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Studies on the interaction between clay soil and concrete with addition of fly ash class-C and due to encroachment of seawater

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Abstract: **This paper inspect the influence of Normal water & Seawater on curing in concrete cubes which is concealed on clay soil near costal zones with three different percentage of clay at 90%, 50% & 30%. Cement concrete cubes of 150x150x150mm were cast using normal water and cured with seawater & normal water with two different mix proportions M-20 & M-30 with 0.45 water cement ratio. The prepared concrete cubes are concealed in Clay soil to understand the effects of seawater and normal water in terms of compressive strength and NDT test. Compressive strength and NDT test are tested during 28th day and 84th day. Totally 108 specimen were cast with normal water. Cement in addition with fly ash class-C of 20% and 30% was also used for this investigation.**

Keywords: **Clay soil, fly ash, Seawater, Compressive Strength, NDT.**

1. INTRODUCTION

In India, coastal zones of soils are prone to substantial change in their geotechnical Properties. The change in geotechnical performance of soil is mainly due to ions in saline water and types of clay mineral in soil layers. Due to sea water intrusion in Costal zones, the soil Properties get changed and causing instability in construction of Substructure and superstructure. Modification of soil not only depends on nature of pollutant but also depend on chemical Composition, physical nature and mineralogical properties.The change in the Atterberg's limits, dry densities and the optimum moisture content leads to the change in the behaviour of the Structural arrangements of soil. The natural arrangement of soil is affected to some extent due to the presence of salinity in the groundwater table.

2. MATERIALS USED

2.1 Clay Soil

Concrete cubes are concealed in locally available clay soil with three different proportions of soil with clay at 90%, 50% & 30%.Nonakuppam, Puducherry, India. The Geotechnical properties of cohesive soil are discussed in this Study.

2.2 Cement

OPC- 43 confirming to IS 8112-1989 used in this project work and ultra tech cement is used. The specific gravity of cement is 3.15.

2.3 Fine aggregate

River sand is used of size 4.75mm passing sieve used in this project. The properties of fine aggregate are determined as per IS 2386-1963 to have a specific gravity of fine aggregate is2.60 confirming at zone II.

2.4 C*oarse aggregate*

The natural crushed granite of 20mm aggregate passing on sieve at 60% used and 12mm of retained at 40% is used in this work. The properties of coarse aggregate are determined as per IS 2386-1963 to have a specific gravity of coarse aggregate is 2.60

2.5 Water

The normal potable water is available in laboratory was used for casting and curing of conventional concrete cube

2.6 Sea water

To study the effect of seawater on geotechnical properties of clayey soil in concrete cubes.

2.7 Fly ash

Fly ash is a by-product of burning pulverized coal in electric power plant. Two types of fly ash are commonly used in concrete; class C and class F. In this work we use class C, it has high calcium fly ashes with carbon content less than 2%.

3. METHODOLOGY

The general mix proportions are provided in IS: 10262-2009, for M20 and M30 grade of concrete was arrived as 1: 1.5: 3 and 1: 0.75: 1.5 with water-cement ratio of 0.45.A concrete cube specimen of size 150mm x 150mm x 150mm were cast and tested the compressive strength at 28th &84th days. The various physical properties and chemical properties of clays soil due to effects of sea water were investigated.

4. RESULTS AND DISCUSION

4.1 Grain Size

To find out the Grain size distribution of clayey soil in coastal zones, the test performed are Sieve analysis and Hydrometer test. From the experimental analysis, clay soil sample are separated into three categories with 90%, 50% % 30% of clay content in collected soil sample. Generally Clay being size less than 0.002 mm in diameter.

4.2 Specific Gravity

Specific gravity of fine-grained soil was determined by density bottle method as per IS: 2720 (Part III/Sec 1).

4.3 Free Swell Index

As per IS 2720 (Part 40), the free swell index is an increase in the volume of a soil without any external restriction, on submergence in ordinary potable water.

4.4 Unconfined compression test

The unconfined compressive strength (qu) is the load per unit area at which the cylindrical specimen of a cohesive soil falls in compression. The stress-strain curve obtained from the unconfined compression test of the soil sample is obtained.

4.5 Atterberg limit

Atterberg limits are the water contents which define transitions between the solid, plastic, and liquid states of a given soil Sample. Due to Seawater intrusion in concrete, Index properties of soil get changed. The index properties of soils are liquid limit (LL), plastic limit (PL), and shrinkage limit (SL) and plasticity index (PI).

