.1.2 LOM of CB in the Central

LOM amounts of CB in the Central in the winter and summer are shown in Table 3 and Fig.5.

The evaporative process of CB in the Central is quite similar in the North. Up to 7 days, the LOM of CB in natural conditions were taken about 3.7% in winter and 2% in summer to 4.05%. Those are respectively higher than 0.36% and 0.42% of specimens covered in plastic bags.

3.1.3 LOM of CB in the South

Test results determining LOM of CB in the South in the dry and rainy seasons are presented in Table 4 and Fig. 6. The LOM of the two groups M7.5 and M10 in both the dry and the rainy seasons are not much different. In natural maintenance, LOMs were higher than 3.5% up to 7 days, and evaporative phenomena were almost stopped after 14 days. Simultaneously, LOMs of bag covered specimens were about 0.3% and 0.7% at the age of 7 days and 28 days.

Table 3 LOM of CB in the Central in winter and summer (%)

Days	1	3	7	14	21	28	56
M10-B.S	0.4	0.42	0.44	0.46	0.81	1.17	1.24
M10-N.S	0.82	1.55	2.1	2.61	3.11	3.85	3.89
M15-B.S	0.38	0.4	0.41	0.46	0.79	1.23	1.35
M15-N.S	1.33	1.64	1.97	2.25	2.7	3.45	3.48
M10-B.W		0.33	0.46	0.5	0.84		1.28
M10-N.W		3.86	4.05	4.31	4.54		4.74
M15-B.W		0.2	0.25	0.35	0.85		1.31
M15-N.W		2.72	3.34	3.67	4.18		4.41

Based on the test results in the three regions, the average evaporation rates of specimens were calculated at 0.007 $kg/m^2/h$ and 0.0009 $kg/m^2/h$ in natural conditions and bag-stored conditions respectively. Those values are much less than critical evaporation rates at 0.5 $kg/m^2/h$ that may cause plastic shrinkage crack in concrete [13]. Simultaneously, the bag-cover method showed a significant effect on decreasing water evaporation.

Table 4 LOM of CB in the South in the dry (D) and rainy (R) seasons (%)

Days	1	3	7	14	21	28	56
M7.5-B.D	0.11	0.22	0.29	0.41	0.49	0.58	0.71
M7.5-N.D	1.45	2.46	3.57	3.87	3.88	3.89	3.94
M10-B.D	0.17	0.23	0.33	0.5	0.59	0.67	0.81
M10-N.D	2.09	2.78	3.83	3.92	3.93	3.94	3.99
M7.5-B.R	0.1	0.33	0.25	0.35	0.45	0.59	
M7.5-N.R	1.42	2.72	3.44	3.67	3.68	3.7	
M10-B.R	0.15	0.2	0.28	0.46	0.53	0.64	
M10-N.R	2.05	2.41	3.56	3.84	3.85	3.86	

