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Evaluation of Mechanical Properties of Engineered Cementitious Composites

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Abstract—This paper investigates the mechanical properties of M40 grade Engineered Cementitious Composite (ECC) with recron and multifilament polypropylene fibre and durability property of conventional concrete and ECC. The values of compressive strength, split tensile strength, flexural strength and modulus of elasticity were measured. M40 grade ECC has higher compressive strength, tensile strength, flexural strength and modulus of elasticity as compared with M40 grade conventional concrete. The replacement of reconfibre by polypropylene fibre reduced the strength of ECC. This paper also presented the comparison of microstructure of conventional concrete and ECC.

Index Terms—Compressive strength, polypropylene fibre, Reconfibre, Split Tensile strength, flexural strength, Modulus of elasticity, strength test, SEM analysis

1 INTRODUCTION

ENGINEERED Cementitious Composite is a type of ductile fibre reinforced cementitious composites. ECC is also known as bendable concrete. ECC has higher tensile strain capacity as compared to other fibre reinforced concrete. Under loading conventional concrete subjected to brittle failure. But in the case of ECC, it shows ductile behaviour. It is developed for the applications in the large material volume usage, cost sensitive construction industry [1]. In this paper two types of fibres are used in ECC such as recron and multifilament polypropylene fibre to check the effect of replacement of rerconfibre by multifilament polypropylene fibre.

2 OBJECTIVES

1. To compare the properties of M40 grade ECC with same grade of conventional concrete.

2. To determine the effect of replacement of recronfibre in ECC with polypropylene fibre.

3. To check the durability property of ECC.

4. To study the microstructure of ECC and compare it with conventional concrete.

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3MATERIALS USED

3.1. Cement

The cement used for the experiment is Ordinary Portland cement (OPC - 53 grade). Specific gravity of cement used is found to be 3.12 and Standard consistency of cement used is found to be 33%.

3.2. Fine Aggregate

Natural river sand is used as the fine aggregate. Fineness modulus of sand used is found to be 1.53 and Specific gravity of fine aggregate used is found to be 2.63.

3.3. Coarse Aggregate

Coarse aggregate used for this paper was collected from a local quarry. Fineness modulus of coarse aggregate used is found to be 3.43and Specific gravity of coarse aggregate used is found to be 2.73.

3,4. Superplasticizer

Superplasticizer used in this study was BASF-Master Glenium Sky 8233. It helps to produce high performance concrete with longer workability retention, and high early strength.

3.5. Fly Ash

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash [2]. The glassy silica and alumina of class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds.

3.6. RecronFibre

TABLE 1
PROPERTIES OF RECRON FIBRE

Properties	Value
Chemical composition	Modified polyester
Cross section	Triangular
Diameter	30-40 micron
Cut Length	12 mm
Elongation	>100%
Melting point	240 – 260 ^{0}C
Softening point	220^0
Specific gravity	1.34-1.40 cc/g

3.7. Multifilament Polypropylene Fibre

Polypropylene is a synthetic hydrocarbon polymer. It will helps in significant reduction of plastic shrinkage cracking and minimizing of thermal cracking.

3.8. Water

Water needed for the study was for the production of concrete and for curing. Potable water is used for the study.

4MIX DESIGN

The mix design for M40 grade conventional concrete is carried out as per IS 10262:2009. Mix proportions for M40 grade conventional concrete is tabulated in Table 2. Mix proportions for M40 grade ECC is tabulated in Table 3. The nomenclatures used in this study are given in Table 4.

TABLE 2
MIX PROPORTIONS FOR M40 CONVENTIONAL CONCRETE

Materials	Cement	Fine Aggregate	Coarse Aggregate	water
Weight (kg/m^3)	350	858.09	1133.64	140

The mix for M40 grade ECC was selected after referring previous journal paper [3]

TABLE 3
MIX PROPORTIONS FOR M40 ECC

Materials	Cement	Flyash	Sand	Water	Super plasticizer	Fibre
Weight (kg/m^3	452	452	199	452	9.03	20

TABLE 4
NOMENCLATURES USED FOR DIFFERENT MIXES

Mix ID	Description
CC40	M40 Mix Conventional Concrete
ECC40/R	M40 ECC with Recron fibre
ECC40/PP	M40 ECC with Multifilament Polypropylene fibre

5 EXPERIMENTAL PROGRAMMES

The ingredients used for preparing ECC are cement, sand, coarse aggregate, fly ash, superplasticizer, recronfibre or polypropylene fibre, and water. Mixing process was done in a standard mixer. Dry mixing was done before adding water [4]. M40 grade conventional concrete was prepared by using materials such as cement, sand, coarse aggregate and water. Before adding water all solid ingredients were mixed thoroughly. 150mmx150mmx150mm moulds were used to cast cubes to determine the compressive strength of concretes. 300mmx150 mm moulds were used to cast cylinders to determine the split tensile strength and modulus of elasticity of the concretes. 100mmx100mmx500mm moulds were used to cast beams to determine the flexural strength of the concretes.

