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**RECYCLING CONCRETE: A POSSIBLE APPROACH TO IMPROVE THE  
ENVIRONMENT**

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**Background**

Construction materials are increasingly judged by their environmental impact. The trouble with construction material waste is that it can't be compacted, and it doesn't decompose. Up till now it has been dumped in landfills, making up about 40% of all landfills. Recycling of concrete rubbles provides a solution to the problem because it protects natural resources and reduces valuable landfill space.

Traditional concrete aggregate consists of sand (fine aggregate) and various sizes and shapes of gravel or stones (coarse aggregate). Recently, there has been a growing interest in substituting alternative aggregate materials, largely as a potential use for recycled materials. While there is a lot of research on many different materials for aggregate substitutes (such as granulated coal ash, blast furnace slag or various solid wastes including fiberglass waste materials, granulated plastics, paper and wood products/wastes, etc.), the only two potentially viable alternatives to natural coarse aggregate are glass cullet and crushed old concrete. This study investigates the strength properties of the later alternative, which incorporates readily available concrete as an aggregate source for new concrete.

Recycling of concrete is not a difficult process. It involves breaking, removing, and crushing existing concrete wastes and rubbles into a material with a specified size and quality (ACI-555 2001). The quality of the finished product depends to a large extent on the quality of the recycled material used in the mixture. Reinforcing steel and other embedded items must be removed from the rubbles, and care must be exercised to prevent contamination by other materials, such as: asphalt, soil gypsum board, sealants, plaster and roofing materials.

Users of recycled concrete aggregate should take adequate precautions to ensure that the material is suitable for the intended application.

## Problem Statement

Even though aggregate typically accounts for 70-80% of the concrete volume, it has been thought of in the past as filler having little effect on the hardened concrete properties. However, recent research has shown that aggregate in fact plays a substantial role in determining workability, strength, dimensional stability, durability and cost of the concrete. Certain aggregate parameters are known to be important for the structural use concrete: strength, hardness and durability.

Because of the importance of the aggregate to the strength properties of concrete, there is a need to investigate its effect on new concrete made from recycled concrete coarse aggregate. In particular, the compressive and tensile strength of recycled plain concrete specimens will be investigated in this study using the relevant ASTM test standards.

## Research Plan

In this study, four different kinds of coarse aggregates are considered: (1) recycled from hardened concrete with  $f'_c = 20.7$  MPa, and (2) recycled from hardened concrete with  $f'_c = 41.4$  MPa, (3) recycled from unknown source, and (4) mixture of natural and recycled aggregates. Furthermore, concrete made with natural coarse aggregate is also considered for bench-marking purposes.

The experimental program consisted of testing hardened concrete in the laboratory. Tests on hardened concrete cylindrical specimens were carried out to determine the compressive and tensile strengths. The strength properties of concrete were obtained at 7, 14 and 28 days. In all cases, each data point represents the average value of two samples.

Two concrete mixes, with different 28-days target strengths, were considered in the study: (a)  $f'_c = 20.7$  MPa, and (b)  $f'_c = 41.4$  MPa. All concrete mixes were proportioned for a 100 mm slump. Concrete made with recycled concrete coarse aggregate required more water for the due to its high porosity. No admixtures were utilized in the mixes. Figure 1 shows a summary of the mix proportions for the concrete with 20.7 and 41.4 MPa target compressive strengths.

