COMPRESSIVE STRENGTH OF CONCRETE USING RECYCLED AGGREGATES, WITH AND WITHOUT FLY ASH, COMPARED TO CONVENTIONAL CONCRETE

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ABSTRACT

This article presents the results of research evaluating the compressive strength of concrete using recycled coarse aggregate, in the case of using fly ash (CP1) and without using fly ash at a content of 5% (CP2). The experimental samples were compressed to test the compressive strength value at different times, including 7 days old, 14 days old and 28 days old. The study designed a recycled concrete composition with a 50-50 ratio of regular aggregate and recycled coarse aggregate, and the concrete has a design compressive strength of 15 Mpa. The compressive strength of concrete was studied and compared in cases with and without fly ash, and compared with another research result on concrete using recycled coarse aggregate.

Keywords: Recycled concrete; fly ash; compressive strength; recycled aggregate.

1. Introduction

In large, developing cities in Vietnam, the issue of reusing construction solid waste from demolition works is a matter of great concern. These construction solid wastes are hardly reused due to many different reasons such as lack of construction solid waste treatment plants, lack of solid waste concentration areas, strict environmental regulations, etc. Reality shows that many investors dump construction solid waste from demolition works into the environment to save time and costs (Figure 1). Research has recorded the appearance of a lot of construction solid waste dumped indiscriminately in less populated areas, ponds and lakes, etc. Therefore, it has a negative impact on the environment in the long run such as causing pollution, deteriorating the landscape, etc. Reusing construction solid waste will contribute to meeting the growing demand for raw stone in construction, which is increasingly in short supply today.

Figure 1: *Solid construction waste*

Current and future thermal power plants in Vietnam are discharging a daily extremely large amount of fly ash and slag waste. If not treated and reused, it will seriously pollute the environment, requiring a very large area of agricultural land for this type of waste. In addition, burying waste from thermal power plants such as fly ash will cause long-term harm to the environment such as polluting underground water sources or harming cropland. Currently, the reuse of this type of waste is being given priority support and in fact fly ash has been used in many construction material production applications such as producing unburnt bricks, used as materials in civil construction such as plastering, waterproofing, etc.

Therefore, research on concrete using recycled aggregates from construction solid waste combined with fly ash is necessary, has scientific significance and is highly practical. From the above analysis, the article clarifies the compressive strength of 150 grade concrete when using recycled coarse aggregate and adding fly ash. The research results will contribute to the reuse of construction solid waste and fly ash resources.

2. Experimental design

2.1. Recycled coarse aggregate

Recycled coarse aggregate is ground from waste concrete obtained during construction demolition. Waste concrete obtained after demolition is crushed by machine. After grinding, the obtained coarse aggregate will be washed, dried and pre-sieved to remove dust particles. This coarse aggregate will be sieved to classify particle sizes, then mixed again to obtain standard coarse aggregate distribution for concrete according to regulations.

To avoid strong water absorption from recycled aggregate, affecting the curing process of recycled concrete, before mixing, the coarse aggregates are soaked in water to absorb water, then left to dry at room temperature.

2.2. Fly ash

The source of fly ash material from Duyen Hai Thermal Power Plant (Tra Vinh) was used. Experimental results show that the fly ash of Duyen Hai Thermal Power Plant is type F because it has a total oxide content of $SiO_2+Al_2O_3+Fe_2O_3 > 70\%$, the technical parameters of fly ash are shown in Table 1.

Table 1: *Technical specifications of Duyen Hai fly ash*

Technical specifications	Outcome (%)	TCVN 10302:2014 (%)
Total oxide content $SiO_2+Al_2O_3+Fe_2O_3$	82.9	≥ 45
Sulfur content and sulfur compounds converted into SO_3	0.03	≤ 6
Concentration of free calcium oxide CaO	0.02	≤ 4
Loss of content when calcined MKN	8.3	≤ 15
Harmful alkaline content (soluble alkali)	< 0.01	≤ 0.1

2.3. Mix composition of recycled concrete

Concrete is mixed with the components shown in Table 2. In this study, an additional amount of fly ash additive was used to add to the concrete composition. To find out the impact of fly ash on recycled concrete, the concrete mix composition is fixed as Table 2, in which the coarse aggregate is divided into 2 parts with a ratio of 50% natural aggregate and 50% recycled aggregate. Additive content for each mix is as follows: CP1: No fly ash, ie fly ash content 0%; CP2: Use fly ash with a content of 5%.

Table 2: *Material composition for 1 m^3 of concrete*

PCB40 cement (kg)	Normalise sand (kg)	Aggregates (kg)	Water (kg)
243.8	674.9	1231.1	195.0

2.4. Experimental samples

The cylindrical concrete mortar mold with dimensions D150 x H300 (mm) (or 15 cm x 30 cm) is used in the experiment to determine the compressive strength of concrete. The mold is made of hard steel with a smooth machined surface and can be easily assembled and disassembled. Thus, after removing the mold, the concrete sample has a diameter of 15 cm and a height of 30 cm (Figure 2).

