Influence of Alkali content of Cement in Alkali Silica Reaction of concrete

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Abstract: The presence of alkali content in concrete from cement is one of the important chemical which can initiate Alkali silica reaction in concrete with potentially reactive aggregate. There are many ways of mitigating ASR in concrete like selection of potentially non-reactive aggregate in concrete, addition of pozzolonic materials in concrete & application of ASR inhibiting salts in concrete and also using of low alkali cement in concrete. Among all the four different ways of preventive measures, using of low Alkali cement is being recommended in different standard and it is recommended to keep the alkali content in cement below 0.6% for concrete with potentially reactive aggregate. So in this paper a research experimental was carried out with different samples of potentially reactive aggregate along with varying alkali content in normal Portland cement CEM-I & blending cement like PPC and PCC to evaluate the ASR expansion in concrete as per ASTM C1260. The research work results shows that alkali content in normal Portland cement (CEM-I) plays an important role in initiation of ASR expansion in concrete. The experimental results shows that cement with higher % of total alkali content in Portland cement CEM-I shows significantly higher expansion of ASR than concrete with low alkali Portland cement CEM-I. The research work also shows that, the influence of blending cement like Portland Pozzolona Cement (PPC), Portland Composite cement (PCC) CEM-II/A-M and CEM-II/B-M shows significant expansion due to Alkali Silica reaction in concrete with increased alkali content in their composition. However the influence of Alkali silica reaction in concrete with blending cement like PPC and PCC is minimum as compared to normal Portland cement CEM-I.52.5N. Thus alkali content in the cement plays a vital role in initiation of ASR in concrete with potentially reactive aggregate.

Keywords —Portland Cement CEM-I, Portland Composite Cement-CEM-II/A-M, CEM-II/B-M, Blast furnace slag cement CEM-III/A, Portland Pozzolana Cement, ASR,

I. INTRODUCTION

Concrete is a heterogeneous material consisting of different ingredient & durability of concrete is primarily depend on the properties of the ingredient used in the concrete & external exposure condition. ASR in concrete is one of the important durability problem in concrete due to potentially reactive aggregate in concrete. There are different preventive measures usually adopted for mitigating ASR expansion in concrete like using of low alkali cement, selection of potentially non-reactive aggregate, application of pozzolonic materials Fly ash, GGBS in concrete along with normal Portland cement & application of different types of ASR inhibiting salt in concrete. Among all the four method the minimization of alkali content in the cement has been recommended for concrete containing reactive aggregate[1].The selection of innocuous type aggregate may not be feasible due to source constraint in many times . So considering the limitation of potentially non-reactive aggregate source usually using of low alkali cement in concrete , application of different types of pozzolonic materials like Fly ash, GGBS, Silica Fumes and also application of ASR inhibiting salt in concrete are being applied as a preventive measure against ASR expansion in concrete. In this research paper a detail laboratory investigation was carried out to evaluate the ASR expansion in concrete with different samples as per ASTM C1260 by using potentially reactive aggregate and normal Portland cement with varying alkali content in their composition and also changing the normal Portland cement with blending cement PPC and PCC of type CEM-II/A-M, CEM-II/B-M. The research work shows that normal Portland cement CEM-I, 52.5N with low alkali content shows minimum level of expansion of ASR & vice versa. However concrete with blending cement like PPC, PCC of type CEM-II/A-M and CEM-II/B-M also shows significantly lower level of ASR expansion in concrete as compared to normal Portland cement. The threshold value of alkali content in the cement

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as recommended in standard as less than 0.6% [11] to mitigate or eliminate ASR expansion in concrete. However the experimental results shows that even the alkali content is less than 0.6% still there is significant ASR problem in concrete with potentially reactive aggregate in it. Thus ASR in concrete containing reactive aggregate cannot be controlled alone by minimizing the alkali content in the cement, however minimization of alkali content in the cement shows significant effectiveness in concrete contain slow reactive aggregate. Hence by minimizing alkali content in cement cannot prevent ASR expansion alone.

II. MATERIALS AND METHOD OF TEST

The materials used for this research work were normal Portland cement CEM-I,52.5N, Portland Composite Cement of type CEM-II/A-M, CEM-II/B-M as per BSEN-197-1, Fly ash based Portland Pozzolana cement as per IS-1489, Part-1 and potentially reactive aggregate of Granite gneiss The test results of different materials used in this research work are briefly tabulated below.

