Effect of zeolite and cement addition on geotechnical properties of granular soil

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Abstract - *It is well known that the cement stabilized sand is one of economic and environmental topics in soil stabilization. The improvement of local soils with cement and zeolite can provide great benefits, including slopes strength through slope stability problems, stabilising poor soils and preventing soil liquefaction. Recently, dosage methodologies are being developed for soil improvement based on a rational criterion as it exists in concrete technology. In this study, based on an experimental program, the effects of zeolite on the characteristics of cement treated sands are investigated. Stabilizing agent includes Portland cement and zeolite. Results show permeability get decreased with increase in cement content. we add 4%, 6%, 8% and 10% cement by the weight of sand after that for 10% of cement add different % of zeolite by the weight of cement which replace the cement in the mix and find permeability, here also permeability get decreased. Similar procedure follow for compaction test also, in compaction test maximum value of MDD is obtain at 10% cement by the weight of sand with 50% Zeolite replacement by the weight of cement.*

Keywords: Geotechnical properties of sand, cemented sand, zeolite, compaction, permeability.

I. INTRODUCTION

Soil stabilization with cement is a ground improvement technique for many years in some engineering applications such as construction of stabilized bases under pavements, canal lining (Khair, 1988; Khair et al., 1991). This reliable and simple soil improvement technique can provide great advantages including increasing shear strength parameters and avoiding the use of borrow materials from elsewhere. The compressive strength of artificially cemented soils has been studied by many researchers (Clough et al., 1981; Coop and Atkinson, 1993; Huang and Airey, 1998; Consoli et al., 2000, 2006, 2007, 2009, 2013; Thomé et al., 2005; Dalla Rosa et al., 2008; Consoli and Foppa, 2014; Horpibulsuk et al., 2014; Yilmaz et al., 2015). However, there has been a little effort devoted to the study on the use of pozzolans such as natural zeolite in cemented sands. Zeolites are three-dimensional, microporous, crystalline solids with well-defined structures that contain aluminium, silicon and oxygen in their regular framework; cations and water are located in the pores. The silicon and aluminium atoms are tetrahedrally coordinated with each other through shared oxygen atoms. Compositionally, zeolites are similar to clay minerals. More specifically, both are alumino-silicates. Similar to other pozzolanic materials, zeolite substitution can improve the strength of cement by pozzolanic reaction with Ca(OH)2, prevent undesirable expansion due to alkaliaggregate reaction, reduce the porosity of the blended cement paste, and improve the interfacial microstructure properties between the blended cement paste due to this permeability get reduced by using zeolite and also maximum dry density and optimum moisture content get increased.

II. MATERIALS USED AND METHODOLOGY

Sand: In the present study the sand sample were obtained from bank of Narmada river Jabalpur district of Madhya Pradesh state of India with latitude 23.1815°N and longitude79.9864°E. The sand of this region is SP as per IS classification. The various properties of sand are tested in the laboratory and results are as given in table2.1.

Table-2.1: Basic properties of Narmada sand

Properties of Sand	Values
Soil type as per IS: 1498-1970	SP
Specific Gravity	2.64
Fine Content (<75μ),%	4.00
Coefficient of uniformity, Cu	2.91
Coefficient of curvature, Cc	1.14
Maximum Dry Density (g/cc)	2.13
Optimum Moisture Content	6.08