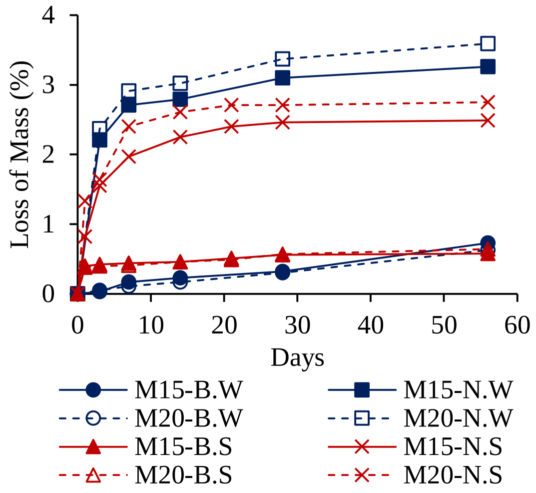


Fig.4 LOM of CB in the North in the winter and summer

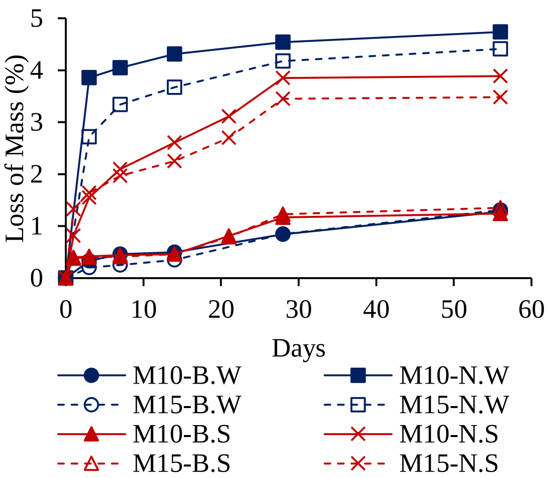


Fig.5 LOM of CB in the Central in the winter and summer (%)

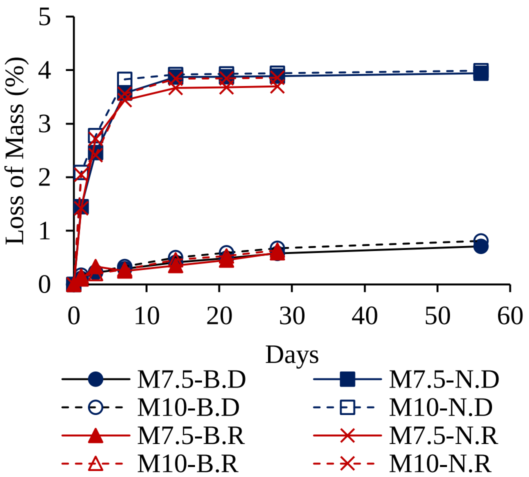
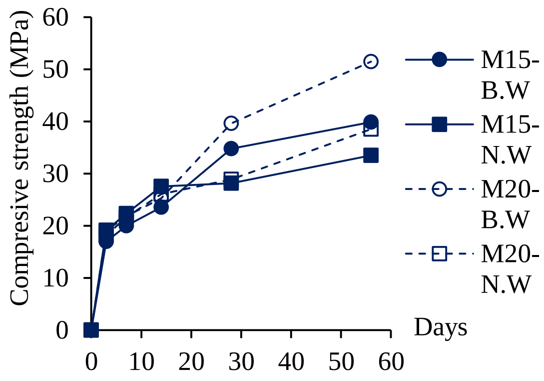


Fig. 6 LOM of CB in the South in the dry and rainy seasons (%)

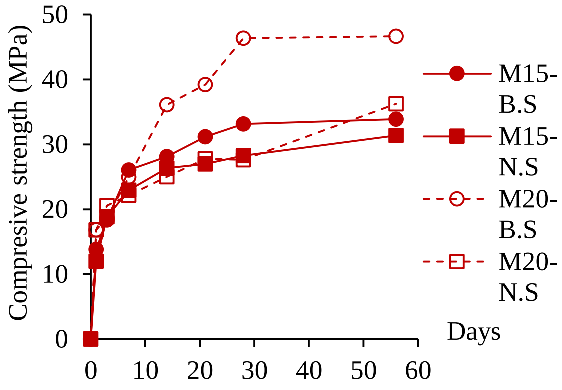
3.2 Compressive Strength of CB

3.2.1 Compressive strength of CB in the North

Test results of CB compressive strength in the North in the winter and summer are given in Fig.7. The results in Fig.7 show that the actual compressive strength of CB almost reaches the design value at the age of 7 days and about 2 times higher at the age of 56 days. Compressive strength kept fairly improvement after the age of 28 days, especially the specimens M20. These are signs that the hydration process can be prolonged due to insufficient water supply. The study results also showed a positive effect of the maintenance process in plastic bags compared with maintenance in natural conditions. The M20-B specimens had a higher compressive strength of about 30% compared to the M20-N group, and 15% with the M15 samples respectively.