Table 1: Cohesive soil Properties before placing concrete cubes in clay soil

Description	Clay Soil
Specific gravity	2.52
Liquid limit	48.61
Plastic limit	25.72
Shrinkage limit	24.28

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Plasticity index	22.89
Free Swell index	6.13
OMC	28.13
UCC	18.73

Table 2: Cohesive soil properties after placing concrete cubes in clay soil at 28th day

Description	**Clay Soil**		
	90%	**50%**	**30%**
Specific gravity	2.42	2.60	2.67
Liquid limit	46.53	35.12	-
Plastic limit	20.09	21.78	-
Shrinkage limit	5.27	2.89	-
Plasticity index	26.44	13.34	-
OMC	15.98	26.54	-
UCC	4.39	3.98	-

Table 3: Cohesive soil properties after placing concrete cubes in clay soil at 84th day

Description	**Clay Soil**		
	90%	**50%**	**30%**
Specific gravity	2.42	2.60	2.32
Liquid limit	46.53	32.12	-
Plastic limit	20.09	20.78	-
Shrinkage limit	5.27	2.87	-
Plasticity index	26.44	11.34.	-
OMC	15.98	28.4	-
UCC	4.39	3.98	-

4.6 Compressive Strength

The standard mould of size 150mm × 150mm ×150mm is used for casting. Curing is done for 28thdays&84th day for concrete cubes and the compressive strength test is done in (CTM) as per IS 516:1959 for ordinary mix using normal water in curing and samples with sea water curing in clay soil without fly ash mix

Table 4: Compressive strength of concrete with normal water curing and sea water curing in clay with 90%, 50%and 30% proportions

Description	**M-20**		**M-30**	
	28th day	**84th day**	**28th day**	**84th day**
Normal water curing	24.13	29.91	25.48	34.60
Sea water curing buried in clay soil (90%)	20.74	18.56	36.82	21.49
Sea water curing buried in clay soil (50%)	9.56	14.54	19.33	22.84
Sea water curing buried in clay soil (30%)	13.36	19.45	19.14	24.72

The above table values are calculated from (CTM) test of three samples from each description and average values is listed out in the table

Figure 1: Compressive Strength

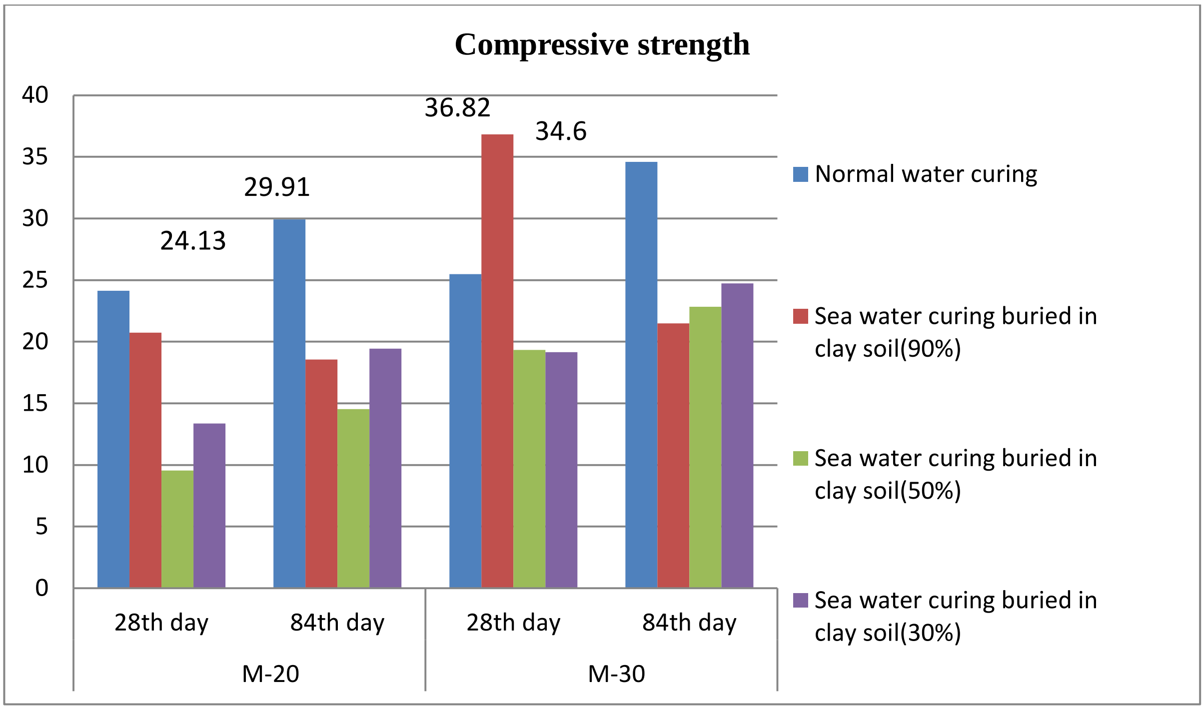

Figure 2: Compressive strength without fly ash class-c.

