Analytical Study of Polypropylene Fiber Reinforced Concrete Beam using Marble Dust as Replacement of Fine Aggregate

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Abstract - *Concrete is a generally utilized structure material for different kinds of development. The strength is limited and because it is a conventional way it is followed in all fields of construction irrespective of the nature of construction. Marble dust powder (MDP) is utilized as a halfway substitution for sand in customary solid which is exceptionally effective in expanding the quality without influencing its properties in crisp and solidified state. In this project the flexural behavior of polypropylene concrete beams using marble dust as a replacement of fine aggregate is studied. Marble dusts are added at 0%, 5%, 10% and 15%. Polypropylene fiber is added to concrete as 0.5%. Poisson's ratio of 0.3 and Elastic modulus equal to 200,000MPa has been used for steel reinforcement. Poisson's ratio of 0.2 is used for concrete, the f_{ck} values are derived from the experimental work, from the f_{ck} value Young's modulus is calculated as per IS 456:2000. Five mix proportions are obtained based on the added concentrate of polypropylene fibers with which 3 types of beams namely RCC beam, partially encased and fully encased beam, total 15 beams are modeled and their structural performances and flexural behavior are investigated. Concrete beam are virtually created in ANSYS software and four point loading test is applied. The parameters like strength, ultimate deflection, ductility is evaluated.*

Key Words: **Marble Dust Powder (MDP), Polypropylene Fiber, Ultimate Deflection, Poisson's Ratio, Ductility**

1. INTRODUCTION

Concrete is a generally utilized structure material for different kinds of development consisting of coarse aggregate, fine aggregate, and required quantity of water, the fine aggregate is usually river sand. The civil engineering construction industry is believed to be one of the most potential consumers of mineral resources. Many alternative methods are used in concrete to increase its mechanical properties thereby increasing the strength of the structure. Due to the rapid growth of construction industry, the available source of river sand is getting exhausted. Therefore, it is necessary to replace fine aggregate by an alternative material either partially or completely without compromising the quality of concrete.

Waste marble dust is one such material which can be used to replace fine aggregate. Marble dust can be used which is highly efficient in increasing the strength of concrete. It is estimated that million tons of waste marble powder are produced during quarrying process. Generally the waste marble is being dumped to any nearby pits or vacant spaces near marble processing industries. This leads to increased environmental risks. Hence utilization of marble powder is an effective way for improved harden properties of concrete. The utilization of marble dust as fine aggregate would turn this waste materials into a valuable resources.

Fiber reinforced concrete is widely used in concrete structures to increase tensile, compressive, flexural strength and modulus of elasticity and also increases ductility and toughness of concrete. Fiber reinforced concrete has a fibrous material which increases its structural integrity. Concrete is a brittle material and has low tensile and flexural strength, thus fibers like polyethylene are added to improve mechanical properties and also improve ductility and impact strength. Some of the commonly used fibers are carbon fibers, asbestos fibers, steel fibers, plastic fibers, organic fibers. Polypropylene fiber is more durable than other types of fibers since it does not rust with time like steel fiber types. Polypropylene fiber is commonly used due to its easily availability and cheap cost and its consistent quality. Aim of this project is to analyze the structural behavior of polypropylene fiber reinforced concrete beam with marble dust as partial replacement of fine aggregate.

1.1 Marble Dust Powder

Marble is a metamorphic rock formed from a pure limestone. The marble purity is responsible for its colour and appearance. Marble dust is a waste product formed during the sawing and polishing of marble rocks and about 25% of the processed marble is turn into powder form. Many researches show that several million tons of waste marble dust are generated annually world widely. It can be used as a filler material in cement or fine aggregates. It contains high calcium oxide content of more than 50%. Many researches are carried out to determine the effect of using marble dust as partial replacement of fine aggregate. Marble can be used to enhance the mechanical and physical properties of conventional concrete.

