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ALKALINITY AND Cl^-/OH^- AFFECTING REINFORCEMENT CORROSION IN ALKALI ACTIVATED CONCRETE

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ABSTRACT

The paper reports the effect of hydroxyl ion (OH) and chloride (Cl) concentrations of pore fluid on reinforcement corrosion in AAC under long term chloride exposure. The OH and Cl are influenced by the activator molarity. AAC has much higher OH than the control Portland cement (PC) concrete at early ages of chloride exposure and the corresponding Cl/OH ratios are lower for AAC. However, under long term chloride exposure, the Cl/OH ratios of AAC start exceeding the PC concrete due to the superior chloride binding capacity of Portland cement. The critical threshold Cl/OH ratio for corrosion initiation in AAC is between 2 and 3.28, whereas it is < 1 for PC concrete. The steel reinforcement in AAC remains free from chloride induced corrosion for a longer period and up to higher Cl^-/OH^- ratios than PC concrete due to the presence of elemental Sulphur (sulfides) on the steel surface in AAC.

Keywords

Alkali activated concrete (AAC); hydroxyl and chloride concentrations; alkalinity; reinforcement corrosion; Cl/OH ratio

INTRODUCTION

Hydrated products of Portland Cement (PC) concrete produce saturated pore solution containing calcium hydroxide $Ca(OH)_2$ and different ions depending on the type of cement and supplementary cementitious materials like fly ash, slag and silica fume (Ghods *et al.*, 2009). These ionic species are principally alkali oxides of calcium, sodium and potassium in the cement component, unlike alkali activated concrete (AAC). Sulphate ions could also be present in the concrete pore solution due to gypsum added during cement production or from contaminated aggregate or mixing water (Neville, 2011). The pH of PC concrete pore solution increases from about 12.5 to 13.5 by the presence of these alkali oxides (Na^+ and K^+) (Angst *et al.*, 2009; Poursaee and Hansson, 2009). However, the pH decreases when mineral admixtures are added (Neville, 2011). For example, a 10% replacement of PC cement with silica fume reduced the pH of the concrete pore solution from 13.5 to 12.6 (Ortolan, Mancio and Tutikian, 2016). This is due to the secondary pozzolanic reactions of the supplementary cementitious material which requires calcium hydroxide $Ca(OH)_2$ from the concrete pore solution to activate these reactions. For a fly-ash-based system, the glassy material is only activated when the pH of the concrete pore solution is about 13.2 (Neville, 2011) but for ground granulated blast-furnace slag (GGBS), the glassy material is activated at a lower pH of about 11.5 (Song and Jennings, 1999). Information on the chemistry of AAC pore solution is limited in literature unlike that of PC concrete pore solution which is fairly well documented.

The pH of PC concrete pore solution at considerably low values less than 12 is suggested to aid the participation of bound chloride in the corrosion initiation in reinforced concrete (Glass and Buenfeld, 2000). It was argued that a low pH favours the dissolution of chloride ions that are physically or chemically bound to the hydration products thereby increasing the free chloride content in concrete (Page and Vennesland, 1983). Contrary to the dissolution of bound chlorides into the pore solution at low pH when the source chloride is NaCl, *Robert* (Roberts, 1962) observed the solubility of Friedel's salt at high pH when the chloride source is from $CaCl_2$. The chemically bound chloride concentrations are released into the concrete pore solution at high pH. The effect of pH on the bound chloride solubility in the concrete pore solution is, therefore, greatly influenced by the source chloride. NaCl is used as the source chloride for this study. Recent investigation on the chloride binding capacity of alkali activated cementitious concrete shows that PC concrete has better chloride binding capacity than AAC concrete due to its effective binding capacity for both the physically and chemically bound chlorides whereas the AAC concrete is effective in binding only the physically bound chlorides while the chemically bound chloride is limited (Mangat and Ojedokun, 2019).