Table-1: Physical properties of all different types of cement

Cement	Cement ID	Sp Gr	Fineness in m2/kg.	% Residue on 45 Micron
PC-CEM-I (Na_2Oeq=0.46%)	C-1	3.15	355	3.87
PC-CEM-I (Na_2Oeq=0.56%)	C-2	3.15	356	3.56
PC-CEM-I (Na_2Oeq=0.86%)	C-3	3.15	356	3.34
PC-CEM-I (Na_2Oeq=0.98%)	C-4	3.15	357	3.28
PCC,CEM-II/A-M	C-5	3.12	363	4.28
PCC,CEM-II/B-M	C-6	3.08	372	4.55
BFSC,CEM-III/A	C-7	2.98	428	5.56
PPC (Fly Ash)	C-8	3.01	382	2.92

Table-2: Chemical properties of all different types of Cement

Oxide	Different types of Cement							
	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8
CaO	63.2	62.35	61.5	62.3	55.4	51.7	53.6	44.3
SiO_2	20.9	21.92	21.7	23.2	25.3	26.2	24.5	29.6
Al_2O_3	5.02	5.32	5.38	5.27	8.21	9.11	8.96	11.5
Fe_2O_3	3.73	3.63	3.66	3.56	3.3	3.65	2.26	3.49
SO_3	2.95	2.85	2.83	2.74	2.63	2.32	2.85	2.75
MgO	2.02	2.08	2.05	2.15	1.82	1.29	2.96	1.94
Na_2O	0.16	0.191	0.27	0.28	0.22	0.27	0.278	0.221
K_2O	0.45	0.56	0.88	1.06	0.51	0.87	0.892	0.642
Na_2Oeq	0.46	0.56	0.86	0.98	0.55	0.85	0.864	0.643

Table-3: properties of Aggregate

Test Parameter	Test Results
Sp Gravity	2.82
Alkali Silica Reactivity as per ASTM C1260	0.23% (Reactive)
Petrographic study of aggregate	Reactive granite

Table-4: Mixing water properties

Test Parameter	Test Results
pH value	7.5
Chloride in mg/L	253
Sulfate in mg/L	1.72
TDS in mg/L	748

The testing method used for this lab investigation was as per ASTM C1260. The samples size used for experimental work was 25 mm x 25mm x 250 mm size with potentially reactive aggregate and normal Portland Cement with varying alkali content in their composition (C-1, C-2,C-3,C-4) and also samples with blending cement Fly ash based PPC (C-8), PCC-CEM-II/A-M (C-5), PCC-CEM-II/B-M (C-6) and sample with Blast furnace slag cement CEM-III/A (C-7) .For each samples comprise of three no's specimen of size 25 mm x25mm x250 mm size mortar bar were casted for evaluation of Alkali silica reactivity level in concrete sample as per ASTM C1260. The curing of the specimen was carried out in 1N NaOH solution at 80^0C for a period of 14-days as per ASTM C126 & testing of the specimen was conducted at 7-days & 14-days respectively .The details of different samples mixes used for this research work is tabulated below

Table-5: Details of samples used for evaluation of Alkali Silica Reactivity studies in concrete.

Cement	Sample ID	Mix combination
PC-CEM-I (Na_2Oeq=0.46%)	C-1	PC-CEM-I (Na_2Oeq=0.46%)+ Reactive Aggregate
PC-CEM-I (Na_2Oeq=0.56%)	C-2	PC-CEM-I (Na_2Oeq=0.56%)+ Reactive Aggregate
PC-CEM-I (Na_2Oeq=0.86%)	C-3	PC-CEM-I (Na_2Oeq=0.86%)+ Reactive Aggregate
PC-CEM-I (Na_2Oeq=0.98%)	C-4	PC-CEM-I (Na_2Oeq=0.98%)+ Reactive Aggregate

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PCC,CEM-II/A-M	C-5	PCC,CEM-II/A-M + Reactive Aggregate
PCC,CEM-II/B-M	C-6	PCC,CEM-II/B-M + Reactive Aggregate
BFSC,CEM-III/A	C-7	BFSC,CEM-III/A + Reactive Aggregate
PPC (Fly Ash)	C-8	PPC (Fly Ash)+ Reactive Aggregate

Fig. 1. Samples for ASR expansion test as per ASTMC1260.

