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Application of Ecological and waste materials on produced Green-Art brick

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ABSTRACT

With regard to the optimization test of mixing ratio between bamboo and cement, the single axial compression strength of the second set (5:95) was the highest. By increasing the mixing ratio to 10:90 and complying with CNS required strength for water permeable bricks. In the test for optimizing the mixing ratio of bamboo charcoal and cement, the second set of single-axial compression strengths was the highest. Further increasing the ratio to 40:60 and complying with CNS required strength of decoration bricks. By means of natural strengthen agents can increase the strength. With addition of strengthen agents, after aging for 28 days and according to the results, it is concluded that the strengthen agents can significantly increase the strength. On the other side, study to reduce production costs of the brick and tile that solve of waste brick and rice husks charcoal on this storage and treat issues of technology development. For competitive strategy for a future market, it should be focused on the creation of differentiation for product and technology, the increase of service and features, as well as the branding effect to become a price-leader.

1. INTRODUCTION

In the past 30 years, the total area of rice growing fields continues to shrink due to the changes in society, economy and diet. However, as of now, the growing of rice still comprises a sizeable percentage in agriculture. This means that rice husk would be the main waste in rice growing. About 1 million tons of rice husk are generated per year in Taiwan. It is quite difficult to store or transport rice husk because it is quite bulky and takes up a lot of space. Rice husk may be a great cultural material because it has high contents of silicon and potassium. Therefore, it would be a good idea to use rice husk as a cultural material so as to increase the value of rice growing and to reduce its adverse impacts on the environment. In the carbonization of rice husk, it is carbonized without the presence of air or with a limited supply of air to undergo thermal decomposition, molecular rearrangement and condensation reaction of its chemical constituents. In the meantime, gases would be generated. After the carbonization, rice husk would become carbonized and become solid state ash (charcoal). Such ash and husk fluid may be used in the development of new products in or of soil improvement, insect prevention, and environmental purification and construction materials (Huang, 2010).

Bamboo is a tropical plant growing in the area of South Asia. It is used very popular, and usually in the applications of furniture, or construction scaffold. In 2006, some studies reported the evaluation and analysis of the influence to the environment and economy resulting from the utilization of bamboo as construction scaffold materials. Generally speaking, in addition to the

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treatment of bamboo by landfill or incineration, some studies reported the evaluation of processing efficiency by making the activated carbon. Those activated carbon made by bamboo was investigated for the treatment of textile wastewater and removing dyes (Ahmad, 2010).

Among other studies for the reuse of bamboo, for example, some researchers reported the production of high strength composite by adding epoxy after the powder grinding or chemical treatment of bamboo skin fibers. Also the thermal and mechanical properties of the composite were investigated. In addition, some studies were reported to investigate the heating and cooling effect to the composition change, so that to understand the manufacturability for the reuse of bamboo (Nakajima, 2011 & Shih, 2007).

Therefore, in our study, we utilized bamboo, bamboo charcoal, rice husk charcoal, clay, and waste tile as the construction and art materials to provide a novel eco-design concept. This is proposed to be able to reduce the consumption of cement, reuse waste tile and rice husk during processing and mitigate the urban heat island effect.

2. MATERIALS AND METHODS

2.1. Application of bamboo and charcoal to make eco-brick (Fig. 1)

2.1.1. Processes of made bamboo charcoal and modify bamboo

(1) Collecting bamboo, and charcoal, dry and screened for later use.
(2) The analysis of screened sample materials.
(3) Adding different ratio of bamboo, bamboo charcoal with cement into the mixer, after adding 30ml water (or strengthening agents) then proceeding to the mixture process.
(4) Then, put mixture slurry into a PVC mold with a dimension of 2.8cm in diameter and 6.0cm in height.
(5) Leaving them in a room temperature environment for aging 6, 14 and 28 days.
(6) Carrying out compression strength tests

2.1.2.Carbonization of Moso bamboo

The 3 to 4 year old Moso bamboo was subject to high temperature (550℃) under conditions of limited air for the organic components to be thermally decomposed. After the organic components are oxidized or evaporated, the residual carbon polymerizes to form a huge carbon skeleton.

