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Experimental Invesigation on Strength and Durability Characteristics of Concrete Developed by using Quarry Dust as Fine Aggregate

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Abstract : Concrete is the widely used building material in the world. River sand has been the most popular choice for the fine aggregate in concrete in the past, but over use of the material has led to environmental concerns, reduction of sources and an increase in price. Quarry dust has been proposed as an alternative to river sand that gives additional benefit to concrete.
Corrosion of reinforcing steel due to chloride ingress is one of the most common environmental attacks that lead to the deterioration of concrete structures. Corrosion related damage to concrete structures is a major problem. The concrete repair industry has developed novel techniques that are claimed to prevent the steel from corrosion and or to restore the protective character of the cover concrete by introducing corrosion inhibitors. The objective of this work is to study the strength and corrosion resistive properties of concrete containing quarry dust as fine aggregate along with organic inhibitorsMethyldiethanolamine and monoethanol-amine is added.
The following tests shall be carried out to determine the strength of concrete such as compressive strength, split tensile strength, flexural strength. The resistance to corrosion is evaluated based on the performance of the concrete for the penetration of chloride ions by means of Rapid Chloride Penetration Test (RCPT), and Gravimetric weight loss method.
Key words : concrete, quarry dust, super plasticizer, corrosion resistance, inhibitors.

1. Introduction

Concrete containing quarry dust as fine aggregate is promising greater strength, lower permeability and greater density which enable it to provide better resistance to freeze/thaw cycles and durability in adverse environment. 100% replacement of quarry dust in concrete is possible with proper treatment of quarry dust before utilization. The compressive strength of quarry dust concrete can be improved with admixture E and also super plasticizers can be used to improve the workability of quarry dust replaced concrete. Concrete produced using quarry fines shows improvement in higher flexural strength, abrasion resistance, and unit weight which are very important for reducing corrosion or leaching. Self-compacting concrete can also be produced using quarry dust. Durability of concrete may be defined as the ability of concrete to resist weathering action, chemical attack and abrasion while maintaining its desired engineering properties.Corrosion of reinforcing steel is a major problem facing the concrete infrastructures. Many structures in adverse environments have experienced unacceptable loss in serviceability of safety earlier than anticipated due to the corrosion of reinforcing steeland thus need replacement, rehabilitation or strengthening. Corrosion can be prevented by chemical method by using certain corrosion inhibiting chemical and coating to reinforcement. According to NACE (National Association of Corrosion Engineers) inhibitors are substances which when added to an

environment decrease the rate of attack on a metal. Corrosion inhibitors function by reinforcing a passive layer or by forming oxide layer and prevent outside agents and reduce the corrosion current. Corrosion inhibitors are becoming an accepted method of improving durability of reinforced concrete in chloride laden environments.

2.Materials

The cement used was Ordinary Portland Cement (43 Grade) conforming to IS 8112-1989. Locally available well-graded quarry dust, conforming to Zone-II of IS 383-1970 having specific gravity 2.68 and fineness modulus 2.70 was used as fine aggregate. Natural granite aggregate having density of 2700kg/m^3, specific gravity 2.7 and fineness modulus 4.33 was used as coarse aggregate. To attain strength of 30 N/mm^2 a mix proportion was designed based on IS 10262-1982 and SP23:1982(21). The mixture was 1:1.517:3.18 with water cement ratio 0.45.

3. Material Tests

Cement

Cement is a well-known binding material and has occupied an indispensable place in the construction works. There is a variety of cement available in the market and each type is used under certain conditions due to its special properties

Table 1properties for cement

S.No	Description	Result
1	Specific gravity	3.15
2	Fineness	3.1%
3	Consistency	32%
4	Initial setting time	30minutes

Fine aggregate(River sand)

IS: 383-1963 defines the fine aggregates as the aggregates most of which will pass 4.75 mm IS sieve .the fine aggregates is often termed a sand size aggregate.

Table 2 properties for fine aggregates(River sand)

S.No	Description	Result
1	Specific gravity	2.63
2	Bulk density	1739kg/m^3
3	Fineness modulus	2.369%

Fine aggregate(Quarry Dust)

IS: 383-1963 defines the fine aggregates as the aggregates most of which will pass 4.75 mm IS sieve .the fine aggregates is often termed a sand size aggregate.

Table 3 properties for fine aggregates

S.No	Description	Result
1	Specific gravity	2.68
2	Bulk density	2700kg/m^3
3	Fineness modulus	2.7%

4. Experimental Program and Test Specimens

The following experiments were conducted to thoroughly investigate the strength, water absorption and corrosion resistance properties of the quarry dust replaced concrete with and without inhibitors. For fully and partially replacement of quarry dust. Tests were conducted on a minimum of three replicate specimens after 3 days, 7 days and 28 days curing and the average values are reported.

