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Durability Properties of Concrete DevelopedUsing Quarry Dust

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Abstract
The availability of natural sand for construction activity is decreases and river bed fall down hence the use of river sand as a fine aggregate in concrete is not possible so we go for a quarry dust as a fine aggregate. Quarry dust are available easily in all places and in concrete it is the best filling material and also achieve more strength than river sand. The setting time of concrete also decreased hence it should be preferred for water log areas. In this paper a durability properties of concrete has been done by use of quarry dust as a fine aggregate in concrete. Corrosion of steel is the major parameter to decreases the structure life. The objective of this work is to study the strength and corrosion resistant behaviour of concrete with quarry dust with addition of some organic inhibitors namely Monoethanolamine and diethenol amine as a weight of cement with 1%, 2%,3%, and 4%. The strength and durability of concrete should be measures and identify the properties. From the results obtained it is found that replacement of sand by quarry dust increases the strength of the concrete, with addition of inhibitor it offers very good resistance against chemical attack and increases corrosion resistance in addition to the overall properties of concrete.
Keywords: *Quarry dust, Monoethanolamine, Diethenol amine.*

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I. 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. Hundred percent 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 admixtures 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 and 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 steel and 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 forming a passive layer around the reinforcing steel 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. This paper deals with the experimental study to investigate the effect of amine groups as inhibitor in concrete containing quarry dust as fine aggregate in resisting corrosion.

II. LITRETURE REVIEW

Mohamed Moafak Arbili et al (2022)[1] have Concluded that Quarry dust (QD), which is generated in significant amounts from quarries and ag- gregates, is a serious environmental issue. These materials might have positive effects on the environment and the economy if they are used in buildings.

Lohani T.K et al (2012)[2] shows the slump value increases with increase in percentage replacement of sand with quarry dust for the same w/c ratio. Concrete does not give adequate workability with increase of quarry dust. Itcan be due to the extra fineness of quarry dust. Increased fineness require greater amount of water for the mix ingredients to get closer packing, results in decreasedworkability of the mix.

Rajkumar et al (2012)[3] have concluded the concrete containing well graded quarry dust as fine aggregate along with plasticizer can be effectively utilized in the construction industry. Among the various percentages 1%, 2%, 3% and 4% of Triethanolamine and Diethanolamine added, the quarry dust replaced concrete with 2% addition of inhibitor shows maximum improvement in the compressive strength, split tensile strength, flexural strength, and bond strength when compared to thecontrol specimen.

III. MATERIAL USED

A. CEMENT

The cement used in this study was ordinary Portland cement (OPC) of grade 43. The specific gravity of cement is 3.15. It has been possible to upgrade the qualities of cement by using high quality limestone, modern equipment's, and closer on line control of constituents, maintaining better particle size distribution, finer grinding and better packing. Although they are little costlier than low grade cement, they offer 10-20% saving in cement consumption and also they offer many other hidden benefits.

Table 3.1 Chemical properties of cement

S.NO	COMPONENTS	WEIGHT
1	Lime (CaO)	63%
2	Silica (SiO_2)	22%
3	Alumina (Al_2O_3)	6%
4	Iron oxide (Fe_2O_3)	3%
5	Magnesium oxide (MgO)	2.5%
6	Sulphur trioxide & loss of ignition (SO_3)	1.5%

B. NATURAL FINE AGGREGATE

Natural Fine aggregate available from the locally available is used. The physical properties of fine aggregate passing through 4.75mm IS sieve with specific gravity of sand found to be 2.67 and fineness modulus of the fine aggregate 3.60 were Tested in IS:2386.

C. QUARRY DUST

Quarry dust (QD) is one of the waste materials abundantly available and unused in a quarry industry. Previous finding showed that the substitution of QD as part of pozzolana gives good performance at fresh stated rheological properties and enhances compressive strength at hardened state. It is economical alternative to the river sand.

Table 3.2 properties of quarry rock dust and natural fine aggregate

CONSTITUENT	QUARRYDUST (%)	NATURAL SAND (%)
SiO_2	62.48	80.78
Al_2O_3	18.72	10.52
Fe_2O_3	06.54	01.75
CaO	04.83	03.21
MgO	02.56	00.77
Na_2O	Nil	01.37
K_2O	03.18	01.23
TiO_2	01.21	Nil
Loss on ignition	00.48	00.37

D. COARSE AGGRAGATE

Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and Portland cement, are an essential ingredient in concrete. Aggregate are the most important constituents in concrete. One of the most important factors for producing workable concrete is a good gradation of aggregates.