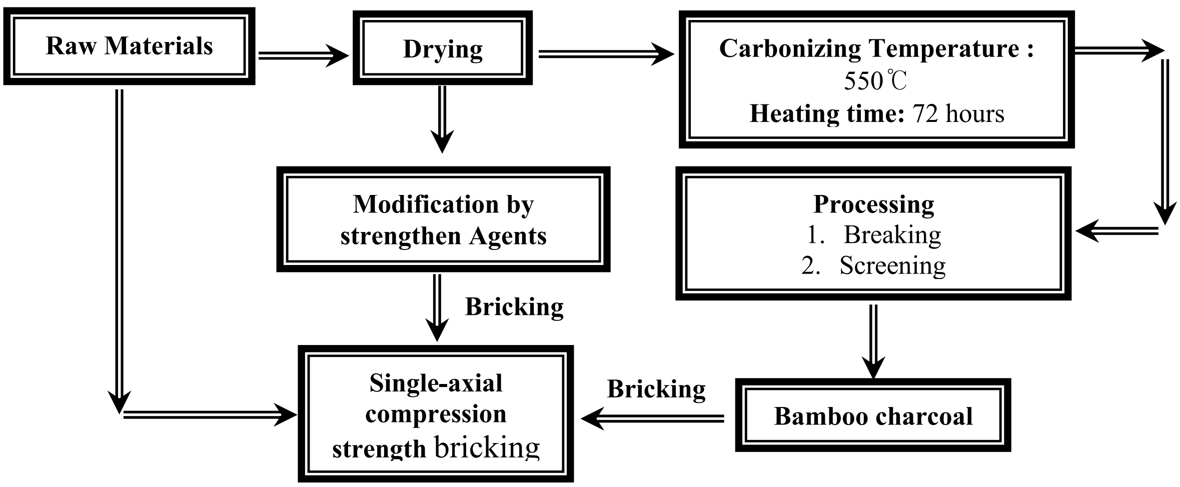


Fig. 1 Processes of made bamboo charcoal and modify bamboo to analysis of single-axial compression strength after bricking

2.2. Application of rice husk charcoal, waste tile with clay to make green-art brick (Fig. 2)

2.2.1. Processes of made green-art brick

(1) Collecting waste rice husk, waste tile, and clay.
(2) The analysis of screened sample materials.
(3) Adding different ratio of waste rice husk, waste tile with clay into the mixer, after adding water to be formed then proceeding to the mixture process.
(4) Then forming and carve, for example art.
(5) Put in to the electric kiln about temperature of 990 to 1100℃.
(6) Carrying out compression strength tests.

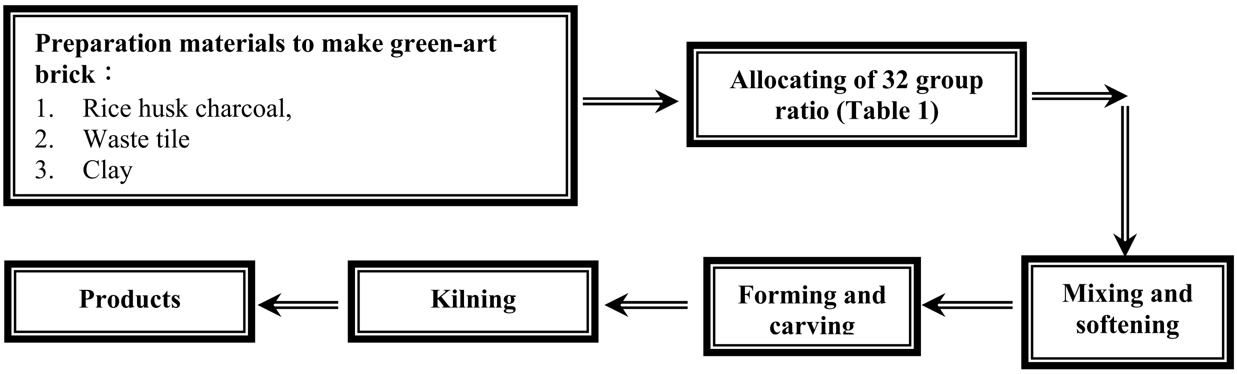


Fig. 2 Processes of made green-art brick

Table 1 Different ratios of waste tile and RHC with clay

Ratios / Materials	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Clay	1	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3
Waste tile	0	1	0	1	1	1	2	0	1	1	1	1	1	1	1	1
RHC	0	0	1	1	2	3	1	1	0	1	2	3	4	0	1	2
Ratios / Materials	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Clay	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4
Waste tile	1	2	2	2	0	0	1	1	1	1	1	2	2	3	3	3
RHC	3	0	1	2	1	3	0	1	2	3	4	1	3	0	1	2