1.2 Polypropylene Fiber

Concrete is brittle in nature and has low tensile and flexural strength so fibers like polypropylene are added to enhance the properties of concrete. Polypropylene fibers have low self-weight and can take tension therefore, are used for tensile applications. The tensile as well as ductile property of concrete could be improved by the addition of polypropylene fibers. The most attractive properties of this type of fiber is very high tensile strength, very high specific modulus, low elongation and low fiber density. Polypropylene fiber is more durable than other types of fibers since it does not rust with time like steel fiber types.

1.3 Scope and Objective of the study

The main objectives of the study are as follows:

- To evaluate the flexural behavior of RCC beams, Partially encased and Fully encased composite beams under various mix designs.
- To evaluate the performances in the basis of output parameters like deflection, ductility.
- To improve the flexural behavior on different types of beam specimens with polypropylene fiber and marble dust powder.

2. ANALYTICAL STUDY

Here ANSYS 16.1 workbench is used for the analysis. Three types of beam mainly RCC beam, Partially encased and Fully encased beam with different percentages of marble dust powder and polypropylene fiber are modeled and analyzed.

Table -1: Properties of composite concrete mix

% of MDP	% of PPF	Modulus of Elasticity	Poisson's ratio	Compressive strength	Split tensile strength
0%	0%	24.19GPa	0.2	23.41	3.30
0%	0. 5%	25.05GPa	0.2	25.10	3.97
5%	0. 5%	26.41GPa	0.2	27.90	4.02
10%	0. 5%	27.32GPa	0.2	29.85	4.38
15 %	0. 5%	22.94GPa	0.2	21.05	3.86

2.1 Analytical Modelling of RCC Beam

RCC beam has an overall length of 1800mm with cross section 150mm x 200mm. The beam is provided with a main reinforcement of 3 no. of 12mm diameter bars at the bottom and 2 no. of 8mm diameter bars at the top. Shear reinforcement provided is 8mm stirrups at a c/c spacing of 160mm.

Properties of steel

Young's modulus = 200GPa

Poisson's ratio = 0.3

Yield strength = 415MPa

Modelling, meshing and analysis of RCC beam is shown in fig 1 to fig 3.