The fig 2 shows that the compressive strength of concrete in normal water curing condition gives you the higher value when compared with seawater intrusion in clay soil with different proportions.

Table 5: compressive strength of concrete with fly ash 20%

Description	**M-20**		**M-30**	
	28th day	**84th day**	**28th day**	**84th day**
Normal water curing	25.94	20.60	39.61	31.85
Sea water curing buried in clay soil (90%)	17.64	20.40	25.22	11.85
Sea water curing buried in clay soil (50%)	16.77	23.61	20.04	20.07
Sea water curing buried in clay soil (30%)	13.36	19.45	19.14	24.72

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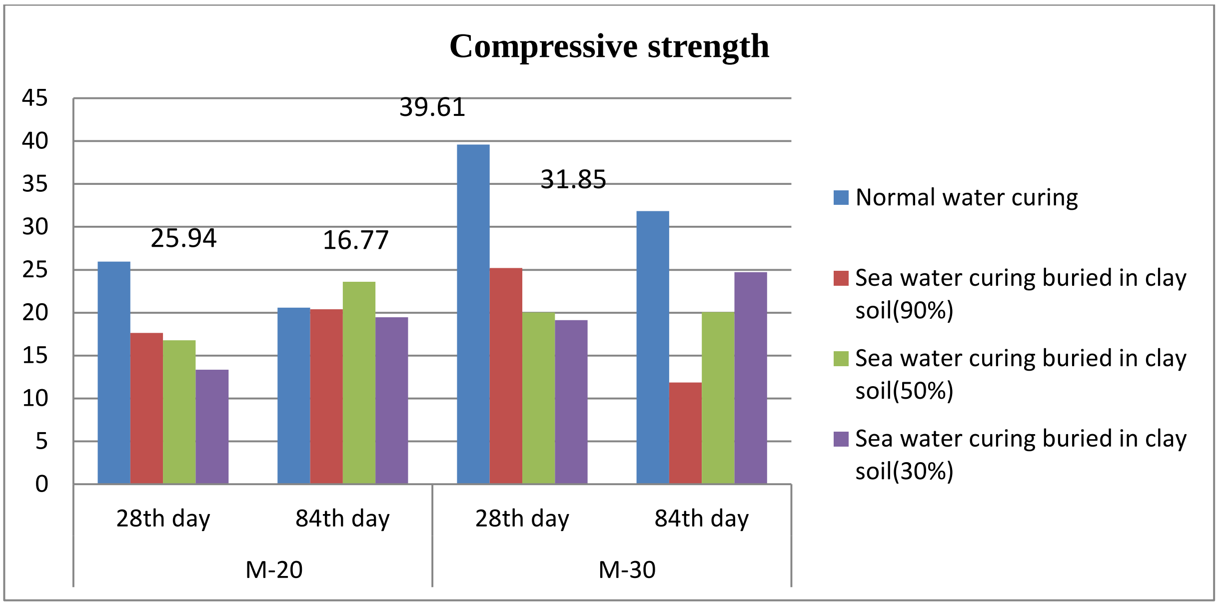

Figure 3: Compressive strength with fly ash class-c at 20%

The fig 3 shows that the compressive strength of concrete in normal water curing condition gives you the higher value in 28th day M-30 grade when compared with seawater intrusion in clay soil with different proportions.

Table 6: compressive strength of concrete with fly ash 30%

Description	M-20		M-30	
	28th day	84th day	28th day	84th day
Normal water curing	22.50	28.14	26.31	29.36
Sea water curing buried in clay soil(90%)	10.81	15.85	19.82	17.55
Sea water curing buried in clay soil(50%)	11.45	15.40	12.62	13.54
Sea water curing buried in clay soil(30%)	15.77	15.65	17.60	16.81

