*Istraživanja i projektovanja za privredu*
*ISSN 1451-4117*
*DOI:10.5937/jaes0-50486*
*www.engineeringscience.rs*

publishing

*Journal of Applied Engineering Science*
*Vol. 22, No. 4, 2024*
*Original Scientific Paper*
*Paper number: 22(2024)4, 1235, 718-726*

# PLASTIC BLOCK FOR BUILDING CONSTRUCTION MATERIAL

***I Nyoman Arya Thanaya*, I Nyoman Karnata Mataram, Muhammad Fathan***

*Udayana University, Civil Engineering Department, Kampus Bukit Jimbaran, Denpasar-Bali, Indonesia*
** aryathanaya@unud.ac.id*

*Plastic wrap waste increase from time to time. Efforts are needed to utilize them as they are less demanded for recycling by the private sectors in Bali and Indonesia. This paper describe effort to use combination of waste thin plastic wrap as plastic block for wall construction material. The plastic wrap wastes were cut into 5-10 mm size, then they were melted in a hot waste engine oil at 200°C. The mixture was then poured into a metal mold, slightly cooled down and compressed using a compression machine. The mixtures produced was without and with added rice husk ash as filling material. The size of the plastic block was 20×10×8cm. It was found that the densities of the samples were less than 1gram/cm$^3$, the compressive strength can achieve 25kg/cm$^2$, the Porosities were low, ranges from 0.220-0.290%, the Initial Rate of Suctions (IRS) were very low ranges form 0.0004-0.00075 kg/m2.minute, and the and water absorptions were also low (0.02-0.03) %.  In general, the compressive strengths were comparable to low quality bricks commonly produced.*

*Keywords: waste thin plastic wrap, waste engine oil, rice husk ash, plastic block*

## 1 INTRODUCTION

### 1.1 Plastic waste in Bali and Indonesia

The study was conducted in Bali, an island in Indonesia that attracts millions of tourists each year. However, there is an environmental issue: plastic pollution. The scale of plastic pollution in Bali and Indonesia is staggering. A study published in the journal Science estimated that Indonesia contributes up to 10% of global plastic pollution, with much of it ending up in the ocean [1]. Bali, with its booming tourism industry, faces a significant portion of this burden. The island generates approximately 3,800 tons of waste daily, of which 13% is plastic waste [2]. Moreover, inadequate waste management infrastructure exacerbates the problem, leading to widespread littering and improper disposal practices.

Several factors contribute to the accumulation of plastic waste in Bali and Indonesia. Rapid urbanization and industrialization have led to increase consumption of single-use plastics. Additionally, a lack of awareness about proper waste management practices among the local population and tourists further worsen the issue. The prevalence of plastic packaging in consumer goods and the absence of effective recycling facilities also contribute to the problem.

The environmental and societal impacts of plastic pollution in Bali and Indonesia are profound. Marine ecosystems suffer as plastic debris entangles marine life and contaminates their habitats. Moreover, microplastics, resulting from the breakdown of larger plastic items, permeate the food chain, posing health risks to both marine organisms and humans [3]. Furthermore, the tourism-dependent economy of Bali faces risks as plastic pollution tarnishes its natural attractions and diminishes visitor experiences.

The plastic waste crisis in Bali and Indonesia demands urgent action from all stakeholders. Concerted efforts are needed to mitigate the environmental, societal, and economic repercussions of plastic pollution. By implementing effective policies, fostering community involvement, and promoting sustainable practices, Bali and Indonesia can pave the way towards a cleaner and healthier future for generations to come.

#### 1.1.1 The plastic wrap waste

Among plastic wastes, the waste of thin plastic wrap is less demanded by the recycling industry in Bali or Indonesia, hence its collection and utilization need to be encouraged to reduced pollution. Some studies had been done in utilizing thin plastic wrap. One promising avenue for repurposing waste plastic wrap lies in the construction industry. Research studies, such as those by [4] and [5], have investigated the incorporation of shredded plastic wrap into asphalt mixtures. By adding plastic particles to asphalt, pavement durability can be improved, reducing cracking and enhancing resistance to deformation. This approach not only diverts plastic wrap from landfills but also enhances the performance and longevity of road surfaces.