After being mixed and cured according to standards, concrete samples were compressed for 7 days, 14 days, and 28 days. Number of samples: 3 samples at 7 days and 3 samples at 14 days, 9 samples at 28 days, shown in Table 3.

Table 3: *Number of samples used in compression tests*

No.	Mixing description	7 days	14 days	28 days
1	CP1: 50% recycled coarse aggregate, 0% fly ash	3	3	9
2	CP2: 50% recycled coarse aggregate, 5% fly ash	3	3	9

Figure 2: E*xperimental sample*s

3. Results and discussions

The experimental results have been published in article [1], in which Figure 3 below shows the strength development of the tested concrete sample corresponding to CP1 - Mixing without using fly ash, and CP2 - Mixing using 5% fly ash. The results show that in the first 7 days, the intensity development speed is very fast. During the 7-28-day period, the speed gradually decreases. At 7 days old, concrete reaches 76% R28 (with recycled concrete without using fly ash) and 77% R28 (with recycled concrete using 5% fly ash). Thus, it can be seen that adding fly ash does not affect the strength development process of concrete in this case study.

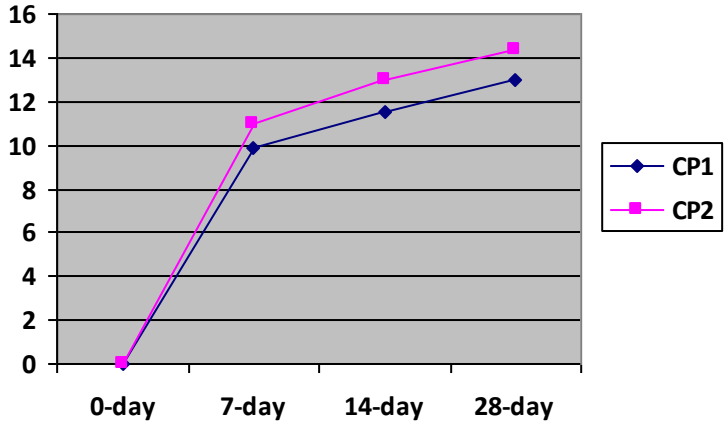

Figure 3: *Strength development of concrete using recycled aggregates [1]*

The strength of recycled concrete using 5% fly ash (CP2) is always higher than the compressive strength of recycled concrete without using fly ash (CP1). This increase recorded during the experiment was 11% at 7 days old, 12% at 14 days old and 10.2% at 28 days old. Thus, it can be seen that using fly ash helps increase the strength of recycled concrete by about 11% compared to the case of not using fly ash [1].

To evaluate the impact of fly ash, the compressive strength of recycled concrete using 5% fly ash (CP2) is compared with the compressive strength of conventional concrete according to design (Rn=15 Mpa), shown in Figure 4. It can be seen that when

using fly ash, the difference between compressive strength is not obvious. This result is quite consistent with a publication by author S. A. Chandio et al. [9].

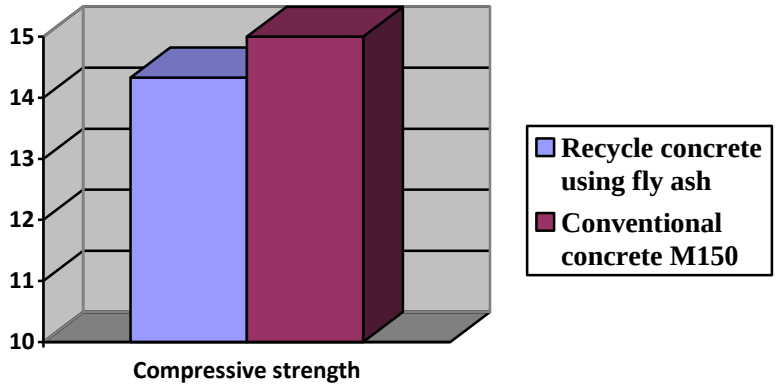

Figure 4: *Comparison of the strength of recycled concrete using fly ash with conventional concrete [1]*

Comparing the compressive strength of concrete in the study, using fly ash with a content of 5%, with the compressive strength of concrete using recycled coarse aggregate contents from 0-20% (Figure 5) indicates that: Fly ash helps increase the strength of recycled concrete by about 11% compared to the case of not using fly ash: When using 5% fly ash (CP2), concrete strength increased by 11% at 7 days old, 12% at 14 days old and 10.2% at 28 days old. The compressive strength of recycled concrete using fly ash is reduced by about 7% compared to conventional concrete.