Strength test

Concrete cubes of size 150 x 150 x 150mm, beams of size 500 x 100 x 100 mm, cylinders of size 150mm diameter and 300 mm long were cast with quarry dust as a fine aggregate for 50% and 100% for compressive, flexural and split tensile strength tests. Triplicate specimens were cast for each percentage of every inhibitor for 3, 7 and 28 days strength. After 3, 7and 28 days curing, the specimens were tested as per IS: 516 - 1964. Cylinders of size 150 mm diameter and 300 mm long.

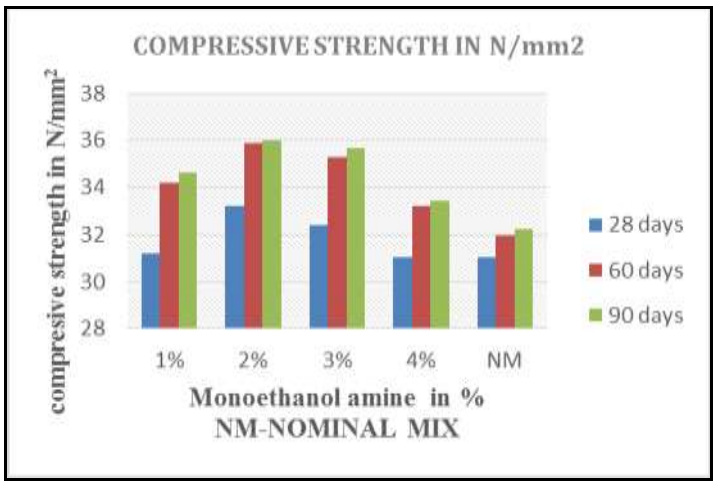
Durability tests

Rapid chloride permeability test (ASTM-C1202)

The Rapid Chloride Penetration Test (RCPT) is used to determine the electrical conductance of concrete to provide a rapid indication of its resistance to the penetration of chloride ions. The RCPT is performed by monitoring the amount of electrical current that passes through concrete discs of 50mm thickness

Compressive Strength Test

Description		Average compressive strength (N/mm^2)		
		28 days	**60 days**	**90 days**
Monoethanol amine	1%	31.2	34.2	34.64
	2%	33.2	35.9	35.98
	3%	32.4	35.3	35.65
	4%	31.02	33.2	33.43
Methyl diethanol amine	1%	32.3	33.2	33.65
	2%	34.62	35.32	35.54
	3%	33.2	35.12	35.34
	4%	32.03	34.98	33.05
Nominal mix	NIL	31.02	31.94	32.23



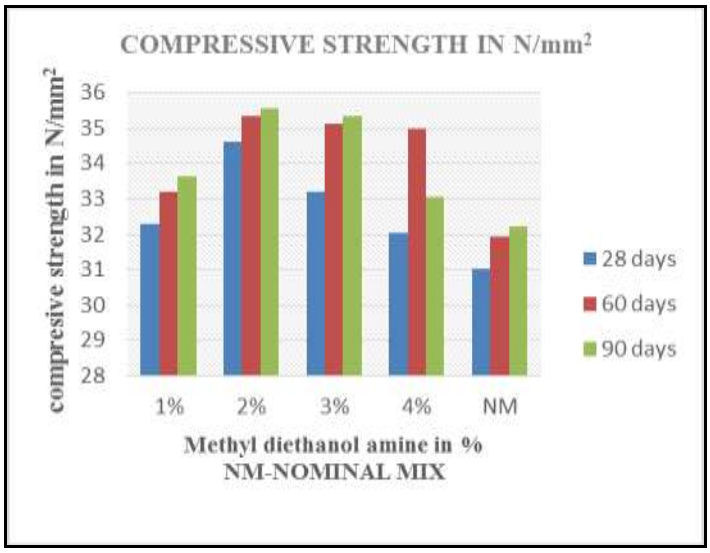
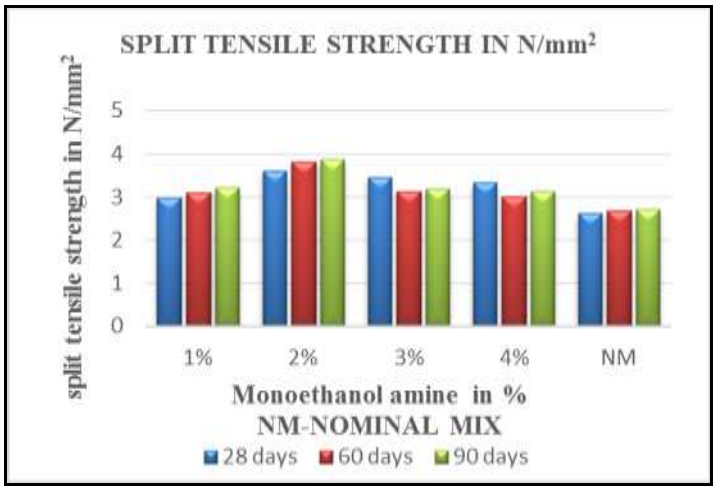


