The Study on Effect of Lightweight Concrete Block by Water Hyacinth Adding

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Abstract: The objective of this study is to examine the pattern of water hyacinths which is a plant that is suitable for making lightweight concrete and can be used to replace sand in lightweight concrete production. The proportion of cement: sand: water: foam is 1: 1: 0.65: 44.08 and the proportion of water hyacinths that will replace the sand by the cement’s weight is 0%, 2.5%, 5%, 7.5% and 10%. The density, water absorption, compressive strength (by the standard of TIS 1505-2541) and heat conduction of the lightweight concrete at 14 days will be studied. The results of the compressive strength of the lightweight concrete (LC) and the cellular lightweight concrete (CLC) are 167.56 ksc and 284.94 ksc, respectively. Both the compressive strength of the cellular lightweight concrete mixed water hyacinth (CLCH) and the lightweight concrete mixed water hyacinth (LCH) were investigated. The compressive strength of the CLCH and the LCH are 156.37 ksc and 172.45 ksc, respectively. The results are that the percentage loss of the CLC and the LC compressive strength are 6.68% and 39.83%. As for the physical properties, which are density and thermal conductivity, decreased. In contrast, water absorption increased by the percentage of water hyacinth by sand replacement. The optimal water hyacinth ratio in this study is 5%. Moreover, the CLC block is specified by the Thai Industrial Standards Institute 1505-2541 and is classified as C16 of the CLC block.

1. Introduction

The growing demand for construction in Thailand has increased the usage of construction materials like lightweight concrete blocks which are used in many types of buildings like residences and warehouses. The benefits of using lightweight aggregate concrete include reduced dead loads which makes savings in foundations and reinforcement, improved thermal properties, improved fire resistance, lessened transporting and handling precast units on-site and a decrease in formwork and propping. On the other hand, conventional concrete making is not completely environmentally friendly and this has enthused research on seeking greener alternative material for concrete. [1]

Water hyacinth (WH) is known as one of the fastest-growing plants. Its primary means of reproduction is by way of runners or stolons, which eventually form daughter plants. It also produces
large quantities of seeds that are viable for up to 30 years. With the fast rate of reproduction of water hyacinths, it has been found that populations often double in size in just two weeks. [2] They flourish in warmer climates and have broad, glossy and thick leaves that are 10-20 cm across. The hanging roots of the plant are feathery and purplish-black.

WH is classified as an aggressive invasive species. It has been named one of the ten worst weeds and the most widespread and damaging aquatic plant species in the world. Its growth rate is among the highest in the among plants, as it reproduces vegetation by having short runner stems that branch out from the base of the plant. This means that it has a huge effect on the life cycle of the environment. Thus, using this weed as cement replacement or concrete aggregate which supports concrete properties is suitable. [3]

Fiber cement material is made of cement paste containing coconut coir fibers and oil palm residues which are used as roof sheets and siding materials to reduce heat transfer through buildings and for energy conservation. The investigation focused mainly on the effects of both cellulose fibers on the physical-mechanical and thermal properties of the products. The results are that, the mixtures of fiber cement products containing 5% of both cellulose fibers by weight of portland cement yielded optimal physical and mechanical properties. The thermal conductivity of the fiber cement paste was 66% less than that of the control specimens. [4, 5]

Similarly, the research investigated the behavior of concrete with rice husk ash after exposure to different high temperatures (200, 300 and 400°C). Then, samples were used to measure the compressive strength and water permeability of the concrete. The results showed that the strength of the concrete reduced after exposure to high temperatures compared with the control concrete and tended to decrease with an increasing percentage of replacement of Portland. [6]

Specifically, the purpose of this investigation is to examine the properties of lightweight concrete blocks mixed water hyacinth by focusing on their compressive strength and various mixing.

2. Methodology

2.1. Materials and mix properties
The water hyacinth was located in Ladkrabang district, a suburb area in Bangkok, Thailand. The water hyacinth was cut into about 5 mm in length using a long knife and then dried in a hot air oven at 60°C for 48 hours. [8] Then it was divided into two parts where some was blended through a blender and some was not. They were classified into three classes 1) 0.5 cm of length, 2) were not passed through sieves No.50 and 3) passed through sieves No.50.

2.1.1. Compressive strength testing by Trial size of water hyacinth.
In the first part of the research, to find the optimal size of water hyacinth, dried specimens were used to determine the trend of maximum compressive strength. The water hyacinth specimens were tested in three sizes as shown in Figure 1 and mixed proportion show in Table 1.

The result was found that A, B1-B5, C1-C5, D1-D5 are 369.02, 233.27, 216.15 and 165.39 ksc of compressive strength, respectively and were presented in Table 2. The dried powder water hyacinth that was passed through Sieve No.50 was the optimal size for this part of the research.

