Partial Replacement of Fine Aggregate Using Waste Materials in Concrete as Roof Tile: A Review

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Abstract. The use of waste material as a partial replacement has become popular in concrete mixture studies. Many research has utilized waste materials like cement, fine aggregate, coarse aggregate, and reinforcing materials substitute. The current paper focuses on some of the waste elements that are utilized in a concrete mortar (use in roof tile) as a partial replacement for fine aggregates such as rubber ash, sawdust, seashells, crumb rubber, pistachio shells, cinder sand, stone dust, and copper slag. There are many variations of mix proportion and water-cement ratio for every waste material. Compressive strength was compared and found that stone dust and the combination of seashell and coconut fiber shows an increase when used to replacing fine aggregate. The suitable replacement level for stone dust is 25% and 50%. While the suitable replacement levels for the combination of sea shell and coconut fiber are 20% and 30%. Material from the rubber families such as rubber crumb and rubber ash is only suitable for replacement levels. Rubber families especially rubber crumbs have shown low water absorption value which is good in the production of roofing products. As we know, the roof should have waterproof properties to prevent any leaks from happening when it rains. Most of the waste materials added as fine aggregates in concrete have increased the amount of water absorption and found that sawdust is the most abundant material with a high percentage of water absorption compared to the others. Research on the partial replacement of fine aggregates replaced with waste materials is needed more extensively to provide more confidence about their use in concrete mortars, especially on roof tiles.

1. Introduction
Construction in the country is developing in this day and age of modernism and sophistication. As a result, the market for building materials increased. Concrete is a mixture of fine aggregate, coarse aggregate, and even cement. A great number of houses have been constructed as a result of the growing population. Shop construction, public building construction, and so into use have advanced significantly. This has resulted in the insufficiency of an article source of construction materials. Due to the lack of construction materials and also dumping of waste materials, researchers are considering methods to create useful waste materials which can reduce the number of resources and costs. Roof tile is a man-made component of durable material, such as ceramic, stone, metal, or glass that is commonly used to cover roofs, floors, and walls. The name comes from the French word "tuile," which comes from the Latin word "tegula." Roof tiles are primarily intended to keep the rain out and are usually made from locally accessible materials such as terracotta or slats.
Most significantly, a roof tile provides excellent insulation and protection such as heavy rains, severe climate conditions burns, and natural disasters [1]. Since the concrete tiles are vulnerable to the outdoors on structure rooftops, it also vulnerable to repeated moisture as a result of rainwater, and weather differences every day as well as more severe weather conditions like hailstorms and heavy rains during storms. Concrete roof tiles are constructed of a sand, cement, and water combination that is molded underneath high heat and pressure. A colour substance can be used to finish the exterior surfaces of a tile. Concrete tiles contain extra water locks, or interlocking ribs, on the edges to prevent water penetration. Concrete tiles can imitate the look of conventional clay tiles, wood shake, slate, and stone [2].

There are various types of roof tiles and each type has its unique forms and styles, as well as its unique production technique. In comparison to ceramic tile, this roofing tile has the advantages which are high durability, the cheaper price of installation, and a wider variety of colours. However, the disadvantage of concrete roofing tiles is heavier than ceramic tiles and requiring a larger support framework. Other than that, zinc sheets are also applied to coat the roofs of buildings. Their benefits include cheap costs but are easily rusted. The poor thermal and acoustic insulation compared to other raw materials are disadvantages. As a result, it is mostly employed in low-cost buildings. As a sophisticated building material, plastic roofing tiles are also being used. Its technological benefits include improved thermal insulation, a wide range of colours, simplicity of fitting, and corrosion resistance. Since it has a shorter lifespan and is less resistant to UV radiation and rain than ceramic or concrete roofing tiles, it has not achieved an identical level of effectiveness [3].