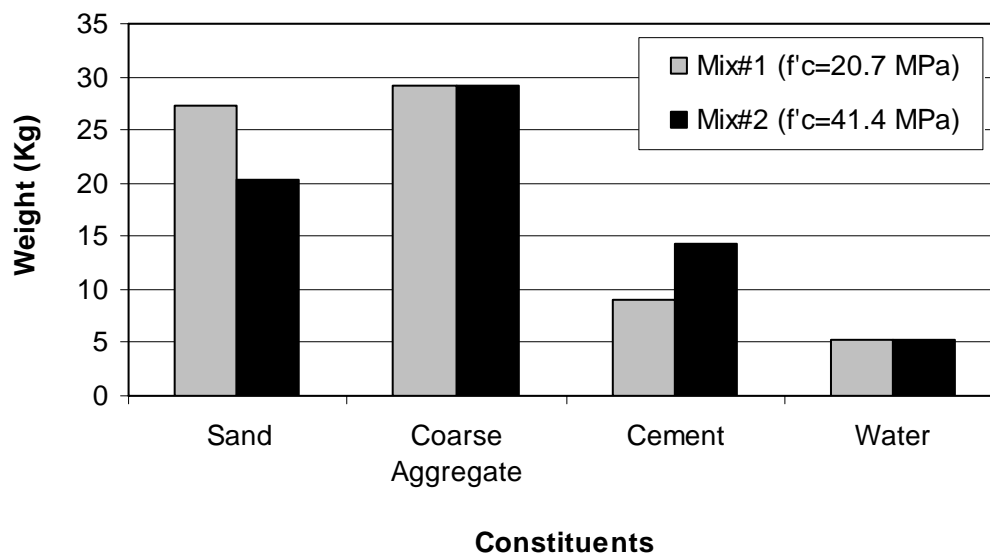


Figure 1: Weight proportions of concrete mixes

## Results

Coarse aggregate composed of recycled concrete generally has lower specific gravity and higher absorption than conventional gravel aggregate. As a result, new concrete made with recycled concrete aggregate typically is less workable than conventional concrete. Therefore, in order to achieve the same workability and slump, the amount of water in the concrete mixture has to be increased by about 10%.

The compressive strength varies with the compressive strength of the original concrete and the water-cement ratio of the new concrete. Figures 2 and 3 show the compressive test results for the natural and recycled concrete with target strengths of 20.7 and 41.4 MPa, respectively. Test results for the recycled concrete included concrete made with recycled aggregates from known ( $f'_c = 20.7$  or 41.4 MPa) and unknown sources. The results are plotted for 150x300 mm cylinders at the age of 7, 14 and 28 days. They indicate that the strength of recycled concrete depends, to some extent, on the mix proportions. For a low target strength (20.7 MPa), recycled concrete is only 10% weaker than natural concrete at the age of 28 days. However, for a high target strength (41.4 MPa), the coarse aggregates greatly affects the strength of the concrete and can reduce the strength by as much as 30%. The reduction in strength of concrete made with recycled aggregates is mainly due to the lower strength of the recycled coarse aggregates and the additional water needed to maintain a 100 mm slump, without the use of chemical admixtures.