(a)



(b)

Fig.7 Compressive strength of CB in the North a) in the winter; b) in the summer

3.2.2 Compressive strength of CB in the Central

Test results in Fig.8 show that CB samples exceeded the design of compressive strength at a quite early age, namely at 7 days in the winter and 3 days in the summer. The CB strength is pretty different between the two maintenance conditions, corresponding to about 25% in winter and 7% in the summer.

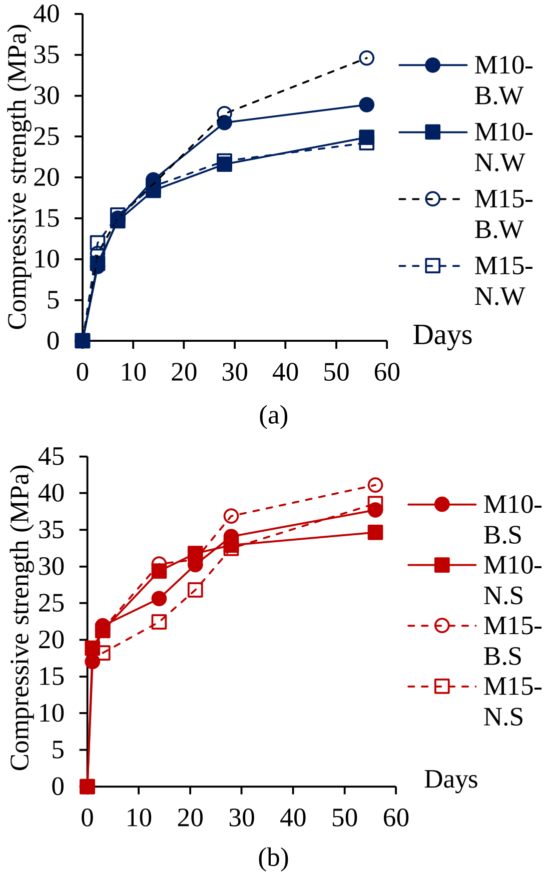


Fig.8 Compressive strength of CB in the Central
a) in the winter; b) in the summer

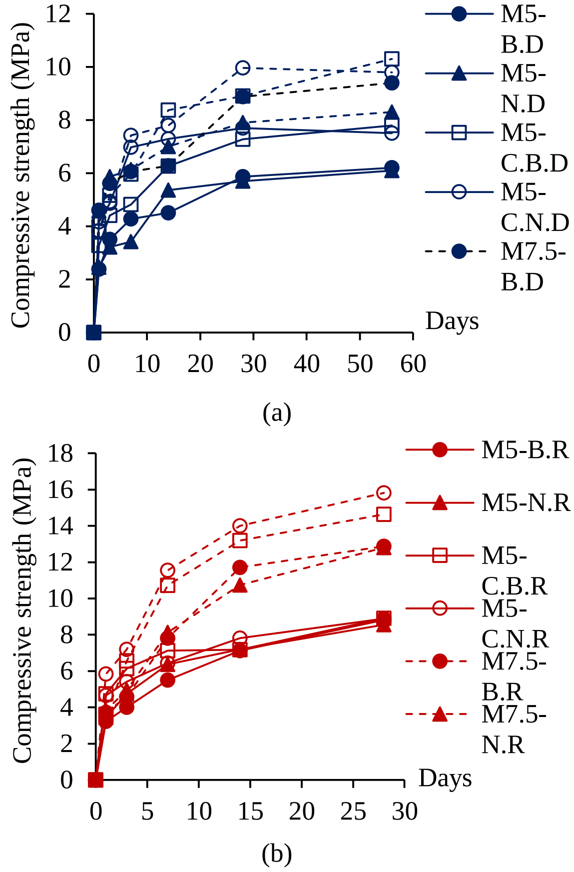


Fig.9 Compressive strength of CB in the South
a) the dry and b) rainy seasons

3.2.3 Compressive strength of CB in the South

Test results determining the compressive strength of CB in the South in the dry and rainy seasons are presented in Fig.9. After forming, specimens M5-C and M7.5-C were cured in tunnels using solar energy. Therefore, the compressive strength of the sample at the age of 1 day was approximately 70-80% of design strength. On the contrary, specimens without curing only got 50% of design strength after 1 day. The compressive strength was continuously increased and reach design strength at 28 days of age. Then the strength was slow down. In the rainy season, the sample had higher compressive strength than that in the dry season about 40%.