Chart 1. Compressive Strength (N/mm^2)

Split Tensile Strength Test

Description		**Average Split Tensile Strength (N/mm^2)**		
		28 days	**60 days**	**90 days**
Monoethanol amine	1%	2.98	3.12	3.22
	2%	3.62	3.83	3.88
	3%	3.47	3.13	3.21
	4%	3.36	3.02	3.14
Methyl diethanol amine	1%	2.83	2.92	3.06
	2%	3.24	3.42	3.58
	3%	3.12	3.24	3.28
	4%	3.05	3.13	3.19
Nominal mix	NIL	2.62	2.68	2.71



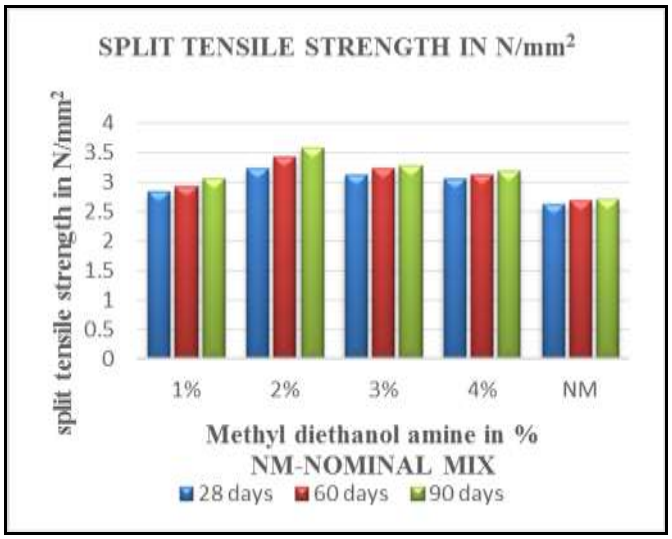
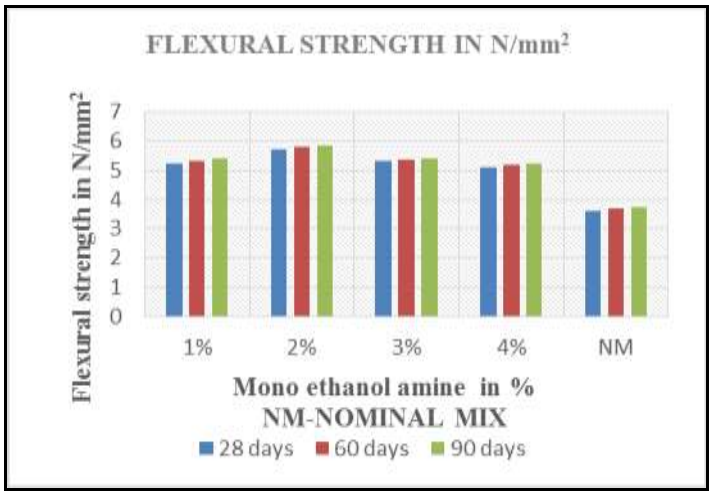


Chart 2. Split Tensile Strength (N/mm^2)

Flexural Strength Test

Description		**Average Flexural Strength (N/mm^2)**		
		28 days	**60 days**	**90 days**
Monoethanol amine	1%	5.23	5.34	5.39
	2%	5.72	5.79	5.84
	3%	5.32	5.35	5.42
	4%	5.12	5.18	5.24
Methyl diethanol amine	1%	4.96	5.04	5.08
	2%	5.54	5.61	5.67
	3%	5.22	5.26	5.32
	4%	5.02	5.08	5.13
Nominal mix	NIL	3.6	3.72	3.76