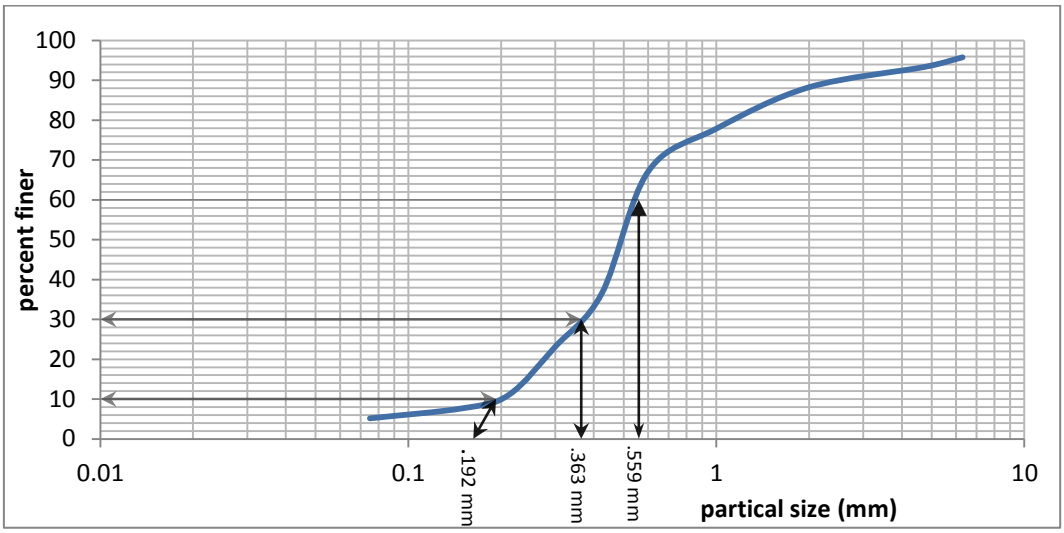

Figure1: particle size distribution curve.

zeolite: The zeolite is of natural clinoptilolite kind and particles smaller than 75µm are referred to as fine aggregates. The zeolite is non-plastic and classified as silt according to the unified soil classification system with specific gravity 2.2 Zeolite have unique characteristics such as high specific surface area and cation exchange capacity as well as ability to store heat between hydration and dehydration cycles (Colella et al., 2001). Moreover, zeolite, which is a softer material than the Portland cemen, increases the fineness of the ground material and reduces the grinding time (Canpolat et al., 2004). The replacement of Portland clinker by zeolitic tuff reduces workability (Sersale, 1995) and increases water demand as a cement–water mixture contacts with zeolite minerals, the alumino-silicate framework of the zeolite starts decomposing, under the attack of OH− in a high-pH solution. Depolymerised species, such as [SiO(OH)3]− and [Al(OH)4]− , enter the solution and react with Ca2 + , forming hydrated calcium silicate and calcium aluminate compounds, very similar to those formed during the hydration of cement**.** These are the chemical composition of zeolite.

Table2.2: chemical composition of zeolite (AKSHAR EXIM CO.PVT.LTD)

SiO2	67.44%
Al2 O3	10.8%
Fe2 O3	0.84%
CaO	1.24%
pH	7.1

cement: Ordinary Portland cement of 43 grade used was applied in this study. Cement can be defined as the bonding material having cohesive & adhesive properties which make it capable to unite the different construction material and from the compacted assembly.

EXPERIMENTAL WORK

Tests on the cemented sand and zeolite samples with different proportion of zeolite were performed in three stages.

In the first stage, Geotechnical characteristics of the sand samples were determined by conducting grain size analysis, specific gravity test, as per Indian Standards.

In the second stage, permeability of sand determine first than permeability is tested for different % of cement addition, after that at 10% cement addition different % of zeolite replaced and find permeability for each sample.

In the third stage, MDD and OMC of sand sample is determine first than with increase in cement content in sand (4%, 6%, 8%, and 10%) MDD and OMC is determined, after that zeolite is replaced with different % by the weight of cement, determine MDD and OMC of the mix.

III. LABORATORY EXPERIMENTS CONDUCTED

Permeability Characteristics (IS: 2720- Part 17, 1986) The permeability of cemented sand and zeolite mixtures was measured by Falling Head Test method.

Formula used: The coefficient of permeability has been determined by the relation.