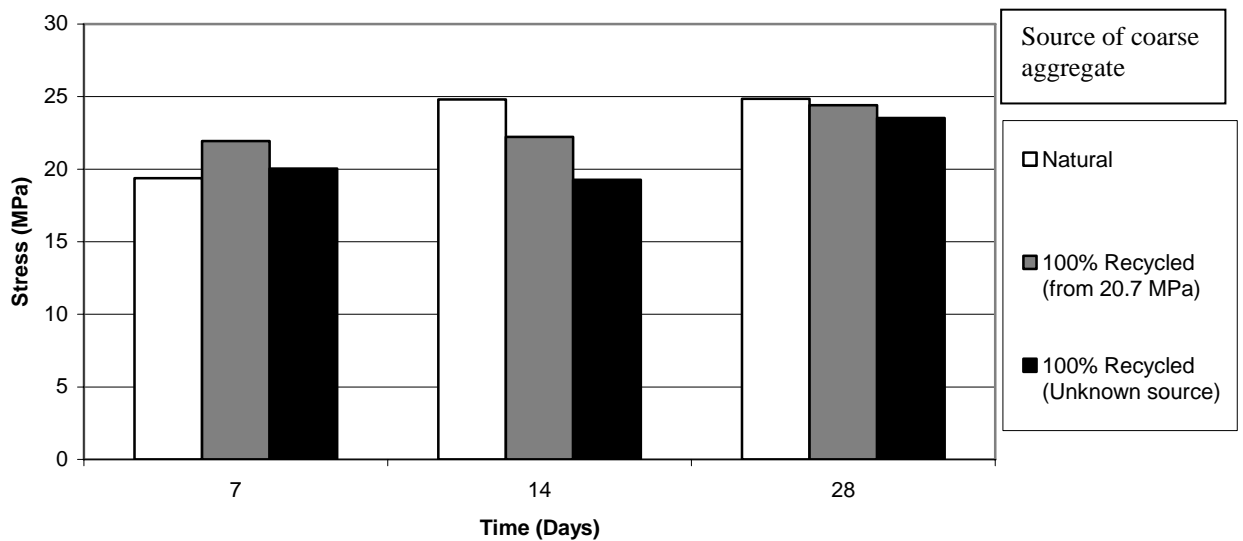


Figure 2: Concrete compressive strength versus time for  $f'_c = 20.7$  MPa.

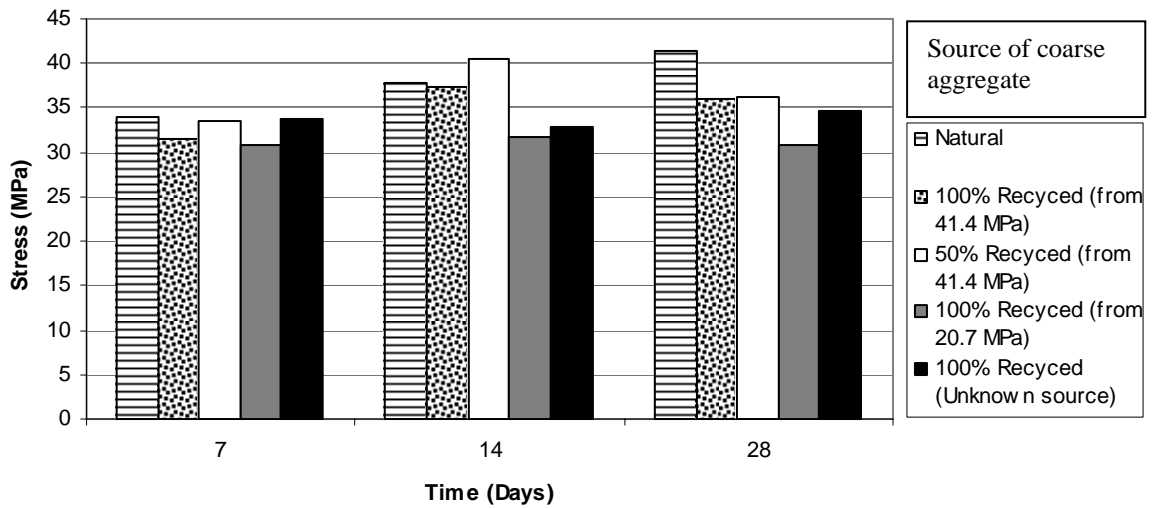


Figure 3: Concrete compressive strength versus time for  $f'_c = 41.4$  MPa.

Tensile strength in this study is measured using the split cylinder testing procedure. The size of the considered cylinders was 100x200 mm. Figure 4 and 5 show the results of the tensile strength tests for the cases of nominal  $f'_c$  equal to 20.7 and 41.4 MPa, respectively. For the two considered target compressive strengths, the recycled concrete has on average 10% lower tensile strength than its natural counterpart.