6RESULTS AND DISCUSSIONS

6.1. Compressive Strength

TABLE 5
COMPRESSIVE STRENGTH OF DIFFERENT MIXES

Specimen	Compressive Strength at 7 day(N/mm^2)	Compressive Strength at 28day(N/mm^2)	% increase
CC40	32.19	41.9	30.16
ECC40/R	23.28	42.6	82.98
ECC40/PP	21.8	39.6	81.65

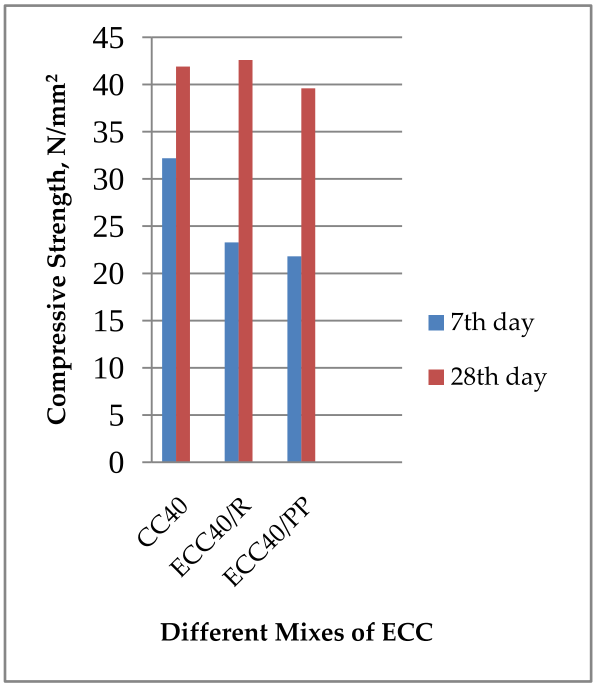

Fig 1. Compressive strength Vs Age of the specimen

It is observed that the percentage increase in compressive strength with age is more for ECC as compared to conventional concrete. The achievement of strength after 7days of curing is higher for conventional concrete than ECC. The replacement of recronfibre in ECC with polypropylene fibre decreases the compressive strength by 1.3%.

6.2. Split Tensile Strength

TABLE 6

SPLIT TENSILE STRENGTH OF DIFFERENT MIXES

Mix	Split tensile strength (N/mm^2)
CC40	4.52
ECC40/R	4.62
ECC40/PP	4.48

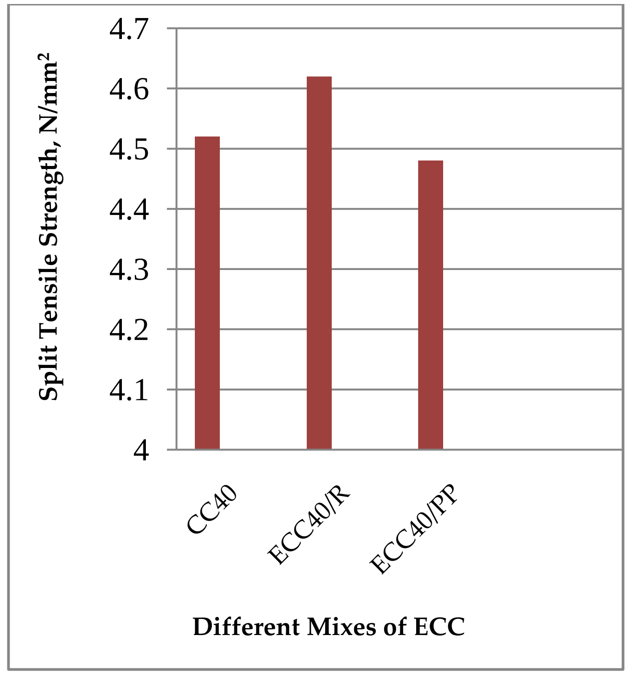

Fig 2. Split tensile strength Vs Age of the specimen

As the compressive strength, split tensile strength also increases and the split tensile strength of ECC is found to be comparable with conventional concrete. But the value is slightly lower for ECC with polypropylene fibres.

6.3. Flexural Strength

TABLE 7
FLEXURAL STRENGTH OF DIFFERENT MIXES

Mix	28 days (N/mm^2)
CC40	4.6
ECC40/R	8
ECC40/PP	7

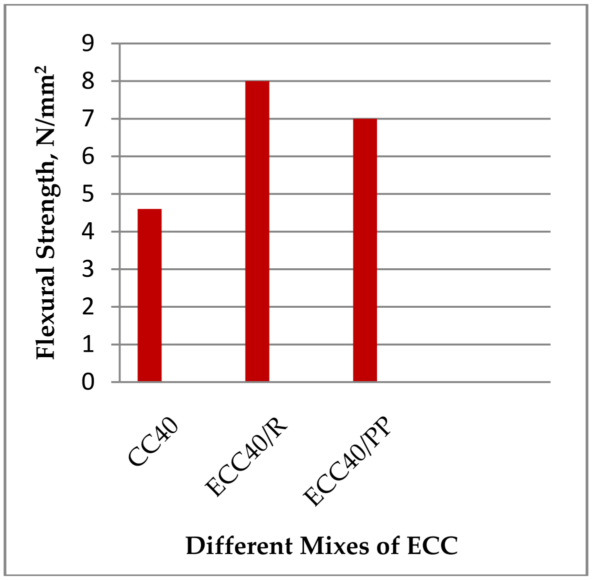

Fig 3. Flexural strength Vs Age of the specimen

Flexural strength of ECC with recronfibre is found to be 1.7 times higher than that of normal concrete for M40 mix. But the value is slightly lesser for ECC with polypropylene compared to ECC with recronfibre.