$$K = 2.303 \frac{aL}{(At)} \log_{10} \frac{h1}{h2}$$

K = Coefficient of permeability in cm/sec. at test temperature

a = Inside cross sectional area of stand pipe in cm2

A = Cross sectional area of soil sample

L = Length of soil sample in cm

h_1 =Initial head in cm

h_2= Final head in cm

t = Time interval in seconds in which the head drop from h_1 to h_2

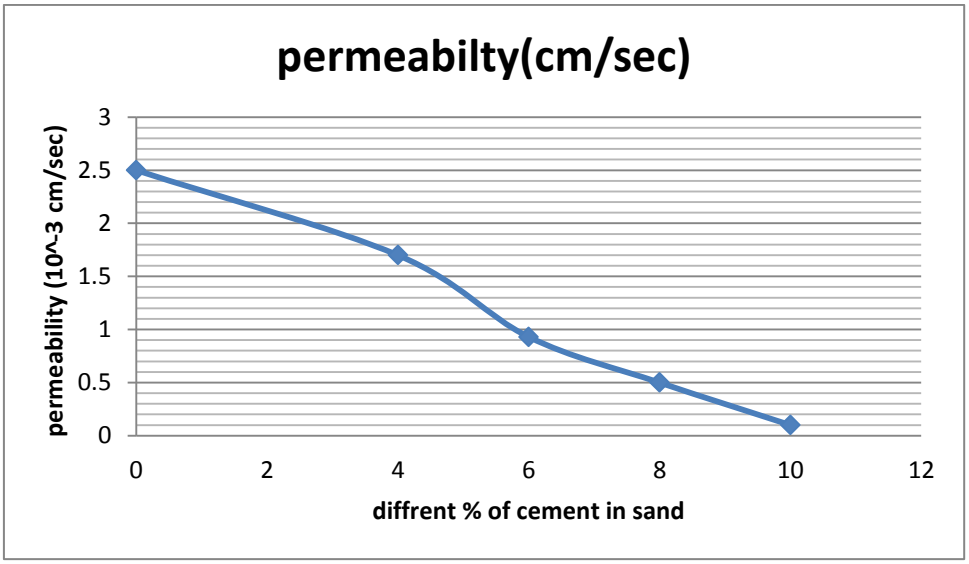

Figure2: permeability comparison for different % of cement in sand.

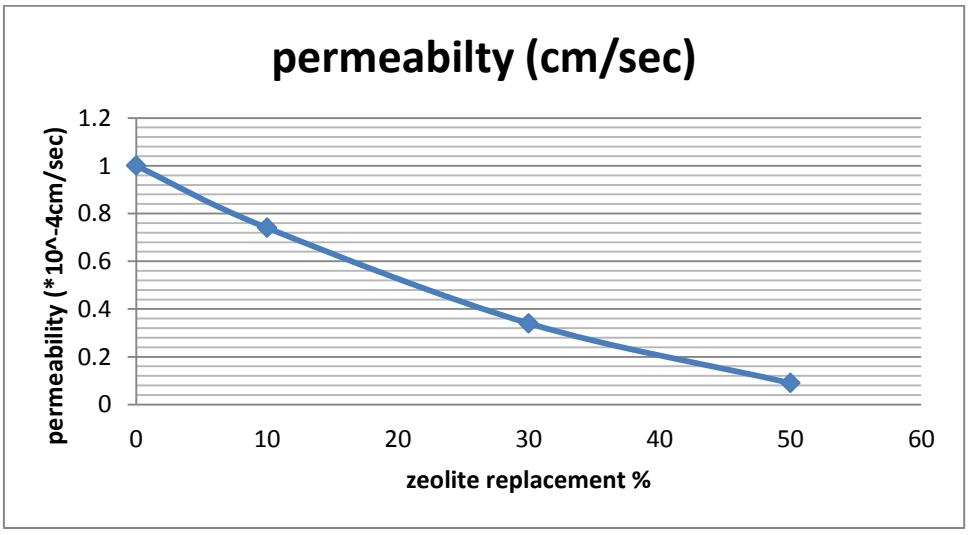

Figure3: permeability comparison of different % of zeolite replacement by the weight of cement, in 10% cemented sand

Modified Compaction Test

Heavy compaction test was carried out on specimens as per IS 2720 (Part 8) 1980. The compaction curves for cemented sand and geolite mixture was obtained and the OMC and MDD curves are also plot in graph. These OMC and MDD values

obtained from laboratory compaction test provide a reference point while estimating the actual water content of the field-compacted soil. The variation of MDD and OMC of the compacted cemented sand and geolite mixtures are presented in the Figure.