Good grading implies that a sample fraction of aggregates in required proportion such that the sample contains minimum voids.

E. MONOETHENOL AMINE

MEA is generally used as a 10 to 20 weight % solution in water. Due to corrosion problems, the acid gas loading is usually limited to 0.3 to 0.35 moles acid gas per mole of amine for carbon steel equipment. Loadings as high as 0.7 to 0.9 mole/mole have been used in stainless steel equipment with no corrosion problems. Although MEA itself is not considered to be particularly corrosive, its degradation products are extremely corrosive. MEA reacts with oxidizing agents such as COS, CS_2, SO_2, SO_3, and oxygen to form the soluble products which must be removed from the circulating system to avoid serious corrosion problems. Degradation or deactivation of MEA also lowers the effective amine concentration but fortunately a re-claimer can recover most of the deactivated amine. Since MEA is a primary amine, it has a high pH which enables MEA solutions to produce a sweetened gas product containing less than 1/4 grain H_2S per 100 SCF at very low H_2S partial pressures.

F. METHYLDIETHANOLAMINE

An accepted set of operating conditions has not been as firmly established for MDEA as for the previously mentioned amines. This has been due to the flexibility and versatility of MDEA and the resulting wide range of applications. Although the range of operating conditions for MDEA is expanding, the present range of successful applications will be discussed below. MDEA is commonly used in the 20 to 50 wt % range. Lower weight % solutions are typically used in very low pressure, high selectivity applications such as a SCOT tail gas cleanup unit. Due to considerably reduced corrosion problems, acid gas loadings as high as 0.7 to 0.8 mole/mole are practical in carbon steel equipment. Higher loadings may be possible with few problems. Exposure of MDEA to oxygen forms corrosive acids which, if not removed from the system, can result in the buildup of iron sulfide in the system. MDEA has several distinct advantages over primary and secondary amines which include lower vapor pressure, lower heats of reaction (600 BTU/lb CO_2 and 522 BTU/lb H_2S), higher resistance to degradation, fewer corrosion problems and selectivity toward H_2S in the presence of CO_2.

G. MIX DESIGN

Grade designation = M30

Type of Cement = OPC 53 grade

Maximum nominal size of aggregate = 20 mm

Minimum cement content = 300 kg / m^3

Maximum water – cement ratio = 0.55

Workability = 100mm (slump)

Exposure Condition = Mild (For Reinforced Cement Concrete)

Degree of supervision = Good

Type of Aggregate = Angular

TEST DATA FOR MATERIALS

Specific gravity of cement = 3.12

Specific gravity of C.A = 2.71

Specific gravity of Quarry Dust = 2.67

Water absorption for Coarse aggregate = Nil

Water absorption for Fine aggregate = Nil

Fine aggregate Conforming to grading Zone III (Table of IS 383)

IV. RESULT AND ANALYSIS

The experiment should be conduct for fresh and harden concrete under 7 days, 14days, 28 days and the result are discussed below.

A. SLUMP CONE TEST

The most important test conducted to fresh concrete to determine the workability of concrete was slump cone test. The proper mixing of concrete are should take in required mix proportion into the cone with the ratio of one third with proper compact of 25 blows using the 16mm diameter after the filling of cone remove the cone smoothly the sliding of concrete is known as slump value it should give the workability of the concrete.

Table 4.1 slump value

S No.	Water cement ratio	Slump value (mm)
1	0.35	Nil
2	0.40	34
3	0.45	100

B. COMPRESSIVE TEST

The test is carried out on 150x150x150 mm size cubes, as per IS: 516-1959. The test specimens are marked and removed from the moulds and unless required for test within 24 hrs, immediately submerged in clean fresh water and kept there until taken out just prior to test. A 1000 KN capacity Universal Testing Machine (UTM) is used to conduct the test. The specimen is placed between the steel plates of the UTM and load is applied at the rate of 140 $Kg/Cm^2/min$ and the failure load in KN is observed from the load indicator of the UTM.