Waste plastic wrap can also find new life in the production of composite materials. Explored by [6] on the use of waste PET bottles, including plastic wrap, in construction materials. By blending shredded plastic wrap with concrete or mortar, manufacturers can create composite materials with improved strength and insulation properties. These eco-friendly alternatives offer a sustainable solution to traditional construction materials, reducing reliance on virgin resources and minimizing environmental impact.

One way of utilizing it is by using it as plastic block for constructing wall or partitions, as an alternative material that can substitute low quality brick or masonry block which typically exhibit compressive strengths ranging from 1.0 MPa to 5.0 MPa. These values are considerably lower compared to high-quality construction materials but can still be suitable for certain non-load-bearing applications or where cost considerations are paramount [6].

### *1.1.2 Low quality bricks*

According to [7], low-quality bricks commonly have compressive strengths in the range of 1.5 MPa to 3.5 MPa, with variations due to factors such as moisture content and curing conditions. Similarly, [8] suggests that masonry blocks of inferior quality may exhibit compressive strengths between 2.0 MPa and 4.0 MPa.

The media used to dissolve the waste thin plastic within this work was waste engine oil. Waste engine oil contains various harmful substances such as heavy metals, polyaromatic hydrocarbons (PAHs), and carcinogenic compounds like benzene and toluene [9]. When improperly disposed of, these contaminants can leach into soil and groundwater, contaminating both surface and subsurface ecosystems [10]. In aquatic environments, oil spills can lead to devastating consequences for marine life, disrupting food chains and causing long-term ecological damage [11]. Within this experiment the production of the block was in a very limited manner, researchers using respiration musk, and air circulation was made adequate. For larger scale production, the emissions need to be more properly handled.

Furthermore, the combustion of waste engine oil releases harmful pollutants into the atmosphere, contributing to air pollution and climate change [12]. Particulate matter and volatile organic compounds emitted during burning pose serious health risks to nearby populations, including respiratory problems and increased cancer rates [13].

In order to incorporate other waste as filling materials, rice husk ash is an attractive option as Bali and Indonesia produce rice. Rice husk ash (RHA) is a byproduct of rice milling, abundantly available globally. It is generated when rice husks, the outer layer of rice grains, are burnt at high temperatures. Traditionally considered a waste material, RHA has garnered attention in recent years due to its diverse applications across various industries, contributing to sustainable waste management practices.

RHA primarily comprises silica (SiO2), with traces of other elements such as carbon, potassium, and calcium. Its amorphous structure and high silica content make it a valuable resource for multiple applications. According to studies by [14], RHA exhibits pozzolanic properties, enhancing the durability and strength of concrete when used as a supplementary cementitious material. Research conducted by [15] highlights the effectiveness of RHA in stabilizing expansive soils, mitigating their detrimental effects on infrastructure.

### *1.1.3 The objective*

The objective of this paper is to evaluate the characteristics of plastic block as building block material, produced by dissolving waste plastic wrap plastic, i.e. shopping bags (crackle plastics), aluminum coated thin plastic waste, and other type thin plastic waste, into waste engine oil, without and with rice husk ash as filling materials.