3.3 Shrinkage

3.3.1 Shrinkage of CB in the North

Shrinkage of CB in the North, in the winter and summer, is given in Fig. 10 and Fig. 11. The average shrinkage of specimens was -1.04 mm/m at 56 days in the winter, clearly higher than that in the summer at - 0.63 mm/m. In winter, samples got strongly shrinkage up to 14 days, then the shrinkage phenomenon was continued but slower. In summer, the specimens quickly contract until the age of 21 days, then shrinkage speed decreased sharply. Generally, the samples were kept in plastic bags had lower shrinkage than the samples stored in natural conditions.

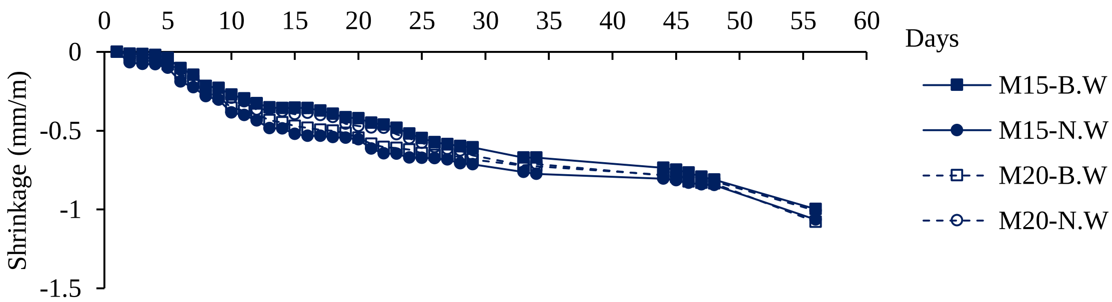


Fig.10 Shrinkage of CB in the North in the winter (mm/m)

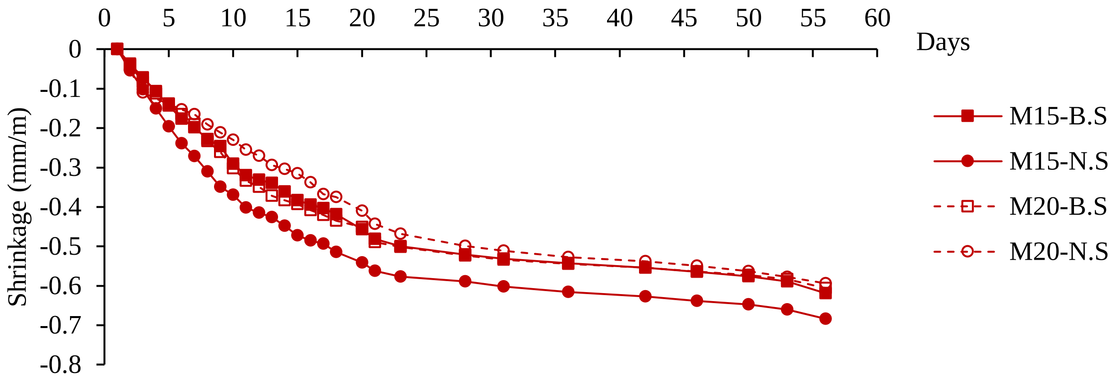


Fig.11 Shrinkage of CB in the North in the summer (mm/m)