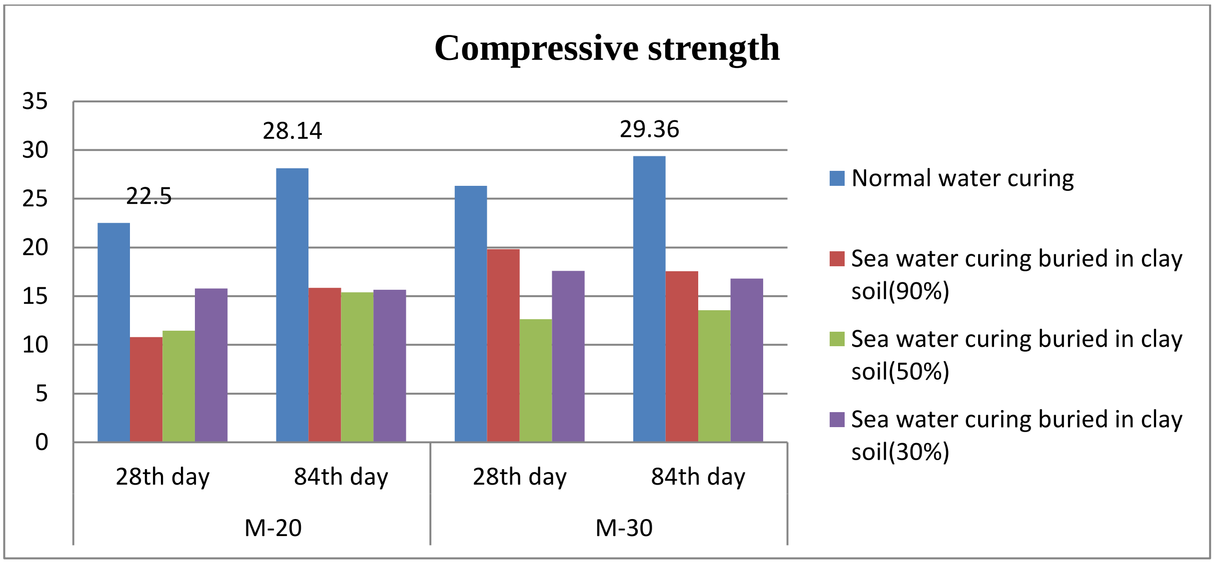

Figure 4: Compressive strength with fly ash class-c at 30%.

The fig 4 shows that the compressive strength of concrete in both the curing condition gives you the higher value in 84th day M-20&-30 grades with seawater intrusion in clay soil with different proportions.

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4.7 Ultra - Sonic pulse velocity method

This test is done to measure the quality of concrete by ultrasonic pulse velocity method as per IS: 13311 (Part 1) – 1992. This method consists of measuring the time of travel of an ultrasonic pulse passing through the concrete being tested. Comparatively higher velocity is obtained when concrete quality is good in terms of density, uniformity, homogeneity.

Table 7: UPV of concrete without fly ash

Description	M-20		M-30	
	28th day	84th day	28th day	84th day
Normal water	4637	4657	4533	4860
Sea water curing buried in clay soil (90%)	4664	4674	4544	4754
Sea water curing buried in clay soil (50%)	4177	4487	4507	4620
Sea water curing buried in clay soil (30%)	4407	4547	4480	4664

