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Investigation of concrete blocks mixed with recycled crumb rubber: A case study in Thailand

Nuttawut Intaboot* and Prachya Kanbua

Department of Civil Engineering, Faculty of Engineering and Architecture, Rajamangala University of Technology Suvarnabhumi, Nonthaburi 11000, Thailand

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Abstract

This research examined the improvement and development of concrete block properties for masonry wall construction. The study aimed to make improvements in the physical and mechanical properties as well as the strengths of heat resistance and sound absorption in building. Waste materials such as crushed tires were used for concrete block production. The crushed tires were used as crumb rubber in replacement of sand. This concept used the advantages of rubber properties, such as being lightweight, having low thermal conductivity and good sound absorption as well as high flexibility, which can improve and develop the properties of concrete blocks. This study used crumb rubber in replacement of sand at 0%, 10%, 20%, 30%, and 40%. The density, water absorption, porosity, compressive strength, stress-strain relationship, static modulus of elasticity, thermal conductivity, and sound absorption were tested. The results found that the increasing in crumb rubber contents decreased the density and increased the water absorption and porosity of concrete block. The compressive strength, static modulus of elasticity, thermal conductivity decreased while flexibility and sound absorption increased with the increasing in crumb rubber contents. Therefore, crumb rubber concrete blocks suitable for the development of wall building materials and can reduce the impact on the environment as well.

Keywords: Crumb rubber, Concrete block, Thermal conductivity, Sound absorption

1. Introduction

Innovation is of great importance to the development of the construction industry. Innovation can only develop when researchers experiment with new ideas, which can be achieved through advanced technology or by the use of waste materials to create better materials.

Concrete blocks are the most widely used building material in Thailand and many other countries around the world. Concrete blocks are used to construct the walls of buildings and residences, both inside and outside. The behavior of concrete blocks will prevent heat from entering the building while locking out outside noise and reducing internal sound reflection. It also offers indirect resistance to the lateral forces of the building. Therefore, it is reasonable to develop and improve the production of concrete blocks to help expand the advantages of those properties. Moreover, it is well known that rubber is a good thermal and sound insulator as well as being lightweight and highly flexible [1]. Therefore, if crumb rubber is used in the production of concrete blocks, it is likely to create innovation as well.

In Thailand, natural rubber is produced for use in the production of automobile tires in large numbers. This industry is growing every year as a result of the many tires that are used and discarded [2]. The tires are discarded, which creates a problem for environmental management. In developed countries, the researcher found that tires tend to be recycled instead of incinerated or cast in a landfill because they are a serious threat to the global ecosystem. Over the past two decades, governments around the world have promoted the recovery and recycling of tires [3]. However, billions of tires have been stocked or buried, which is expected to continue to increase over the next decade [4].

The recycling of rubber in some areas is used for fuel industrial plants. However, this method is still a problem for air pollution and destroys the environment [5]. In this respect, the construction industry has an important role in bringing about alternative uses for tires. Recently, crumb rubber has been added to concrete production [6, 7]. However, the researchers aimed to study the development of new lightweight building products made from precast concrete or mortar containing recycled rubber as an environmentally friendly material [8]. Crumb rubber is widely used in prefabricated products for construction, such as hollow blocks and masonry bricks. However, the literature shows that the use of crumb rubber concrete is impractical in many structural applications due to a dramatic decrease in strength [9-12]. Despite the limited mechanical properties of crumb rubber concrete, there is a market for non-structured concrete products with medium to low strength requirements. These products also show superior properties in terms of thermal and sound insulation and shrink resistance compared to conventional units [13-15]. Sound absorbers and barriers are often used to eliminate ambient noise and take advantage of renewable waste. Crumb rubber concrete is a durable composite material that can absorb and reflect sound [16]. Additionally, the use of ribbed masonry units in vertical walls or slabs is an excellent energy-saving strategy as it reduces the annual energy use for building maintenance [17].

*Corresponding author. Tel.: +6689 910 9781
Email address: Nuttawut098@gmail.com
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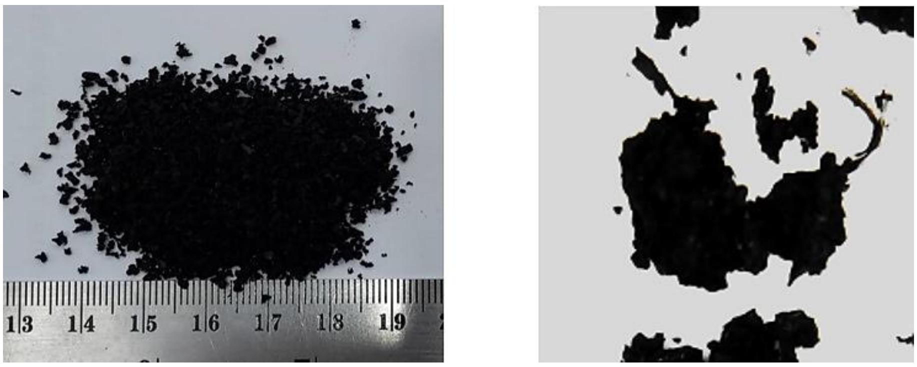
Ordinary hollow concrete blocks are large square bricks used in construction. Concrete blocks are made from cast concrete such as Portland cement and aggregate. It usually contains small gravel with enough water to produce the dry mix. Such hollow concrete blocks are known for their heavy unit blocks, including heat resistance, sound absorption, and low to mechanical properties. Due to their disadvantages, hollow concrete blocks are a relatively unpopular building material among developers. Therefore, improving these disadvantages is important. Accordingly, many researchers have aimed to study the use of rubber scraps for mixing into the production of wall building materials. Amin AF et al. [18] used rubber scraps in the mixture for the production of interlocking blocks. This enables the reuse of waste materials to benefit and develop the materials used in construction. The results showed that crumb rubber could help the bricks have high flexibility; compressive strength was decreased due to the effect of the surrounding air in rubber particles. Further, Amin et al. [19] studied the mechanical properties of the rubber cement interlocking block by adding fly ash as a binder. The study showed that the compressive strength of both hollow blocks and grouted specimens was reduced by 15-20%. The failure originates from web splitting, vertical cracking, and skin peeling. In this regard, further study [20] focused on brick and crumb rubber mixtures were carried out by considering an out-of-plane load, with and without pre-compression load. It was found that bricks mixed with crumb rubber exhibited more deformation. In addition, Zhang B. and Poon C.S. [21] studied the improvement of the sound insulation properties of lightweight concrete made from rubber crumbs. The findings suggested that the pre-treatment method resulted in weaker bonding between the rubber aggregate and cement paste, thus increasing the vibration absorption capacity and enhancing the noise insulation properties of the concrete.