$$\text{Compressive strength} = \text{Load / Area N/mm}^2$$

C. Split Tensile Strength Test

The splitting tensile strength of concrete cylinder was determined based on 516-1959. The load shall be applied nominal rate within the range 1.2 N/ (mm^2/min) to 2.4/ (mm^2/min). The test was carried out on diameter of 150mm and length of 300mm size cylinder

$$\text{Split Tensile Strength} = \frac{2P}{\pi DL}$$

Where, P = Compressive Load in N

L = Length in mm

D = Diameter in mm

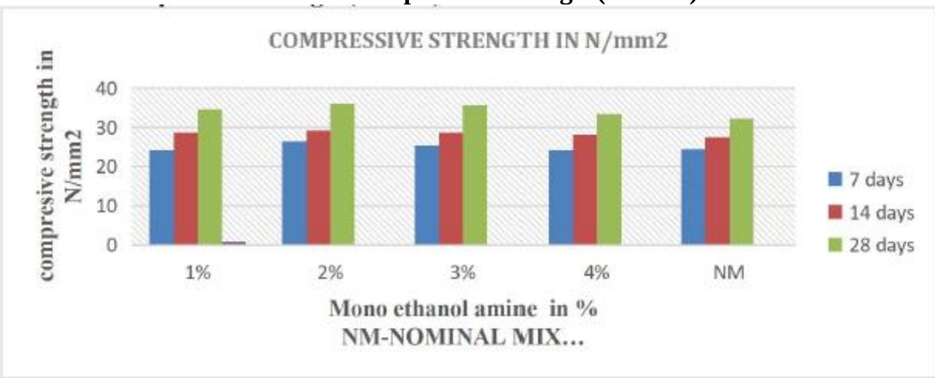
D. Flexural Strength Test

The flexural strength of concrete prism was determined based on IS: 516 –1959. Place the specimen in the machine in such a manner that the load is applied to the upper most surface as cast in the mould along two lines spaced 13.3cm a part. Apply load without shock and increase continuously at a rate of 180 kg/min and it is increased until the sample fails. Measure the distance between the line of fracture and nearest support.

Table No. 4.2 Compressive strength in (N/mm^2)

Description		**Average Compressive Strength (N/mm^2**		
		7 days	**14 days**	**28 days**
Mono ethanol amine	1%	24.2	28.6	34.64
	2%	26.4	29.2	35.98
	3%	25.4	28.7	35.65
	4%	24.2	28.2	33.43
Methyl diethanol amine	1%	24.8	26.8	33.65
	2%	26.4	28.4	35.54
	3%	25.6	26.2	35.34
	4%	24.2	26.1	33.05
Nominal mix	NIL	24.5	27.5	32.23

Chart 4.1 compressive strength(N/mm^2)



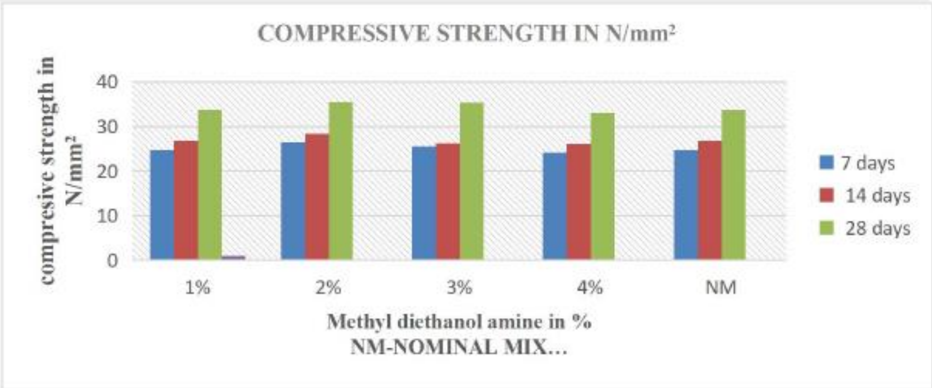


Table No. 4.3 Split Tensile strength in (N/mm^2)

Description		Average Split Tensile Strength (N/mm^2)		
		7 days	**14 days**	**28 days**
Mono ethanol amine	1%	1.62	2.12	2.98
	2%	1.92	2.32	3.62
	3%	1.66	2.24	3.47
	4%	1.61	2.02	3.36
Methyl diethanol amine	1%	1.68	2.22	2.83
	2%	1.98	2.46	3.24
	3%	1.72	2.26	3.12
	4%	1.66	2.16	3.05
Nominal mix	NIL	1.66	2.28	2.62

Chart 4.2 Split Tensile strength(N/mm^2)