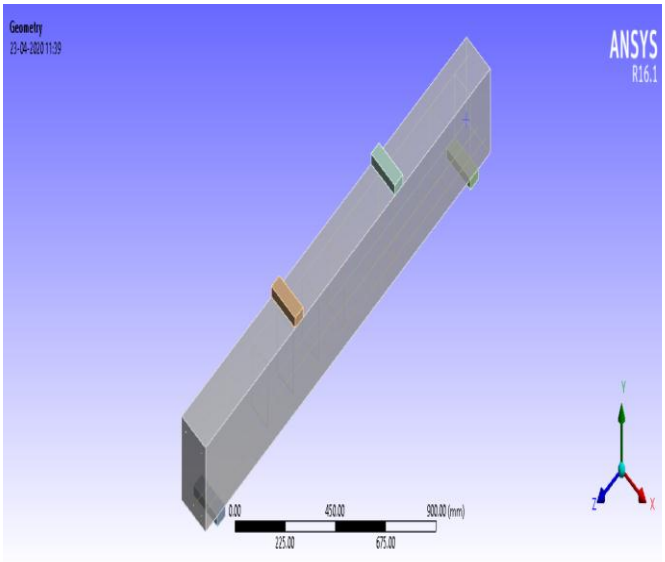

Fig-1: Model of RCC beam

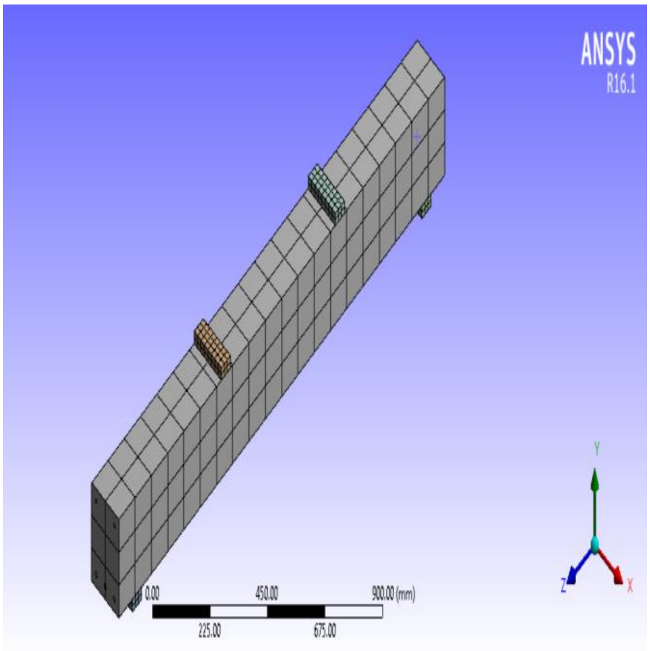

Fig-2: Meshed RCC beam

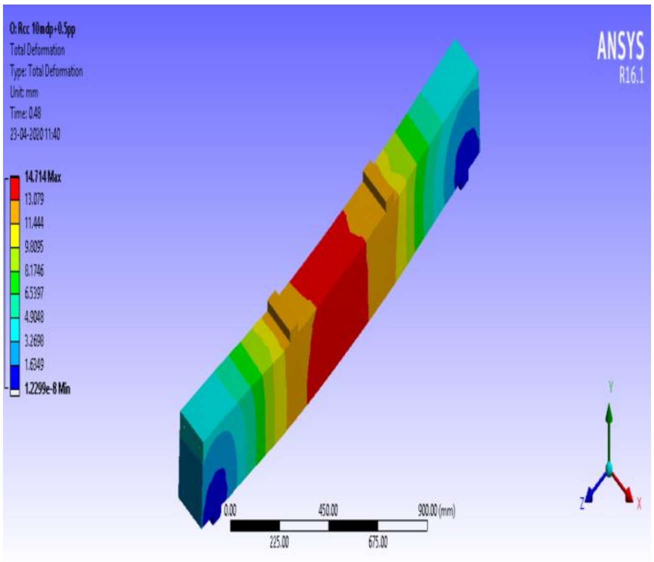

Fig-3: Deflection of RCC beam

The values obtained after analysis is shown in table 1.

Table -2: Analytical values of RCC beam

Percentage of mdp and pp	0mdp+ 0pp	0mdp +0.5p p	5mdp+ 0.5pp	10mdp +0.5pp	15mdp +0.5pp
Ultimate displacem ent	14. 54	14.24	15.71	14.71	15.25
Ultimate load	93.02	104.9 6	106.15	112. 51	102.77
Percentage increase in load	1	12.83	14.11	20.95	10.48
Yield displacem ent	3. 57	3. 59	3.60	3.60	3.59
Ductility	4.08	3.96	4.37	4.08	4.25

The graph showing load deflection of RCC beam is shown in fig 4.

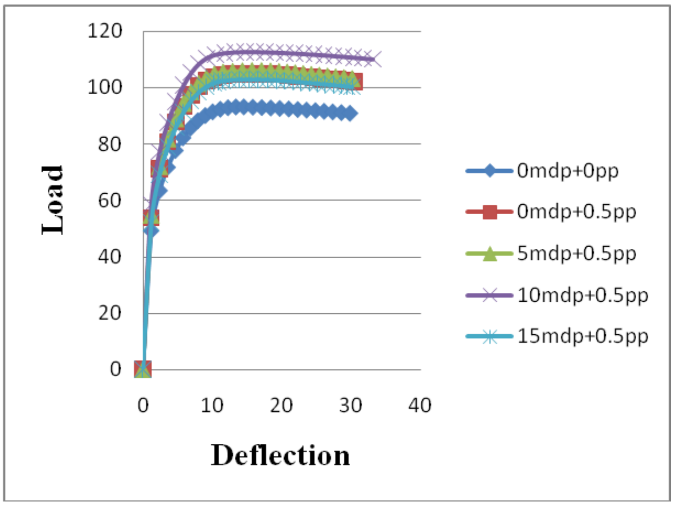

Fig-4: Load-deflection graph of RCC beam

2.2 Analytical Modelling of Partially Encased Beam

The Partially encased beam has a total width of 150mm, total depth of 200mm. Thickness of the web is 1.65mm, thickness of the flange is 1.65mm. Web openings are provided in the I-s/n. The number of web openings provided is 9. Diameter of each web opening is 180mm.

