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Comparison of Conventional Concrete and Engineered Cementitious Composites in the Joints

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Abstract: Over a decade it has been seen that to improve the performance of the conventional concrete different types of materials has been added to it.
These type of materials are in the form of admixture, fibers etc. A new type of material commonly known as bendable concrete or engineered cementitious composite (ECC) found to significantly improve the performance of a structure. Thus, in order to know its behavior an experimental study has been carried out on the beam column joint for both conventional concrete and ECC. L-shaped specimen were prepared consisting of beam and column portion.
This study showed that by applying ECC in the beam column joint the performance of the joint is increased remarkably and showing increase in load carrying capacity, ductility and stiffness. Bar charts have been developed to show the difference.
Keywords: Engineered Cementitious Composite (ECC), Conventional Concrete, L-shaped specimen, Ductility, Stiffness

I. INTRODUCTION

One of the most important portion in a structure is beam column joint [1]. As the failure of the beam column joint can result in life lost. The portion of beam column joint is usually made up of concrete and we all know that concrete is brittle nature [2]. So in order to increase the strength, ductility and also to avoid the brittle failure, what can be done is to increase the reinforcement ratio. But by increasing the reinforcement it will cause some problems; one of the main issue which it will cause is that there isn't sufficient space in the joints region so it becomes difficult to place the reinforcement and other main issue is the compactness of concrete is not properly done, so still leading to deficiency [3].
In order to overcome these problems, a new type of material commonly known as engineered cementations composite (ECC) is introduced which is also known as bendable concrete and found to be advantageous than the conventional concrete [4]. ECC consists of the same material as that of conventional concrete, it replaces the coarse aggregates and instead of that it used fibers, which develops strain hardening behavior in the ECC and as a result there are multiple cracks develops rather than the same cracks being opened further. ECC is found to have excellent properties than the conventional concrete [5].

II. MATERIALS

The materials used for the construction of the specimen are as follow;

A. Cement

Cement used for the preparation of the specimen was ordinary Portland cement generally known as type-I cement. This type of cement was used in both the conventional concrete and engineered cementitious composite. The consistency was found to be 28%, having average particle size less than 33μm.

B. Fine Aggregates

A very fine aggregates were used both for the concrete and the ECC. Sieve analysis was done for the fine aggregates and it was found that fineness modulus was 2.3.

C. Coarse Aggregates

Coarse aggregates were used only in the conventional concrete and they were not being used in the ECC. As we have discussed early that ECC does not contain coarse aggregates. The aggregates used were of different size so that properly compaction was governed. The fineness modulus for this was found to be 5.6.

D. Water

Portable water was used in mixing and curing of the sample.

E. Fly Ash

There are variety types of fly ash are found. In our research type F fly ash was used due to it's excellent properties, having lower calcium and the strength increase after 28 days makes the best choice to be used. The fly ash was used only in the preparation of the ECC [6].

F. Admixture

A high range water reducer accelerating admixture was used namely chemerite. As in ECC the content of admixture is very low so we have to mix it with water and then have to add it to the other material for it's proper mixing. It was used 1% by weight of the cement.

G. Fibers

One of the important property of the ECC is having fibers. There are variety of fibers present but polyvinyl alcohol fibers are found to have excellent properties than the rest of the fibers [7]. So in our research we also used PVA fibers. The details of the fibers is given in the **table 1** below:

Table 1: Fibers Properties

Fiber name	REC 15x8mm
Manufacture	Kurary
Origin	Japan
Material	PVA
Color	White
Diameter (dtex)	14.3
Length (mM)	8.0
Tensile Strength (Mpa)	1716
Elongation (%)	6.9

III. EXPERIMENTAL PROGRAM

The methodology followed in the research is as under:

A. Sample Preparation

L-shaped samples were prepared, of which one side of the L-shape portion was column and while the other side was of beam [8]. The length of both of the sides of sample were of 2 feet as shown in the figure 3.1. A total of 4 types of sample were prepared, 2 of which were of conventional concrete and 2 were of ECC, which were then tested in the uniaxial testing machine. In order to prepare the sample, a formwork was prepared. The cross section of the beam and column were of not the same size. Therefore, special care was taken in formwork. Beam is having a cross-section of 4 inch x 6 inch, while column is having a cross section of 4 inch x 4 inch. The reinforcement in both the beam and column was also different. A detail of cross-section of both beam and column along with the reinforcement is shown in the figure 3.2.