Inadequate management procedures are the main difficulty of unsafe, waste management which has caused ecological difficulties. Solid garbage is mostly produced by outpost and residential, businesses building, and private companies [4]. Currently, the main difficulty in developing countries is a huge amount of waste materials from different types. Comprehensive waste recycling researches are being carried out to reduce environmental impact. Many sectors have done their respective responsibilities such as recycling and manufacturing businesses have also made progress in utilizing these waste items [5]. Among the examples of initiatives or innovations that can be done to reuse waste materials such as sea coat, ash rubber, crumb rubber, cider sand, copper slag, pistachio shell, sawdust, or stone dust to substitute fine aggregates partially in roof tile construction.

1.1. Sea shell
Sea shells have become a waste formed by the decomposition of deceased animals close to the seaside. It is deposited by waves on the shore of course. In a recent study in India, the use of sea shells has been widely used as a building material. The increased use of shells would not only save these building materials but also help with the problem of trash disposal. Therefore, the need to replace current materials such as concrete must be changed by making some innovations in the concrete mix to meet the structural demands. The availability of affordable raw resources can also reduce manufacturing costs coupled with recycled materials. Thus, the construction of housing can be saved and building materials affect whether the construction of the building is cheap or expensive [6].

1.2. Saw dust
Sawdust is generally removed through combustion and causes smoke that can be harmful to human health. The use of cement composites is more ecologically beneficial. A large amount of sawdust is used in producing furniture and is also discarded by the wood industry. As an innovation in the construction sector, wood dust can be used to replace fine aggregates in a mortar and horticultural goods to minimize the burden of scarce natural resources. Savings are characterized by composites with limited mechanical performance, low durability, and poor compatibility. The integration of sawdust into the concrete and mortar manufacturing process not only minimizes environmental damage but also preserves conventional components from concrete and mortar. It has numerous advantages over conventional concrete, including weight reduction (dead load reduction transmitted to the base), high economic efficiency over standard concrete weights, low damage, and longer life of coating because of lower exercising pressure, easy handling, mixing, and placing of other types of concrete. Although this is advantageous, the sawdust concrete is subject to irregular setting times and low flexibility [7].
1.3. Pistachio shell
The pistachio can be found throughout Asia Minor, from the Mediterranean islands in the west to India in the east. It is also widely found in Syria, Iraq, and Iran. It has probably been formed in wilderness areas since it requires lengthy warm summers for the development of organic products, is dry and salt-tolerant. Several studies discussed replacing sand with many different forms of waste materials such as the use of recycled glass bottles as fine aggregates in cement mixture was conducted by Ganiron [8]. He concluded that recycled glass bottles are a decrease in unit weight, the value of the elastic modulus and the cost of concrete as an alternative fine aggregate and that recycle bottles are not a useful alternative of fine aggregates for structural elements such as columns, beams, and suspended plates. Another researcher was investigated groundnut as a replacement to fine aggregates. They found that the use of groundnut shells in concrete decreases concrete workability because the groundnut shell is highly absorbed by water. The densities and compressive strength of concrete decreased with an increased percentage of groundnut shells [9].

1.4. Copper slag
Copper slag is an industrial by-product material formed by the copper process. About 2.2 tons of copper slag are created for every ton of copper output. The world copper sector has calculated that about 24.6 million tons of slag are produced. Although copper slag is commonly utilized in the sandblasting business and in the production of abrasive equipment, it is removed without further reuse or recycling. A group of researchers examined the influence on strength qualities of employing copper slag as a substitute for fine aggregate. M25 grade cement was employed and experiments were carried out with 0 % to 100 % of concrete for varying quantities of copper slag substitution with sand. The results show that the compressive strength of concrete increased by 55 % to 40 % when finer aggregates were replaced with copper lacquer [10].

1.5. Stone dust
There are many stone crushers in the country of Saurashtra producing enormous amounts of copper slag during stone cutting. The dust in sandstone causes a problem of disposal, environmental problems because of its non-fertile qualities, and health risks. In manufacturing development, the use of stone dust such as powder of marble, stone slurry, etc. as a substitute for the fine aggregate was implemented, and the substitution produced mixed results in the qualities of mortar [11]. In advanced industries, the use of stone dust such as stone slurry and marble powder have been well accepted as substitutes for fine aggregates. It can be concluded that replacement gives a batter capable of producing the properties of the mortar itself.