RHC: rice husk charcoal

3. RESULTS AND DISCUSSION

3.1. Application of bamboo and charcoal to make eco-brick

3.1.1. The functional groups and holocellulose, α-cellulose, lignin content examination analysis

Table 2 shows the examination of holocellulose , α-cellulose and lignin content. It was found that the lignin accounts for 18.0 %, holocellulose accounts for 43.7 % of total amount in the results. Table 3 shows the FT-IR analysis spectrum, and identified that 3400 cm^{-1} representing OH free-radical signal; 2800 cm^{-1} representing CH_2 signal; 2300 cm^{-1} representing CO_2 signal; 1600, 1300, 1050, and 700 $cm^{-1}$are the signals of C=O, C-O-OH, C-O, and aromatics respectively. Therefore, the surface functional groups are mainly OH, CH_2, CO_2, C-O-OH, C=O and C-O, which are beneficial to the increase of cross-linking capability, and in turn to increase the single-axial compression strength.

Table 2 The holocellulose, α-cellulose, lignin content test results for bamboo

	Benzene-alcohol extractive	Holocellulose	α-cellulose	Lignin
	------------------	%	------------------	
Bamboo	4.2	43.7	29.1	18.0

Table 3 The results of functional groups analysis for bamboo and bamboo charcoal

	Wave number (cm^{-1})		Bamboo	Bamboo charcoal
Hydroxyl group (-OH)	3400	Transmittance (%)	0.807	0.891
Methyl group($-CH_2-$)	2800		0.883	0.919
C=O bond	1600		0.888	0.900
Carboxyl group (-COOH)	1300		0.731	0.752
Carbonyl group (-CO-)	1050		0.805	0.907
Aromatic group	700		0.965	0.958

3.1.2.The Analysis of Single-Axial Compression Strength Tests For Different Mixing Ratio of Bamboo and bamboo charcoal

In the tests of optimization mixing ratio between bamboo and cement, the second set was found with a highest single-axial compression strength (282 kgf/cm^2 after 28-day aging). The second best was the third set with 198 kgf/cm^2 after 28-day aging. As shown in Table 4, based on literature review and internal discussion, we proposed that these two sets could be improved in strength by reducing the material length (fiber), or increasing the acidic functional groups on surface (surface acidity modification) (P. van der Lugt, 2005 & Keith, 2006).

In the tests of bamboo charcoal and cement, the second set was found with a highest single-axial compression strength (229.4 kgf/cm^2 after 28-day aging). The second best was the third set with 92.4 kgf/cm^2 after 28-day aging. As shown in Table 4, based on literature review and internal discussion, we proposed that these two sets could be improved in strength by reducing the particle size, increasing the acidic functional groups on surface (surface acidity modification), or increasing the content of calcareous materials (increasing the cementation property and reducing the usage of cement). With the porous property of carbon material, the target market is for decoration bricks, and targeting the strength of 80 kgf/cm^2 only for Chinese National Standard (CNS). If carbon content can be increased so that the modulation of indoor moisture and absorption of indoor air pollutant can be enhanced, and hence expanding the applications and markets.

Table 4 The compression strength of bamboo and bamboo charcoal

	Single-axial compression strength (kg/cm^2)		
Bamboo: Cement	28 days	Bamboo charcoal: Cement	28 days
0:100	318.0	0:100	318.0
5:95	282.1	20:80	229.4
10:90	197.7	40:60	92.4
20:80	<1.0	60:40	19.1
30:70	<1.0	80:20	<1.0
40:60	<1.0	-	-

3.1.3. The Modification Results By Strengthen Agents

In order to modify the surface of bamboo materials to possess acidic groups that can tightly combine with Ca and Mg in cement, our team developed natural strengthen agents to modify the acidity of the bamboo fiber surface. The results of acidity modification shown that the strength of each mixture was all improved (Table 5). After adjusting the mixing ratio, the results of single-axial compression strength were reported as follows. The strengths for the mixture of bamboo: cement (12:88) was 39.0 kg/cm^2 after 28 days aging respectively. With the addition of strengthen agents, the strengths was increased to 210.5 kg/cm^2 after 28 days aging respectively. As for the mixing ratio of bamboo: cement (14:86), the strengths was 4.8 kg/cm^2 after 28 days aging respectively. With addition of strengthen agents, the strengths was increased to 149.0 kg/cm^2 after aging periods of 28 days respectively.