### *1.1.4 Properties of the plastic blocks tested*

The properties of plastic blocks tested are: compressive strength (kg/cm$^2$), porosity (%), and water absorption based on water immersion for 24 hours (%). The plastic block material samples float in water, so the determination of volume cannot be done properly using water replacement method, hence the volume can be obtained by measuring the dimension of the samples to enable the determination of density. The calculation of Porosity (P) that uses Equation 2, can be done after calculating the specific gravity of the mix ($SG_{mix}$), i.e. The max theoretical density using Equation 1 [16].

$$SG_{mix} = \frac{100}{\frac{\%a}{SG_a}+\frac{\%b}{SG_b}+\frac{\%c}{SG_c}+\cdots\ldots\ldots\ldots+\frac{\%\,oil}{SG\,oil}} \quad (1)$$

$$P = \frac{SG_{mix}-D}{SG_{mix}} = \left(1-\frac{D}{SG_{mix}}\right) \times 100\,\% \quad (2)$$

where a, b, c are the percentage of the parts of the mixture by weight of total mix, and the SG is the specific gravity of each part of the mixture, and D is the density.

Initial Rate of suction (IRS) is another property that need to be determined. The IRS test was done by soaking the sample in water at 3mm depth for 60 second. The IRS is the weight of water absorbed divided by the area soaked in water. Typically, IRS value on clay brick in the United Kingdom is 0.25-2.0 kg/m$^2$.minute. Samples with higher IRS value would absorb more water from sand cement mortar, hence the wall block material needs to be soaked before it is placed on a sand cement mortar layer [17]. Several clay brick samples taken from some building materials shops in Denpasar-Bali, had been tested and gave average IRS values of 6.4 kg/m$^2$.minute which is a lot higher the above IRS range [18].

## *2 MATERIALS AND METHOD*

The materials used was: waste engine oil that was taken from car and motor cycles service stations. The plastic used was combined waste thin plastic wrap: plastic shopping bags (crackle plastics), aluminum coated thin plastic waste, and other type thin plastic waste, and rice husk ash from local sources. The waste plastics were cut into about 5-10mm sizes. For viscosity comparison, original engine oil of Honda E-Pro Turbo 0W-20 SAE 0W-20 was used as well as waste engine oil [19]. Sybolt Furol viscosity testing equipment was used for viscosity testing. The specific gravity of the thin waste plastic, waste engine oil, and rice husk ash, were tested using pycnometer [20], meanwhile the viscosity of the oil was tested according to Indonesian Specification [19], where the flow time of 60 ml oil through the standard opening of the equipment at 30 °C was recorder (in second) and then correlated with a kinematic viscosity table (in centistokes).

The samples were produced by dissolving the combined proportion of waste thin plastic wrap into a frying pan with hot waste engine oil at 200 °C then evenly mixed. The proportion of the materials used include the rice husk ash, was based on trials and ease of manual mixing. The proportion of the materials is given in Table 3. The resulted plastic mixture was then poured into a metal mold. The temperature was cooled down to about 110-125 °C to obtain compressible mixture and was pressed using a simple hydraulic jack compression machine. The size of the samples was 20x10x8cm, which is in line with minimum size of Indonesian National Standard size [21]. The processes of sample production are shown in Fig. 1 (a to i). The typical of the samples are presented if Fig. 2. The samples were tested for their density, compressive strength, porosity, Initial Rate of Suction (IRS), and water absorption.

a. Weighing combined waste plastic wrap

b. Weighing waste engine oil

c. Weighing rice husk ash

d. Heating waste engine oil

e. Pouring waste thin plastic wrap

f. Mixing

g. Thick mixture result

h. Pouring the mixture into a mould

i. Compressing the mixture.

Fig. 1. Sample production process


Fig. 2. Typical of the plastic block samples

## 3 RESULTS AND DISCUSSIONS

### 3.1 Properties of the materials used

The density of the materials used is shown in Table 1, where the density of all of them are less than 1, hence floated in water. The viscosity of the engine oil used was tested using Saybolt Furol Viscosimeter [22], with its data on Table 2, where it is shown that the flow time of the waste engine oil was faster than the new engine oil which indicate that it is more fluid or less viscous after it is used.