1.6. Cinder sand
Cinder industrial waste is usually utilized in sunken areas of the slabs as a lightweight filler material. This is permeable in nature and irregularly available. It can be utilized as a coarse concrete aggregate in breakage to uniform sizes of 20mm or 12 mm, reducing the density of concrete and being used for structural purposes. By employing self-curing compounds instead of water treatment and M-sand in concrete rather than the river sand, natural resources like water and sand are conserved [12]. Cinder is a waste substance produced as coal leftover from the power plant blast furnace. The material has been taken from burnt store boilers in Jamshedpur and mostly contains silica and metal oxides. Slag is another waste substance formed during the production of molten iron as a byproduct. It is made through the fusing of limestone and also other streams with the coke ash and the ferrous ore's silicone and aluminum components. It comprises silica, aluminum, iron, and other oxides [13].

1.7. Rubber ash
The collection of waste tires, especially in Malaysia, is one of the biggest environmental challenges in the globe. Because scrap pneumatic materials are non-degradable, they can pose major environmental and public health hazards. One solution to solve the growing quantity of waste pipes is to include scrap rubber into concrete mixes to generate rubberized concrete. In a concrete mixture, rubber can replace fine particles. This strategy can help prevent sites from being landfilled. Pyrolysis is a word based on
the Greek "pyr," meaning fire, and "lysis," meaning separation. Pyrolysis is a material disintegrating process and normally works at 430 °C (800 °F) at a higher temperature. This process is done if the organic material is burned otherwise without oxygen. In the absence of oxygen, pyrolysis is also characterized as a means of recycling discarded tires, by thermal decomposition [14]. In addition, discarded tires can lead to flames especially in the summer because it is difficult to extinguish. The potential options for reducing waste rubber are to integrate it as a partial substitute for natural aggregates into cement concrete. This approach could be environmentally benign (as it helps to reduce discarded material and minimize pollution) and more economic since some of the costlier natural aggregates can be preserved. The usage of rubber in concrete has attracted considerable interest. Previous research shows that replacing aggregates with waste pneumatics in the concrete mixture can significantly boost toughness and ductility [15].

1.8. Crumb rubber
Waste rubber can be used as a component of the fine aggregates, coarse aggregates, or both. The use of rubber in mixtures of concrete or mortar creates the prevention of waste and reduces the depletion of raw virgin substances. Crumb rubber is the name given to any substance generated by the reduction to uniform granules of waste tires and other rubber with intrinsic reinforcement components such as stain and fiber, removed together with inert impurities of any kind, such as dust, glass, and rock. Crumb rubber is produced from two basic feed stocks: tire retrieval, and tire scrap rubber [16].

Crumb rubber is used in concrete to generate rubbercrete as a partial replacement for fine aggregates. Compared to the fine aggregate it has a lower specific gravity of 0.51 to 1,2 kg/m3, low water absorption, resistance, and steepness of 524 kg/m3 to 1273 kg/m3. Crumb rubber is a hydrophobic and non-polar substance that repels the surface of the water and entails the air. It also has a different gradation than the finely aggregated aggregate which in particle size analysis falls below the lower curve limit. Therefore, it alters the grading to a not continuous aggregate gradation if the fine aggregate is partially replaced by rubbercrete. Partial substitution of fine aggregate with rubber cream is usually carried out by the material volume due to the lower specific gravity of the crumb rubber than the fine aggregate [17].