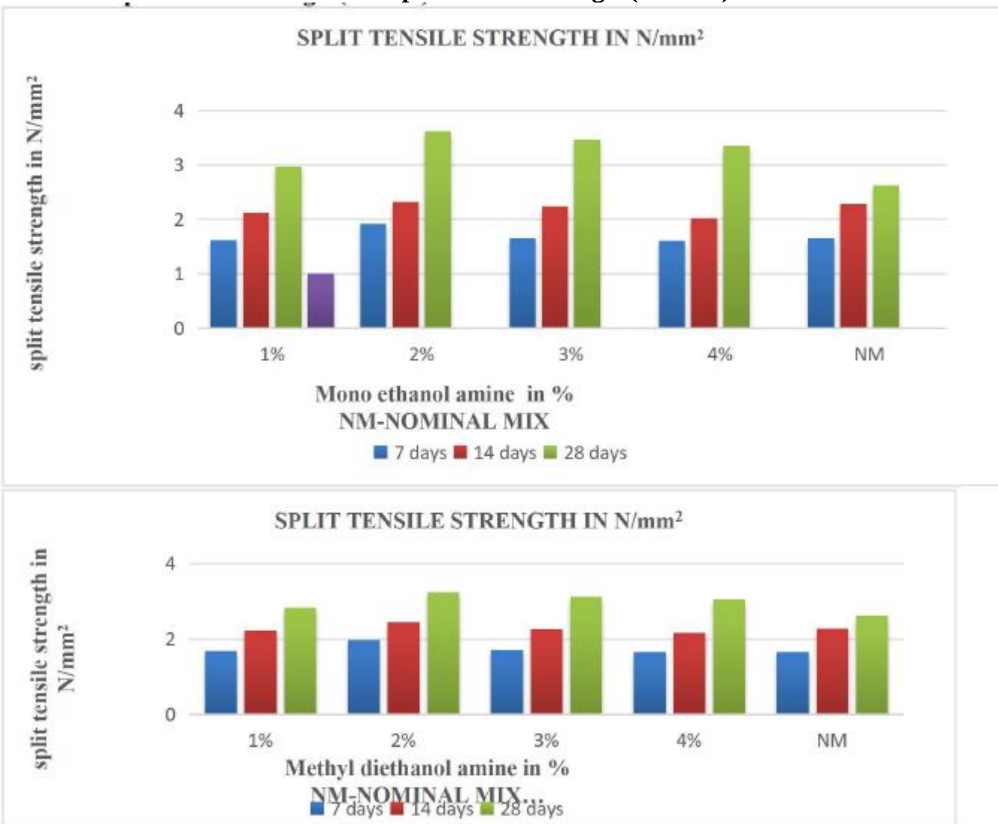
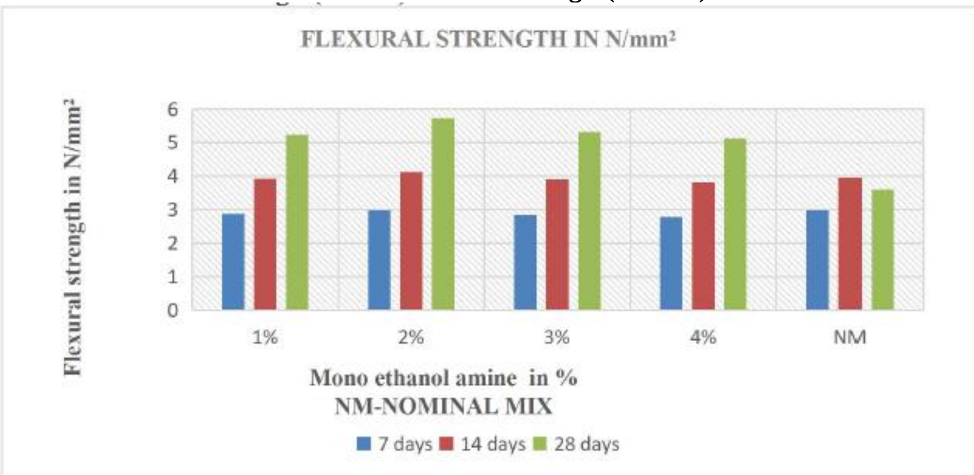


Table 4.4 Flexural strength in (N/mm^2)

Description		Average Flexural Strength (N/mm^2)		
		7 days	**14 days**	**28 days**
Mono ethanol amine	1%	2.88	3.92	5.23
	2%	2.98	4.12	5.72
	3%	2.84	3.91	5.32
	4%	2.78	3.82	5.12
Methyl diethanol amine	1%	2.98	3.98	4.96
	2%	3.10	4.23	5.54
	3%	2.92	4.12	5.22
	4%	2.88	3.94	5.02
Nominal mix	NIL	2.98	3.96	3.6

Chart 4.3 Flexural strength(N/mm^2)



