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USE OF DAIRY INDUSTRY WASTEWATER IN MIXING AND CURING OF CONCRETE CUBES AND ANALYSE STRENGTH, DURABILITY AND WORKABILITY USING MIX DESIGN

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Abstract— The search for sustainable development methods are gaining more prominence throughout the globe. This can help our future generations to maintain earth as a better living place. Higher growth of population and advanced developmental activities in various fields are becoming greater challenges for mankind. Importance to be given for research in the field of reuse of natural resources where ever possible. Demand on water by construction industry is growing day by day. This demand includes water for washing of aggregates, concrete curing, cleaning of construction equipment's and machines. Water required for mixing of concrete should be fresh water and sea water cannot be used for concrete works. Wastewater generated from various industries can be treated and be recycled and can be used for construction activities, if the quality of water adheres the standards. Dairy industry is one among the most contaminating industries in food sector. This is due to the production of large volumes of wastewater and has high impurities. In this study an attempt has been made to use dairy industry wastewater for mixing and curing of concrete in three different formulations. Freshwater used for mixing and wastewater after treatment for curing has good structural property. Compressive strength of concrete was 32.88 N/mm^2 after 28 days of curing. This was observed in the case of Formulation II. Indicating the applicability of wastewater in curing. Split Tensile Strength on cylinders was carried out and the increase in strength was noted as 2.95 N/mm^2. This was more when compared with formulation I. This indicates that the dairy wastewater is a good alternative for freshwater for curing purpose. Flexural Strength Test was carried out on beams and the results depicted that the formulation II was best suited for the same. The strength of 10 N/mm^2 was obtained. The curing water subjected for testing indicated that the chemical constituents of the water change after curing. The curing water had an increase COD, BOD, Alkalinity and Total solids. A slight increase in pH, turbidity was also noted.

Keywords-Construction, Wastewater,pH, Mixing and Curing, Tests On Concrete

1. INTRODUCTION

The search for sustainable development methods are gaining more prominence throughout the globe. Focus is on development of various construction activities with minimal or no damage to mother earth. The sustainable use of existing resources in an effective manner and friendly to nature is the need of the day. This can help our future generations to maintain earth as a better living place. Sustainable development can be achieved by conserving the available resources than just spending more and more money on technologies which are simply name sake green solutions.

Higher growth of population and advanced developmental activities in various fields are becoming greater challenges for mankind. Importance to be given for research in the field of reuse of natural resources where ever possible. Implementation of reuse includes the use of process materials in such a way that the products should be able to be reused for a longer time. This reduces the demand on the raw material, decrease in energy usage pattern, less air (incineration) pollution, soil (landfills) pollution and water pollution (dumping into natural waters). Efficient methods of waste minimization and management using modern technologies can be a major component in sustainable development.

2. STUDY AREA

There are numerous sources of wastewater in our nation. Effective utilization of such waste resources is a major benefit to the environment. The major goal of this study is to analyze the results on the use of treated and untreated dairy industry wastewater on curing of concrete. The following are specific objectives:

- To carryout study on various problems in curing of concrete.
- To make maximum benefit of dairy industry wastewater.
- Analyze the physical, chemical characteristics of dairy industry wastewater.
- To study the effect of using Dairy Industrial effluent on strength, durability and workability of concrete as of mixing water and curing water.
- To study the workability characteristics of concrete produced by treated and untreated Dairy industrial effluents.
- To study the Strength characteristics of concrete produced by treated and untreated Dairy industrial effluents.
- To study the Durability characteristics of concrete produced by treated and untreated Dairy industrial effluents.
- To study dairy industrial characteristics of waste water before and after treatment.
- Design M30 grade of concrete.
- To study strength characteristics and durability of M30 grade of concrete.
- Curing of concrete using treated dairy industry wastewater.
- Evaluation of results obtained after the study.