2. Mix proportion ratio of concrete with waste material as partial replacement
Table 1 shows selected mix proportions waste material as partial replacement in concrete. Researchers experimented with a variety of goal strengths, including varied waste material kinds, fine aggregate replacement levels, and water-cement ratio. The type of cement was using ordinary Portland cement (OPC) for all the experiments. Venkatesh [18] using cinder sand as a partial replacement for fine aggregate with 20% and 40%, and water-cement ratio 0.45 by using 1:3 (cement: fine aggregate).

| Waste material used          | Replacement level (%) | Water cement ratio | Mix proportion (cement: fine aggregate) | Size of aggregate | Reference |
|-----------------------------|-----------------------|--------------------|----------------------------------------|------------------|-----------|
| Rubber Ash                  | 0, 3, 5, 7            | 0.55               | 1:2                                    | < 4.75 mm        | [15]      |
| Saw dust                    | 5, 10, 15, 20, 30, 50 | 0.55               | 1:3                                    | 0.15mm to 2 mm   | [7]       |
| Sea shells and coconut fiber| 0, 20, 30             | -                  | 1:4                                    | -                | [6]       |
| Crumb rubber                | 5, 10, 15, 50         | 0.56               | 1:2                                    | 3mm to 5mm       | [19]      |
| Pistachio shells            | 0, 10, 20, 30, 40, 50 | 0.48               | 1:3                                    | < 4.75 mm        | [9]       |
| Cinder sand                 | 20, 40                | 0.45               | 1:3                                    | -                | [18]      |
| Stone dust                  | 0, 25, 50             | 0.60               | 1:3                                    | < 4.75 mm        | [11]      |
| Copper slag                 | 20, 40, 50, 60, 80, 100| 0.45              | -                                      | 4.75mm to 20 mm  | [10]      |
According to experiment conduct by Reddy et al. [10], the waste material that was used is copper slag to replace the fine aggregate by 20%, 40%, 50%, 60%, 80%, and 100% with a water-cement ratio of 0.45. A researcher conducts an experiment by replacing fine aggregate with crumb rubber by 5%, 10%, 15%, and 50% by using a ratio of 1:2 (cement: fine aggregate) and a water-cement ratio of 0.56 [19]. Experiment using pistachio shells as a partial replacement for fine aggregate has been conducted by Alsalami [9] with for 0%, 10%, 20%, 30%, 40%, 50%, and 60% with using a water-cement ratio of 0.48 and mix proportion ratio of 1:3 (cement: fine aggregate).

Senin [15] using rubber ash with 0%, 3%, 5%, and 7% as a partial replacement for fine aggregate with a mix proportion ratio of 1:2 (cement: fine aggregate) and water cement ratio of 0.55. Jonathan and Charles [7] have been conducted partial replacement for fine aggregate using sawdust with 5%, 10%, 15%, 20%, 30%, and 50% with a mix proportion ratio of 1:3 (cement: fine aggregate) and a water-cement ratio of 0.55. Another waste material which is sea shells was used to replace the fine aggregate in the concrete mixture [6]. The percentage of sea shells to replace the fine aggregate is between 0% - 30% with a mix proportion ratio of 1:4 (cement: fine aggregate). Gamit and Patel [11] conducted stone dust as waste material by using 0%, 25%, and 50% for partial replacement of fine aggregate with a mix proportion ratio of 1:3 (cement: fine aggregate).

### 3. Compressive strength in concrete for each types of waste materials

This section discussed on strength of concrete mixed with waste materials from previous researchers. Table 2 was described the compressive strength of concrete mortar for combination from different types of waste materials used as partial replacement of fine aggregate. Among the types of waste materials are used in mix proportion of fine aggregate such as rubber ash, sawdust, sea shells, coconut fiber, rubber crumb, pistachio shells, cinder sand, stone dust and copper slag.