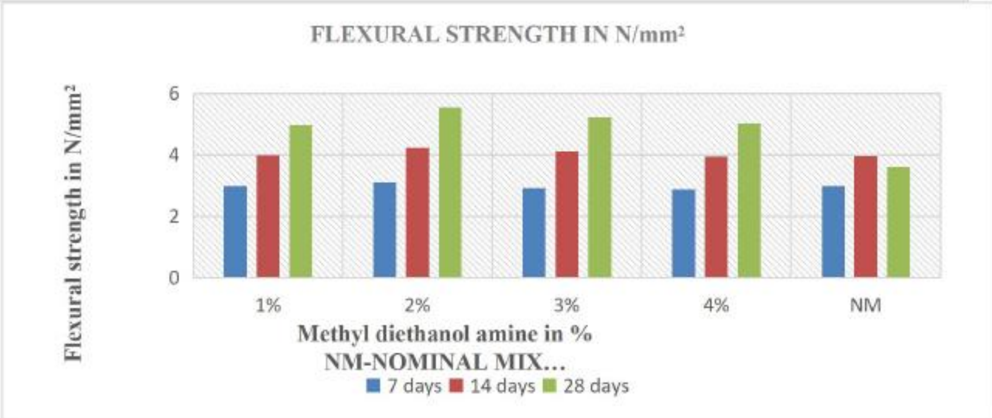
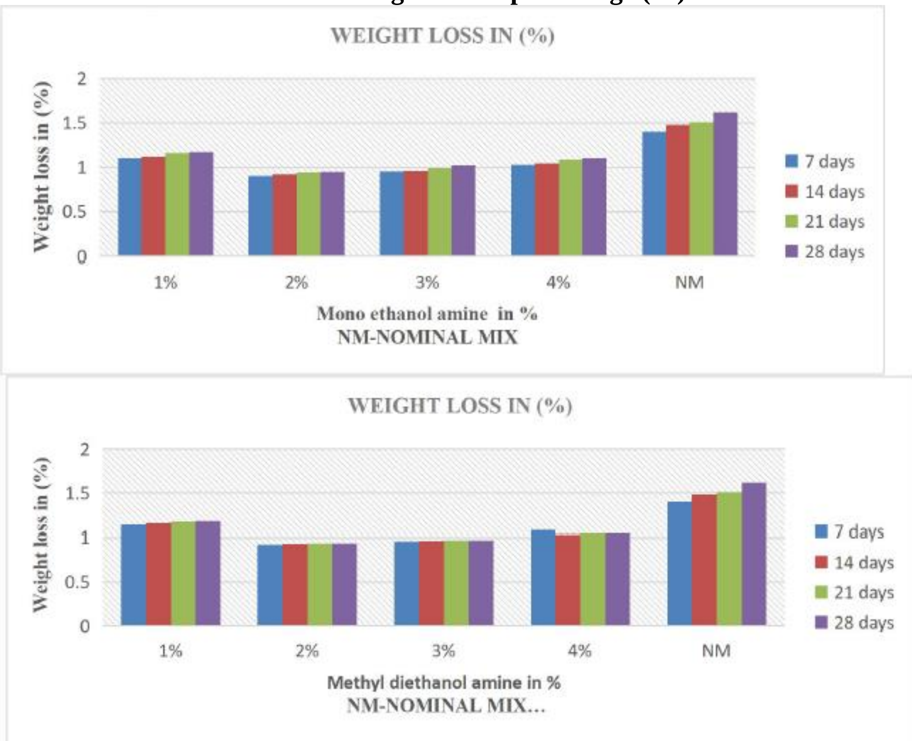


Table 4.5 Weight loss in percentage (%)

Description		Weight loss in percentage (%)			
		7 days	14 days	21 days	28 days
Mono ethanol amine	1%	1.104	1.122	1.162	1.172
	2%	0.902	0.923	0.941	0.951
	3%	0.953	0.961	0.992	1.023
	4%	1.026	1.045	1.084	1.103
Methyl diethanol amine	1%	1.142	1.159	1.174	1.180
	2%	0.925	0.931	0.934	0.938
	3%	0.961	0.964	0.970	0.972
	4%	1.084	1.04	1.047	1.049
Nominal mix	NIL	1.403	1.480	1.510	1.620

Chart 4.5 Weight loss in percentage (%)



V. 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% by volume of cement.
- The strength of the concrete increased in the percentage of 2% addition of monoethanolamine and methyldiethanolamine increases the strength at the age of 28, 60, 90 and 120 days.
- It was observed monoethanolamine and methyldiethanolamine 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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