3. METHODOLOGY

- This study has been accomplished by performing the following tasks mentioned in the sections explained below.
- Selection of raw materials needed to prepare concrete.
- Designing mix proportions, mix design for concrete, selection of grade of concrete for this work.
- Obtaining test data for the materials used for preparing concrete, calculation of target strength for mix proportions, finalizing water cement ratio, mix calculation.
- Preparation of cube, beam, cylinder. Curing the same for 14 and 28 days.
- Obtaining waste water from dairy for curing and mixing. Treated wastewater from dairy plant is used for curing and mixing.
- Conducting compaction factor test, compression strength test, split tensile test, flexural test.
- Performing test on wastewater to know the physical, chemical parameters. Test like pH, BOD, COD, Turbidity, Conductivity, Chlorides, Sulphates, Total alkalinity, Acidity to be conducted on treated and untreated dairy wastewater [The tests for wastewater quality analysis are carried out as prescribed by "Standard Methods for Examination of Water and Wastewater" (American Water Works Association and American Public Health Association) and "Guide Manual: Water and Wastewater Analysis, CPCB"].

4. RESULTS AND DISCUSSION

4.1. General

The results obtained during this research has been documented in this section. Subsections of this chapter throw light on the results and discussion of the same with the results obtained by researchers with homogeneous objectives.

4.2 Wastewater Analysis Results

The standards set by central pollution control board and World Bank for the disposal of dairy industry wastewater effluents is presented in the table below.

Table No. 4.1: Discharge Standards for Dairy industry effluents
(Shete B.S. and Shinkar N.P., 2013)

PARAMETER	MAXIMUM VALUE (mg/l)	
	WORLD BANK REPORT	CPCB, INDIA
pH	6-9	6.5-8.5
BOD_5	50	100 (based on BOD_5)
COD	250	-
Total Suspended Solids	50	150
Oil & Grease	10	10
Total Nitrogen	10	-
Total Phosphorous	2	-
Temperature Increase	$<= 3^{\circ}C$	-
Coliform Bacteria	400 Most Probable Number / 100 ml	-

Table No. 4.2: Values of wastewater parameters of Dairy Industry wastewater and Freshwater

	Parameter	Freshwater	Treated Wastewater
1.	pH	6.8	6.8
2.	Turbidity in NTU	2	8
3.	Conductivity	20	100
4.	Chlorides in mg/L	60	210
5.	Total Alkalinity (as $CaCO_3$) mg/L	20	550
6.	Acidity (as $CaCO_3$) mg/L	-	-
7.	Chemical Oxygen Demand in mg/L	0	200
8.	Biochemical Oxygen Demand in mg/L	0	110
9.	Oil and Grease in mg/L	0	5
10.	Total Solids in mg/L	10	800

The wastewater was tested in the lab for various parameters. The results obtained are mentioned in the above table. Freshwater and treated wastewater combination was used for mixing and curing of concrete cubes, beams and cylinders as mentioned in chapter 3, section 3.3.4. These water and wastewater samples were placed in different containers so that the cubes, cylinders and beams can be placed and cured. The wastewater used for this purpose was tested to check the change in the parameters (quality).

4.2.1 Formulation I

In this method Dairy industry wastewater was used for mixing of concrete and freshwater was used for curing. After 14 and 28 days the water from the curing tank was subjected to analysis and the following results were obtained.

Table No. 4.3: Test results of curing water 14 and 28 days (Formulation I).

Sl. No.	Parameters	Day 14	Day 28
1.	pH	7.5	7.6
2.	Turbidity in NTU	10	15
3.	Conductivity	35	60
4.	Chlorides in mg/L	80	90
5.	Total Alkalinity (as $CaCO_3$) mg/L	55	70
6.	Acidity (as $CaCO_3$) mg/L	-	-
7.	Chemical Oxygen Demand in mg/L	20	35
8.	Biochemical Oxygen Demand in mg/L	15	18
9.	Oil and Grease in mg/L	10	10
10.	Total Solids in mg/L	50	60