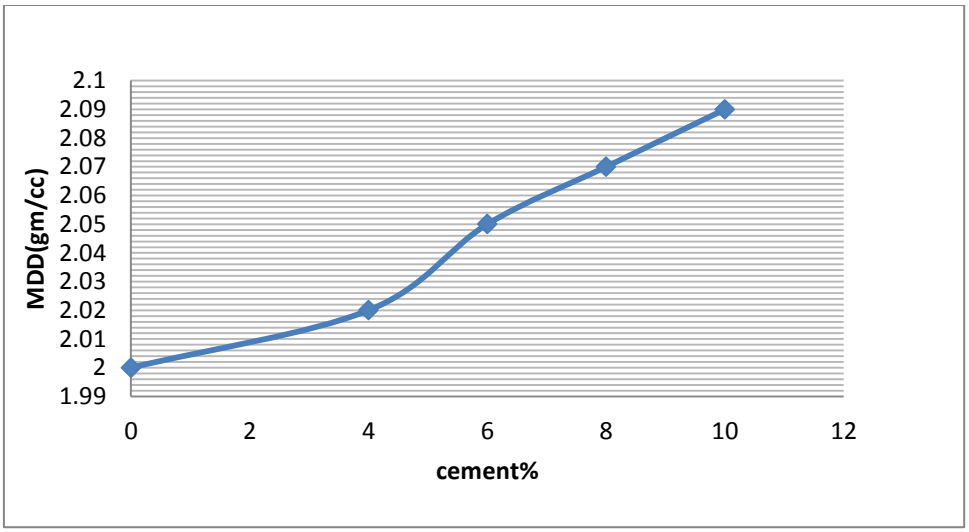

Figure4: variation of MDD with different % of cement in sand.

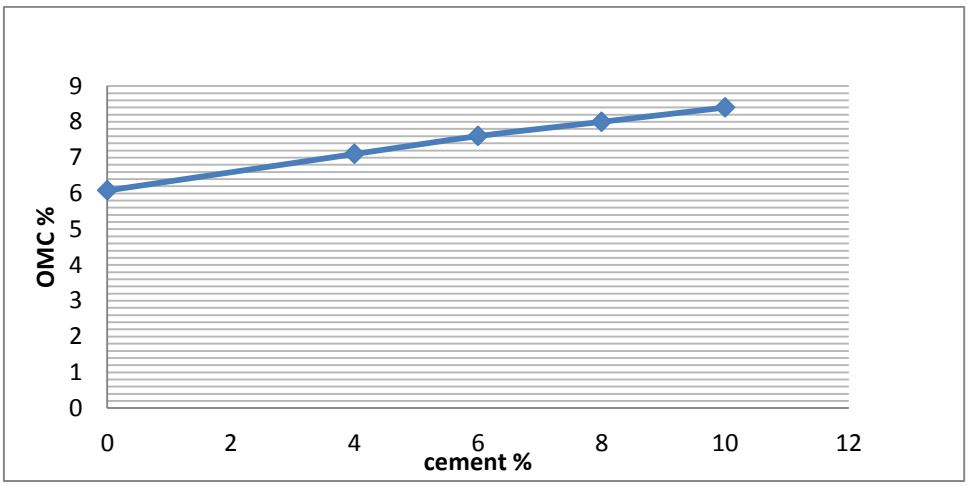

Figure5: variation of OMC with different % of cement in sand.

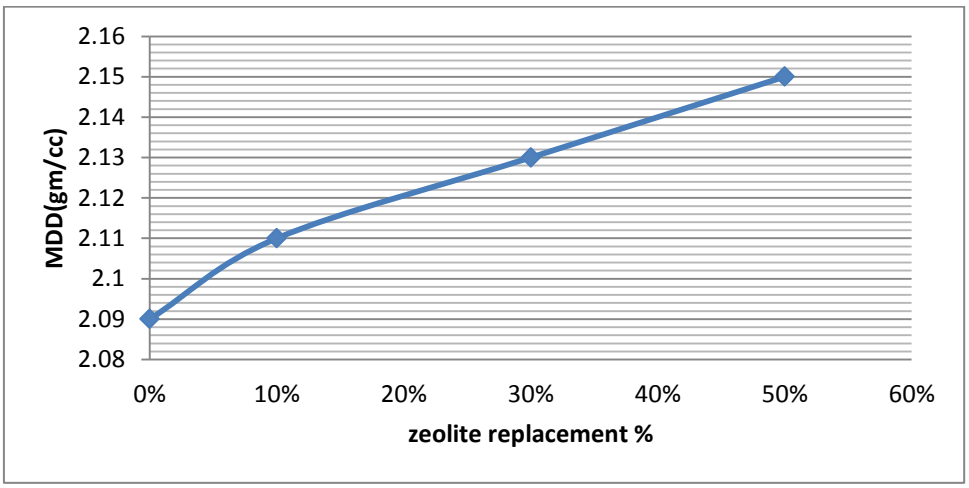

Figure6: variation of MDD with zeolite replacement in cemented sand at 10% cement.