The reinforcement for both the beam and column were prepared and tied properly. Then, the bars were placed in the formwork as shown in the figure 3.3. After that, concrete and ECC were prepared, and ECC was applied in the joints only in the 2 sample of ECC, while rest was of conventional concrete. ECC M45 mix design proportion by weight was used: Cement 1, Fly ash 1.2, Water 0.56, Sand 0.8, high range water reducer 0.012, fiber 2% [9]. The prepared specimen is shown in the figure 3.4.

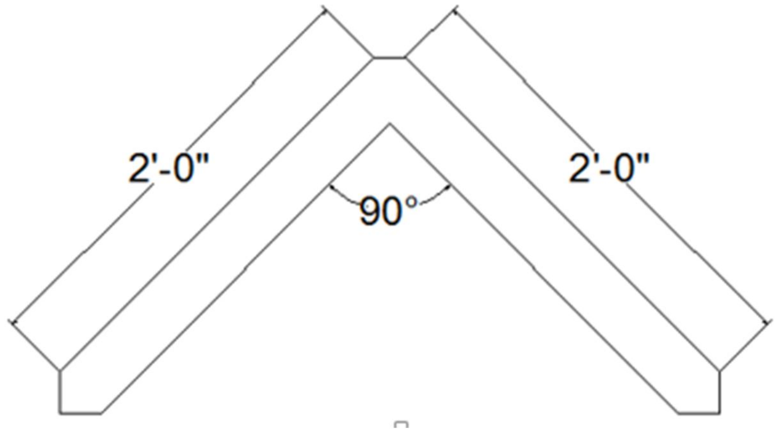

Figure 3.1: L-shaped Frame

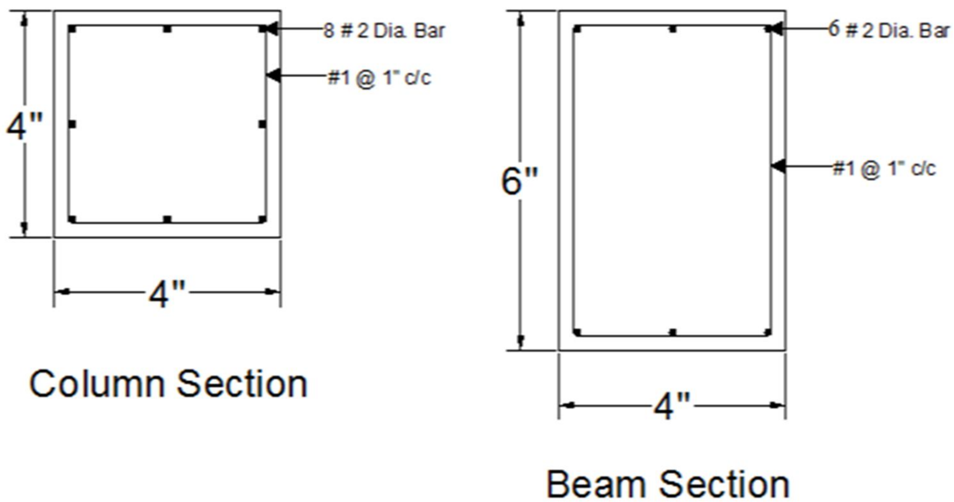

Figure 3.2: Cross-section of beam and column with reinforcement detail

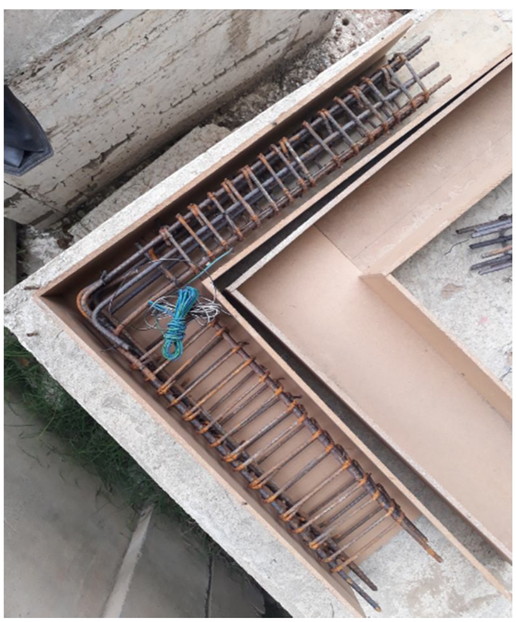

Figure 3.3: Placing of the bars in the formwork

Figure 3.4: Prepared sample

B. Test Setup

L-shaped sample were then placed under uniaxial testing machine. They were placed in such a manner that the toe of both beam and column touched the ground as shown in the figure. One hinge and one roller support was provided to it. Dial gauges were installed at the roller support and below the joint region to the displacement of sample. A Load cell was attached at the top from where the load was applied to the joints. The overall test setup is shown in the figure 3.5.

Figure 3.5: Test setup

IV. RESULTS

Result from the test obtained showed that the performance of ECC was very good than the conventional concrete. The cracks develop in ECC were of multiple cracks and it resist the opening of same cracks while in case of conventional concrete opening of same cracks was observed as shown in the figure 4.1. In load carrying capacity, the load taken by the conventional concrete CC1 and CC2 was upto 16.87kN and 17.02kN, while the load taken by the sample ECC1 and ECC2 was 21.97kN and 21.77kN. The ductility of the specimen CC1, CC2, ECC1 and ECC2 was found to be 4.04, 4.11,8.18 and 7.40. Similarly the stiffness of the samples CC1, CC2, ECC1 and ECC2 was found to be 8.43, 8.51, 10.98 and 10.88. The bar charts of all the specimen are shown in figure 4.2, 4.3, 4.4.

Figure 4.1: Cracks development in the conventional concrete (left) and ECC (right).