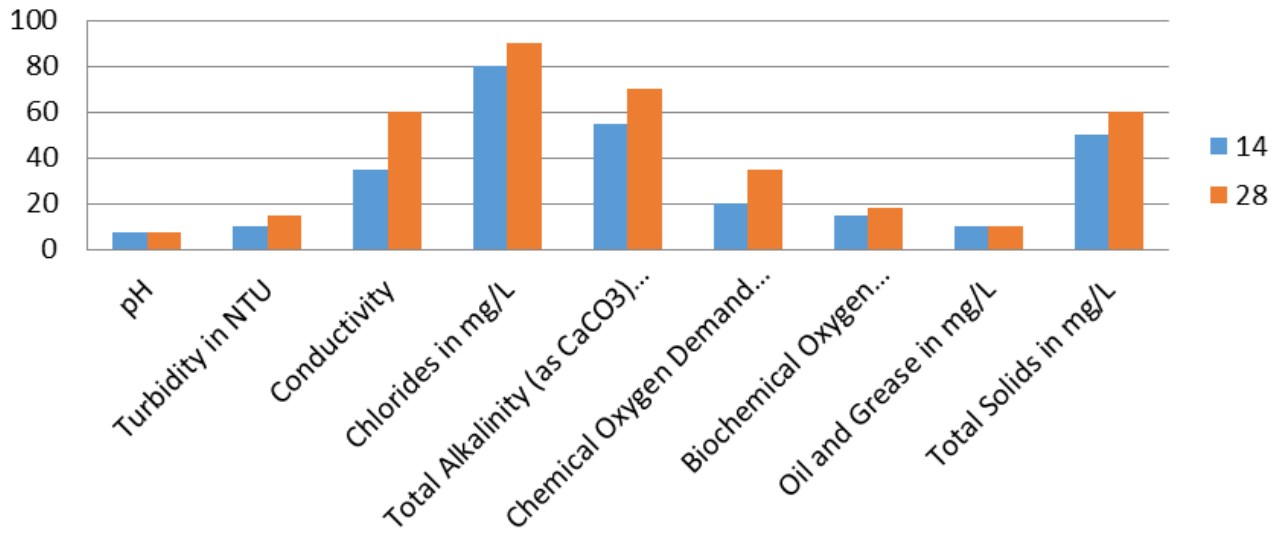

Fig 4.1: Test Results of curing water 14 and 28 days (Formulation I)

Freshwater was used for curing in this case. The BOD, COD and other parameters increased after the curing period. This can be attributed to the fact that the organic and inorganic constituents were being included into the curing water from the concrete blocks.

4.2.2 Formulation II

In this method freshwater was used for mixing of concrete and dairy industry wastewater was used for curing. After 14 and 28 days the water from the curing tank was subjected to analysis and the following results were obtained.

Table No. 4.4: Test results of curing water 14 and 28 days (Formulation II).

Sl. No.	Parameters	Day 14	Day 28
1.	pH	7.6	7.7
2.	Turbidity in NTU	14	20
3.	Conductivity	180	290
4.	Chlorides in mg/L	300	330
5.	Total Alkalinity (as $CaCO_3$) mg/L	800	850
6.	Acidity (as $CaCO_3$) mg/L	-	-
7.	Chemical Oxygen Demand in mg/L	250	280
8.	Biochemical Oxygen Demand in mg/L	170	190
9.	Oil and Grease in mg/L	20	20
10.	Total Solids in mg/L	900	1000