III. RESULTS & DISCUSSIONS

Table-4: Average expansion in concrete due to ASR in concrete for different samples.

Sample ID	Av Expansion at 7-days	Av Expansion at 14-days
C-1	0.123	0.148
C-2	0.165	0.215
C-3	0.178	0.228
C-4	0.198	0.242
C-5	0.134	0.152
C-6	0.158	0.198
C-7	0.161	0.201
C-8	0.148	0.169

From the research work results it shows that Alkali silica reactivity in concrete with potentially reactive aggregate and normal Portland cement of varying alkali content shows significant influence on ASR expansion in concrete. The results shows that normal Portland cement with higher alkali content shows significantly higher level of expansion than concrete with lower level of alkali content in cement. The investigation results also shows that normal Portland cement even with alkali content less than 0.6% still it shows significant ASR expansion with potentially reactive aggregate. The investigation results also shows that blending cement like PPC, Portland composite Cement (PCC) CEM-II/A-M, CEM-II/B-M and Blast furnace slag cement CEM-III/A having higher alkali content still they shows significantly lower level of ASR expansion in such cement as compared to Portland cement CEM-I,52.5N having same alkali content, due to pozzolonic reaction mechanism in blending cement & thus reduction in production of OH^- in concrete which helps to minimizing ASR in concrete [3].

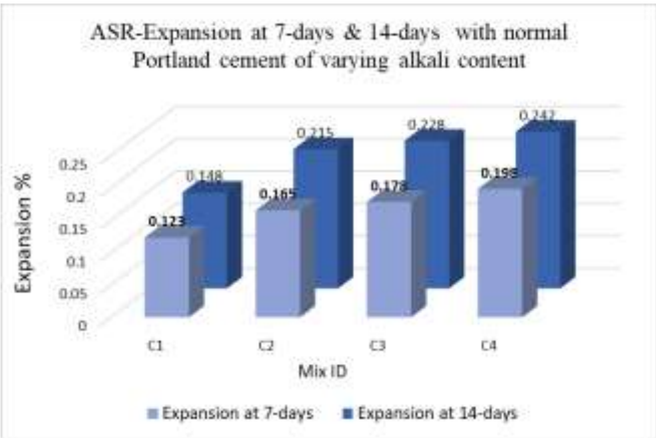

Fig-2: ASR expansion of concrete with normal Portland cement of different alkali content.

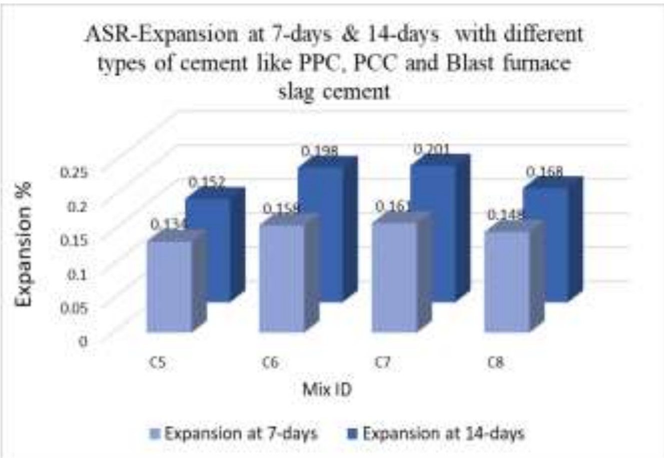

Fig-2: ASR expansion of concrete with PPC, PCC of CEM-II/A-M, CEM-III/B-M and Blast furnace slag cement CEM-III/A

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VII. CONCLUSION

The research works comes to the following concluding findings are hereby briefly explained.

I. The alkali content in normal Portland cement CEM-I, 52.5N shows significant influence in Alkali silica reactivity in concrete with potentially reactive aggregate.

II. The alkali silica reactivity in concrete with potentially reactive aggregate still exist even the alkali content in cement is kept less than 0.6%.

III. Concrete with blending cement like Fly ash based Portland Pozzolana Cement as per IS-1489, P-1, Portland Composite Cement CEM-II/A-M, CEM-II/B-M and Blast furnace slag cement CEM-III/A as per BSEN-197, P-1 shows significantly controlled ASR expansion than normal Portland cement CEM-I of same level of alkali content.

IV. The mitigation of ASR expansion in concrete only by minimizing the alkali content in the normal Portland cement does not meeting the requirement when concrete contain reactive aggregate.

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