Properties of steel

Young's modulus = 200GPa

Poisson's ratio = 0.3

Yield strength = 250MPa

Modelling, meshing and analysis of Partially encased beam is shown in fig 5 to fig 7.

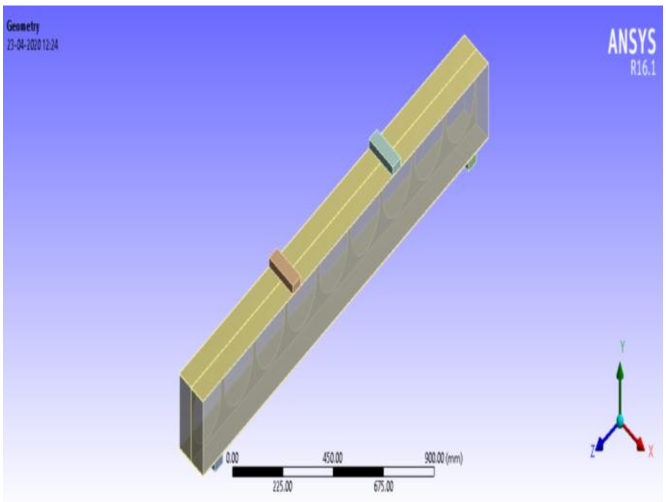

Fig-5: Model of Partially encased beam

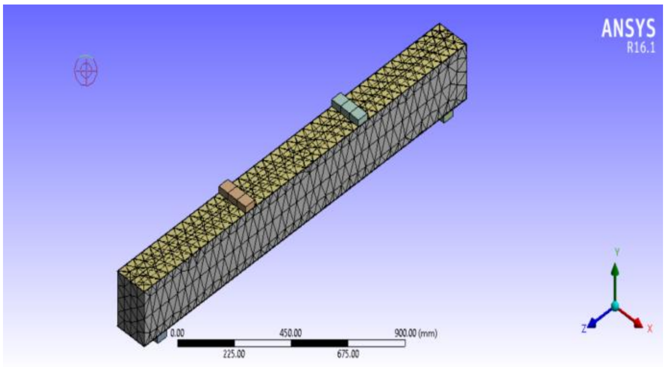

Fig-6: Meshed Partially encased beam

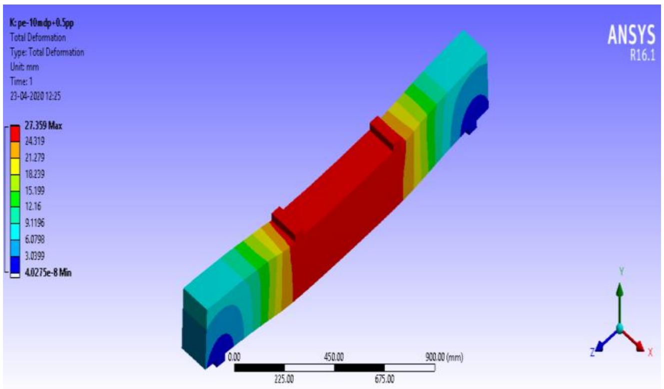

Fig-7: Deflection of Partially encased beam

The values obtained after analysis is shown in table 2.