2.1.2. The experiment for finding optimal ratio of water hyacinth dried powder pass through sieves NO.50.
In the second part, after the optimal size of the dried powder water hyacinth was found, it was used to determine the trend of maximum compressive strength for the research. The ratio of water hyacinth by sand replacement was classified in five states, as 0%, 2.5%, 5.0% 7.5% and 10%.

Part 2.1 The sample of the mortar with dried powder water hyacinth passed through Sieve NO.50 adding: Mixed proportion was shown in table 3.

Part 2.2 Sample of the mortar with dried powder hyacinth passed through Sieve No.50 and CLC foaming agent adding: Mixed proportion is shown in Table 4.
Table 1. Mixed proportions.

| Description | Ratio (C S WH W) |
|-------------|-----------------|
| A Cement plate | 1.00 2.00 - 0.60 |
| B1-B5 Cement plate with water hyacinth dried powder pass through sieves NO.50 | 1.00 2.00 0.03 0.60 |
| C1-C5 Cement plate with water hyacinth dried powder do not pass through sieves NO.50 | 1.00 2.00 0.03 0.60 |
| D1-D5 Cement plate with water hyacinth dried 0.5 cm of length | 1.00 2.00 0.03 0.60 |

Table 2. Result of compressive strength Test by Trial size of water hyacinth.

| Description | Weight(g) | Cross-sectional Area (cm²) | Age (days) | Compressive Strength (ksc) |
|-------------|-----------|---------------------------|------------|---------------------------|
| Mortar by non-water hyacinth adding | 258.01 | 25.10 | 14 | 369.02 |
| Mortar with water hyacinth dried powder pass through sieves NO.50 adding | 251.52 | 25.47 | 14 | 233.27 |
| Mortar with water hyacinth dried powder do not pass through sieves NO.50 adding | 252.08 | 25.35 | 14 | 216.58 |
| Mortar with water hyacinth dried 0.5 cm of length adding | 247.29 | 25.32 | 14 | 165.39 |

Table 3. Mixed proportions of mortar with water Hyacinth dried powder pass sieves NO.50 adding.

| Description | Ratio (C S WHSR* W) |
|-------------|---------------------|
| A Mortar | 1.00 1.00 0% 0.65 |
| B1-B5 Mortar with water hyacinth dried powder pass through sieves NO.50 adding | 1.00 1.00 2.5% 0.65 |
| C1-C5 Mortar with water hyacinth dried powder do not pass through sieves NO.50 adding | 1.00 1.00 5.0% 0.65 |
| D1-D5 Mortar with water hyacinth dried 0.5 cm of length adding | 1.00 1.00 7.5% 0.65 |
| E1-E5 Mortar with water hyacinth dried 0.5 cm of length adding | 1.00 1.00 10% 0.65 |

Table 4 Mixed proportions of mortar with water Hyacinth dried powder pass through sieves NO.50 adding and CLC foaming agent.

| Description | Ratio (C S WHSR* W CLCFA*) |
|-------------|-----------------------------|
| A Mortar | 1.00 1.00 0% 0.65 44.08% |
| B1-B5 Mortar with water hyacinth dried powder pass through sieves NO.50 adding and CLC foaming agent | 1.00 1.00 2.5% 0.66 44.08% |
| C1-C5 Mortar with water hyacinth dried powder do not pass through sieves NO.50 and CLC foaming agent adding | 1.00 1.00 5.0% 0.67 44.08% |
| D1-D5 Mortar with water hyacinth dried 0.5 cm of length adding and CLC foaming agent adding | 1.00 1.00 7.5% 0.68 44.08% |
| E1-E5 Mortar with water hyacinth dried 0.5 cm of length adding and CLC foaming agent adding | 1.00 1.00 10% 0.69 44.08% |
3. Physical Properties Testing

3.1. Compressive strength testing

The sample (after 14 days), was tested for compressive strength according to TIS. 1505-2541 by ensuring the compressive load was controlled between 0.05 - 0.20 N/mm²/sec until failure.

3.2. Dry density testing

The dry density of the mortar testing was according to TIS. 1505-2541 by measuring the sample volume then dried in a hot air oven at 105±5°C for 24 hours.

3.3. Water absorption testing

Water absorption testing also followed by institute TIS. 1505-2541 where the sample was dried in a hot air oven until constant weight is reached in more than 24 hours at 105±5°C. Then after more than four hours, it cooled down to room temperature, so its mass was measured. Once the sample was cured for 24 hours in water, its surface was wiped and the hardened mortar mass was measured in three minutes.

4. Result

4.1. Compressive strength testing of WHSR mortar and WHSR and CLCFA mortar

The representative of the compressive strength of the WHSR mortar was measured by the compressive load test shown in Table 3, where the mass of cement and water cement ratio were controlled by mortar cement ratio 1 : 1 The non-WHSR is 284.94 ksc in compressive strength. Figure 1 presents the results of this study as the WHSR ratio of 2.5%, 5%, 7.5% and 10% are 225.99 ksc, 171.45 ksc, 6.09 ksc and 4.23 ksc in compressive strength, respectively.