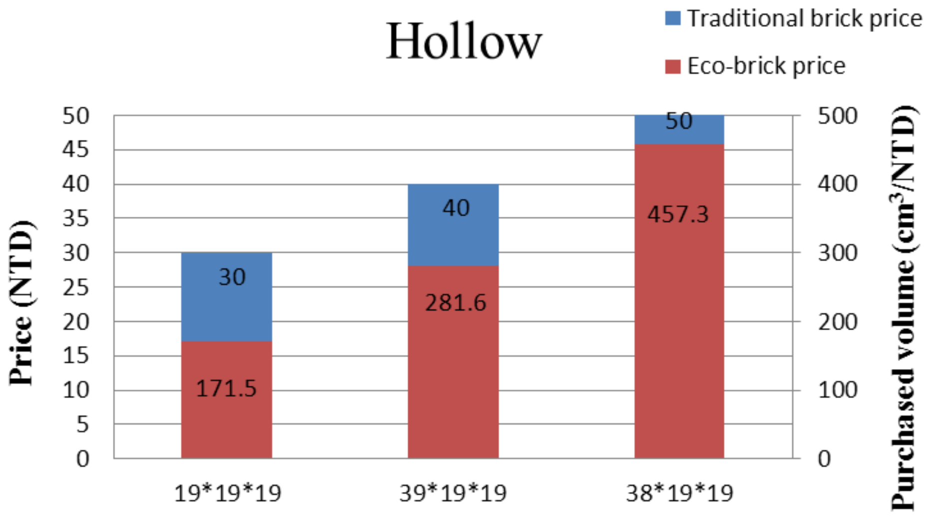
Table 5 The strengths after adjusting bamboo mixing ratio and modification

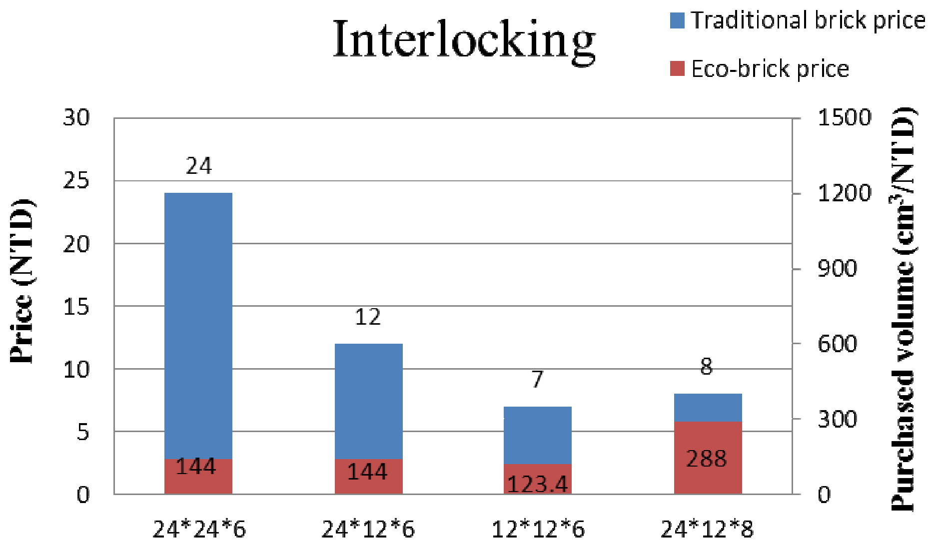
	Without agents	With agents
	----------------------------Days----------------------------	
	28	28
Bamboo: Cement	Single-axial compression strength (kgf/cm^2)	
10:90	147.1	101.7
12:88	39.0	210.5
14:86	4.8	149.0
16:84	<1.0	118.3
18:82	<1.0	6.0

3.1.4. The analysis for the market prices of conventional brick and eco-brick

The eco-bricks used in Taiwan are still primarily aiming towards the outdoors application with a better drainage capability. Therefore, three kinds of eco-bricks, including hollow brick, interlocking brick and grass-planting brick produced by ourselves were used for the comparison analysis of market price with respect to conventional bricks. As in the following three figures, basing on the surveys of the market price, we can estimate the volume that can be purchased by 1 NTD (cm^3/NTD). The calculated sale price of eco-brick compared with those of conventional bricks is approximately with the ratio of 30% to 60% (Fig. 3) .

