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Compressive Strength and Water Absorption of Concrete Containing Foundry Sand as Fine Aggregate Replacement

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Abstract: Foundry sand is a high-quality silica sand that is pure, evenly sized, and used in foundry casting processes. In the foundry sand process, sand from finished metal castings is very often reused. Foundry sand was being used as a moulding casting material for ages. Sand is one of the most difficult wastes and less recyclable especially in Malaysia and it require a massive amount of energy and cost while through the process to produce mould. Concrete, which is mostly made up of fine aggregate, is one of the most often used materials in the building industry. This objective of this study is to determine the compressive strength and water absorption of concrete contain foundry sand as fine aggregates replacement. Theis objective of this study is to determine the behavior of concrete that used waste foundry sand as fine aggregate. There are several percentages of WFS that were used in this study, which is 10, 20, 30 and 40%. Every mix proportion give different result toward concrete strength. From the sieve analysis test, the percentages of waste foundry sand (WFS) have passed the specification of size distribution according to the British Standard. The highest slump value is 45mm with replacement of 30% WFS, beyond that the slump value will drop but still acceptable. The strength of the concrete is increase when 10% of WFS of foundry sand was used for 7 and 28-days curing. The highest value compressive strength is 23.40 MPa and 36.12 MPa for 7 and 28 days. The increasing amount of WFS replacement will increase the percentage of water absorption. Referring to the result, the 40% of WFS is still acceptable for water absorption. As conclusion from this study the optimum percentage of WFS is 10% was improve the concrete behavior.

Keywords: Foundry Sand, Compressive Strength, Water Absorption

1. Introduction

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The selection of high-quality raw materials, as well as the quality techniques used throughout the foundry operation, are essential for producing high-quality castings [1]. Sand is a popular and widely used material in foundry sand moulds, and its features have a significant impact on the mould properties. Foundry sands are nearly completely made up of the mineral silica (SiO2) in the form of quartz. The sand composition, purity, size, and form are all crucial components in a successful moulding process. Natural sand, silica sand, and special sand are the three types of sand often used in moulding [2]. Foundry sand is a high-quality silica sand that is pure, evenly sized, and used in foundry casting processes. Sand is blended to produce moulds or patterns for ferrous (iron and steel) and nonferrous (copper, aluminum, and brass) metal castings. In the foundry sand process, sand from finished metal castings is very often reused. Foundry sand is used to mould iron and steel components, as well as aluminium and copper-based alloys

Particularly in places such factories and workshops that manufacture products for the automobile, building, and machine industries, as well as the steel industry [3]. Malaysia's automotive industry has expanded dramatically, with 27 car factories currently operating in the land. It is an industry that contributes 4 percent, or RM40 billion to Malaysia’s Gross Domestic Product and according to the Malaysia Automotive Institute approximately 80% of the domestic ecosystem's parts and component suppliers are Malaysian owned. Along with its strong heat conductivity, foundry sand was being used as a moulding casting material for ages. The physical and chemical properties of foundry sand are mostly determined by the type of casting process used and the industry sector from which it is produced. Moulding sands are recycled and reused multiple times throughout the casting process. The recycled sand, on the other hand, eventually degrades to the point that it can no longer be usable in the casting process. The old sand is displaced from the cycle as a by-product at this stage, new sand is added, and the cycle continues [4].

Therefore, this study investigates the particle size distribution of waste foundry sand. In this study the waste foundry sand is replaced with fine aggregates. The objective of this study is to determine the compressive strength and water absorption for concrete that containing waste foundry sand as fine aggregates replacement. This study is used concrete cube size 100 x 100 x 100mm for testing.

2. Materials and Methods

Specimen for this study consist of foundry sand with partial replacement. There was 10%, 20%, 30% and 40% of foundry sand that replace fine aggregate. The specimen will be tested for workability, mechanical performance, and durability. For indicator, the control concrete mixture also will make to make comparison data with this new concrete mixture. The concrete will be curried at 7 and 28 days before the compressive test and 24 days for water absorption testing. The process for this study shown in Figure 1.