Based on research from the past to the present, there has been continuous development the use of concrete and block construction materials. However, it is worth noting that little research has been carried out on the hollow concrete blocks used in Thailand. Based on the aforementioned, the main objective of this study was to improve and develop innovative concrete blocks. Crumb rubber was used as a material in the mixture to partially replace the sand. This point reveals the innovation of both the physical and mechanical properties as well as the strengths of heat resistance and sound absorption in the building. The results from this research could enable wall material that is lightweight, has medium strength within the standard, good flexibility, low thermal conductivity, and sound absorption for building. These advantages will develop concrete block properties for future construction.

2. Materials and experimental methods

2.1 Materials

Ordinary Portland cement (OPC) type 1, according to ASTM C150 [22] standards, is used as a binder in the manufacture of concrete blocks. The fine aggregate consists of natural sand and limestone dust with 0 to 4 mm in size. The unit weights are 1,678.85 and 1,762.82 kg/m^3 for sand and limestone dust, respectively. The fineness moduli are 3.00 and 2.65 for sand and limestone dust, respectively. The size of crumb rubber is 2 mm, with a specific gravity of 0.89. The water absorption value is 1.70%, the fineness modulus is 2.62, as shown in Table 1, and has an irregular shape, as shown in Figure 1. The sieve analysis of river sand, limestone dust, and crumb rubber is presented in Figure 2 according to standard ASTM C-136-05 [23].



Crumb rubber Rubber particle

Figure 1 Crumb rubber and rubber particle shape

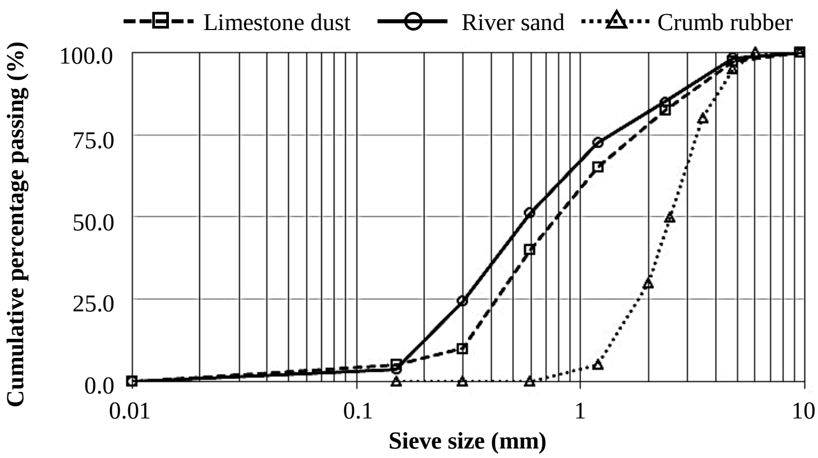


Figure 2 Gradation curve of river sand, limestone dust, and crumb rubber

Table 1 Physical properties of fine aggregate

Fine aggregate	Bulk density (kg/m3)	Specific gravity	Water absorption (%)	Fineness modulus	Moisture content (%)
Limestone dust	1,762.82	2.69	2.60	2.65	0.55
River sand	1,678.85	2.65	0.85	3.00	3.85
Crumb rubber	589.80	0.89	1.70	2.62	-

2.2 Mix proportion and preparation

The preparation of crumb rubber begins with a shredding process, reducing the size of crumbs to 100 mm - 50 mm, followed by a granulating process that further reduces the size from 50 mm to 10 mm. The separation of steel wire from rubber scrap takes place after the preliminary sorting. Before being fed into the final granulation process, the crumbs are ground to smaller sizes to produce customized crumb rubber by grinding in rolling mills. Gravity and magnetic sieves/separators are used to remove metals and fibers, respectively, in the manufacturing process.

Table 2 shows the mix proportion consisting of five trial mixes at four proportions of crumb rubber replacement (10%, 20%, 30%, and 40%) by weight and a control mix. This controlled mixture is used to make commercial concrete blocks in Thailand. In the production process, the sample is produced in 2 parts, which is the production of concrete blocks from the factory to produce samples from the lab. In factory sample production, concrete blocks are produced with the steps and standards according to the factory production process (Figure 3).

Production quality is controlled and monitored in order to meet standards, starting from the use of clean materials. The specified proportions are mixed in the mixer and compatibility is checked periodically. When combined appropriately, the mixture is extruded into a hollow concrete block mold. Subsequently, it is removed from the printer and the shape of the hollow concrete block is checked; there must be no chipping, breakage, or other damage. In the production of samples in the lab, the ingredients that have been mixed in the factory are collected and stored in the lab until used in the production of samples for certain tests such as elastic modulus, sound absorption, and thermal conductivity.