Table -3: Analytical values of Partially encased beam

Percentage of mdp and pp	0mdp+ 0pp	0mdp +0.5pp	5mdp+ 0.5pp	10mdp +0.5pp	15mdp +0.5pp
Ultimate displacement	14.73	14.06	14.09	14.31	13.99
Ultimate load	128.14	143.55	144.7	152.28	141.01
Percentage increase in load	1	12.03	12.92	18.84	10.04
Yield displacement	2.36	2.38	2.38	2.39	2.38
Ductility	6.25	5.92	5.91	5.98	5.89

The graph showing load deflection of RCC beam is shown in fig 8.

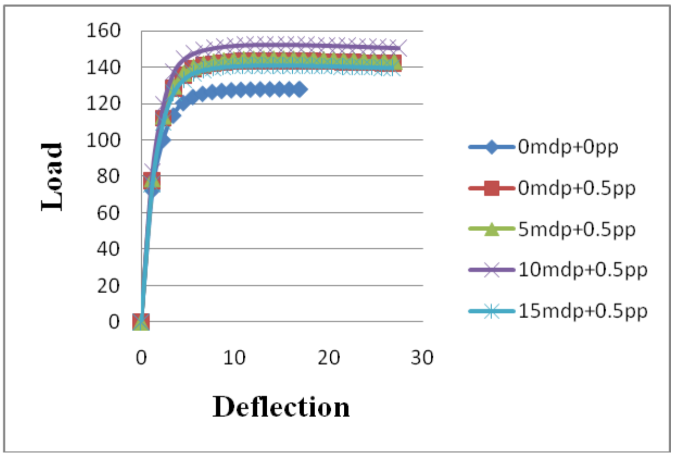

Fig-8: Load-deflection graph of Partially encased beam

2.3 Analytical Modelling of Fully Encased Beam

The Fully encased beam has a total width of 150mm and depth of 200mm. The main reinforcement provided is 4 no. of 8mm diameter bars. Shear reinforcement provided is 6 no. of 6mm diameter bars. Height of the I-s/n is 125mm, thickness of the web is 1.65mm and thickness of the flange is 1.65mm. Web openings are provided in the I-s/n. The number of web openings provided is 9. Diameter of the web opening provided is 107mm.

Properties of steel

Young's modulus = 200GPa

Poisson's ratio = 0.3

Yield strength = 250MPa

Modelling, meshing and analysis of RCC beam is shown in fig 9 to fig 11.