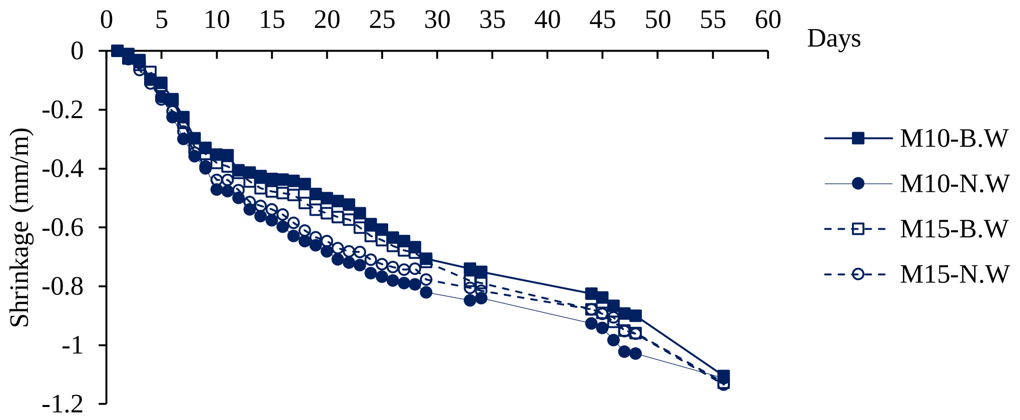


Fig.12 Shrinkage of CB in the Central in the winter (mm/m)

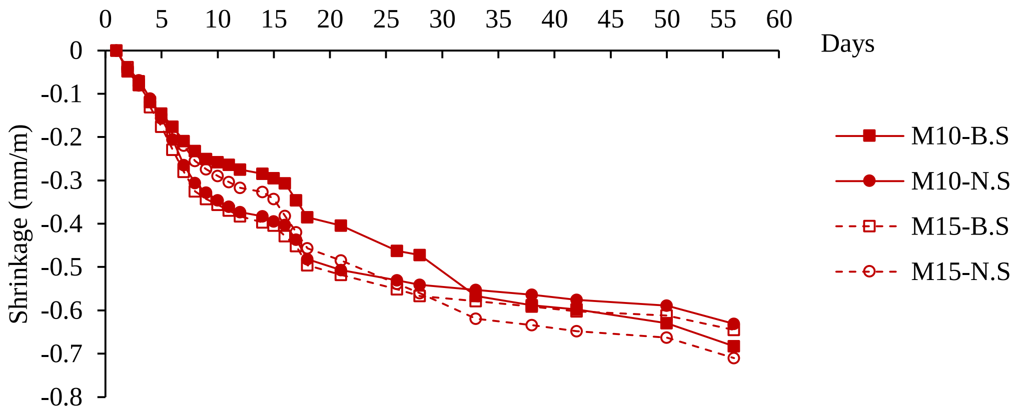


Fig.13 Shrinkage of CB in the Central in the summer (mm/m)

3.2.2 Shrinkage of CB in the Central

As shown in Figs.12 and 13, the effects of the weather seasons to CB's shrinkage in the Central quite similar to the influence of the North. In the winter, the shrinkage of samples was -1.14 mm/m at 56 days, and that was at -0.63 mm/m in the summer. The shrinkage degree the Central is higher than the value in the North, which corresponds with LOM value higher.

3.3.3 Shrinkage of CB in the South

Shrinkage of CB in the South in the dry and rainy seasons are given in Fig.14 and 15. In the dry season, CB in the south has a fairly stable shrinkage until the age of 40 days, reaching a value of -1.14 mm/m. Then the shrinkage rate is markedly reduced. In the rainy season, the shrinkage process was monitored only to the age of 28 days, the samples reached shrinkage values of about -0.56 mm/m.