Table 2 Mix proportions

Sample ID	Rubber content (%)	Crumb rubber (kg)	Sand (kg)	Cement (kg)	Limestone dust (kg)	Water (kg)
Control	0	0	12	8	32	9
RB10	10	1.2	10.8	8	32	9
RB20	20	2.4	9.6	8	32	9
RB30	30	3.6	8.4	8	32	9
RB40	40	4.8	7.2	8	32	9

2.3 Test procedure

The compressive strength, density, porosity, and water absorption were tested with concrete blocks size of 70 mm x190 mm x390 mm made from the factory in accordance with the requirements of ASTM C140 [24]. The compressive strength test was performed using a compression testing machine plus a rigid steel plate, as shown in Figure 4(a) at 28 days of curing. The surface of the sample must be saw-cut to smooth the surface prior to testing. The stress-strain relationship and elastic modulus were tested as per ASTM C 469 [25] using a cylinder sample size of 150 mm x300 mm at 28 days in air curing for curing followed by molding 24 h later. The capacity loading of testing machine was a UTM 500 tons, and a measure displacement sensor with a precision of 0.001 mm was used, as in Figure 4(b). Thermal conductivity used a sample size of 200x200x20 mm for the test in accordance with ASTM C518 [26]. The samples were place in the oven at 100 ^{0}C for 24 hours to dehumidify prior to testing. Sound absorption was tested following ISO10534-2 [27] by using the impedance tube method.

Figure 3 Concrete block manufacturing process in the factory

(a) Compressive strength test (b) Elastic modulus test

Figure 4 Mechanical properties test

3. Results and discussion

3.1 Density, water absorption, and porosity

The physical properties of materials including porosity, water absorption, and density demonstrated the values shown in Table 3 and Figure 5. It was found that the values of density between 1,727-1,993 kg/m^3 decrease 0-13.3%. This is consistent with study by Topcu [28] that reported a 13% decrease in density when maximum amounts of rubber were used as a replacement for fine aggregate. The density of concrete blocks in the case of the control mixes used in construction in Thailand will be less than normal concrete. Moreover, increasing the rubber content to replace sand will further decrease the density because the rubber material has less density than sand. Therefore, the weight of concrete blocks with an increase in rubber content will be less when mixing in large quantities and extruding in equal volumes. This has a positive effect on construction because the wall material can save on structural design if it is lightweight.

Table 3 Test results of crumb rubber concrete block properties

Sample ID	Density (kg/m^3)	Water absorption (%)	Porosity (%)
Control	1,992	3.80	11.52
RB10	1,922	4.91	13.24
RB20	1,884	6.25	14.76
RB30	1,801	7.17	15.58
RB40	1,727	8.21	16.01

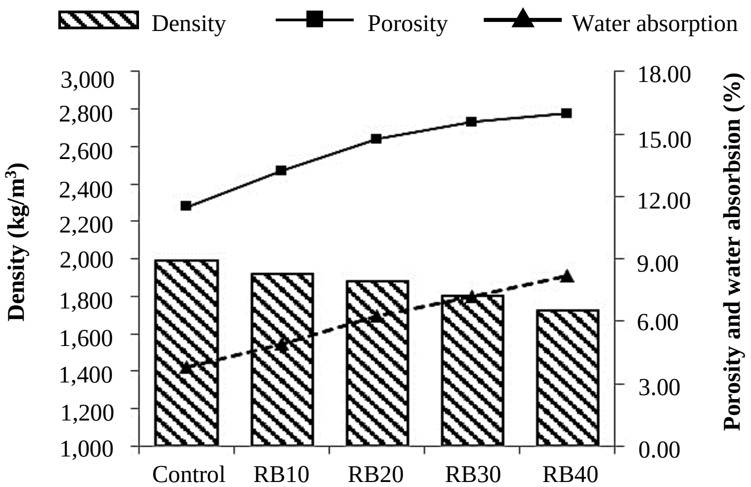


Figure 5 Density, porosity, and water absorption of crumb rubber concrete blocks

Table 3, it was found that the porosity and water absorption increased when the rubber content increased. The rubber granules are the cause of porosity and the rubber is also able to trap the infiltrated air, which means more interconnected porosity [29]. Thus, larger rubber content equates to greater porosity. This effect may be due to the non-polar nature of rubber and its tendency to trap air on rough surfaces [30]. Mohammed [31] explains that the rubber surface area binds with loose cement mortar, resulting in trapped air on the rubber surface. Considering the microstructure of crumb rubber concrete in this study, as shown in Figure 6. Concrete blocks mixed with crumb rubber form capillaries that are easily filled with water, resulting in crumb rubber concrete blocks that have higher gaps and water absorption. However, the water absorption in this study was lower than 25% that specified by TIS 58-2533 [32].

For considering the relationship between water absorption and porosity of crumb rubber concrete blocks, as shown in Figure 7, it was found that both values increased when the rubber content increased, similar to the previous reason. It is noteworthy that the trend will rise in a straight line with a slope of the graph that is similar. In other words, it will change at the same rate. When analyzing the linear regression of the two relationships, the result is the relationship according to Figure 7, which will give more than 90% accuracy. When comparing water absorption and porosity, as shown in Figure 8, there is a linear relationship. It was found that, when the porosity of the crumb rubber concrete block was increased, the water absorption was also increased, which will be increased at the same rate (Slope=1). This is consistent with the Intoboot [33] study, which found that the slope of the curve between the two relationships was 1. It is also consistent with previous research [34, 35] showing that the water absorption increases with the volume of the gap and variable in a straight line. Therefore, the linear equations obtained from this experiment can be represented in the predictive analysis between the two variables.