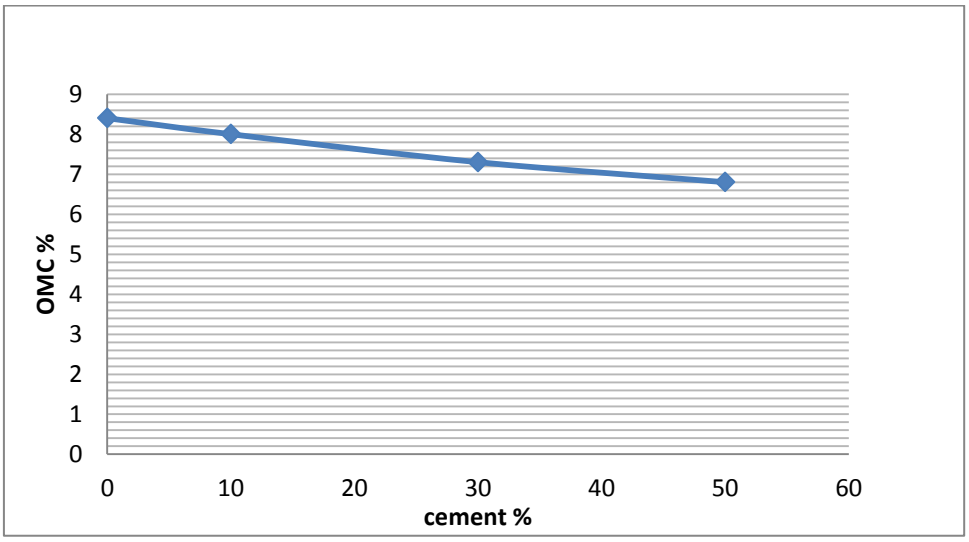

Figure7: variation of OMC with zeolite replacement in cemented sand at 10% cement

CONCLUSIONS

With Based on the findings of the present investigations, the following conclusion can be drawn.

1. Permeability of sand get significantly decreased due to addition of cement.
2. If we replace cement partially with zeolite permeability of mix gets further decreased.
3. With the increase in the cement content maximum dry density and optimum moisture content get increased.
4. If cement is partially replaced by zeolite MDD gets increased but OMC gets decreased.

Based on the above test results it can be oncluded that cement treated sand replaced with different % of zeolite by the weight of cement decreases permeability and OMC of mix and increases MDD value of mix.

REFERENCES

1. Ameta N.K. and Wayal AbhayShivaji(2008), Ahmadi, B. and Shekarchi, M. 2010. Use of natural zeolite as a supplementary cementitious material, Cement and Concrete Composites, **32**, (2), 134–141.

2. Astm D 2166. 2000. Standard test method for unconfined compressive strength of cohesive soil, Philadelphia, American Society for Testing and Materials.

3. ASTM D 422. 2003. Standard test method for particle-size analysis of soils, Philadelphia, American Society for Testing and Materials.

4. ASTM D 2487. 2006. Standard classification of soils for engineering purposes, Philadelphia, American Society for Testing and Materials.

5. ASTM D 4253. 2000. Standard test methods for maximum index density and unit weight of soils using a vibratory table, Philadelphia, American Society for Testing and Materials.

6. ASTM D 4254. 2000. Standard test methods for minimum index density and unit weight of soils and calculation of relative density, Philadelphia, American Society for Testing and Materials.

7. ASTM C 150. 2007. Standard specification for Portland cement, Philadelphia,

8. ASTM D 854. 2000. Standard test methods for specific gravity of soil solids by water pycnometer, D 854, Philadelphia, American Society for Testing and Materials.

9. Bilim, C. 2011. Properties of cement mortars containing clinoptilolite as a supplementary cementitious material. Construct. Build. Mater., **25**, (8),3175–3180.

10. Canpolat, F., Yılmaz, K., Kose, M. M., Sumer, M. and Yurdusev, M. A. 2004.Use of zeolite, coal bottom ash and fly ash as replacement materials in cement production. Cem. Concr. Res., 34, (5), 731–5.
11. Clough, G. W., Sitar, N., Bachus, R. C. and Rad, N. S. 1981. Cemented sands under static loading. J. Geotech. Eng. Div., 107, (6), 799–817.
12. Colella, C., Gennaro, M. and Aiello, R. 2001. Use of zeolitic tuffs in the building industry. Rev. Mineral Geochem., 45, (1), 551–87.
13. Consoli, N. C., Cruz, R. C., da Fonseca, A. V. and Coop, M. R. 2011. Influence of cement-voids ratio on stress-dilatancy behavior of artificially cemented sand. J. Geotech. Geoenviron., 138, (1), 100–109.