Table 1. The density of the materials

| Material | Density (gram/cm$^3$) |
|---|---|
| Cracle Plastic | 0.8889 |
| Aluminium coated plastic | 0.8845 |
| Other thin plastic | 0.8865 |
| Waste engine oil | 0.08392 |
| Ruce husk ash | 2.055 |

Table 2. Viscosity of the engine oil

| No | Materials | Temperature (Celcius) | Flow time (second) | Viscosity (Centistokes) |
|---|---|---|---|---|
| 1 | Waste engine oil | 30° | 44 | 88 |
| 2 | New engine oil | 30° | 51 | 102 |

### 3.2 Proportion of the material

The materials were proportioned after trials (Table 3), in order to obtain the thickest mixture that can be mixed manually. This material proportion is an initials trial and can be varied further.

Table 3. Proportion of the materials

| Mix name | Material proportion | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crackle plastic | | Alm coated plastic | | Other thin plastic | | Waste engine oil | | Rice husk ash | | Total | |
| | (gram) | (%) | (gram) | (%) | (gram) | (%) | (gram) | (%) | (gram) | (%) | (gram) | (%) |
| A | 625 | 27,8 | 312,5 | 13,89 | 312,5 | 13,89 | 1000 | 44,4 | - | - | 2250 | 100,00 |
| B | 750 | 41,7 | 125 | 6,94 | 125 | 6,94 | 800 | 44,4 | - | - | 1800 | 100,00 |
| C | 625 | 26,3 | 312,5 | 13,16 | 312,5 | 13,16 | 1000 | 42,1 | 125 | 5,3 | 2375 | 100,00 |
| D | 750 | 39,5 | 125,0 | 6,58 | 125 | 6,58 | 800 | 42,1 | 100 | 5,3 | 1900 | 100,00 |

### 3.3 Properties of the mixtures

Mixture properties presented are: density, compressive strength, porosity, initial Rate of Suction (IRS), and water absorption, as shown in Fig. 2 to Fig. 6.

#### 3.3.1 Density

For density calculation requires weight and volume. Volume determination commonly done by weighing the samples in air and in water (*water replacement method).* As the samples density were lower than 1 (as shown in Fig. 3) hence float on water, weighing in water was not possible, therefore the volume was taken by measuring the average dimension of the samples. Mixture C is densest as it contains rice husk ash (Table 3).

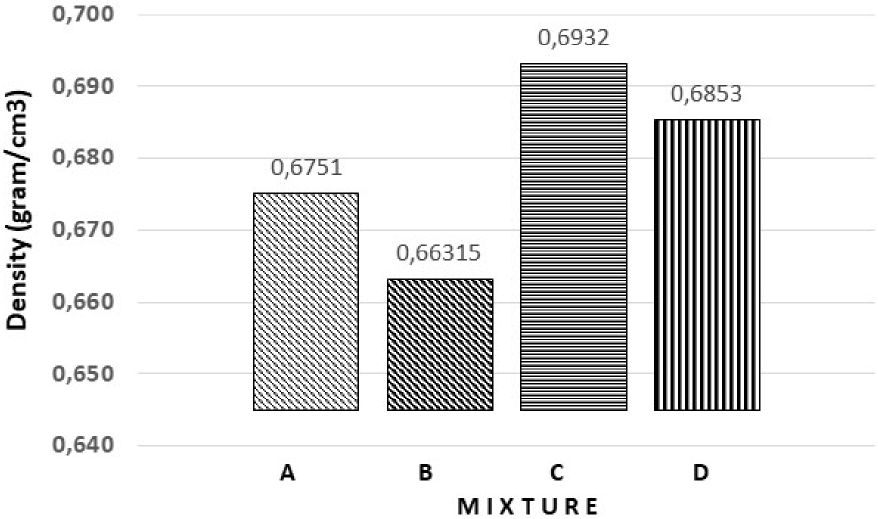


Fig. 3. The density of the compacted mixtures

#### 3.3.2 Compressive strength

The main samples property is compressive strength. The unsoaked and soaked compressive strength (after 24 hours soaking in water) samples of each mixture are presented in Fig. 4, where mixture C and D gave higher compressive strength, in line with the rice husk ash content.