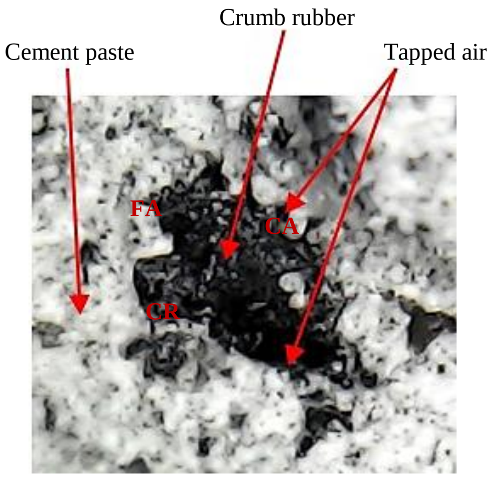


Figure 6 Microstructure of crumb rubber concrete block

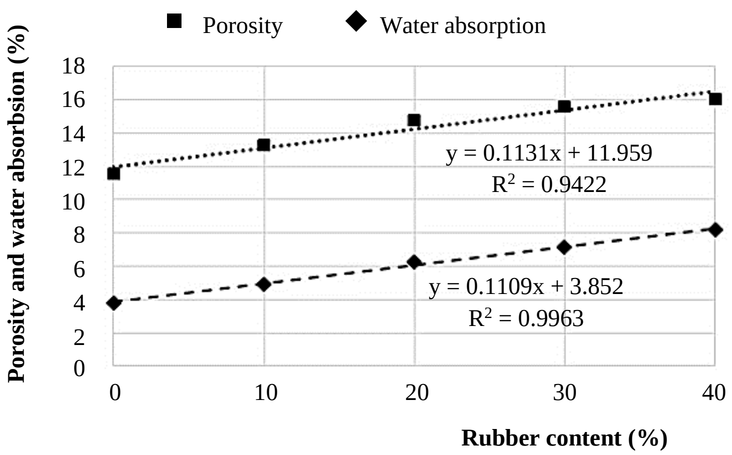


Figure 7 Relationship of porosity and water absorption to rubber content

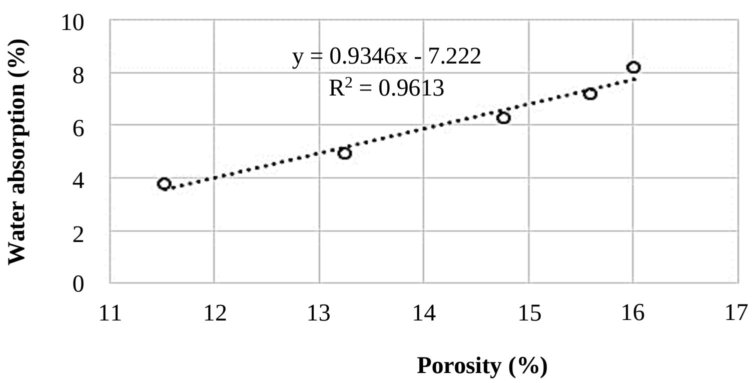


Figure 8 Relationship between porosity and water absorption

3.2 Compressive strength

Compressive strength is a mechanical property of crumb rubber blocks which have 8.64, 7.41, 6.54, 5.05, and 2.96 MPa in the mixture of control, RB10, RB20, RB30, and RB40, respectively. It was found that the compressive strength was reduced when the rubber content increased, as shown in Figure 9, which is consistent with the previous studies [36, 37]. There are some reasons for this. First, the rubber particles are much weaker than the surrounding matrix. Therefore, cracks formed quickly around the rubber particles in the mixture, which is an accelerated part of the deterioration of concrete. The second is the lack of adhesion between the rubber particles and the mixture since soft rubber particles may behave like voids in concrete [38, 39]. The specific gravity and unit weight of sand and rubber are very different. The replacement of rubber by weight may also lead to a reduction in the binder content to aggregate ratio. Third, the reduced strength is due to the weak adhesion between the cement paste and rubber particles. The weak bond caused by air trapped on the surface of the rubber particles is due to the non-polarity of crumb rubber causing water to repel [31]. The air retention of the rubber and cement paste surface joints partially reduces the bonding force in the concrete matrix, as shown in Figure 6. The rubber particles were not completely bonded to the cement matrix but were more strongly bonded to the fine aggregate (FA) and coarse aggregate (CA) surfaces. While the load is applied to the crumb rubber concrete block during testing, micro-cracks form a weak interface between the cement paste and crumb rubber, which is due to the stress concentration and will eventually lead to failure with continuous loading [31].

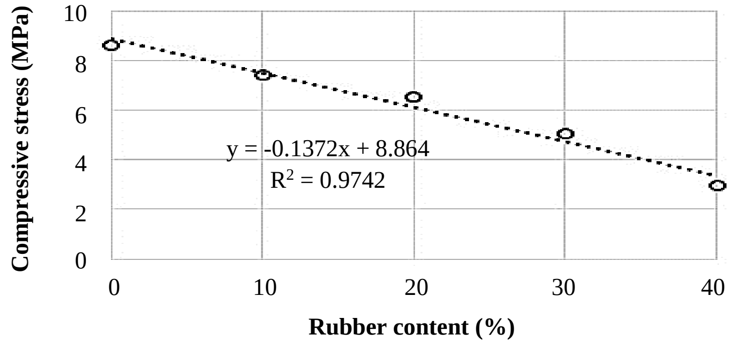


Figure 9 Relationship between compression strength and rubber content

In addition to the impact of the reduced compression from the increase in rubber content, the effect water absorption is another factor in reducing compressive strength. The presence of more pores within the mortar weakens the matrix structure of the mortar; the porosity will cause faster cracks when under load [40]. Figure 10 shows that an increase in water absorption leads to a decrease in compressive strength. There is a good correlation between the water absorption values and the compressive strength of mortar, with an R^2 value of 0.955. However, the minimum compressive strength is 2.96 MPa at 40% rubber content, which is a compressive strength that meets TIS 58-2533 [32] industrial product standards for non-load-bearing bricks. However, the standard compressive strength of non-load-bearing bricks must not be less than 2.5 MPa. Therefore, the crumb rubber concrete block obtained from this study could be used for masonry construction.