On the other hand, the CLCFA non-WH is 167.56 ksc in compressive strength. WHSR and CLCFA mortar shown in Figure 2 as WH with sand replacement of the ratio 2.5%, 5%, 7.5% and 10% and CLCFA are 136.85, 156.37, 5.39 and 6.26 ksc in compressive strength, respectively.

4.2. Dry density testing of WHSR mortar and WHSR and CLCFA mortar

The representatives of the dry density of the WHSR mortar were measured and followed by equation 1.1. The non-WHSR is 1696.57 kg/m³ in dry density. Figure 2 shows the results of this test as the WH sand replacement ratio of 2.5%, 5%, 7.5% and 10% are 1656.59, 1533.52, 1388.49 and 1347.14 (kg/m³) of dry density, respectively.

In the same way, the CLCFA mortar (non-WHSR) is 1526.98 (kg/m³) in dry density. Figure 3 presents the results of this test as the WH sand replacement ratio of 2.5%, 5%, 7.5% and 10% are 1445.57, 1460.66, 1373.41 and 1324.31 (kg/m³) in dry density, respectively.
4.3. Water absorption testing of WHSR mortar and WHSR and CLCFA mortar

The representatives of the water absorption of the WHSR mortar were measured and followed by equation 1.2. The general mortar (non-WHSR) has a 16.29% rate of water absorption. Figure 3 shows the results of this test as the WH sand replacement ratio of 2.5%, 5%, 7.5% and 10% are 14.64%, 17.84%, 30.73% and 33.89% of water absorption, respectively.

Similarly, the CLCFA mortar (non-WHSR) has a 16.95% rate of water absorption. Figure 3 presents the results of this test as the WH sand replacement ratio of 2.5%, 5%, 7.5% and 10% has a 17.09%, 18.15%, 30.8% and 34.2% rate of water absorption, respectively.

5. Conclusion

The study has investigated the possibility of making a LC with WH, which was qualified from TIS, and its physical and mechanical properties. The main results can be concluded as follows:

1) The compressive strength decreased when the percentage of the WHSR was increased. It was significantly reduced by the WHSR on 7.5. The optimum percentage of the WHSR ratio, both of the WHSR mortar and the WHSR and CLCFA mortar at 5% of water WHSR are 171.45 and 156.37 ksc in compressive strength, according to the TIS 2601-2556.

2) The percentage of WHSR increased which then caused the density to decrease. The lowest density was obtained from the WHSR mortar, the WHSR and CLCFA mortar on 10% as 1347.14 and 1342.21 (kg/m3) respectively. Nonetheless, this did not pass the standard of the TIS 2601-2556. Hence, the optimum percentage of the WHSR ratio was 5% as the WHSR mortar, the WHSR and CLCFA mortar, with a density of 1533.52 and 1460.66 kg/m3, respectively which can be classified in the lightweight concrete block type C16 according to the TIS 2601-2556.

3) Water absorption increased as the percentage of dried water hyacinth sand replacement increased. The lowest water absorption rate was obtained from the WHSR mortar, the WHSR and CLCFA mortar on 2.5% which are 14.64% and 17.09% respectively, which is also lower than the mortar. For this result, the optimum percentage of dried WH sand replacement ratio is 5% as the WHSR mortar and the WHSR and CLCFA mortar, has a density of 17.84% and 18.15%, respectively which is suitable according to the TIS 2601-2556.

This study investigated the mixing of WHSR ratio, the size of WHS in which compressive strength testing, dry density and water absorption testing were carried out. This was done in a ratio where the optimal size and ratio of dried powder water hyacinth which is passed through Sieve No.50 can be summarized. As a result, the compressive strength is much higher than the standard of the TIS 2601-2556 which is 20.4 ksc, the WHSR mortar which have 7.5 and 10% of WHSR did not pass the standard. Hence, 2.5 and 5.0% of WHSR are the optimal conditions for producing lightweight concrete blocks. The mortar which contained 2.5% of the WHSR is 225.99 ksc in compressive strength, which is the highest in this study compared to the 5.0% of WHSR and CLCFA which is 156.37 ksc in compressive strength. In contrast, the density and the water absorption of the 5.0% of WHSR and CLCFA are 1460.66 kg/m3 and 18.15% which is the best condition. The optimal condition does not necessarily have to have a high compressive strength load but it has to be over the qualification of the TIS and focus on eliminating more WH volume. As a result, 5.0% of WHSR and CLCFA mortar is the optimal condition. Furthermore, it would reduce water hyacinth in 1 m2 in the canal by the standard size of lightweight concrete block production which is an environmentally-friendly material.

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