For comparison, building block from coarse and fine aggregate with cement binder should have minimum compressive strength of 25 kg/cm$^2$ [21]. As the binder of the plastic block is not cement, there is no specification yet available. Nonetheless mixture C can achieve > 25 kg/cm$^2$. It is affected by the proportion of the materials incorporated.

For low quality brick studied by [23] the compressive strength of the unfired earth brick air dried at shade condition for 28 days, gave compressive strength 2.55 kg/cm$^2$. Other researcher produced sundried dried brick from mud and sand, after 25 days achieve compressive strength around 15.2 kg/cm$^2$ [24]. The plastic block studied in this experiment can achieve compressive strength comparable to most low-quality brick [7, 8] even somewhat better, depending on the proportion of the materials.

Meanwhile compressive strength of hollow concrete block on market are about 12-28 kg/cm$^2$, and 36-40 kg/cm$^2$ for the solid bock [25]. Other result from [26] obtained compressive strength of concrete blocks with cement binder within range of 40-250 kg/cm$^2$, which is common for building block using aggregate and cement binder.

For ease of analysis the above researches result is summarized in Table 4.

Table 4. Summary of research results

| No | Description | Compressive strength (kg/cm2) | References |
|---|---|---|---|
| 1 | Compressive strengths low-quality bricks variations | 15-35<br>20-40 | [7]<br>[8] |
| 2 | Minimum compressive strength requirement of concrete block in Indonesia | 25 | [21] |
| 3 | Compressive strength of the unfired earth brick air dried at shade condition for 28 days | 2.55 | [23] |
| 4 | Sundried dried brick from mud and sand, after 25 days | 15.2 | [24] |
| 5 | Hollow concrete block on markets in Indonesia | 12-28 | [25] |

| No | Description | Compressive strength (kg/cm2) | References |
|---|---|---|---|
| 6 | Solid concrete block on markets in Indonesia | 30-40 | [25] |
| 7 | Compressive strength of concrete blocks with cement binder | 40-250 | [26] |

Considering to point no 1 to 4 in Table 4, the compressive strength achieve on these initial trials were satisfactory (Fig. 4). The addition of rice husk ash (in Mix C and D), can increase the average compressive strength of mixtures without filing materials (Mix A and B) to about 36% on the unsoaked condition and up to 60% on the soaked condition, as the density of the mixtures increases. Referring to Table 3, in principle the thicker the mixture would be stronger, as long as the mixture can be thoroughly mixed. However, there is limitation in manual mixing ability.