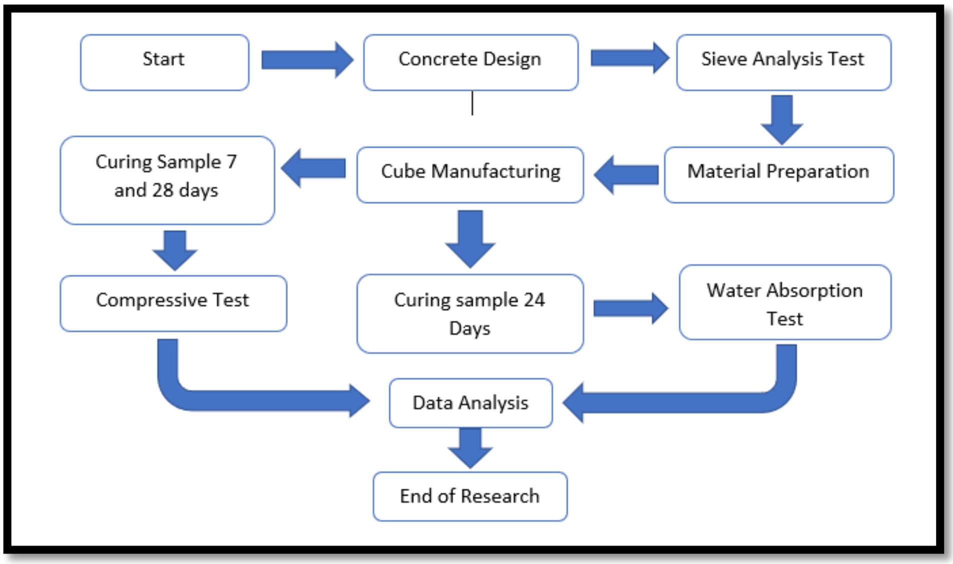

Figure 1: Flow Chart

2.1 Foundry sand

In this project the waste foundry sand was take from Meta Cast company as shown in the Figure 2. The type of the waste foundry sand is sodium silica sand. The foundry sand were sieve and the foundry sand that pass 5mm used to replace the fine aggregate

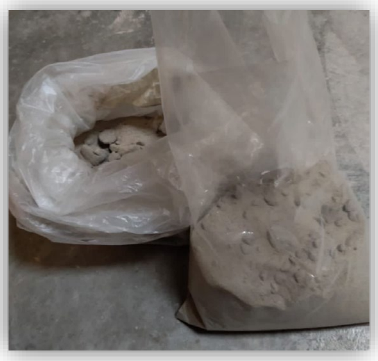

Figure 2: Sodium silica sand

2.2 Manufacturing of concrete contain foundry sand

In this research the concrete cube size 100mm × 100mm × 100mm were manufactured using concrete mixture located at UTHM advance structural laboratory. First, cleaned up the mould from any dirt then oil it inside the mould to make it easier for extracted it from the mould after hardened process. Cement, sand, natural aggregate, foundry sand, and water were mixed appropriately by using mixture machine with 0.55 water cement ratio. During mixture process aware precaution were taken to ensure that all material mix properly. After finished mixing process the concrete poured into the moulds (3 layers) and compressed with steel bars up to 35 times for each layer. After 24 hours, the concrete cubes were removed from the moulds and wrote the date and graded mix on each sample. Finally Immersed in water, curing for 7, 24 and 28 days. The amount of the waste foundry sand will be replaced by following the Table 1.

Table 1: Mix design proportion

No	Symbol	Foundry Sand %	Fine Aggregates %
1	Control	0	100
2	WFS10	10	90
3	WFS20	20	80
4	WFS30	30	70
5	WFS40	40	60

2.3 Curing Sample

The curing process were done in water at temperate of 20±5ºC, and relative humidity not less than 95% based on BS EN 12390-2,2000 [5]. In this study the sample was curing in the tank at UTHM advance structural laboratory. Curing processed were 7 and 28 days for compressive strength test and for water absorption test the sample was curing for 24 days. The sample were immediately curing after the hardened process.

2.4 Compressive Strength Test

After the sample were reached for 7 and 28 days the sample were test for the compressive strength. Cleaned up the sample and dry up a little bit by using any clothes. Cleaned the compressive machine and the sample was put in the middle of the plate. The load was applied until the sample was crack. The load was applied to sample and maximum strength was record.

2.5 Water Absorption Test

When such specimens are 24 to 28 days old, they should begin to dry. To begin, all specimens were put in a 105ºC drying oven at not less than 25 mm from any heating surface or from one another. In the oven, dry the specimens for 72 hours ±2 hours. After the drying procedure, each specimen was kept cool in a dry airtight jar for 24 hours ± 0.5 hours. After each specimen had cooled, the weight was recorded. Then completely immersed each specimen in the tank with its longitudinal axis horizontal and at a depth at which there is 25 mm ±5 mm of water above top of the specimen for 30 min ±0.5 min. After that, the samples were shaken to remove the bulk of the surface water and dry it with a cloth as rapidly as possible until all free water is removed from the surface. Finally weight each specimen and mass was record.

3. Results and Discussion

The results and discussion section presents data and analysis of the study. This section presented the analysis result and objectives achievement.

3.1 Sieve analysis of waste foundry sand

In the Figure 3 there are 2 lines shows the minimum and maximum passing size distribution for fine aggregate that use in concrete according to BS 882:1992 [6]. The foundry sand is from disposal Metal Cast at pekan Pahang. From the result, WFS size is still in the range. The result shows that majority of WFS size is 0.60mm and the highest amount is at 1.18mm. Only 3.5 % of WFS exceed the maximum passing percentages at sieve 0.15mm. It can be note that to replace fine aggregate with 100% WFS is appropriate since the distribution size it still in the range according to standard size of fine aggregates.