Hydroxyl ion concentrations is as important as the chloride concentrations in the pore solution of concrete because it affects the initiation and rate of corrosion of steel in concrete (Neville, 2011). There is the likelihood of depassivation of steel embedded in concrete with an increase in the chloride/hydroxyl ion concentrations, although no valid conclusion exists on its threshold values. However, the threshold value of 0.61 for the chloride/hydroxyl ion concentration proposed by *Hausmann* (Hausmann, 1967) for the initiation of corrosion in cement based materials does not normally apply. For example, *Lambert et al.* (Lambert, Page and Vassie, 1991) presented a chloride/hydroxyl concentration threshold of 3 for steel rods embedded in PC concrete. The chloride/hydroxyl concentration as high as 320 did not result in corrosion of steel fibres embedded in fly-ash concrete (Mangat and Gurusamy, 1988). Similarly high threshold value of chloride/hydroxyl concentration in silica fume concrete was observed by *Page* *and Havdahl* (Page and Havdahl, 1985) for corrosion initiation. The reasons attributed to such high values were the lower chloride binding and pH which increases the Cl^-/OH^- ratio in its pore solution. *Hausmann* (Hausmann, 1967) based the chloride/hydroxyl concentration threshold of 0.61 on an idealized solution to represent the pore solution of hydrated cement. This model electrolyte cannot simulate an oxygen depletion or limited mobility of chloride ion within the cement matrix unlike the concrete pore solution (Page and Vennesland, 1983). This makes it unreliable for predicting corrosion behaviour of steel in concrete. The threshold of chloride/hydroxyl ion concentrations in AAC is expected to be different from PC concrete because of the differences in the compositions of their pore solutions.

The alkalinity of concrete pore solution is a determinant factor for the formation of a passive thin film comprising of iron oxide around the steel surface, which inhibits the corrosion process of embedded steel or fibres in concrete. The prolonged action of free chloride as well as lower alkalinity in PC concrete destroys this protective film (Neville, 2011). However, it is argued that a reduction in alkalinity of the pore solution due to partial replacement of PC cement with supplementary cementitious (pozzolanic) material does not necessarily result in the depletion of the protective thin film around the embedded steel surface (Ortolan, Mancio and Tutikian, 2016). Therefore, the electrochemical reaction between the free chloride and embedded steel in supplementary cementitious concrete is partially affected by the low alkalinity of the concrete pore solution.

The corrosion initiating relationship between the free chloride and pH of pore solution in AAC concrete is not established in literature. This paper will address the relationship between the two parameters as well as their relationship with bound chlorides.

EXPERIMENTAL PROGRAMME

Details of Mixes, Curing and Testing

Three AAC concrete mixes 1, 2 and 3 and a control PC concrete were investigated. Their details are as follows: Binder: fine aggregate: coarse aggregate proportions of AAC mixes are 1: 0.72: 1.8, Liquid/binder ratio = 0.47. Activator dilution of mixes AAC 1,2 and 3 is 0%, 3.88% and 7.76%. Binder: fine aggregate: coarse aggregate proportions of PC concrete mixes is 1:1.3: 2.22, w/c=0.47. Concrete slabs of dimensions 250 x 250 x 75 mm were cast into polystyrene moulds. After casting, the moulds were covered with polythene sheets and cured for 24 hrs in the laboratory air at 20 ± 2^0C and approximately 65% R.H. The slabs were demoulded 24 hrs after casting and cured in tap water at 20 ± 2^0C for a further 27 days before exposure to chloride solution. Two units of 250 x 250 x 75 mm slab specimens were produced per mix. Eight slab specimens were produced in total. Further details are given elsewhere (Mangat, Ojedokun 2019, 2020, Mangat, Ojedokun and Lambert 2021).

Testing

Bulk diffusion tests according to (NT BUILD 443, 1995; DD CEN/TS 12390-11, 2010) were adopted to measure the long-term chloride diffusion into the AAC and PC concrete specimens. *DD CEN/TS 12390-11* (DD CEN/TS 12390-11, 2010) and *NordTest 443* (NT BUILD 443, 1995) test methods which are commonly used to determine the chloride bulk diffusion in concrete have similar procedures apart from the concentration of the chloride exposure solution. *DD CEN/TS 12390-11* (DD CEN/TS 12390-11, 2010) specifies 3% NaCl solution (by weight) whereas *NordTest 443* (NT BUILD 443, 1995) specifies 165 g ± 1g NaCl per dm^3 solution (16.5% NaCl solution by weight). A 5% NaCl solution in tap water was prepared for chloride exposure of the test specimens. The 5% NaCl solution provides an accelerated chloride diffusion test which gives higher chloride concentrations at given depths than under normal marine exposure. Therefore, the permissible chloride concentrations allowed in *DD CEN/TS 12390-11* (DD CEN/TS 12390-11, 2010) for different types of chloride exposure cannot be directly related to the data presented in this paper. The transportation mode of chloride ion was by diffusion only. This was achieved by curing the test specimens in water for 28 days after casting to fully achieve saturation of concrete pores, thereby eliminating the initial sorption effect upon chloride exposure. All the faces of the chloride diffusion test specimens were coated with 1 mm thick layer of bituminous paint except the 250 x 250 mm bottom face of the slab (in its as cast position) to be exposed to the 5% NaCl solution.