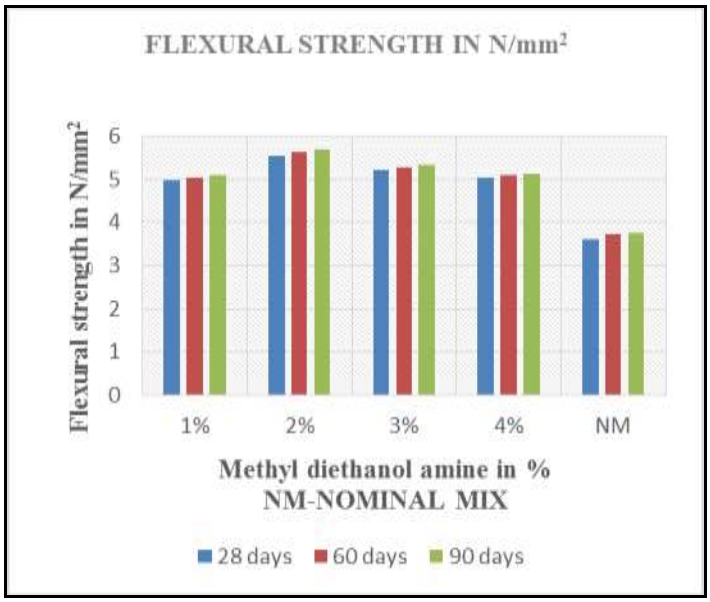
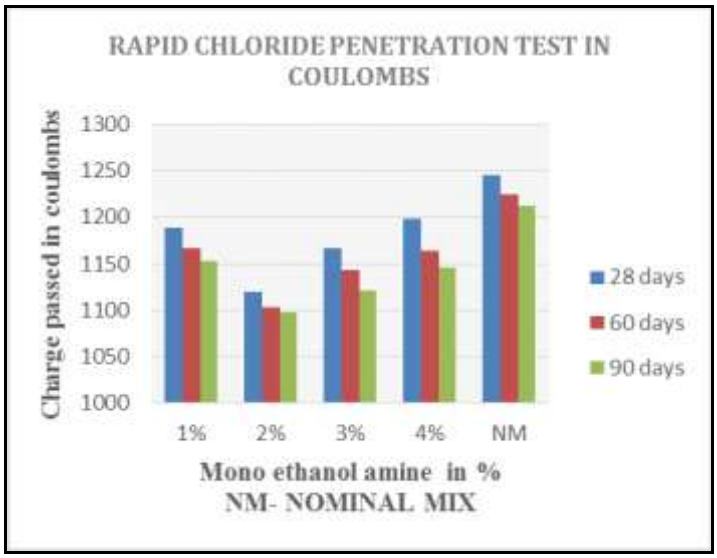


Chart 3. Flexural Strength test (N/mm^2)

Rapid Chloride Penetration Test

Description		**Charge passed in coulombs**		
		28 days	**60 days**	**90 days**
Monoethanol amine	1%	1189	1167	1153
	2%	1120	1103	1098
	3%	1167	1143	1121
	4%	1198	1164	1146
Methyl diethanol amine	1%	1167	1153	1123
	2%	1124	1114	1102
	3%	1154	1142	1121
	4%	1187	1157	1128
Nominal mix	NIL	1246	1224	1212



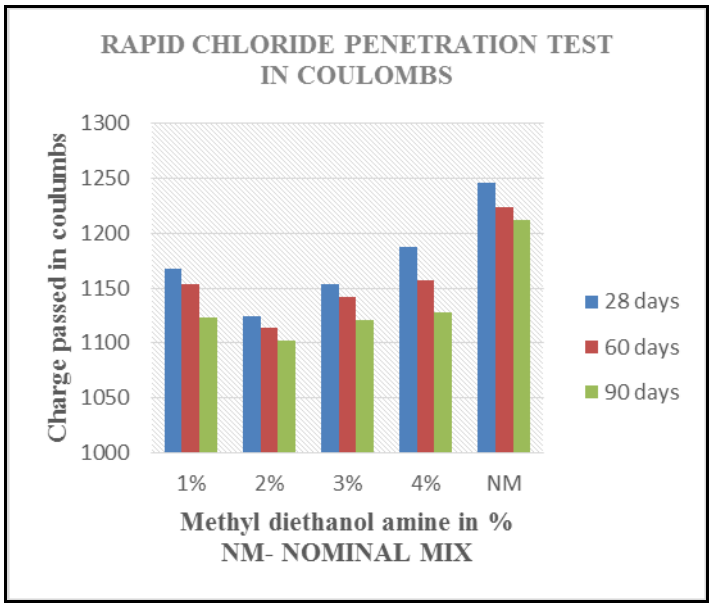
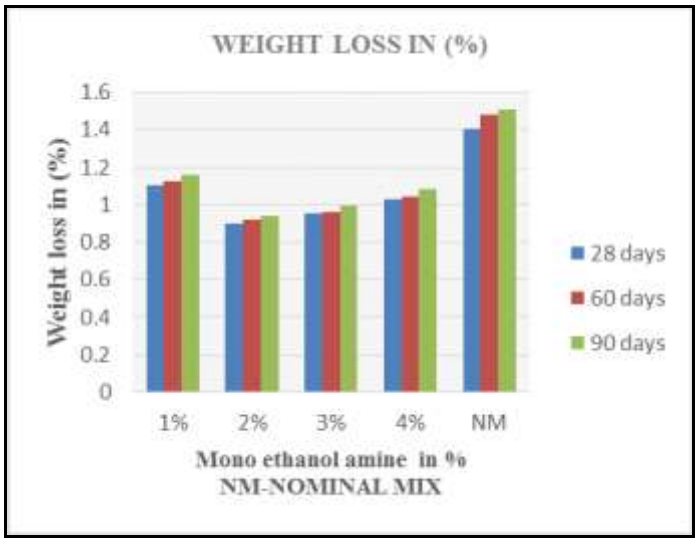