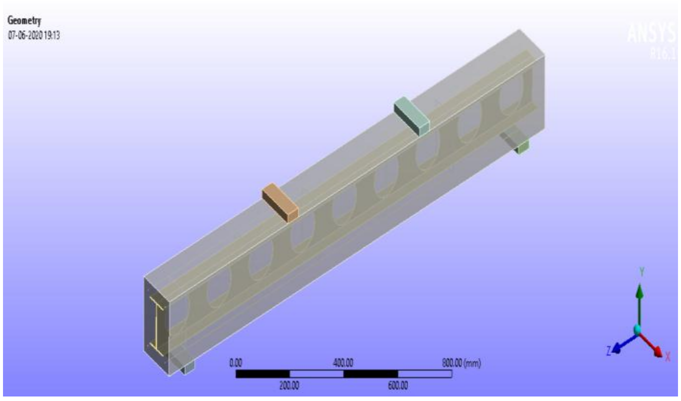

Fig-9: Model of Fully encased beam

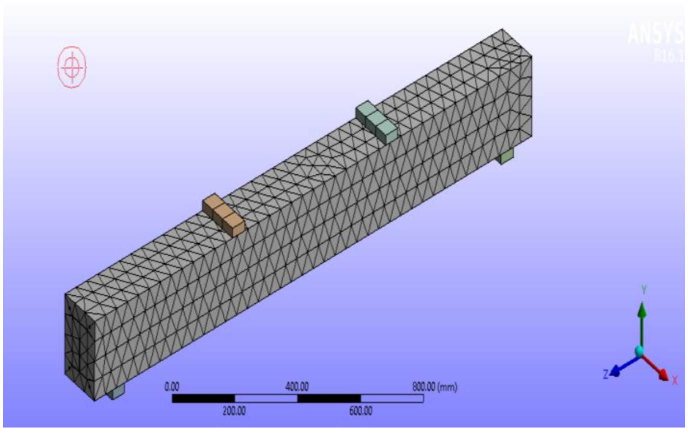

Fig-10: Meshed Partially encased beam

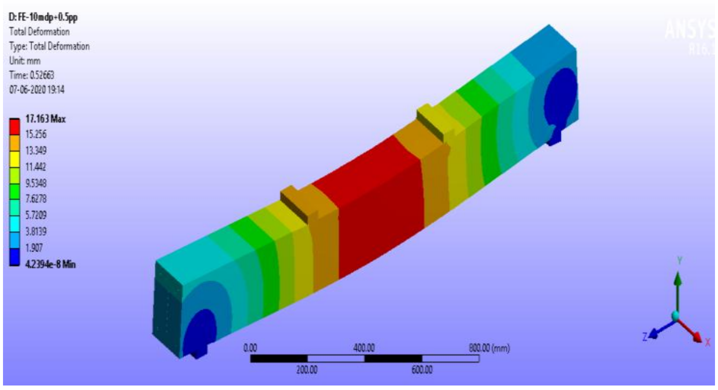

Fig-11: Deflection of Fully encased beam

The values obtained after analysis is shown in table 3.

Table -3: Analytical values of Fully encased beam

Percentage of mdp and pp	0mdp+ 0pp	0mdp +0.5pp	5mdp+ 0.5pp	10mdp +0.5pp	15mdp +0.5pp
Ultimate displacement	13.38	16.36	17. 65	17.16	16.43
Ultimate load	98.29	105.92	107.19	111.24	104.04
Percentage increase in load	1	7.76	9.05	13.17	5.84
Yield displacement	4.97	4.88	4.88	4.89	4.87
Ductility	2. 69	3.35	3.61	3.51	3.37

The graph showing load deflection of RCC beam is shown in fig 11.

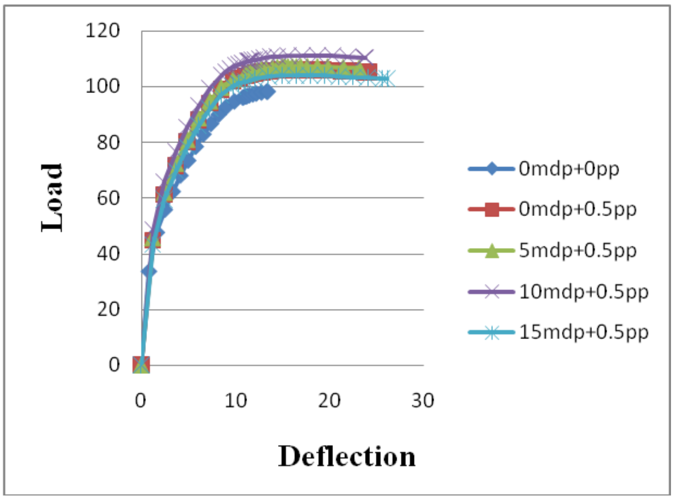

Fig-12: Load-deflection graph of Fully encased beam

3. RESULTS AND DISCUSSIONS

From the analytical study, for RCC beam the maximum load obtained is 112.51kN and deflection is 14.71mm at 10% of marble dust powder and 0.5% of polypropylene fiber. For partially encased beam the maximum load obtained is 152.28kN and deflection is 14.31mm at 10% of marble dust powder and 0.5% of polypropylene fiber. For Fully encased beam the maximum load obtained is 111.24kN and deflection is 17.16 mm at 10% of marble dust powder and 0.5% of polypropylene fiber.

4. CONCLUSIONS

Modelling and validation of specimens was done using Ansys 16.1. RCC beam carries 21% more load than the conventional beam. Partially encased beam carries 19% more load than the conventional beam. Fully encased beam carries 13% more load than the conventional beam. The load increases up to addition of 10% of marble dust powder and 0. 5% of polypropylene fiber. The maximum load is obtained for Partially encased beam.

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