Pore Fluid Sample Extraction

Concrete pore fluid was extracted at a mean depth of 10mm, 30mm and 50mm from the chloride-exposed surface of the AAC 1, 2, 3 and PC concrete slabs. The pore fluid samples were used to determine the free chloride and hydroxyl ion concentrations (BS 1881-124:2015+A1, 2021) at 180, 270, 540, 860 and 1750 days exposure to the chloride solution. In addition to pore fluid extraction, concrete powder samples were extracted by drilling at 8mm, 15mm, 20mm, 25mm, 35mm, 50mm and 65mm depths from chloride-exposed surfaces of the AAC 1, 2, 3 and PC concrete slabs. These specimens were used to determine the free chloride and hydroxyl ion concentrations at 180, 270, and 1750 days Cl exposure.

Concrete Pore Fluid Sample

Four cores of 50mm diameter x 60mm depth were obtained from each AAC and PC concrete slab. The concrete coring was performed after 180, 270, 540, 860 and 1750 days of Cl exposure in a solution of 5% NaCl by weight. Each core was sawn into three discs of 50mm diameter x 20mm depth representing depths of 0 - 20mm (10mm mean depth), 20 - 40mm (30mm mean depth) and 40 - 60mm (50mm mean depth) from the concrete face exposed to the Cl solution. The pore solution extraction was performed on the 20mm thick concrete discs obtained from the cores of AAC and control PC concrete slabs. This was carried out by placing three discs from the same depth, for example, 0 - 20mm (10mm mean depth) obtained from the three cores for each mix, into a pore fluid extraction device. The pore solution extraction device, with the three discs inside it, was placed in a compression testing machine and a compressive load was applied at a steady rate of 10kN/sec. The pore solution was extracted by a suction action without allowing contact with air. It was immediately stored in plastic vials, labelled, and sealed with parafilm. The same procedure was repeated on concrete core discs representing 10mm, 30mm and 50mm mean depth.

Concrete Powder Sample

Extraction of dry powder samples was carried out in accordance with the relevant standards (NT BUILD 443, 1995; DD CEN/TS 12390-11, 2010). Two 250 x 250 x 75mm concrete slabs per mix at each test age were sawn into two equal halves along the plane perpendicular to the uncoated concrete face. Dry powder samples were extracted at 8, 15, 25, 35, 50 and 65mm depths from the uncoated concrete face through which chloride diffusion occurs. A minimum of six holes were drilled per profile depth by means of a hammer drill using 4mm diameter SDS drill bits. Powder samples collected at each profile depth were combined to provide approximately 15grams of a sample extracted from the two slab specimens of each concrete mix. The powder samples from each profile depth were sieved through 150µm sieve to obtain a finely ground sample which was carefully stored in a self-sealing plastic bag and labelled accordingly. The retained coarse material was discarded while the finer powder samples were used to determine free chloride and hydroxyl ion concentrations.

EXPERIMENTAL RESULTS AND DISCUSSION

Free Hydroxyl Concentrations

The free hydroxyl ion concentration profiles of AAC 1, 2, 3 and PC concrete at early (180 and 270 days) and later (540, 860 and 1750 days) chloride exposure periods are shown in Figures 1a and 1b respectively. The profiles of free chloride, and Cl^-/OH^- ratios are shown in Figures 2a, b and 3a, b respectively. The data in Figures 1,2 and 3 represent mean depths from the chloride-exposed surface of 10 mm, 30 mm and 50 mm.