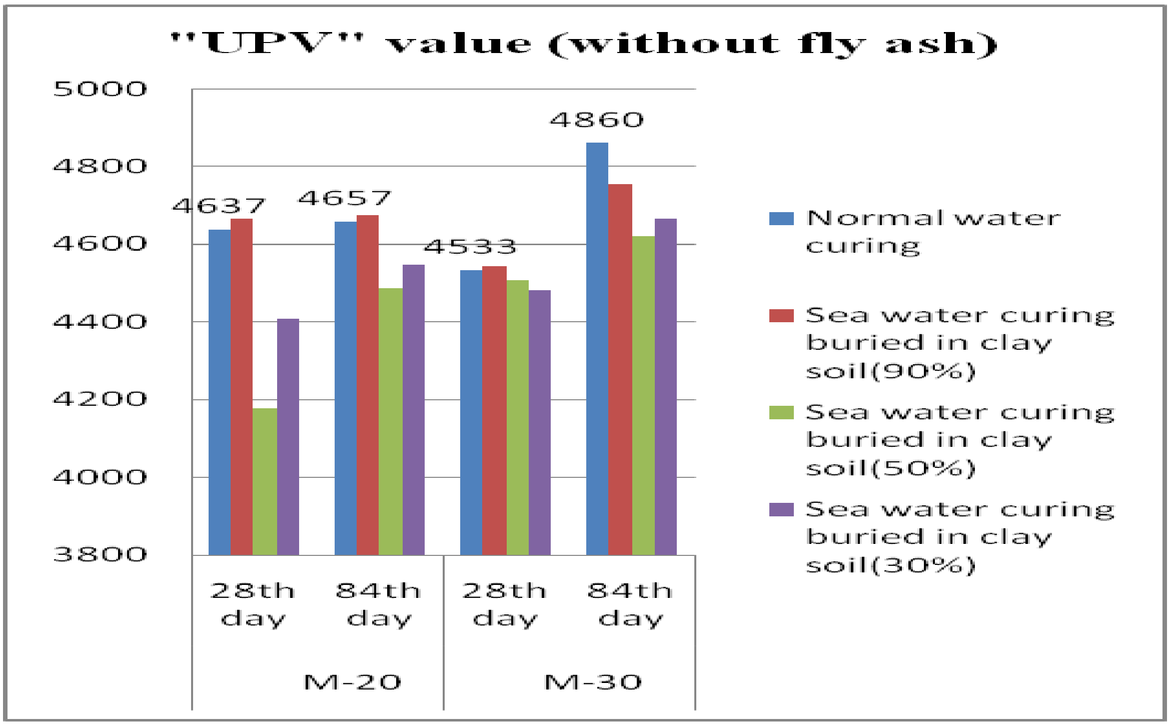

Figure 5: UPV for concrete without fly ash

The fig 5: shows that the UPV of concrete in normal water curing condition gives higher value in 84th day M-30 grades with seawater intrusion in clay soil with different proportions.

Table 8 UPV of concrete with fly ash -20%

Description	M-20		M-30	
	28th day	84th day	28th day	84th day
Normal water	4747	4357	4734	4460
Sea water curing buried in clay soil (90%)	4377	4520	4540	4477
Sea water curing buried in clay soil (50%)	4150	4467	4197	4637
Sea water curing buried in clay soil (30%)	4494	4447	4477	4454

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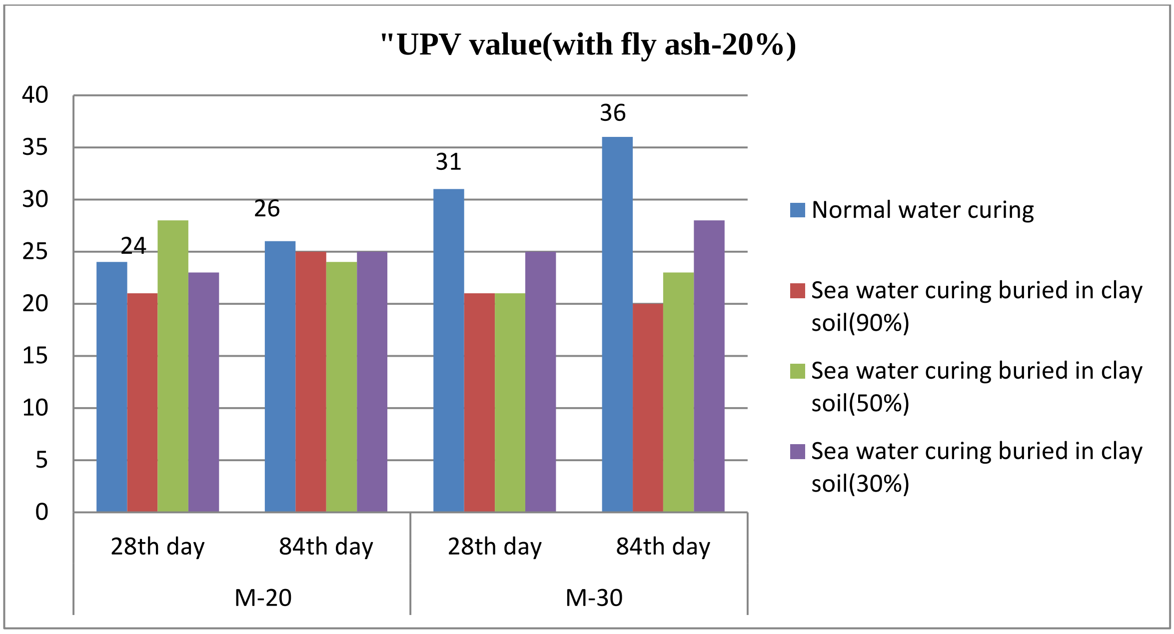

Figure 6: UPV for concrete with fly ash -20%

The fig 6 shows that the UPV of concrete in normal water curing condition gives higher value in 24th day M-20 grades with seawater intrusion in clay soil with different proportions.