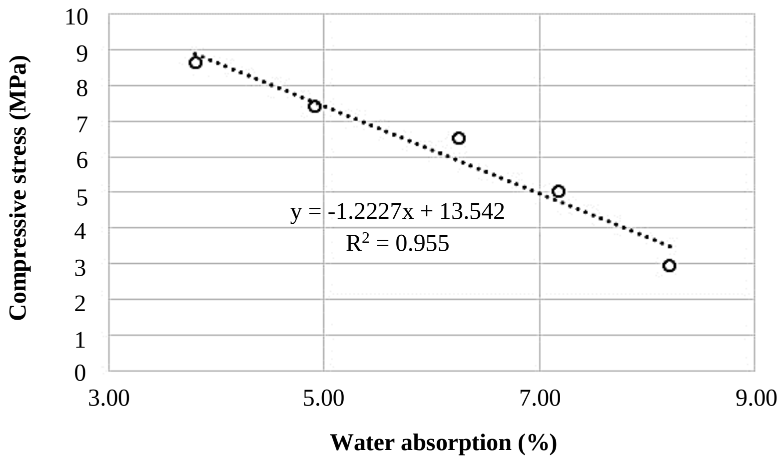


Figure 10 Relationship between water absorption and the compressive strength of crumb rubber concrete block

3.3 Stress-strain relationship

Uniaxial compressive testing in accordance with ASTM C39 [41], a 150 mm x 300 mm cylindrical sample was tested for compressive strength using UTM; the displacements were recorded to construct the stress-strain relationship of different samples, as shown in Figure 11. The relationship between stress-strain shows that the compressive strength varies with the increase in rubber content. This will affect the mechanical properties of concrete blocks. However, the increased rubber content causes a lower compressive strength, but results in the development of concrete block deformation ability.

Figure 11 shows that the increased rubber content will increase the deformation of the concrete block. Considering RB40 at maximum stress, the deformation value was 83.76%, or 6.16 times greater than the control concrete block. It shows that the rubber content helps to enable more ductility and resistance to flexibility. Likewise, this additional rubber content allows the concrete block to be greatly deformed when applied load. The crumb rubber concrete blocks have a lot of strain at the beginning of stress (at 0-1 MPa). Ling [42] explained that the rubber content inserted in the aggregate allows the concrete block to be flexible. The concrete matrix compresses when bond stress is applied to the rubber particles, as shown in Figure 12. Such behavior will result in rubber being compressed, creating an initial strain curve. After the rubber is compacted until tight, the stress-strain relationship will be a linear variation because the crumb rubber concrete block will form a dense matrix. The bound stress acts on solid particles. It results in the crumb rubber concrete block taking more strength. Therefore, it can be concluded that, when the concrete block is added to a large amount of rubber content, the behavior of the material becomes more flexible.

