# Properties of High Strength Concrete Containing Spent Garnet as Sand

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**Abstract.** Spent garnet is a waste resulting from abrasive media known as garnet and disposed into the landfill which can become threat to the environment. Meanwhile, the step of substituting sand by spent garnet can reduce sand exploitation activities which have been ongoing to fulfil the continuous development and construction. This work attempts to investigate the mechanical properties of specimens made of concrete that contains spent garnet. This new material replaces sand partially at different percentages of 10% and 20% by weight. The compressive strength test as well as splitting tensile test have been both conducted after 7 days and 28 days water curing. The results show an improvement of the strength during the compressive test. The increment appears to be in positive relationship with the replacement percentage. Meanwhile, splitting tensile strength testing shows that 20% performs better than 10% sand replacement. In conclusion, the inclusion of spent garnet in reasonable amount to take place instead of sand has improved the concrete's properties.

**Keywords:** *Spent garnet, Sand substitution, High strength concrete, Mechanical properties*

## 1. Introduction

Malaysia is known as a developing country that grows rapidly especially in terms of the population which also increase the quantity of waste generated. Consequently, this led to environmental problems. such that, spent garnet is waste when it is disposed unproperly will affect the nearby areas. Furthermore, construction industry also brings other environmental issues such as sand exploitation, landfill due to construction waste and other related issues [1]. Reprocessing waste materials as secondary resources is one of the feasible solutions to reduce the environmental pressures and achieve sustainability [2]. There are many researches regarding the utilization of waste materials as fine aggregates replacement for example bottom ash [3], seashells [4], ceramic tiles waste [5], iron ore tailings [6], etc.

In this research, spent garnet has been utilised to replace the fine aggregates. There are several researches on the incorporation of waste materials from landfill in concrete to substitute fine aggregates

but the spent garnet was among the least focused on. For example [7] has shown the possibility of including a different percentage or ratio of the spent garnet instead of the sand in geopolymer concrete. However, studying the incorporation of this sand-like waste in high strength concrete (HSC) has yet to receive sufficient attention and research. As it has been known that, some concrete properties such as the mechanical performances are crucial to evaluate the strength of concrete [8]. Therefore, workability and compressive strength have been considered in this study besides split tensile strength as parts of these properties. An appropriate understanding of the behaviour of this material is essential to fulfil this requirement. Where the strength of aggregates used in concrete affects the behaviour of the concrete [9], [10].

## 2. Materials and methods

The materials use in conducting this study as followed: Ordinary Portland Cement (OPC), 10 mm coarse aggregates, Fine aggregates (sand), Water (tap water / clean water), Spent garnet, Superplasticizer as water reducer to produce HSC with designed 60 MPa as target strength. Table 1 presents the details of mix proportion used. Concrete mixture prepared by considering different amounts of spent garnet in each mixture. Specimens were prepared in cubes and cylinder. Water curing was the main curing method for all specimens until reach the specified testing age.

**Table 1.** Mixing ingredients and proportions

| Material | Unit | Mixture | | |
|---|---|---|---|---|
| | | C00 | C10 | C20 |
| Cement | kg/m³ | 590 | 590 | 590 |
| Water | kg/m³ | 205 | 205 | 205 |
| Sand | kg/m³ | 570 | 513 | 456 |
| Spent garnet | kg/m³ | 0 | 57 | 114 |
| Aggregate | kg/m³ | 1055 | 1055 | 1055 |
| Ratio of W/C | % | 0.35 | 0.35 | 0.35 |

Consistency and uniformity are usually observed by conduction slump test for many types of concretes. Slump test in this case carried out as detailed in BS EN 12350: Part 2 [11]. The true slump to be reported to the nearest 10 mm. Whereas, BS EN 12390-3:2009 [12] was observed while preparing and the specimens' preparation for compressive strength test based on. The splitting tensile test was conducted using the cylinder-shaped specimens with diameter of 100 mm and usual height of 200 mm. All the specimens' preparation and the test conducted by referring to BS EN 12390-6:2009 [13].

## 3. Results and discussion

The 7 days result obtained by testing the specimens in the laboratory as the load were applied until the cube failed or cracked. The compressive strength of 28 days was predicted using ratio taken as 1.4 based on 7 days result. The compressive strength seems to improve as the percentage of spent garnet goes higher. The maximum replacement percentage of 20% achieved the strength of 62.8 MPa at 7 days and 87.9 MPa at 28 days testing. In this experiment, C20 results are higher than both control and higher than concrete C10. Figure 1 presents the results of compressive strength.