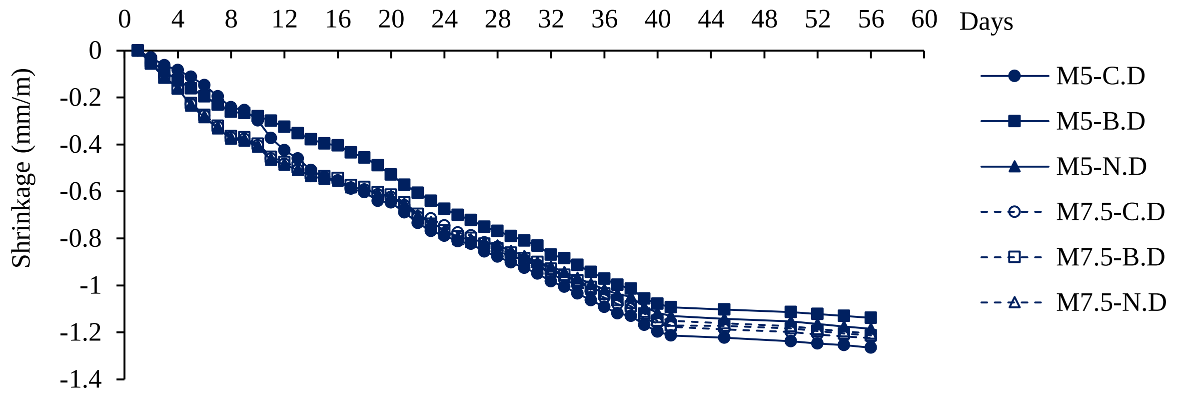


Fig.14 Shrinkage of CB in the South in the dry season (mm/m)

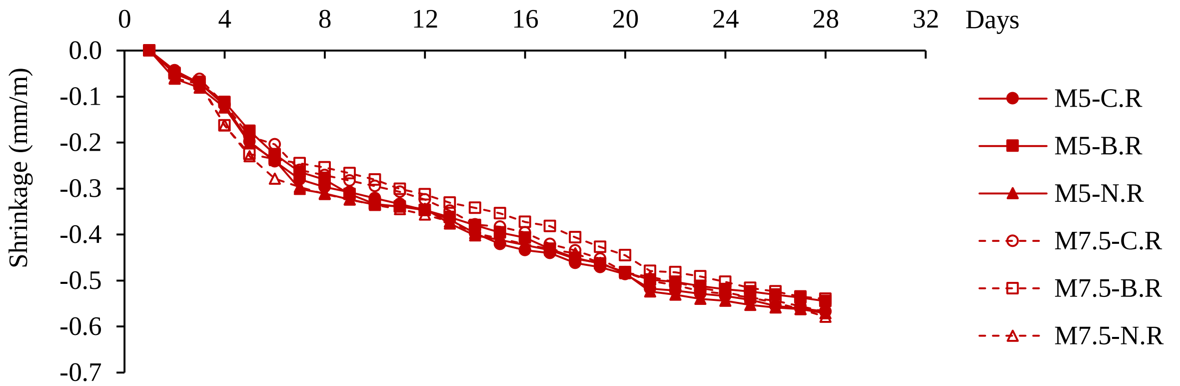


Fig.15 Shrinkage of CB in the South in the rainy season (mm/m)

4. CONCLUSION

Based on the results of this research, the following conclusions can be drawn:

- CB's evaporation rate in natural conditions occurs very quickly, the LOM can be 3-4.2% of brick weight after 2 weeks. This greatly affects the process of hydration, strength development, and shrinkage of GBT. Therefore, appropriate curing for CB is required to minimize the evaporation of water in the early days after shaped.
- The change of CB's shrinkage behavior in quite the same in different climate zones, in which, specimens covered by plastic bags or cured get lower shrinkage than specimens in natural conditions respectively. By the age of 14 days, CB's shrinkage is about 0.35-0.6 mm/m, which is the phase with the highest shrinkage rate. This parameter should be taken care of in the design and construction of CB walls.
- Maintaining CB by covering or curing is required to avoid large evaporation at an early age. Especially that is in winter conditions in the North and Central, the dry season in the South.

5. ACKNOWLEDGMENTS

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