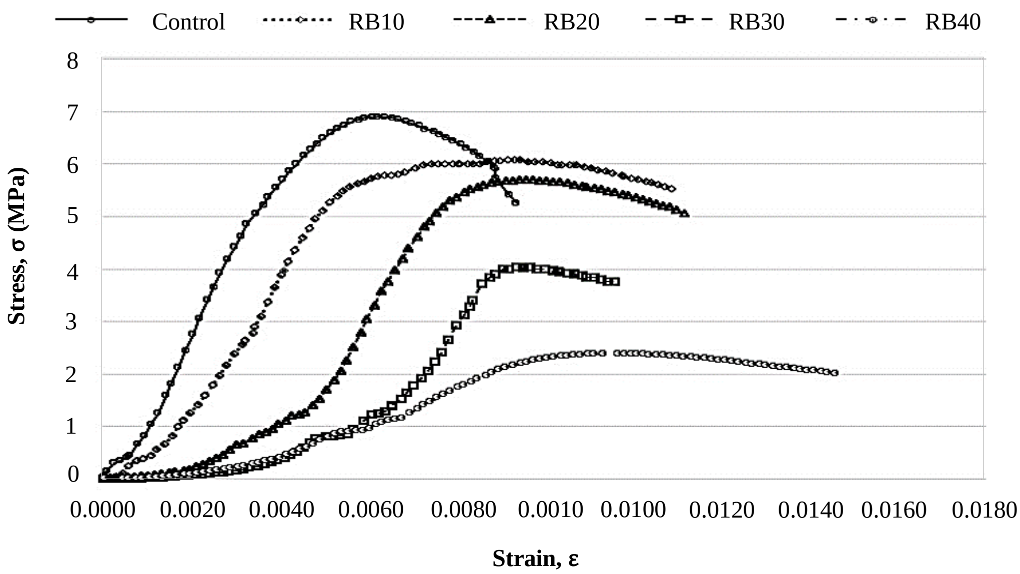


Figure 11 Stress-strain relationship of crumb rubber concrete block

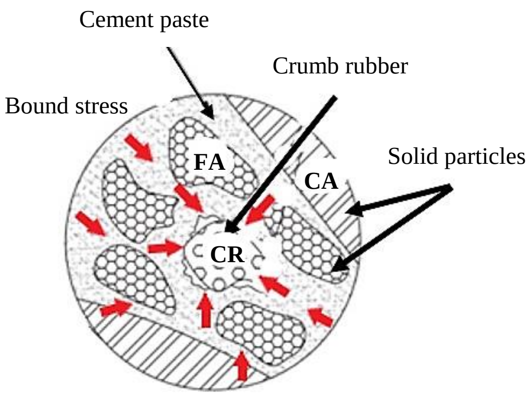


Figure 12 Mechanism behavior of soft rubber and solid particles

The behavior of the ductile concrete block with rubber content is different from that of concrete block without rubber content (control). For concrete blocks containing rubber, the material will deform significantly when the peak stress is reached. The stress value does not drop immediately, causing the material to be deformed immediately. In contrast, the concrete block in the control mixes had no rubber content; when the stress reached a peak, the stress value will drop rapidly and break, as shown in Figure 11. This is an advantage when being used as wall construction material. The walls of a building can crack when stress is applied. Therefore, it helps to reduce the effect of cracking when rubber is used as an ingredient.

3.4 Static modulus of elasticity

The stress-strain relationship does not exhibit an initial linear region, as in Figure 11. Secant Modulus is used for calculating the static modulus of elasticity of that relationship in accordance with ASTM D638 [43]. The secant modulus, average ultimate compressive strength, strain at peak compressive stress, and failure strain, are presented in Table 4. The secant modulus decreases as the rubber content increases. Such a reduction is nonlinear, as shown in Figure 13. It shows that the decrease in this modulus is not directly proportional to the rubber content. Figures 14-15 show the relationship between modulus and compressive strength and density, respectively. It was found that the transformation was polynomial to 2 degrees, providing an accuracy of R^2=0.99, which is a high-precision value. This is different from the previous research which found that the modulus of the rubber-mixed concrete was linearly proportional to the compressive strength and linearly proportional to the density [44-46]. This is because concrete blocks are materials with low compressive strength. They contain a combination of highly flexible materials, thus resulting in low strength. The variation is high, so a concrete block with a small increase in rubber content will significantly reduce its modulus.

Table 4 Mechanical properties of concrete block

Sample ID	Ultimate comp. strength (MPa)	Strain at peak comp. stress (mm/mm)	Failure strain (mm/mm)	Secant modulus (MPa)
Control	6.90	0.0062	0.0094	1,442.70
RB10	6.08	0.0095	0.0129	863.25
RB20	5.70	0.0096	0.0132	478.37
RB30	4.04	0.0094	0.0127	208.58
RB40	2.40	0.0118	0.0166	181.70