| Code     | Waste material used              | Replacement level (%) | Curing time | Control sample | Compressive strength | Reference |
|----------|----------------------------------|-----------------------|-------------|----------------|----------------------|-----------|
| ASTM C109-02 | Rubber Ash                     | 0, 3, 5, 7             | 28          | 30.97 MPa      | 3% = 28.90 MPa       | [15]      |
|          | (BS EN 1015-11) Sawdust          | 5, 10, 15, 20, 30, 50 | 28          | 7.52 MPa       | 5% = 6.99 MPa        | [7]       |
|          | IS10262-2009 Sea shells and Coconut fiber | 20 % seashell 30% seashell | 28          | 7.95 MPa       | 20% = 8.7 MPa        | [6]       |
|          | - Rubber crumb                  | 5, 10, 15, 50         | 14          | 44 MPa         | 5% = 9.1 MPa         | [19]      |
| B.S 1881-part 4 - 1989 pistachio shells | 0, 10, 20, 30, 40, 50, 60 | 28          | 71.47 MPa     | 15% = 11.7 MPa    | [9]       |
|          | - Cinder sand                   | 20, 40                | 28          | 36.31 MPa      | 20% = 37.90 MPa      |           |
| IS 2250-1981 Stone dust | 0, 25, 50                      | 28          | 22.27 MPa     | 20% = 37.90 MPa    | [18]      |
|          | - Copper slag                   | 20, 40, 50, 60, 80, 100 | 28          | 42 MPa         | 20% = 38 MPa         | [10]      |
A group of researchers has conducted the concrete using rubber ash as partial replacement to fine aggregate. They refer to the ASTM C109-02 standard as their procedure to conduct the test. The compressive strength test showed that 5% replacement of fine aggregate to rubber ash can increase the strength of concrete from 30.97 MPa to 31.50 MPa. However, concrete containing 3% and 7% of rubber ash showing a reduction in compressive strength which is 28.90 MPa and 25.60 MPa compare to the control sample [19].

An experiment was performed using sawdust as a partial replacement for fine aggregate in concrete by using a mix proportion ratio of 1:3 (cement: aggregate). The test was conducted according to BS EN 1015-11 standard and been test after 28 days. For the control sample which does not have any replacement of sawdust with the compressive strength is 7.52 N/mm². However, after replaced the fine aggregate with sawdust for 5%, 10%, 15%, 20%, 30%, and 50%, the compressive strength shows a reduction which is 6.99 N/mm², 6.72 N/mm², 4.71 N/mm², 4.02 N/mm², 2.61 N/mm², and 2.33 N/mm² follow by percentage of sawdust. The porosity of each component of a multiphase material such as mortar is the main reason for a source of strength loss. Due to their crystalline form (aggregate or sand) as traditional (natural) aggregates are often thick and powerful, while sawdust is woody and mushy when approaching water [7].

Many researchers have been conducted compression tests with sea shells and coconut fiber as a partial replacement for fine aggregate in concrete. The results showed that the addition of sea shells and coconut fiber increased the compressive strength of concrete. The test was done referring to IS10262-2009 as the standard for the compressive test of concrete by using a mix proportion ratio of 1:4 (cement: aggregate). A control sample was used as a guideline and the result shows the strength of concrete without any replacement is 7.95 N/mm². The compressive strength of concrete increased to 8.7 N/mm² when the combination of 20% of sea shells and 0.5% of coconut fiber are replaced in fine aggregate. It is also the same when the combination of 30% of sea shells and 0.6% of coconut fiber has been replaced as fine aggregate and gives the strength incensement to 9.1 N/mm². The addition of coconut fiber and sea shells as an admixture will improve the compressive strength of the materials [6]. Natural fiber is one of the alternatives in composite parts that can be replaced or added into the original or conventional material of the composite itself. Among the natural fibers that have good tensile strength values are such as kenaf, banana leaves, coconut and pineapple leaves [20].

Crumb rubber was used as a partial replacement of fine aggregate in concrete to test its compressive strength. In the test, the partial replacement has been divided into 5%, 10%, 15%, and 50%. The result of compressive strength was taken after 14 days. A control sample was prepared and showed a compressive strength of 44 MPa. Based on the results, the compressive strength on partial replacement of fine aggregate with crumb rubber was decreased to 19 MPa, 14.1 MPa, 11.7 MPa, and 2 MPa. The researcher also highlighted that 50% of replacement is not suitable because the compressive strength is lowest [19].