Chart 4. Rapid Chloride Penetration Test coulombs

Weight Loss Method

Description		**Weight loss in percentage (%)**		
		28 days	**60 days**	**90 days**
Monoethanol amine	1%	1.104	1.122	1.162
	2%	0.902	0.923	0.941
	3%	0.953	0.961	0.992
	4%	1.026	1.045	1.084
Methyl diethanol amine	1%	1.142	1.159	1.174
	2%	0.925	0.931	0.934
	3%	0.961	0.964	0.970
	4%	1.084	1.04	1.047
Nominal mix	NIL	1.403	1.480	1.510



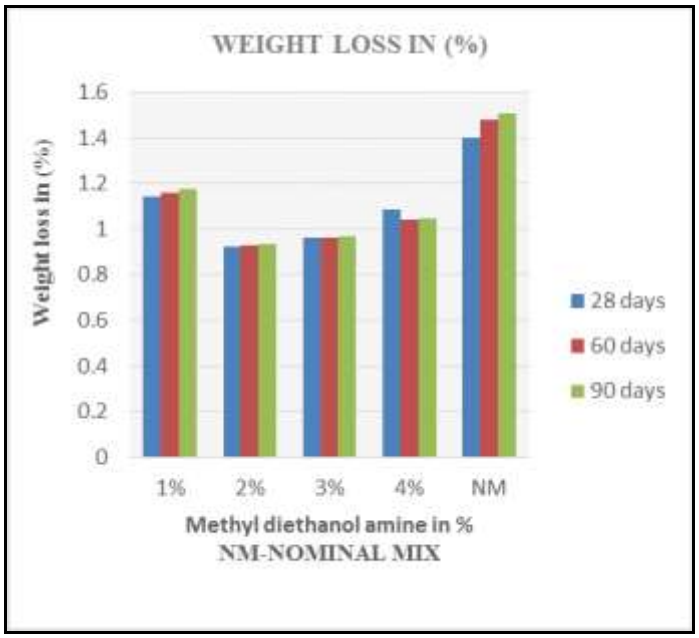


Chart 5. Weight loss method (%)

Test setup

Fig1: Compressive strength test on cube

Fig2. Split Tensile strength test on cylinder

Fig3: Flexural strength testing on prism

Fig 4. Rapid chloride penetration test

Fig 5. Sulpuric acid curing

Fig 6. After acidic curing

Conclusion

- The 100% replacement of quarry dust in the concrete mix resulted in improved structural performance measure in terms of ultimate load carrying capacity.
- The Compressive Strength on cube, Split Tensile test on cylinder, Flexural Test on beam, Rapid chloride penetration test of cylinder and weight loss test on cube has been Carried out on quarry dust as a 100% replaced fine aggregate and by using organic inhibitors of various mix proportions of 1%,2%, 3%, 4%byvolumeof cement.
- The strength of the concrete increased in the percentage of 2% addition of mono-ethanolamine and methyl-di-ethanolamine increases the strength at the age of 28, 60, 90 and 120days.
- It was observed mono-ethanolamine and methyl-di-ethanolamine as a good corrosion resistant agents in concrete at 2% when compare to nominal mix.
- The cost of the construction should be reduced by using quarry dust as an fine aggregate, because of quarry dust are the waste materials released from quarry industries.

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