Table 9: UPV of concrete with fly ash -30%

Description	M-20		M-30	
	28th day	84th day	28th day	84th day
Normal water	4564	4364	4684	4584
Sea water curing buried in clay soil (90%)	4497	4354	4180	4700
Sea water curing buried in clay soil (50%)	4464	4290	4300	4484
Sea water curing buried in clay soil (30%)	4406	4190	4744	4354

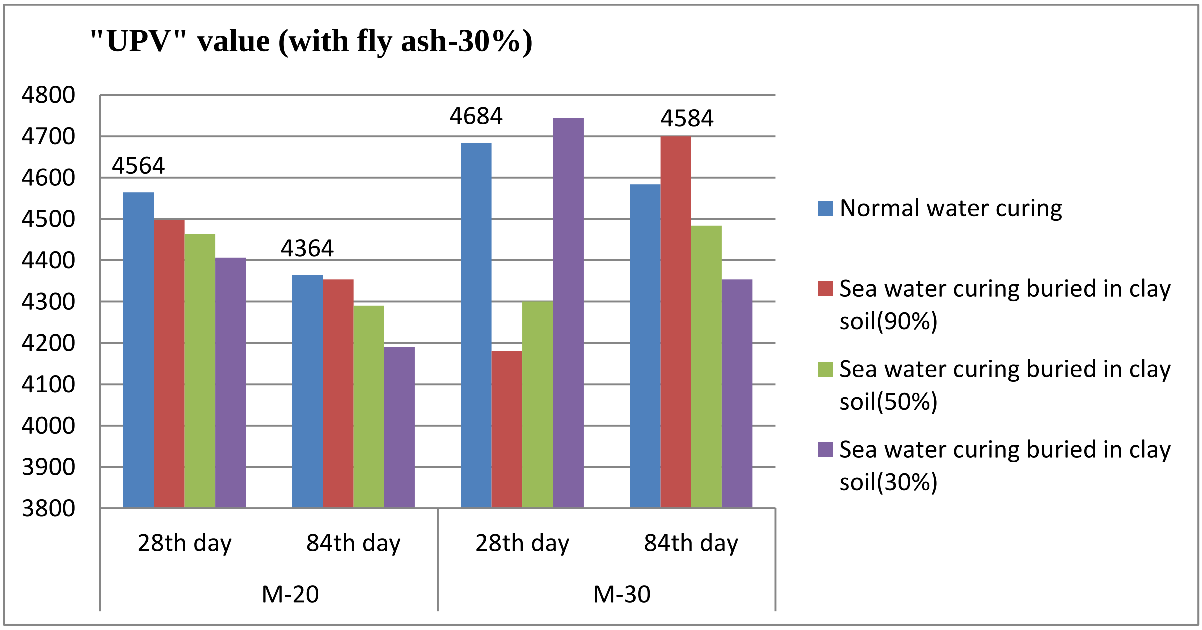

Figure 7: UPV for concrete with fly ash -30%

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The fig 7 shows that the UPV of concrete in Seawater curing condition gives higher value in 24th day M-30 grades with seawater intrusion in clay soil with different proportions.

4.8 Rebound hammer test

Rebound hammer test is done to find out the compressive strength of concrete by using rebound hammer as per IS: 13311 (Part 2) – 1992. The underlying principle of the rebound hammer test. The rebound of an elastic mass depends on the hardness of the surface against which its mass strikes.

Table 10: UPV of concrete with fly ash -30%

Description	M-20		M-30	
	28th day	84th day	28th day	84th day
Normal water	23	28	28	32
Sea water curing buried in clay soil (90%)	27	21	25	24
Sea water curing buried in clay soil (50%)	24	23	31	36
Sea water curing buried in clay soil (30%)	24	28	25	30