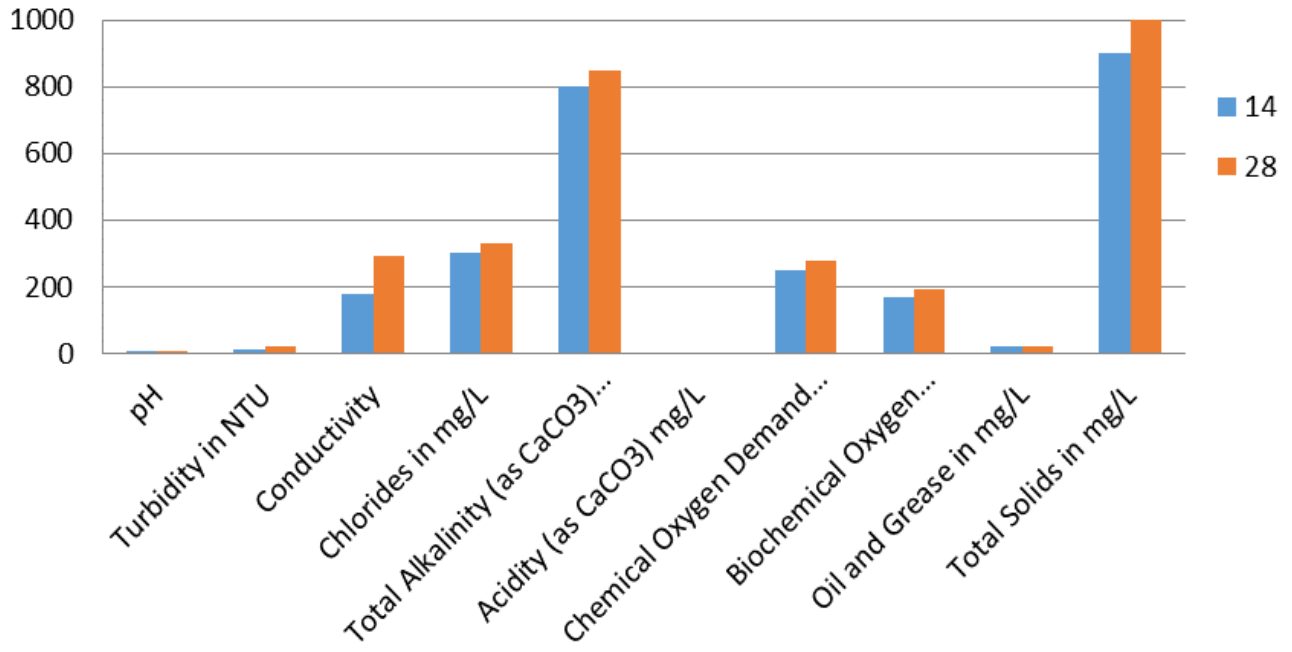

Fig 4.2: Test results of curing water 14 and 28 days (Formulation II)

In this case the curing was carried out in dairy industry wastewater. There was a considerable increase in the water quality parameters after the curing period. Total solids were nearing 1000 mg/l after 28 days of curing. Indicating the addition of solids from concrete blocks. Change in alkalinity was also observed in this formulation.

4.2.3 Formulation III

In this method Dairy industry wastewater was used for mixing and for curing of concrete. After 14 and 28 days the water from the curing tank was subjected to analysis and the following results were obtained.

Table No. 4.5: Test results of curing water after 14 and 28 days (Formulation III).

Sl. No.	Parameters	Day 14	Day 28
1.	pH	7.7	7.7
2.	Turbidity in NTU	16	23
3.	Conductivity	170	300
4.	Chlorides in mg/L	350	400
5.	Total Alkalinity (as $CaCO_3$) mg/L	900	1000
6.	Acidity (as $CaCO_3$) mg/L	-	-
7.	Chemical Oxygen Demand in mg/L	280	300
8.	Biochemical Oxygen Demand in mg/L	180	200
9.	Oil and Grease in mg/L	20	20
10.	Total Solids in mg/L	950	1100