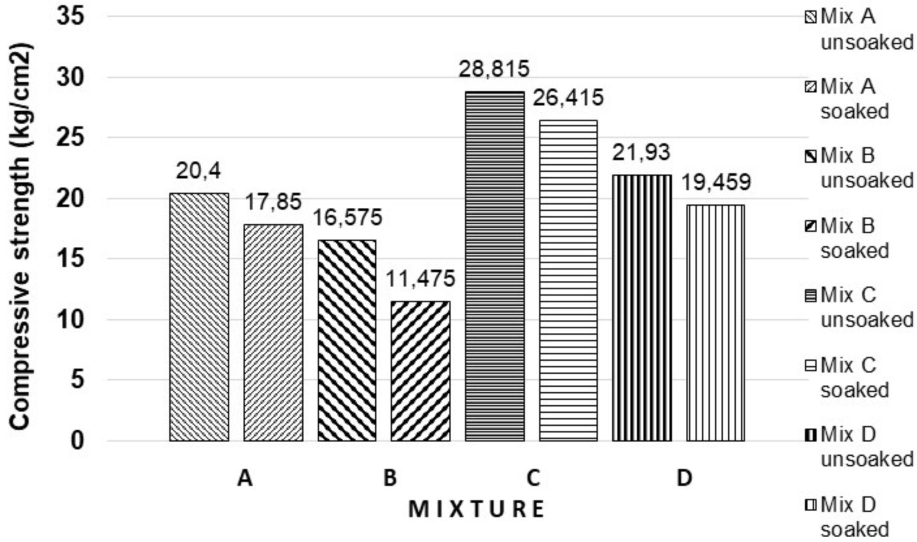


Fig. 4. The compressive strength of the compacted mixtures

To compare researches on the use of waste plastic in concrete mixtures had been done by some researchers, such as [27] reviewed several research results, summarized that the use up to 10% finely shredded or pulverized waste Polyethylene Terephthalate (PET) and Low-Density Polyethylene (LDPE) plastic waste as fine aggregate replacement gives satisfactory performance in concrete, where it can maintain the mechanical properties of concrete. Plastic waste incorporation can also improve workability od the concrete, and absorbs less water. This can reduce demand on natural aggregates resources. Meanwhile [28] within [29] reported the use of plastic bags in concrete mixes in different percentages reduces the compressive strength and tensile strength. But the reduction in strength was within 10% and it is acceptable.

Researcher [29] also found that there increase in slump values in concrete added with plastic aggregates. The compressive strength, flexural and split tensile strength of concrete mixture was also reduced as the plastic content increases. Therefore, limitation of waste plastic content is necessary to maintain the properties expected.

### *3.3.3 Porosity*

Average porosities of the mixtures are shown in Fig. 5, which are of low porosity compared to concrete block with porosity around 15-25% [25]. Porosity for lower quality building block is mostly not specified [30].

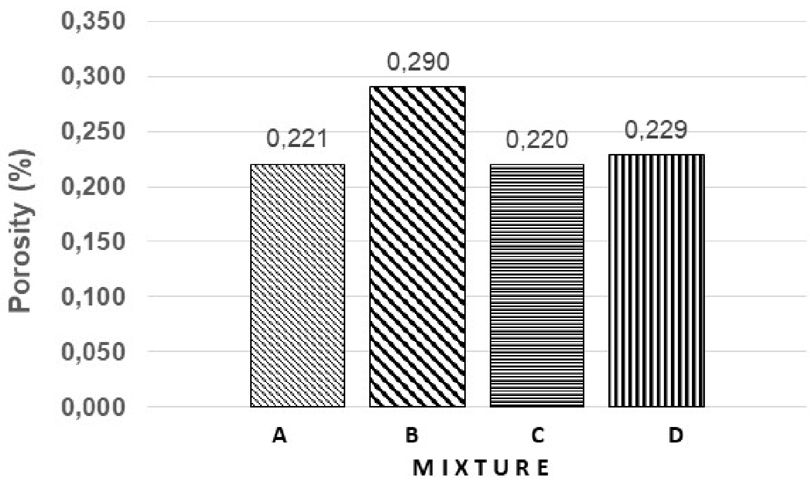


Fig. 5. The porosity of the compacted mixtures

### 3.3.4 Initial Rate of Suction (IRS)

The data are shown in Fig. 6 The IRS value are higher on mixture A and B, which are a lot lower than the typical IRS value of brick in England 0.25-2,0 kg/m$^2$.menit [17]. The IRS of claybricks available in Denpasar, Bali much higher about 6.4 kg/m$^2$.minute [18]. Low IRS indicate low initial water absorption of the mixture; hence it does not require soaking before it is bonded with sand cement mortar.