According to above analysis regarding the cost and sale price, the eco-bricks have considerable advantage with market prices. Therefore, the improvement of manufacturing technology and stable eco-materials source will be the major factors affecting the product penetration in the market. Focusing on the improvement of manufacturing technology will enhance the endurance for eco-brick applications, and convince more customers to accept these new products. The stabile sources of eco-materials can address the demand of a mass production, so as to gain the benefits of economic production scale, the advantage of pricing competitiveness or a larger margin for profit.





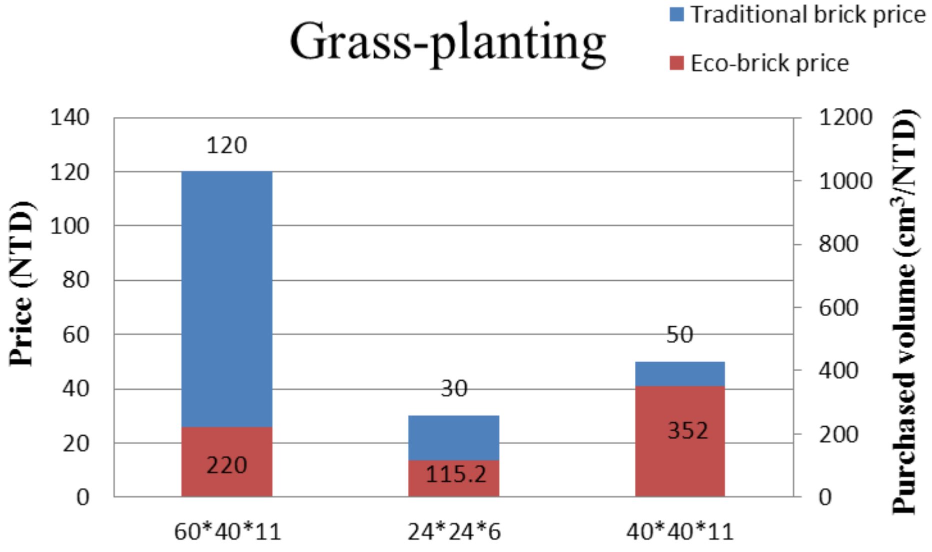


Fig.3 The analysis of market sale prices for conventional and eco-bricks

3.2. Application of rice husk charcoal, waste tile with clay to make green-art brick

This study to reduce production costs of the brick and tile that solve of waste brick and rice husks charcoal on this storage and treat issues of technology development. Parameter distribution of three kinds of materials in the testing process can scale to consider emphasis on forming and will therefore test parameter distribution ratio as a proportion of 32 groups.

3.2.1 Analysis of specific gravity

The green-art tile added of RHC and waste tile with clay in the 32 group mix ratios (5th, 9th, 16th, 19th, 26th, 32th groups) that can significantly drop the specific gravity to show added the two materials will be significantly decrease the weight of installation art, and reduce the cost of raw materials (clay) and removal storage and handling problems (Table 6).

3.2.2 Test of adsorbing water

Water absorption test of parameters is to identify good water absorption and distribution in proportion, increase the versatility of installation art, make large installations in addition to decorations to enjoy can adjust indoor humidity, creating a comfortable living space. By graphs and tables can be found in the 6th, 9, 19, 25, 26 and 32 units of water absorption is above 11.8%, as traditional brick and tile times 10 times, quite suitable for multifunctional use.