The compressive strength of pistachio shells as a partial replacement for fine aggregate in concrete based on B.S 1881-part 4-1989 was tested by the researchers. They reported that pistachio shell substitution as a fine aggregate showed a drastic decrease in compressive strength after 28 days. The compressive strength for the control sample (purely cement and aggregate) is 71.47 MPa. However, after replacing fine aggregate with 10%, 20%, 30%, 40%, 50%, and 60% of pistachio shell, the compressive strength decreased to 51.54 MPa, 14.1 MPa, 6.2 MPa, 4.35 MPa, 2.5 MPa, and 1.75 MPa. The reduced workability of the mixture caused by the absorption of water by the pistachio shells during mixing could explain the decrease in compressive strength as replacement levels increased. Furthermore, the low density of pistachio shells relative to fine aggregate may lead to the compressive strength being lesser [9].

Venkatesh [18] has conducted the compressive strength of cinder sand to replace a fine aggregate in concrete. The mix ratio for the concrete is 1:3 (cement: aggregate) and a water-cement ratio of 0.45. The percentage of cinder sand that was used in the experiment to replaced fine aggregate is 20% and 40%. The compressive strength increased at 20% of replacement which is from 36.31 N/mm² (as control sample) to 47.04 N/mm². However, the compressive strength is decreased from 47.04 N/mm² to 37.90 N/mm² when a partial replacement of cinder dust is 40%. The use of lightweight industrial waste aggregates like cinder with a combination of natural sand (20% from fine aggregate) and industrial waste
admixture, has proven to be rather adequate in terms of various strengths evaluated [18]. All the procedures and testing such as casting, compaction and curing were accomplished according to IS 2250-1981. The compression testing has been conducted after 28 days of curing with 0%, 25%, and 50% of replacement percentage of fine aggregate. A control sample has been conducted first and after 28 days, the compressive strength showed 22.27 MPa. For the concrete mixture of a partial replacement of 25% stone dust, the compressive strength is decreased to 21.47 MPa. Besides that, a partial replacement for 50% stone dust, the compressive strength is increased to 23 MPa. It can be concluded that there is not much increase in compressive strength by the replacement percentage of sand stone dust [11]. However, the results show with added stone dust in the concrete mixture can be increased the compressive strength.

The researcher has cast the concrete using copper slag as a partial replacement of fine aggregate with 20%, 40%, 50%, 60%, 80%, and 100% replacement percentage. The compression testing after 28 days of the curing process has been conducted. A control sample has been tested first and showed a compressive strength is 42 MPa. For partial replacement results, the compressive strength of concrete containing 20%, 40%, and 50% of copper slag was higher than the control sample concrete. The strength is increased from 42 MPa to 43 MPa, 45 MPa, and 44 MPa according to the replacement percentage. The compressive strength starts to drop when the replacement percentage reaches 60% - 100% of copper slag. Copper slag replacement can provide compressive strength that is comparable to or higher than that of the control mixture in cement mortars [10].

4. Water Absorption
Water absorption and porosity are crucial markers of hardened concrete's longevity. The properties of concrete such as performance and life expectancy can be considerably improved by reducing water absorption and porosity. Reducing porosity also helps compressive and flexural strengths, as porosity and solid strength have a fundamental inverse relationship [21]. A water absorption test was performed on a concrete specimen to assess the amount of water that was getting through the concrete. Table 3 shows the water absorption percentage values of pistachio shells, sea shells with coconut fiber, rubber crumb, and sawdust with different replacement percentages. It shows that the percentage of replacement becomes increases, the water absorption also increases. The value of water absorption for pistachio shells is increased from 0.47% (control sample) to 6.04% (60% of fine aggregate replacement). The sample from the combination pistachio shell mixture is dried in a 105°C oven for 24 hours. The dried specimens were weighed after cooling until reach room temperature (25 °C). The dried specimens were submerged into water, and then the weight of the specimen was collected at predefined intervals [9]. For sea shells with coconut fiber combination, the water absorption value also increases to 6.8% (at 30% replacement) compare to a control sample with only 5.4%.