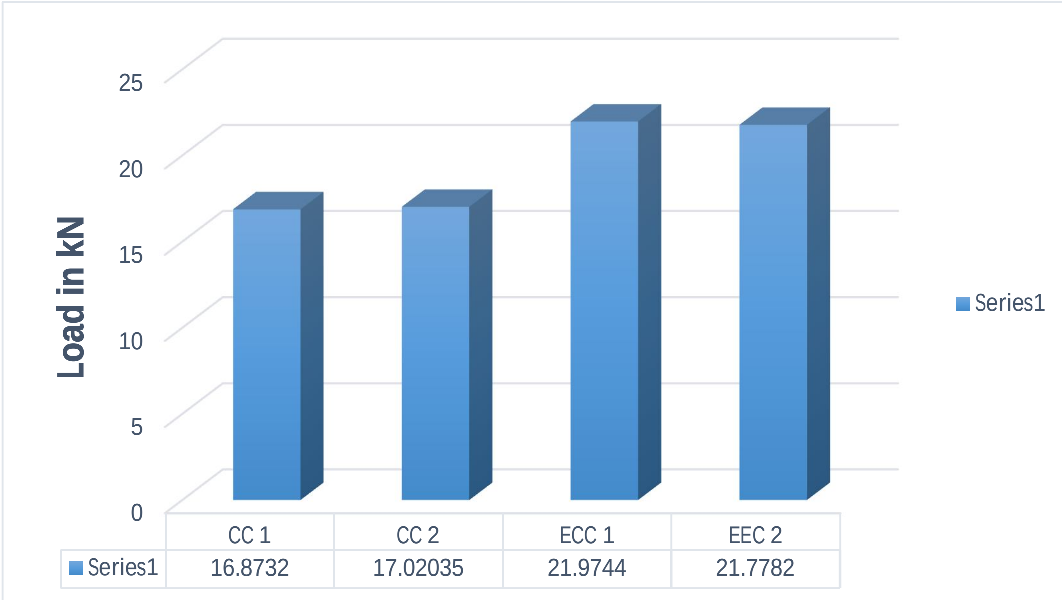

Figure 4.2: Load carrying capacity of each specimen

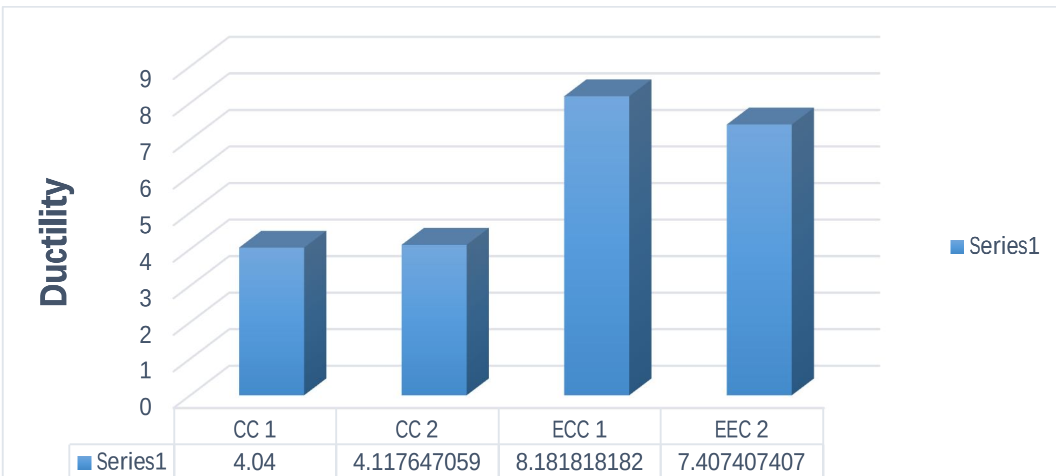

Figure 4.3: Ductility of each specimen

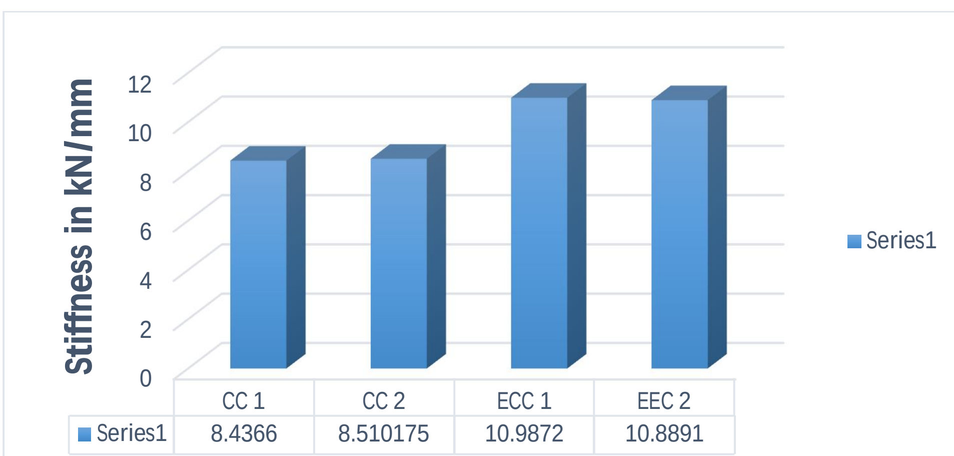

Figure 4.4: Stiffness of each stiffness

Comparison of the results is shown in the table 4.1;

Table 4.1: Comparison of all the specimens

Specimen	Load carrying capacity kN	Ductility	Stiffness kN/mm
CC1	16.87	4.04	8.43
CC1	17.02	4.11	8.51
ECC1	21.97	8.18	10.98
ECC2	21.77	7.40	10.88

V. SUMMARY AND CONCLUSION

In this thesis, total four sample were tested. Two of which were conventional concrete and two were of engineered cementitious composite. L-shaped samples were prepared and they were tested at the joints to compare the result of the both. Results showed that the behavior of the joints in ECC has improved than the conventional concrete. Moreover, there was also increase in the performance of ductility, stiffness and load carrying capacity.

The load carrying capacity was increased upto 23% in the ECC and this was due to the strong bonding of the ECC material with each other. As fibers are present which resist further opening of the same cracks and in terms of which multiple cracks develops and thus it also increases ductility, which was almost increased twice than the conventional concrete. Similarly, stiffness of the ECC was also increased as it resist the deformation, load being still increased.

The maximum opening of the crack observed in the ECC was less than 60µm while in case of conventional concrete the size of the crack was greater than 100µm. Thus, replacing the conventional concrete with the ECC is very advantageous and increasing the overall behavior of the structure and also in resisting of the cracks.

VI. ACKNOWLEDGEMENT

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