3.2.3 Single-axial compression strength

Although this research and development is towards device art uses, in Taiwan has not yet has related strength provides, therefore for seeking market advantage this products (green-art tile) seeks to meet CNS of decoration with brick single axis compressive strength standard (80 kg/cm^2), research and development results for: all 32 group parameter distribution proportion of single axis compressive strength are than 80 kg/cm^2, was quite happy of is has five Group (2nd, and 13, and 23, and 30 and the 31 group) of single axis compressive strength than 350 kg/cm^2, Already complies with the standards of high pressure brick (CNS)

Table 6 Analysis of 32 groups mix ratios for specific gravity, adsorbing water, and single-axial compression strength

Ratios / Materials	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
specific gravity (g/cm^3)	2.24	2.13	2.06	2.05	1.81	2.06	2.09	2.07	1.95	2.00	1.99	1.99	2.04	2.30	2.04	1.83
Adsorbing water (%)	1.43	4.57	10.63	8.90	8.21	11.83	7.12	5.35	11.82	11.25	11.31	11.00	9.01	1.22	4.58	5.70
Single-axial compression strength (kg/cm^2)	250	356	257	297	291	278	329	223	302	264	338	308	356	291	269	241
Ratios / Material	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
specific gravity (g/cm^3)	2.19	2.23	1.94	2.10	2.02	2.13	2.20	2.26	2.15	1.90	2.23	2.13	2.13	2.40	2.06	1.89
Adsorbing water (%)	9.78	2.50	12.61	6.20	8.24	7.98	8.45	7.50	12.71	12.54	3.99	5.05	8.94	7.71	11.24	14.22
Single-axial compression strength (kg/cm^2)	302	312	216	295	122	133	350	338	105	207	327	219	287	367	393	222