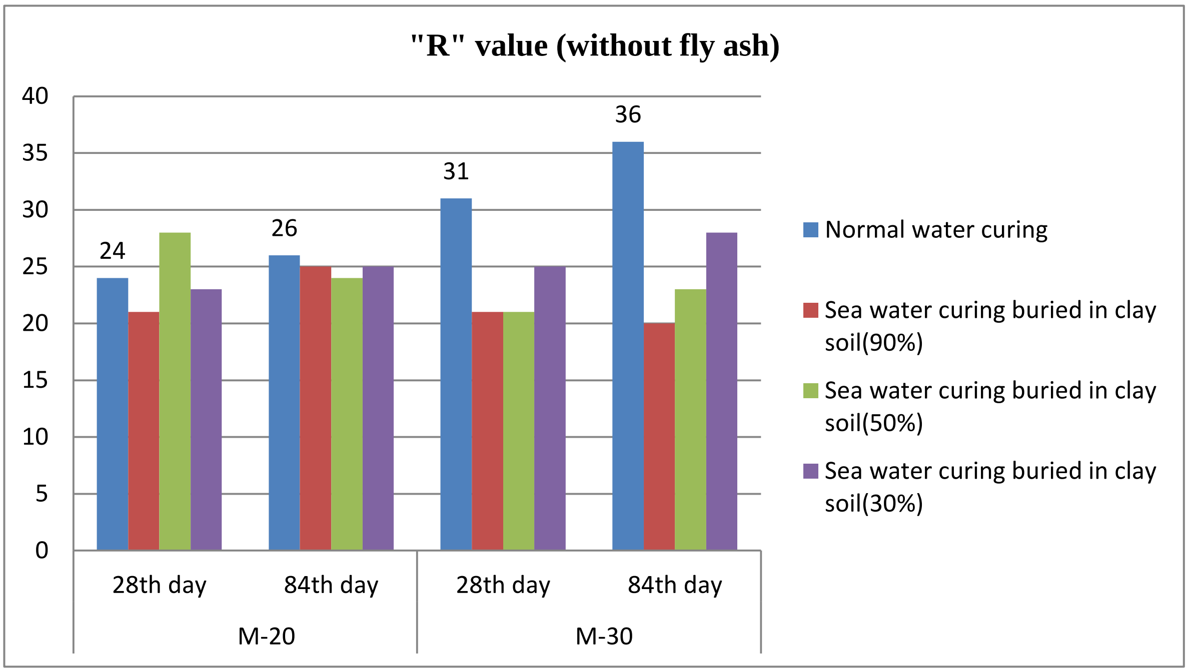

Figure 8: R value for concrete without fly ash

The fig 8 shows that the UPV of concrete in Normal water curing condition gives higher value in 84th day M-30 grades with seawater intrusion in clay soil with different proportions.

Table 11: UPV of concrete with fly ash -200%

Description	M-20		M-30	
	28th day	84th day	28th day	84th day
Normal water	24	28	31	32
Sea water curing buried in clay soil (90%)	26	21	24	20
Sea water curing buried in clay soil (50%)	31	23	26	30
Sea water curing buried in clay soil (30%)	25	24	23	24

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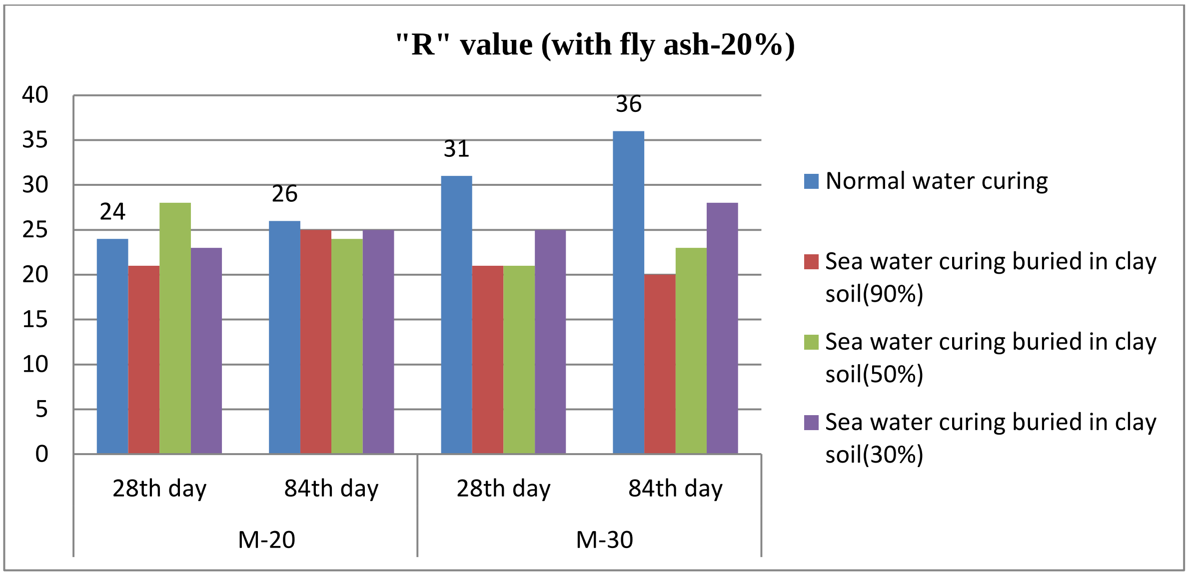

Figure 9: R value for concrete with fly ash-20%

The fig 9 shows that the R value of concrete in Normal water curing condition gives higher value in 84th day M-30 grades with seawater intrusion in clay soil with different proportions.