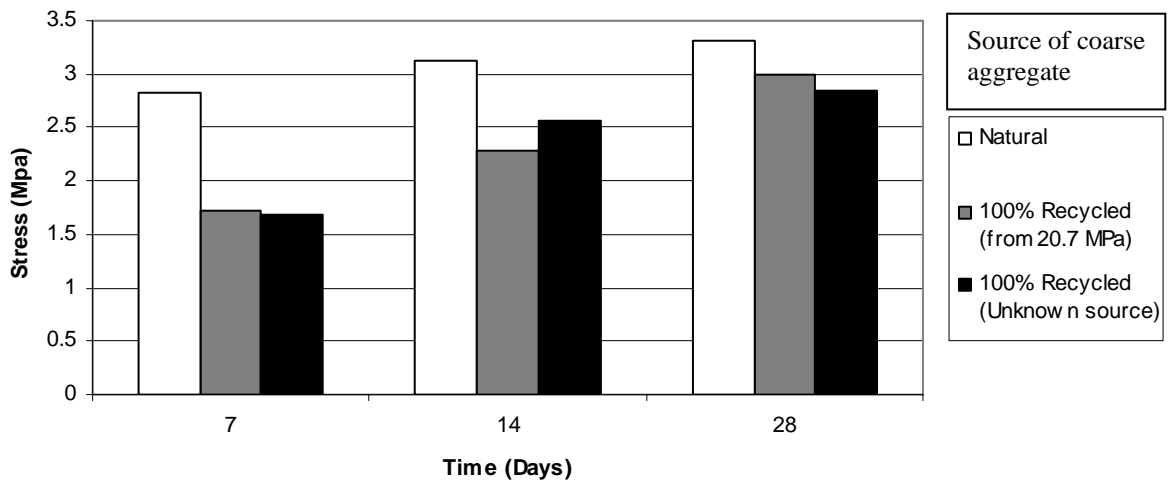


Figure 4: Concrete tensile strength versus time for  $f'_c = 20.7$  MPa.

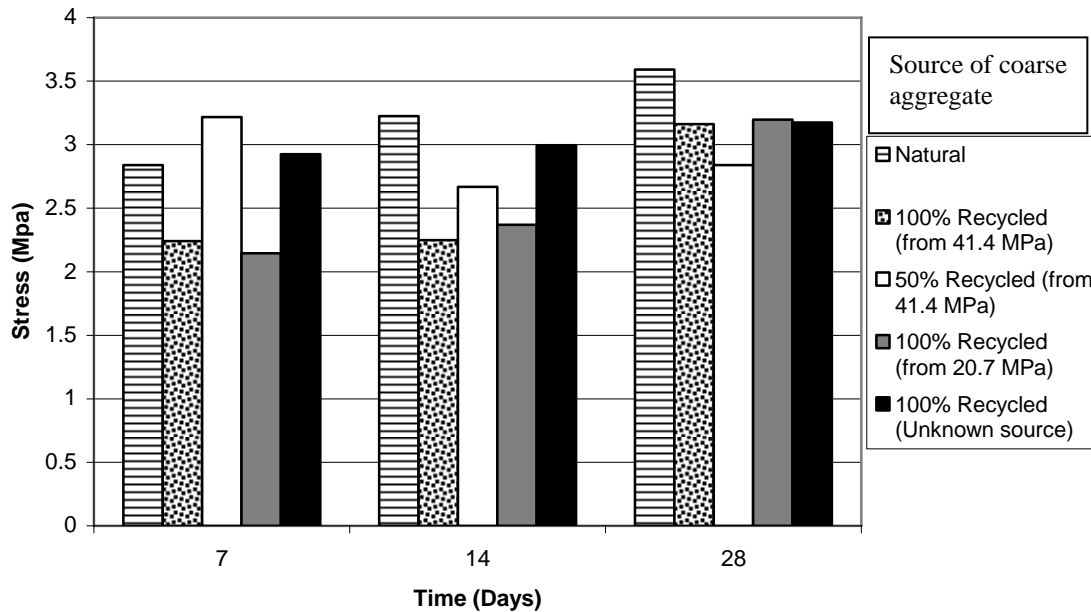


Figure 5: Concrete tensile strength versus time for  $f'_c = 41.4$  MPa.

#### Summary and Conclusions

Use of any recycled material helps to keep that waste material out of landfills. Recycling practices also can decrease the environmental impact of obtaining/manufacturing the material from virgin resources.

New concrete made from recycled concrete coarse aggregate generally has 10-25% lower compressive and tensile strengths than concrete made with stone or gravel aggregate. This is mainly because the recycled concrete aggregate requires 10% more water than the natural aggregate due to its high absorption and low specific gravity.

Lack of widespread reliable data on aggregate substitutes can hinder its use. To design consistent, durable recycled aggregate concrete, more testing is required to account for variations in the aggregate properties.

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#### References

ACI Committee 555, *Removal and Reuse of Hardened Concrete*, ACI 555R-01, ACI Committee 555 Report, American Concrete Institute, Farmington Hills, Michigan, 2001, 26 pages.

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