6.4. Modulus of Elasticity

TABLE 8

MODULUS OF ELASTICITY OF DIFFERENT MIXES

Mix	Modulus of Elasticity (N/mm²)
CC40	37000
ECC40/R	39486.28
ECC40/PP	36950.64

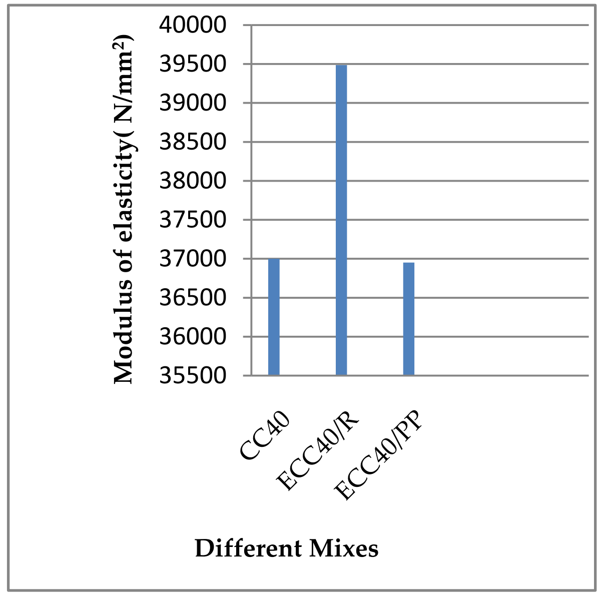

Fig 4. Modulus of elasticity Vs Age of the specimen

The modulus of elasticity of ECC is also comparable with conventional concrete of same grade.

6.5. Durability Properties of Concrete - Water Absorption Test

TABLE 9

WATER ABSORPTION TEST OF DIFFERENTMIXES

Mix	Water Absorption (%)
CC40	2.65
M40ECC/R	2.5
M40ECC/PP	2.53

Water absorption of ECC is lower than that of conventional concrete of same grade .This may be due to the presence of flyash as constituent in ECC which reduces the pore size in the concrete.

6.6. Microstructure - SEM Analysis Results

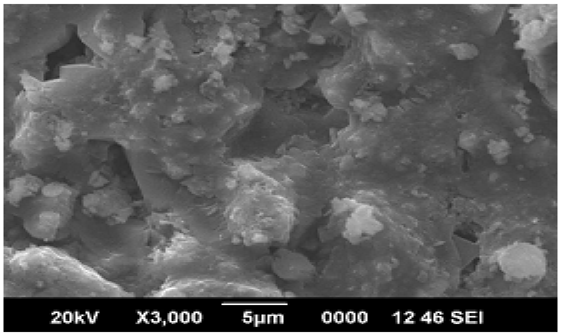

Fig 5. SEM image of CC

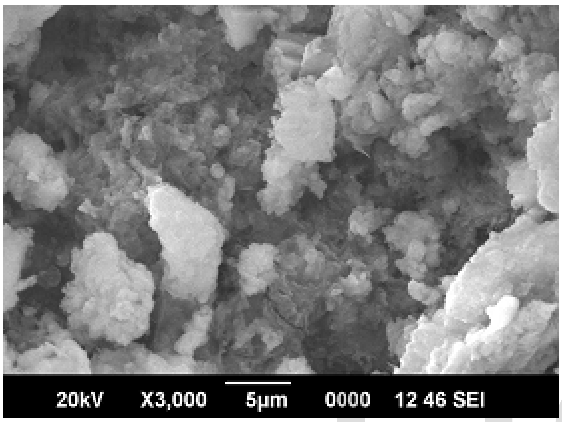

Fig 6. SEM image of ECC

SEM analysis result shows that there is considerable variation in the microstructure of ECC compared to conventional concrete. But the presence of some unhydratedflyash is also same in the SEM image of ECC.

7. CONCLUSIONS

1. M40 grade ECC has higher compressive strength, tensile strength, flexural strength as compared with M40 grade conventional concrete.
2. Compressive strength, tensile strength, flexural strength of ECC reduced when recron fibre is replaced with polypropylene fibre.
3. Water absorption of ECC is lower than that of conventional concrete of same grade. This may be due to the presence of flyash as constituent in ECC which reduces the pore size in the concrete.
4. SEM analysis result shows that there is considerable variation in the microstructure of ECC compared to conventional concrete.

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