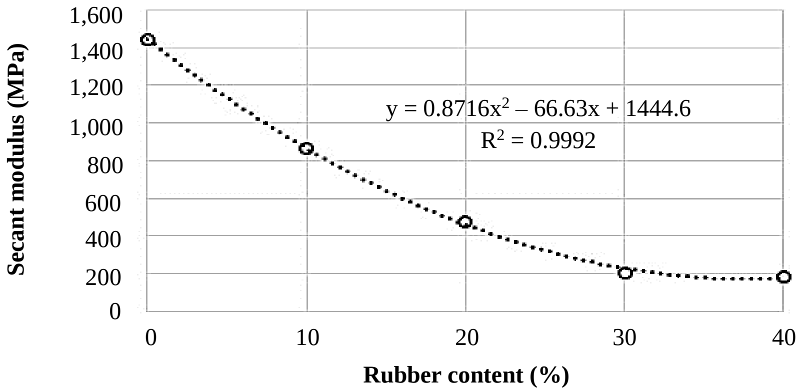


Figure 13 Relationship between secant modulus and rubber content

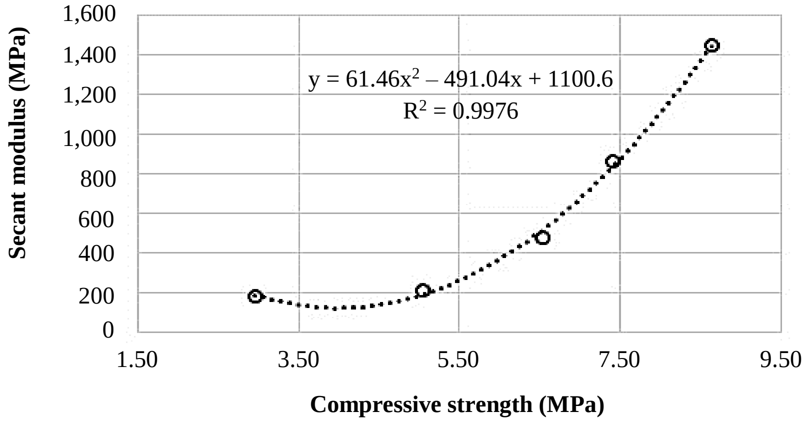


Figure 14 Relationship between secant modulus and compressive strength

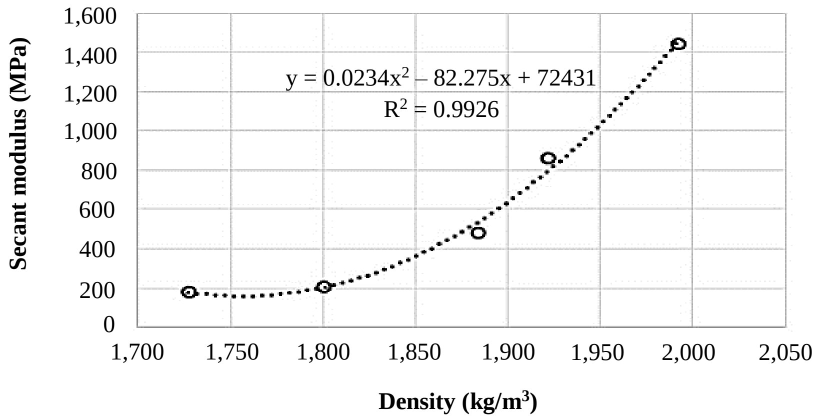


Figure 15 Relationship between secant modulus and density

3.5 Thermal conductivity

The highlighted features of masonry materials such as masonry brick, interlocking block, and concrete block include their thermal conductivity and sound absorption. Therefore, an innovative, energy-saving, and environmentally-friendly wall material can be created if the properties of the concrete block include low thermal conductivity. The thermal conductivity test of the crumb rubber concrete block is shown in Figure 16.

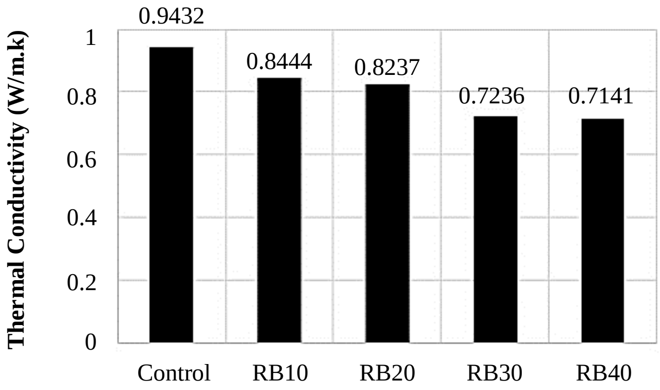


Figure 16 Thermal conductivity of crumb rubber concrete block

Figure 16 shows that the rubber content increases as the thermal conductivity decreases. This decrease in thermal conductivity is due to various reasons. First of all, the rubber has thermal insulation properties with a low thermal conductivity of 0.16 W/mK, while sand has a thermal conductivity of 1.5 W/mK, which is higher than that of rubber [31]. Therefore, the total thermal conductivity of the concrete block is reduced when replacing sand with rubber. Secondly, increasing the rubber content causes the amount of cavitation in the concrete block to increase, as described previously. The thermal conductivity of air is 0.025 W/mK, which is less than concrete with thermal conductivity of 1.7 W/mK [31]. Therefore, the internal air gap resists the thermal transfer through the concrete block. In addition, Benmansour et al. [47] reported that thermal conductivity is regulated by the number of voids in the material. This shows that a more porous material will have lower thermal conductivity. This is consistent with previous research [48]. In addition, Mo et al. [40] suggested that higher water absorption values resulted in lower thermal conductivity, consistent with the results shown in Figure 17.

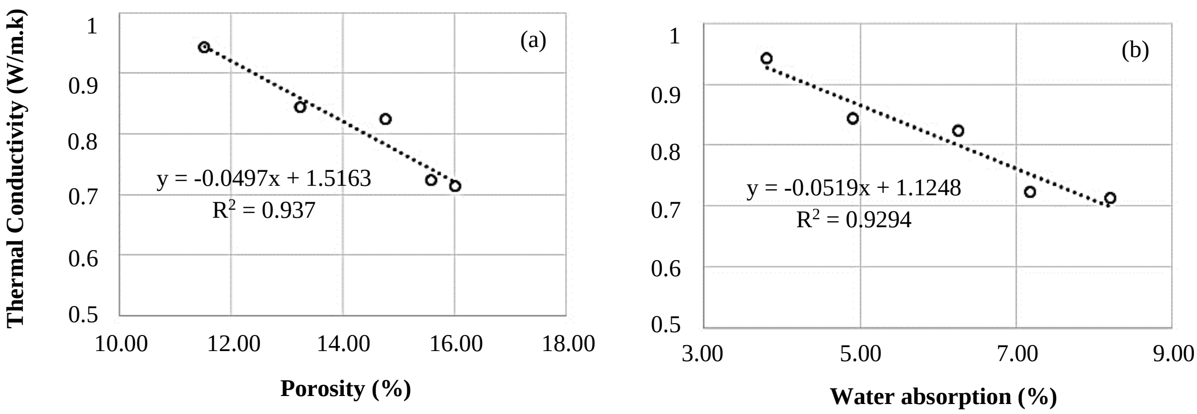


Figure 17 Relationship between thermal conductivity and (a) porosity, (b) water absorption

In addition to porosity and water absorption affecting thermal conductivity, density also has an effect. Due to reason of the increase in both, the density is reduced, while the thermal conductivity is also reduced. However, the results of this study are consistent with Mohammed et al. [31], which reported 0-50% crumb rubber hollow concrete blocks had a thermal conductivity of 1.13-0.61 W/mK, explaining that the results are within the norm.

3.6 Sound absorption

Sound absorption tests were performed experimentally in accordance with ISO 10534-2. The sound absorption coefficient (α) was determined with an impedance tube. The experimental set was installed with two microphones to test the sound absorption coefficient of the crumb rubber concrete block. Figure 18 shows a comparison of the sound absorption coefficients of 5 samples used in the test. The results showed that the sound absorption coefficient increased with the rubber content. Sound absorption was carried out in the high-frequency band (1000HZ-4000HZ) more than the low-frequency band (125HZ-500HZ). This is because increasing the rubber content caused the sample to form trapped air with gaps. These characteristics result in the sample having the properties of a porous or dissipative absorber material. In these materials, air molecules vibrate in the gaps of the porous material when the sound hits. The vibrations of air molecules cause a large amount of energy loss when the incident sound is at high frequencies [33], so it absorbs sound well at high frequencies. On the other hand, a membrane absorber is a good sound-absorbing material for sound absorption in the low-frequency band. The membrane absorber is formed by samples of a mixture with small particle material [33]. However, the ability to absorb both the sound and frequency bands obtained in this experiment was not difference.