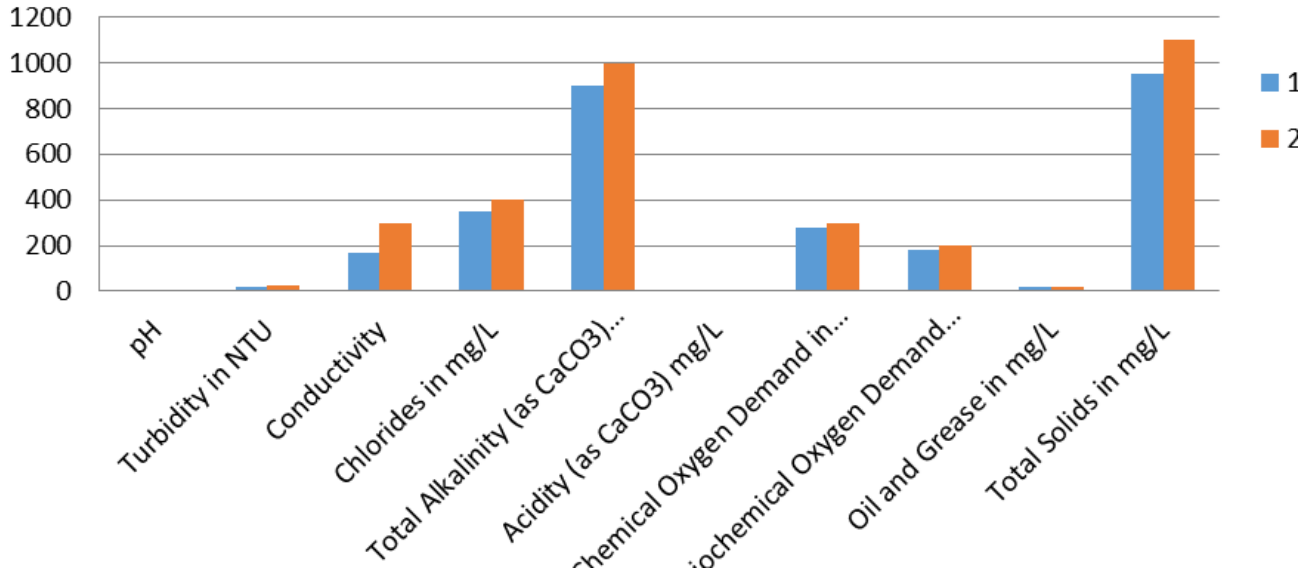

Fig 4.3: Test Results of curing water 14 and 28 days (Formulation III)

The use of dairy industry wastewater was done for mixing and curing concrete in this formulation and was found to have an impact on the water quality. In this case dairy wastewater can be utilized and consumed effectively, if the other concrete properties are not altered in a much greater manner.

4.3 Tests on Concrete and Obtained Results

In this section the results obtained on tests carried out on concrete are presented one by one in the following subsections.

4.3.1 Result of Compressive Strength Test conducted on Cubes (IS: 5816 - 1959)

The cubes were subjected to test under a compression testing machine of 2000 KN capacity. The stress = (Load/Area) = (P/A)

Area of the cubes were = 150 X 150 = 2250 mm^2

The results obtained after the study are presented in the following table. The Graph depicts the obtained results clearly.

Table No. 4.6: Results of Compressive Strength in N/mm^2 (M30).

Sl. No.	Formulation	Details	Load (KN)		Compressive Strength N/mm^2	
			14 Days	28 Days	14 Days	28 Days
1.	Formulation I	Mixing Dairy wastewater, curing using Freshwater	435.1	621.6	19.33	30.62
2.	Formulation II	Mixing freshwater, curing using Dairy wastewater	524.12	740.60	23.28	34.88
3.	Formulation III	Mixing and curing using Dairy wastewater	390.40	580.80	17.3	29.8

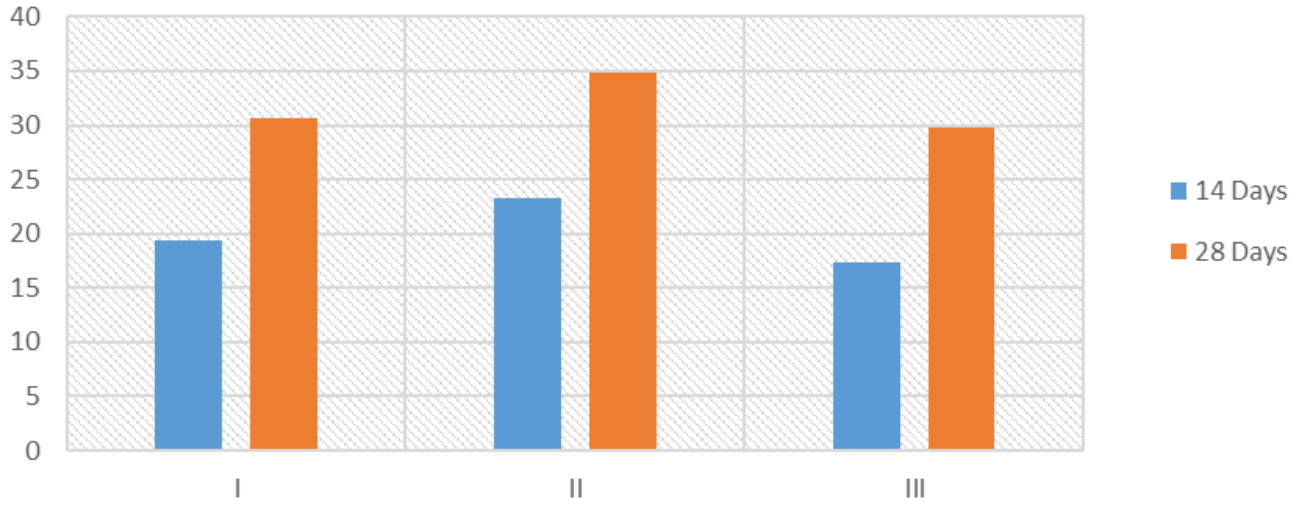

Fig 4.4: Results of Compressive Strength in N/mm^2

In the above graph it can been clearly observed, that the Compressive strength of concrete cube (formulation II) i.e., wastewater used for curing has the highest strength among all. The strength achieved by formulation II is 34.88 N/mm^2 for 28 days. This indicates that dairy industry wastewater can be used for curing of concrete.