Table 12: UPV of concrete with fly ash -30%

Description	M-20		M-30	
	28th day	84th day	28th day	84th day
Normal water	24	26	31	36
Sea water curing buried in clay soil (90%)	21	25	21	20
Sea water curing buried in clay soil (50%)	28	24	21	23
Sea water curing buried in clay soil (30%)	23	25	25	28

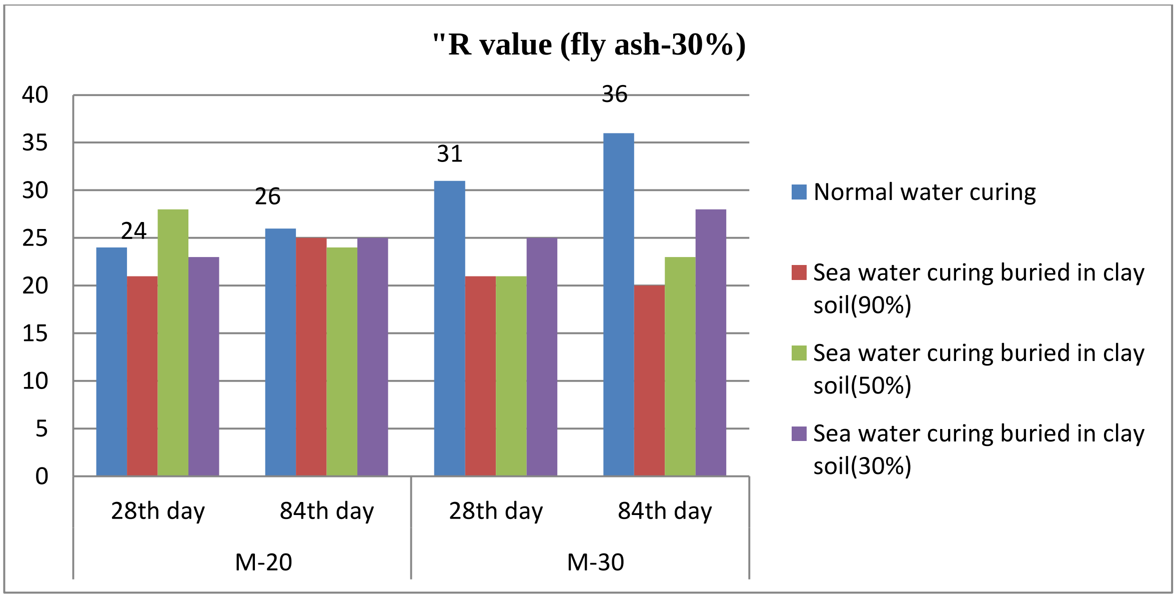

Figure 10: R value for concrete with fly ash-30%

The fig 10 shows that the R value of concrete in Normal water curing condition gives higher value in 84th day M-30 grades with seawater intrusion in clay soil with different proportions.

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5. CONCLUSIONS

Based on the test results, it is concluded that:

[1] The characteristics of soil show the major changes after the intrusion of sea water in clay soil.

[2] The compressive strength of concrete is decreased at both M20 and M30 grade of concrete used in sea water curing, compared to curing on normal water.

[3] The addition of fly ash will increase the compressive strength of normal water curing.

[4] The results show that M-30 grade of concrete has the highest value 34.6 N/mm^2 of 84th day compressive strength, when comparing to other type of grades while curing in both type of waters.

[5] The results show that M-30 grade of concrete has the highest value 39.61 N/mm^2 of compressive strength, when comparing to other type of grades with addition of 20% fly ash class C.

[6] The results shows that M-30 grade of concrete has the highest value 29.36 N/mm^2 at 84th day of compressive strength ,when comparing to other type of grades with addition of 30% fly ash class C .

[7] The UPV result shows that without addition of fly ash in M-30 grade at 84th day in normal water shows the maximum value when compared with seawater intrusion in different proportion of clay soil.

[8] In rebound hammer test, normal water curing shows the maximum value for M-30 grade during 84Th day when compared with seawater interruption in clay soil.

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