Most researchers followed standards to AS 4046.4-2002 (Methods of testing Roof tiles – Determination of Water Absorption). For rubber crumbs replacement, the amount of water absorption shows increased from 1.40% (control sample) to 4.83% (50% rubber crumb replacement) when it has been tested after 14 days of curing. Due to rubber particles are much softer than the surrounding particles, a mixture of concrete and rubber will make it easy to bend. Based on the findings obtained, table 3 shows that combination of rubber and concrete mixtures produce the lowest water absorption compared to other mixtures. Rubber is among the materials that are easily compacted aid to fill pores in concrete mixtures and will produce small porosity [19]. The same incensement also happens when replacing sawdust as partial replacement to fine aggregate. The amount of water absorption for a control sample is 11.97% and increased to 20.54% with the replacement of 50% sawdust.
Table 3. Water absorption of concrete for difference type of waste materials

| Waste material used          | Replacement level (%) | Testing day | Control sample | Absorption percentage | Reference |
|------------------------------|-----------------------|-------------|----------------|-----------------------|-----------|
| Pistachio shells             | 0, 10, 20, 30, 40, 50, 60 | 28          |                | 0.4695%              | [9]       |
|                              |                       |             | Control sample | 10 = 0.80%            |           |
|                              |                       |             |                | 20 = 2.04%            |           |
|                              |                       |             |                | 30 = 3.20%            |           |
|                              |                       |             |                | 40 = 4.01%            |           |
|                              |                       |             |                | 50 = 5.03%            |           |
| Sea shells + coconut fiber   | 0, 20, 30             | 28          | 5.40%          |                       | [6]       |
|                              |                       |             |                | 20 = 6.09%            |           |
|                              |                       |             |                | 30 = 6.80%            |           |
| Rubber crumb                 | 5, 10, 15, 50         | 14          | 1.40%          |                       | [19]      |
|                              |                       |             |                | 5 = 2.56%             |           |
|                              |                       |             |                | 10 = 3.19%            |           |
|                              |                       |             |                | 15 = 3.91%            |           |
|                              |                       |             |                | 50 = 4.83%            |           |
| Saw dust                     | 5, 10, 15, 20, 30, 50 | 28          | 11.97%         |                       | [7]       |
|                              |                       |             |                | 5 = 12.13 %           |           |
|                              |                       |             |                | 10 = 12.96%           |           |
|                              |                       |             |                | 15 = 14.55%           |           |
|                              |                       |             |                | 20 = 16.72%           |           |
|                              |                       |             |                | 30 = 18.92%           |           |
|                              |                       |             |                | 50 = 20.54%           |           |

5. Conclusion
Replace waste material as a partial replacement to fine aggregate in concrete is has a positive result in the properties of concrete. Compare to normal concrete, the strength of concrete can be seen increased in a few types of waste materials such as cinder sand, copper slag, and sea shells with the replacement percentage that has been studied. For materials such as rubber ash, cinder sand, and cooper slag the compressive strength of concrete was increased when the percentage of partial replacement was added in little and then decreased when replacing in a large percentage. For sea shells with coconut fiber, the compressive strength of concrete increased with the review percentage of replacement. Lastly, stone dust can be used until 50% replacement of fine aggregate to obtained high compressive strength. It has been observed by replacing fine aggregate with waste material in concrete has shown the amount of water absorption is increase. There is no waste material that is being used to show low water absorption. The physical form of waste materials that are sensitive to water such as pistachio shells and sawdust are unnecessarily used because moisture affects the weight and strength. For the other waste material, the incensement of water absorption level is still low if being replaces for a small amount of percentage especially rubber crumb. This paper focused on compressive strength and water absorption for the combination of waste material and fine aggregate as concrete mortar (roof tile). This is because these elements are very important to determine the effective combination of mixed proportion.

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