4.3.2 Result of Split Tensile Strength on cylinders (IS: 5819 - 1970)

The prepared cylinders after proper curing were subjected to split tensile strength test. The capacity was 1000 KN.
Stress = (Load/Area) = (2P/πDL) in N/mm^2
P is applied load in Newtons; D is diameter of the cylinder; L is length of the cylinder.
Area of the cylinder was = 300 X 150 = 45000 mm^2

Table No. 4.7: Results of Split Tensile Strength in N/mm^2.

Sl. No.	Formulation	Details	Load (KN)		Split Tensile Strength N/mm^2	
			14 Days	28 Days	14 Days	28 Days
1.	Formulation I	Mixing Dairy wastewater, curing using Freshwater	100	140	1.141	1.97
2.	Formulation II	Mixing freshwater, curing using Dairy wastewater	130.4	209.3	1.84	2.95
3.	Formulation III	Mixing and curing using Dairy wastewater	92.7	127	1.31	1.79

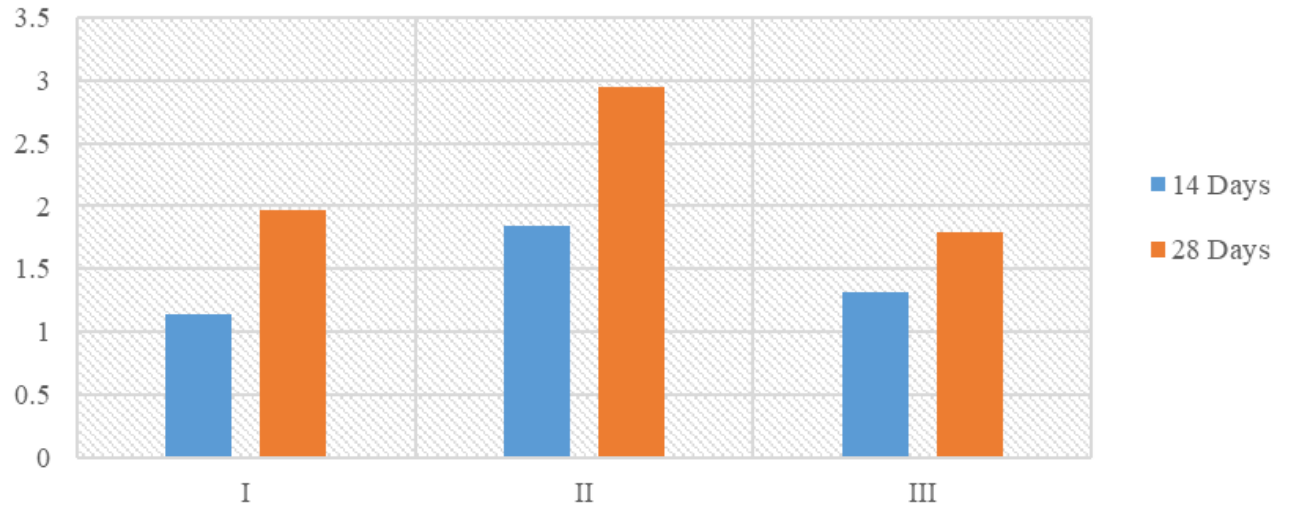

Fig.4.5: Results of Split Tensile Strength in N/mm^2

The results obtained from Split Tensile Strength tests are presented in the graph above. The results show that the highest strength was achieved from curing cylinders in dairy industry wastewater. The result is 2.95 N/mm^2 for 28 days (Formulation II).

4.3.3 Result of Flexural Strength Test on Beam (IS:5816-1970)

The Flexural Strength Test was carried out on beams and the results obtained are presented below.

Stress at center = (Load/Area) = (PL/BD^2)

Where L is effective spam = 500 – (2 X 50) = 400 mm

Stress at side = (Load/Area) = (3Pa/BD^2)

Where a = 133.33

Table No. 4.8: Results of Flexural Strength Test on Beam in N/mm^2.