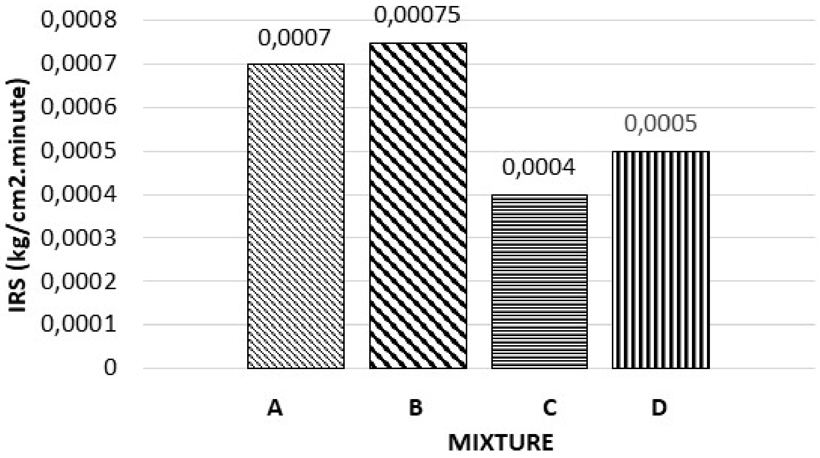


Fig. 6. The IRS of the compacted mixtures

### 3.3.5 Water Absorption

The water absorptions of the mixture are shown in Fig. 7, in which they are just marginally different, where Mixture C is highest. This is in line with the density of the compacted mixtures and generally of low absorption, and much lower than concrete block water absorption that can be of 10% [24] or 7-16% [26], and also lower than water absorption of fired clay brick in Bali with absorption of 22-34 % [30].

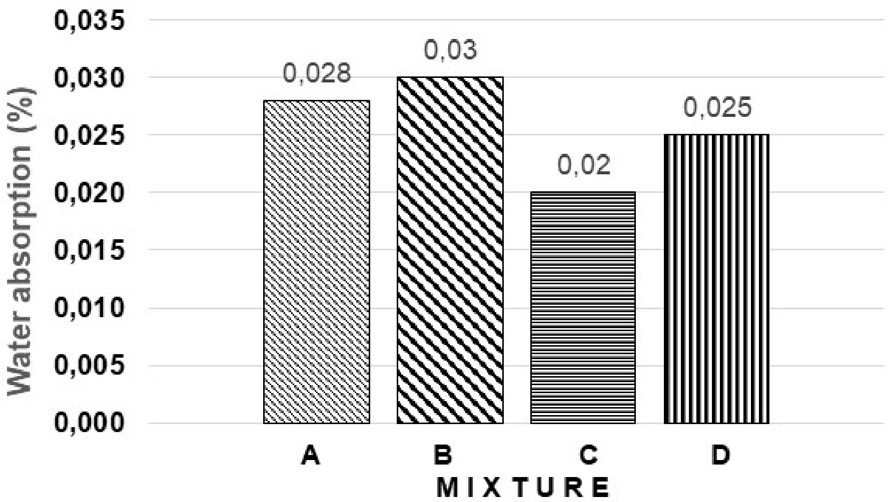


Fig. 7. The water absorption of the compacted mixtures

Considering the results in Figs. 5, 6 and 7, Mixture C is less affected by water. Nonetheless, other property especially the compressive strength is the main parameters targeted and mentioned on the specifications.

## 4 CONCLUSIONS

By analyzing the data, it can be concluded as follow:

1. The proportions of the materials affect the properties of the compacted mixtures.
2. The compressive strength of the mixture can achieve 25 kg/cm2, and are generally of better strength than most low-quality brick.
3. The Porosities were low, ranges from 0.220-0.290%, the Initial Rate of Suctions (IRS) very low ranges form 0.0004-0.00075 kg/m2.minute, and the and water absorptions were also low (0.02-0.03) %.

## 5 ACKNOWLEDGMENT

The writers would like to thank the Head of Civil Engineering Department Udayana University, The Dean of Faculty of Engineering Udayana University, and Rector of Udayana University, for assisting the research works and facilitating research fund for this research.

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*Paper submitted: 16.04.2024.*
*Paper accepted: 21.10.2024.*