A Noise Reduction Coefficient (NRC) is a value that indicates the sound absorption capacity of a material. It is the average value of the sound absorption coefficient at all frequencies. It was found that increasing the rubber content resulted in better sound absorption. NRC increased by 10 times the control mixes to increase the rubber content to RB10. NRC increased 28.98%, 47.58%, and 15.52% of the step-by-step for the RB20, RB30, and RB40, respectively, as shown in Figure 19. This increase in NRC is due to the increase in particle volume. A larger surface area and heavier grade tires can absorb more sound [49]. However, Holmes et al. [49] reported that, in addition to the added amount of rubber, the size of the rubber also affects sound absorption. Sound absorption is defined as the sound of an event hitting the material and not reflecting. Therefore, sound is readily absorbed through air trapped on the crumb rubber surface within the microstructure of the crumb rubber hollow concrete block; Sukhontasukkul [1] reported the same observation.

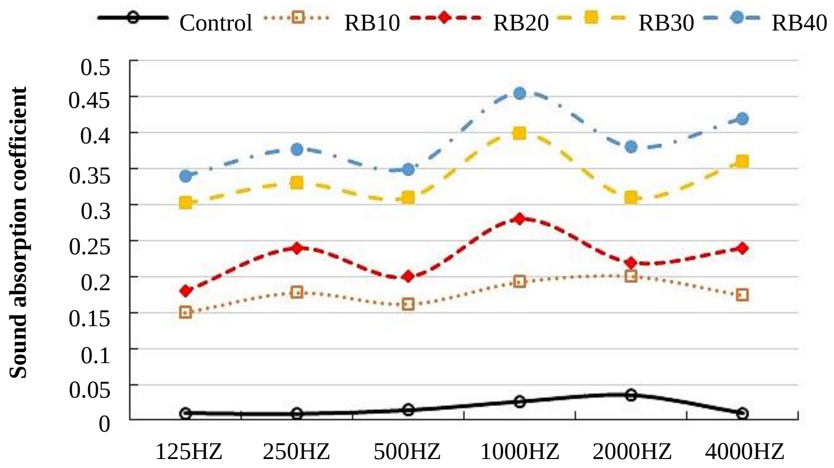


Figure 18 Sound absorption coefficient of crumb rubber hollow concrete block

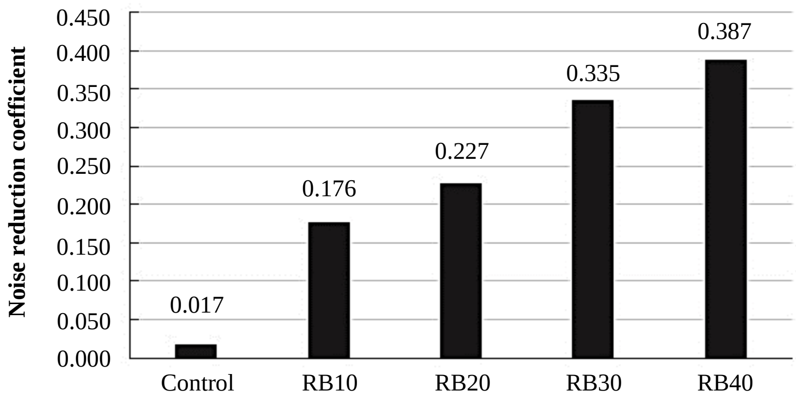


Figure 19 Noise reduction coefficient of crumb rubber hollow concrete block

4. Conclusions

This study examined the development of innovation in the production of building materials, specifically those for brick walls in Thailand. This study used crumb rubber to replace sand in the concrete block manufacturing process, which enabled the advantages detailed below.

1. The use of rubber in the manufacturing process reduces density. However, porosity and water absorption in this study were increased compared to control concrete blocks.

2. The compressive strength is reduced. It is due to the weak adhesion between the cement paste and rubber particles. Such a decrease followed an increase in rubber content.

3. Crumb rubber concrete blocks can be deformed and have high flexibility because rubber is a flexible material. After the rubber is compacted, the stress-strain relationship will be a linear variation because the crumb rubber concrete block will form a dense matrix.

4. Crumb rubber concrete block comprises a low-strength material, resulting in a non-linear relationship between the modulus and compressive strength, rubber content, and density.

5. Crumb rubber concrete blocks have lower thermal conductivity compared to normal concrete blocks. The thermal conductivity gradually decreases as the rubber content increases. This makes it possible to reduce energy consumption for air conditioners in tropical regions and is thus more environmentally friendly.

6. Using rubber in the mixture helps to prevent noise and reduce echo sounds. Crumb rubber concrete blocks are suitable for making walls, especially exterior walls. Because, the most absorbent materials are fabrics, sponges, or foams, these materials are not resistant to moisture or heat.

Therefore, crumb rubber used in the production of concrete blocks for building walls is appropriate. It is known that such concrete blocks have reduced weight as well as higher flexibility than normal concrete blocks. Further, they are resistant to heat entering high-rise buildings and possess the ability to absorb waste as well as greatly reduce noise. Crumb rubber concrete blocks exhibit many advantages, as revealed in this study. However, the appropriate proportion of the rubber content should not exceed 40% of the sand replacement, which depends on the usage. Finally, the use of recycled materials should be encouraged to help reduce waste and reduce damage to the environment while increasing the value of waste materials.

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