Sl. No.	Formulation	Details	Load (KN)		Flexural Strength Test on Beam N/mm^2	
			14 Days	28 Days	14 Days	28 Days
1.	Formulation I	Mixing Dairy wastewater, curing using Freshwater	16.7	22.4	6.68	8.96
2.	Formulation II	Mixing freshwater, curing using Dairy wastewater	18	25	7.2	10
3.	Formulation III	Mixing and curing using Dairy wastewater	14.8	19.2	5.92	7.68

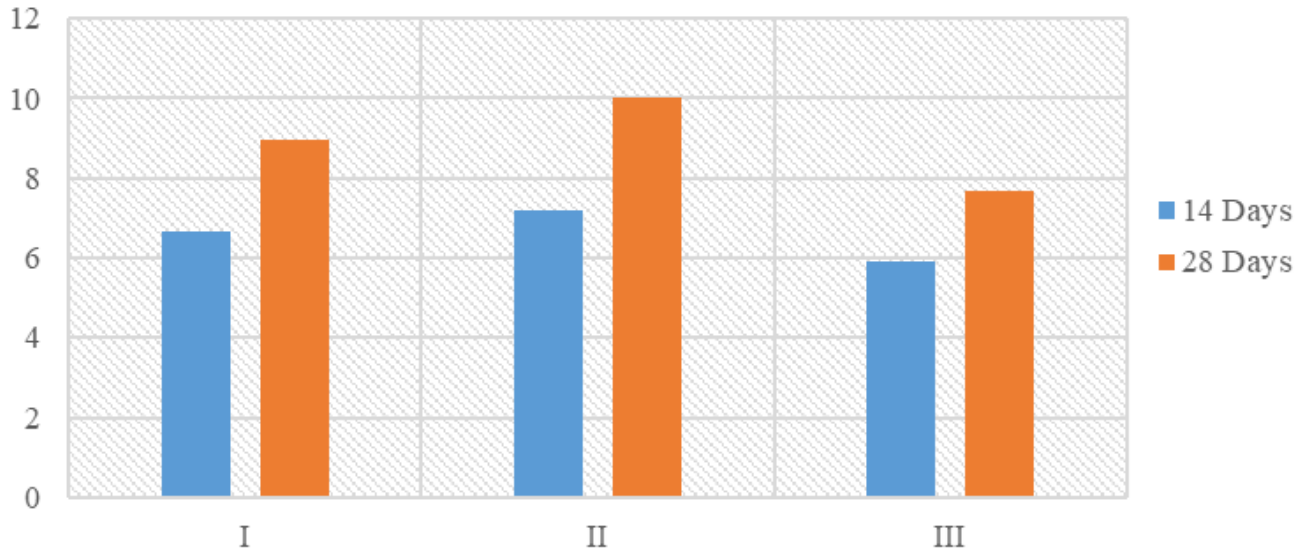

Fig 4.6: Results of Flexural Strength Test on Bean in N/mm^2

The results obtained show highest Flexural strength on 28 days' beam which was cured under wastewater. The result was 10 N/mm^2. Formulation II was best for beam and its strength.

5. CONCLUSION

The following conclusions can be drawn from the above study. The above study is a set example for effective utilization of industrial wastewater in a safer manner.

- The dairy industry wastewater after proper treatment can be utilized for curing and mixing of concrete.
- The results obtained are promising in case of formulation II. Freshwater used for mixing and wastewater after treatment for curing has good structural property.
- Compressive strength of concrete was 34.88 N/mm^2 after 28 days of curing. This was observed in the case of Formulation II. Indicating the applicability of wastewater in curing.
- Split Tensile Strength on cylinderswas carried out and the increase in strength was noted as 2.95 N/mm^2. This was more when compared with formulation I. This indicates that the dairy wastewater is a good alternative for freshwater for curing purpose.

- Flexural Strength Test was carried out on beams and the results depicted that the formulation II was best suited for the same. The strength of 10 N/mm^2 was obtained.
- The curing water subjected for testing indicated that the chemical constituents of the water change after curing.
- The curing water had an increase COD, BOD, Alkalinity and Total solids. A slight increase in pH, turbidity was also noted.

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