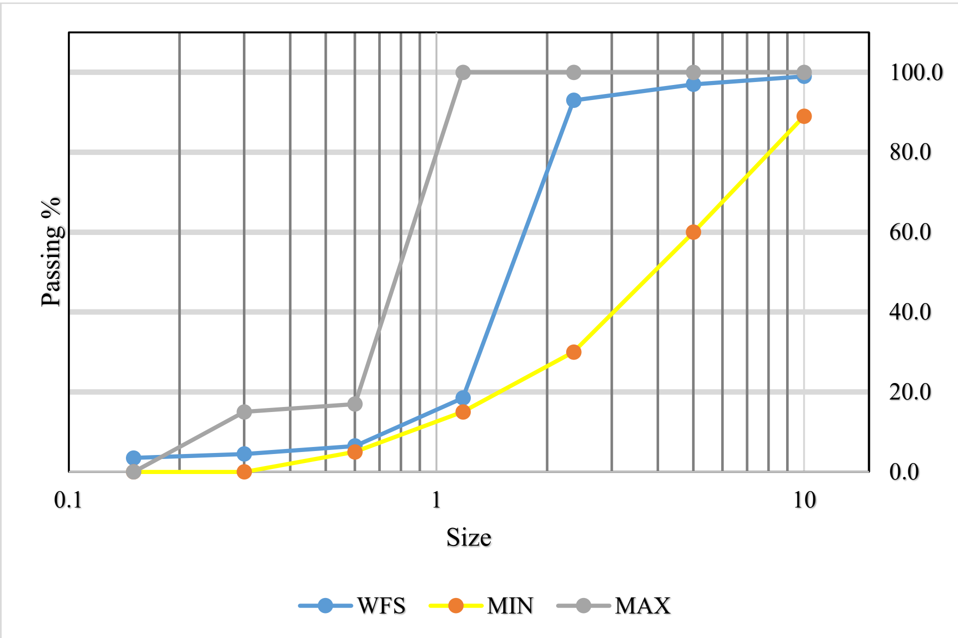

Figure 3: Sieve analysis of WFS

3.2 Workability for concrete

The highest collapse height is WFS30 with slump value 45mm. The different percentage of WFS20 and WFS30 with control are 20% and 80%. This show that with increasing the amount of the foundry sand in concrete will increase the workability of concrete but beyond 30% of WFS replacement will reduce the slump value but it is still acceptable in specification. The trend of this result almost similar with research from Manjunatha [7] with the optimum amount replacement of foundry sand in that research is 30%.

Table 2: Slump test of concrete containing waste foundry sand

Sample	Collapse Height (mm)
Control	25
WFS10	25
WFS20	30
WFS30	45
WFS40	26

3.3 Compressive strength for concrete containing WFS at 7 Days

The strength for WFS10 is 23.4Mpa higher than control mixture. The strength of WFS20 is 16.5Mpa drop from control while the strength for WFS30 and WFS40 are 17.6Mpa and 17.4Mpa higher than WFS20 as shown in the Table 2. This result show that the optimum replacement with WFS is 10% with increasing the strength of concrete approximately 10%. Other than that, it will reduce the strength of concrete lower than the control cube.

Table 3: Compressive strength of concrete containing waste foundry sand at 7 days

Sample	Average Strength (Mpa)
Control	21.20
WFS10	23.40
WFS20	16.50
WFS30	17.60
WFS40	17.40

3.4 Compressive strength for concrete containing WFS at 28 days

The control concrete strength was 33.74Mpa which mean it has reached the concert strength for grade 30. The strength for WFS10 is 36.12.4Mpa higher than control mixture. The strength of WFS20 is 27.64Mpa drop from control while the strength for WFS30 and WFS40 are 27.81Mpa and 28.67Mpa higher than WFS20. This result show that the optimum replacement with WFS is 10% with increasing the strength of concert approximately 7%. Other than that, it will reduce the strength of concrete and the strength did not reach the grade specification.

Table 4: Compressive strength of concrete containing waste foundry sand at 28 days

Sample	Average Strength (Mpa)
Control	33.74
WFS10	36.12
WFS20	27.64
WFS30	27.81
WFS40	28.67

3.5 Water absorption for concrete containing waste foundry sand

Table 4.4 show the average of water absorption for each concrete mix. Water absorption for control mixture is 1.90%, while for WFS10, WFS20, WFS30, and WFS40 are 2.61%, 2.66%, 2.89% and 3.08% respectively. It shows that increasing the amount of WFS will increasing the amount of water absorption in concrete. The result for water absorption is acceptable because the water absorption for concrete must below 10% according to BS EN 1992-1-1:2004 [8].

Table 5: Water absorption result for concrete containing waste foundry sand

Sample	Average water absorption %
Control	1.90
WFS10	2.61
WFS20	2.66
WFS30	2.89
WFS40	3.08

4. Conclusion

Based on the result of the compressive strength concrete for 7 and 28 days. The maximum compressive strength of the concrete for both curing day is 10% of WFS will enhance the strength. Beyond that the strength will drop below the control sample strength. The percentage of the water absorption did not increase drastically comparing to every each of mix. This shows that the replacement of foundry sand until 40% in concrete is acceptable because this percentage of water absorption still following the specification.

Acknowledgement

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