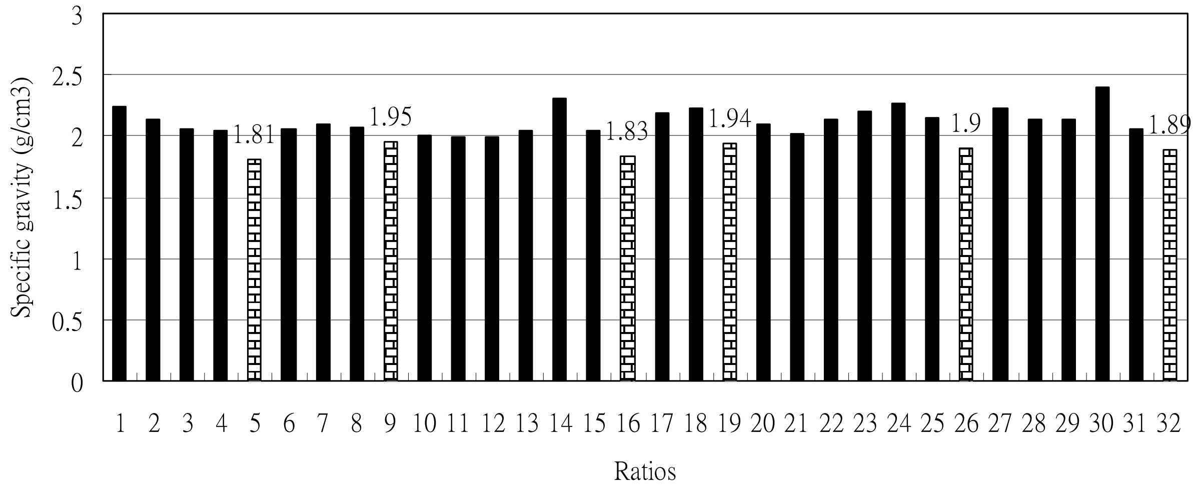


Fig.4 Analysis of specific gravity for 32 groups of different rations

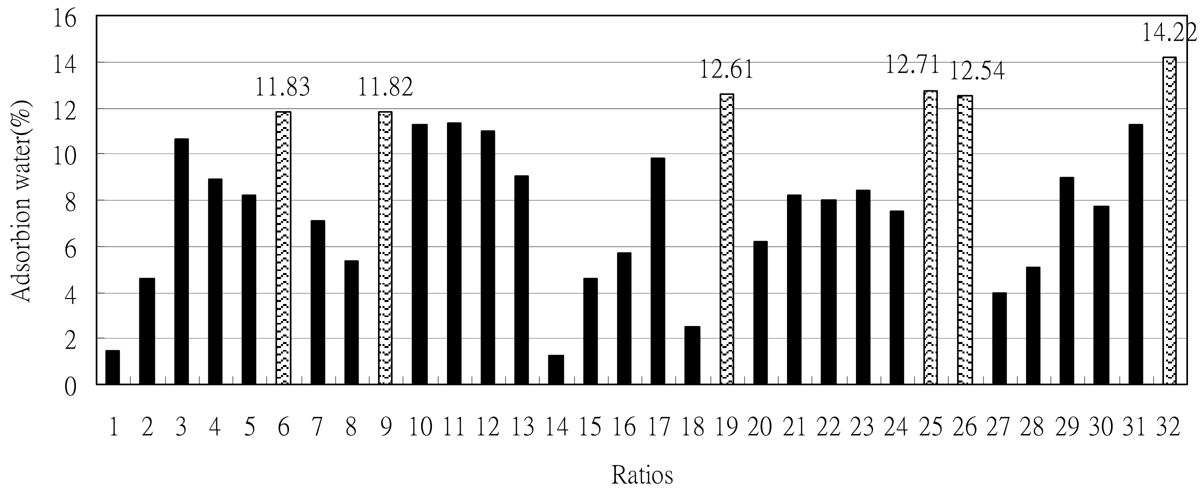


Fig.5 Test of adsorbing water for 32 groups of different rations

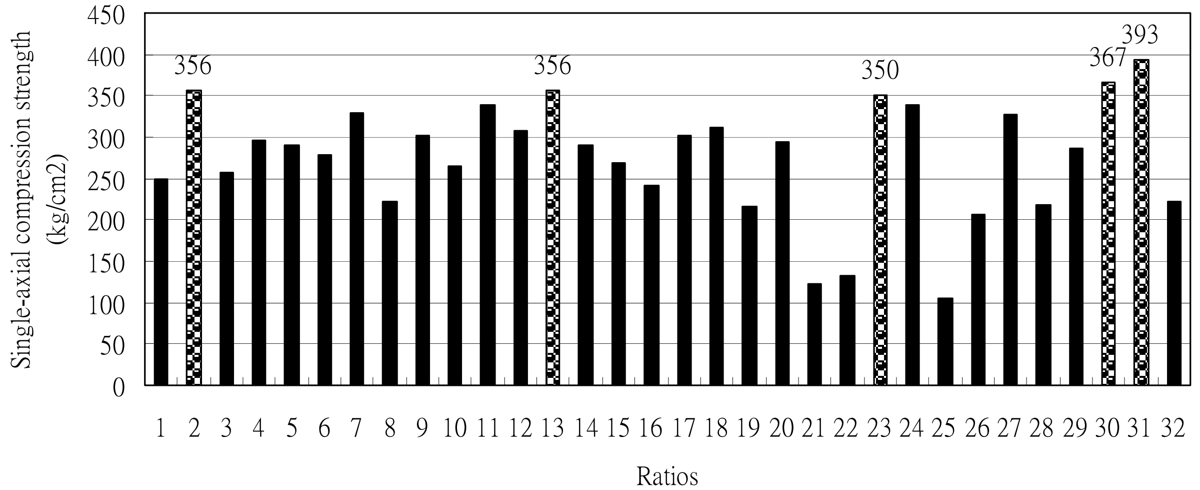


Fig.6 Single-axial compression strength for 32 groups of different rations

CONCLUSION

The material becoming eco-friendly design is inevitable, and focusing on the market needs to provide different style of the eco-bricks is also a future trend. The bamboo and bamboo charcoal with cement were used in this study to produce the eco-bricks. Among all the optimization tests for mixing ratios for different materials, the highest single-axial compression strength was observed after a 28-day aging. With a proper acidity modification to the surface of the bamboo materials, the increasing of surface acidic functional groups will enhance the eco-brick strengths.

The green-art tile added of RHC and waste tile with clay in the 32 group mix ratios reduce the cost of raw materials (clay) and removal storage and handling problems, that green-art tile have multi-function for weight light, adsorbing water, and fill the bill with CNS.

For competitive strategy for a future market, it should be focused on the creation of differentiation for product and technology, the increase of service and features, as well as the branding effect to become a price-leader. Accordingly, focusing on the improvement of manufacturing technology will enhance the endurance and multi-features of eco-brick applications, and convince more customers to accept these new products. Furthermore, stabilizing the sources of eco-materials will address the demand for the mass production, the benefits from economic production scale, the advantage of pricing competitiveness, as well as a larger profit margin.

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