To compensate for the loss of strength due to the use of recycled coarse aggregate, the use of fly ash alone is not sufficient. Consideration should be given to adding other additives or combining with reinforcing fibers.

From Figure 5, it can be seen that the decrease in strength of concrete when using recycled coarse aggregate is significant, especially in cases where the recycled aggregate replacement rate exceeds 20%. Therefore, in future studies, it is necessary not to exceed this proportion of recycled coarse aggregate.

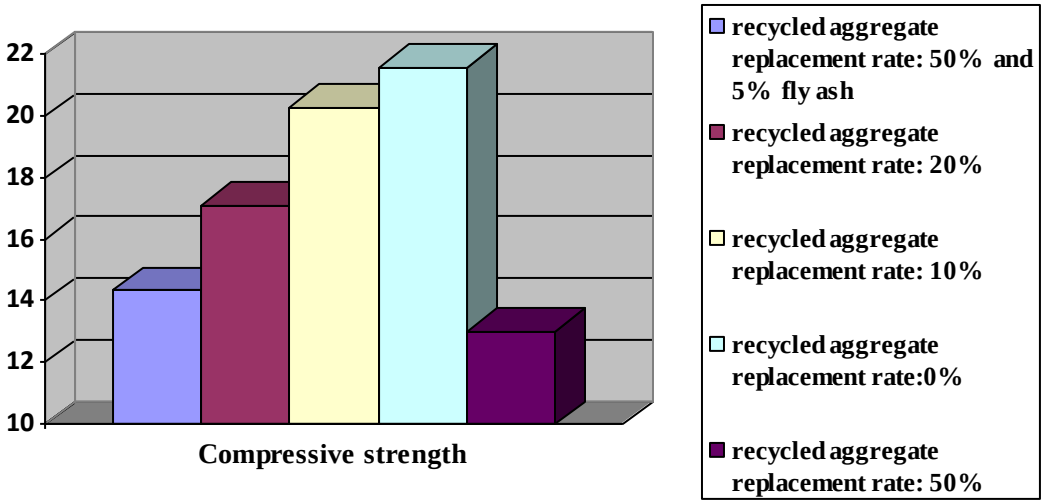

Figure 5: *Compare the compressive strength of recycled concrete in experimental cases*

3. Conclusions

This article presents the results of research evaluating the compressive strength of concrete using recycled coarse aggregate, in the case of using fly ash (CP1) and without using fly ash at a content of 5% (CP2). The compressive strength of concrete was investigated and compared in cases with and without fly ash, and compared with another experimental result on concrete using recycled coarse aggregate. Fly ash helps increase the strength of recycled concrete by about 11% compared to the case of not using fly ash*:* When using 5% fly ash (CP2), concrete strength increased by 11% at 7 days old, 12% at 14 days old and 10.2% at 28 days old. The compressive strength of recycled concrete using fly ash is reduced by about 7% compared to conventional concrete. To compensate for the loss of strength due to the use of recycled coarse aggregate, the use of fly ash alone is not sufficient. Consideration should be given to adding other additives or combining with reinforcing fibers. The decrease in strength of concrete when using recycled coarse aggregate is significant, especially in cases where the recycled aggregate replacement rate exceeds 20%. Therefore, in future studies, it is necessary not to exceed this proportion of recycled coarse aggregate.

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TÓM TẮT

SO SÁNH CƯỜNG ĐỘ CHỊU NÉN CỦA BÊ TÔNG SỬ DỤNG CỐT LIỆU TÁI CHẾ VỚI BÊ TÔNG THÔNG THƯỜNG, TRƯỜNG HỢP CÓ SỬ DỤNG TRO BAY VÀ KHÔNG SỬ DỤNG TRO BAY

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Bài viết trình bày kết quả nghiên cứu đánh giá cường độ chịu nén của bê tông sử dụng cốt liệu thô tái chế, trường hợp có sử dụng tro bay (CP1) và không sử dụng tro bay ở hàm lượng 5% (CP2). Các mẫu thí nghiệm được nén để kiểm tra giá trị cường độ chịu nén ở các thời điểm khác nhau, bao gồm 7 ngày tuổi, 14 ngày tuổi và 28 ngày tuổi. Nghiên cứu đã thiết kế thành phần bê tông tái chế với tỷ lệ cốt liệu thông thường và cốt liệu thô tái chế là 50-50, bê tông có cường độ chịu nén thiết kế là 15 Mpa. Cường độ chịu nén của bê tông được nghiên cứu và đối sánh ở các trường hợp có và không có tro bay, đồng thời đối sánh với một kết quả nghiên cứu khác về bê tông sử dụng cốt liệu thô tái chế.

Từ khóa: Bê tông tái chế; tro bay; cường độ chịu nén; cốt liệu tái chế.