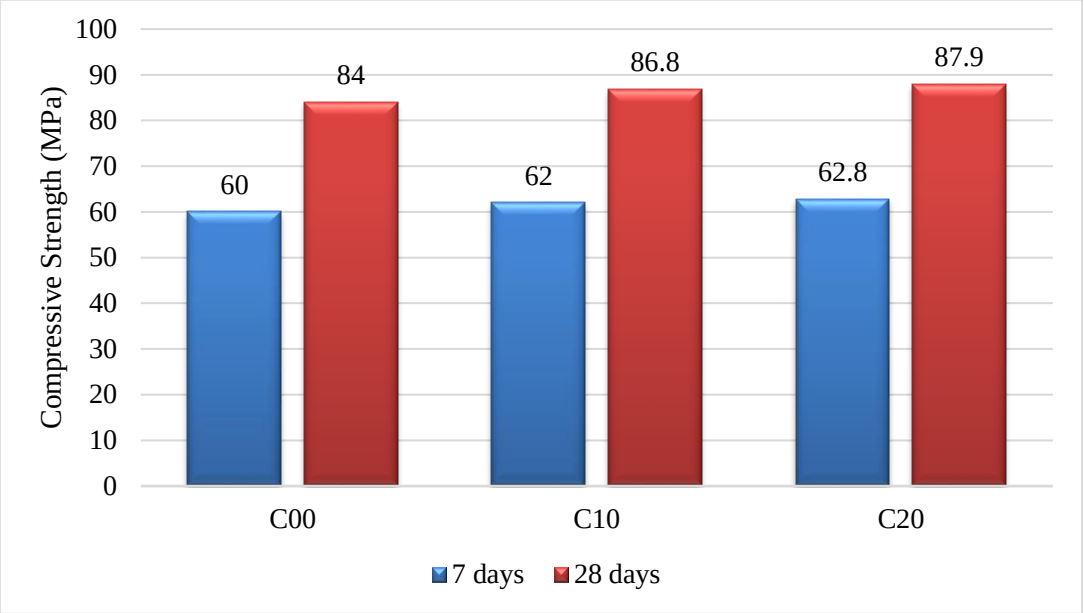


**Figure 1.** Compressive strength results

The splitting tensile concrete cylinders were tested at 7 days of water submersion in the laboratory. The load applied until the specimens cracked. The results show that, the lowest tensile strength was recorded for control specimens with 2.89 MPa lower than the C10 specimens which showed 3.46 MPa. Whereas, 3.98 MPa was recorded for concrete C20 specimens. The result for 28 days obtained by using ratio method based on 7 days results with also having the same trends as 7 days results. All results are shown in Figure 2. Similar studies have been found in literature where tensile strength have the same trend as compressive strength results [7]. That could be attributed to the nature of the newly introduced material as sand replacement unlike materials which introduced to replace cement.

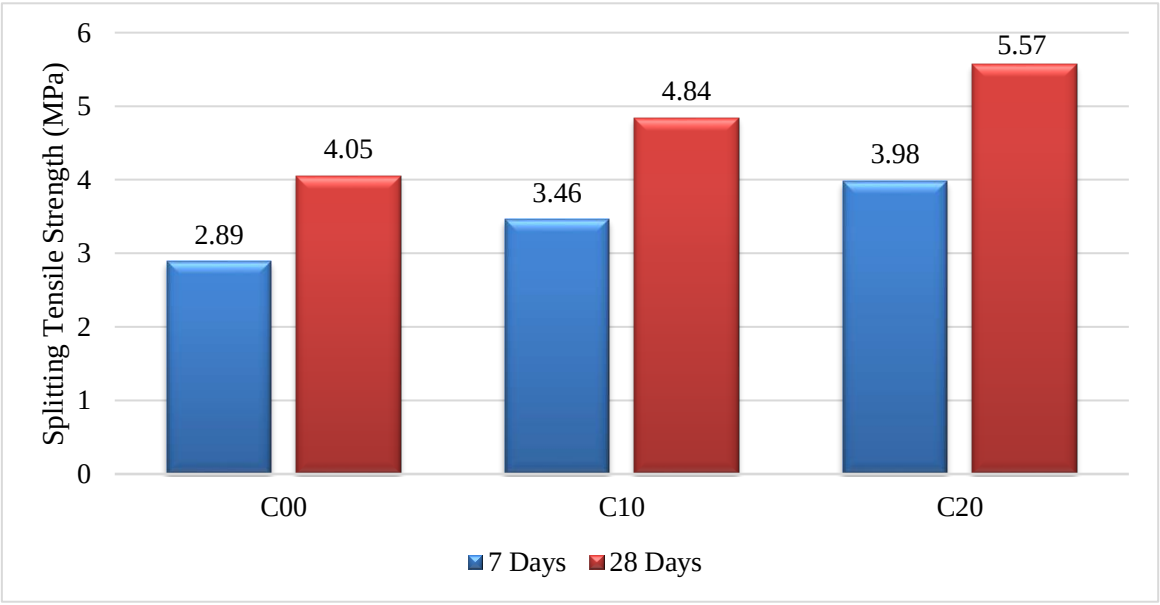


**Figure 2.** Splitting tensile strength result.

## 4. Conclusion

The compressive strength of this concrete (HSC) with spent garnet as the sand replacement shows that 20% (C20) spent garnet gives the highest strength. Meanwhile, the splitting tensile strength test showed the mix (C20) has slightly higher value followed by concrete (C10). From this, it can be concluded that the presence of spent garnet as a sand replacement can improve the properties of the high strength concrete. Therefore, it provides an opportunity to utilise spent garnet in making of concretes and also reduces the dependency on natural sand.

## 5. References

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**Acknowledgments**
Acknowledgement from the authors for funding should be to Universiti Malaysia Pahang through internal grant RDU190314.