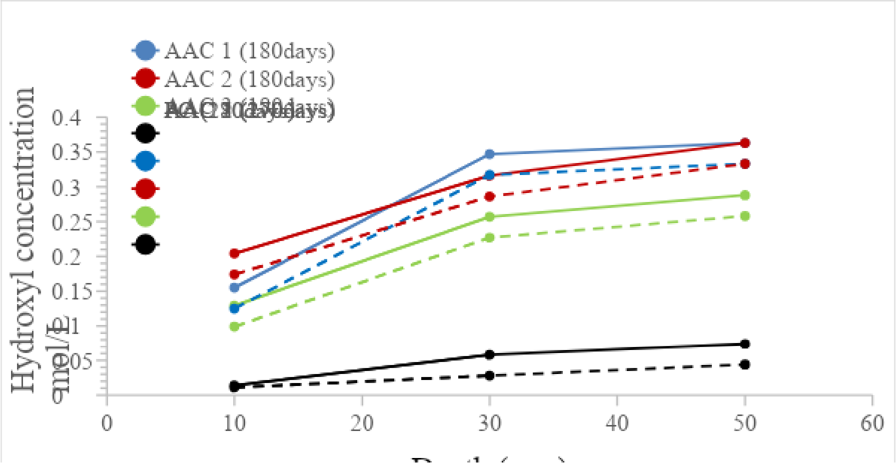

Fig. 1a. Hydroxyl concentrations of AAC 1, 2, 3 and control PC concrete at 180- and 270-days exposure

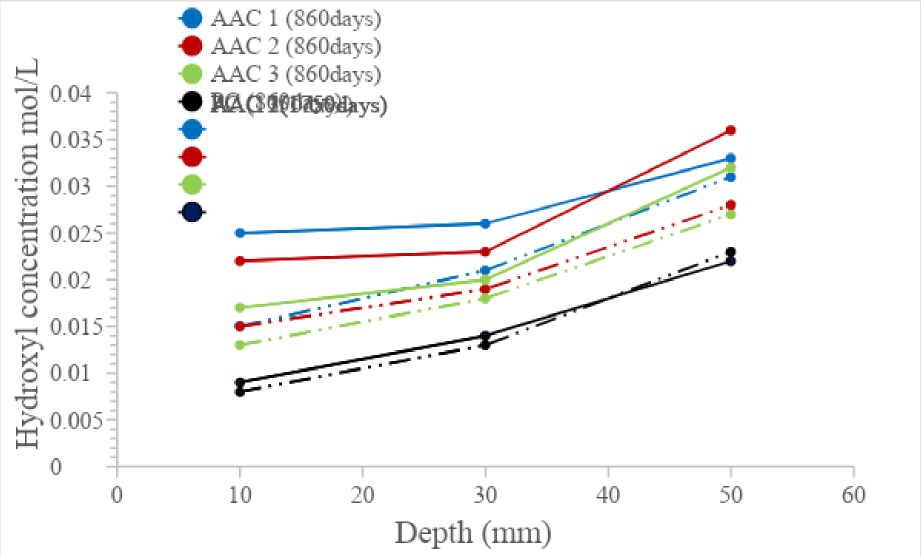

Fig. 1b. Hydroxyl concentrations of AAC 1, 2, 3 and control PC concrete at 540, 860 and 1750 days exposure

The free hydroxyl ion concentrations of all AAC mixes are very much higher than PC concrete as shown in Figure 1a. The free hydroxyl ion concentrations are within the range of 0.011 mol/L to 0.074 mol/L for PC concrete compared to 0.099 mol/L to 0.363 mol/L for AAC at 180- and 270-days chloride exposure. A clear distinction in the alkalinity of AAC is amplified by the alkali activator concentration that was utilized in the AAC mixes. The alkalinity is greater at the inner core of the slab specimens. AAC 1 and 2 exhibited the highest free hydroxyl ion concentrations of 0.363 mol/L in relation to PC concrete having 0.074 mol/L at 50 mm mean depth after 180 days chloride exposure. A similar trend is observed for 270 days of chloride exposure (Fig. 1a). However, the difference between free hydroxyl ion concentrations of PC relative to AAC at 860 and 1750 days in Fig. 1b is lower than at 180 and 270 days in Fig 1a. There is a notable depletion of hydroxyl ions towards the concrete surface for all profiles shown in Figures 1a and 1b. The depletion is steeper between 10 mm and 30 mm depths in AAC at both 180 and 270 days chloride exposure. For example, the hydroxyl ion concentrations of AAC 1 at 180 days of exposure are 0.155 mol/L, 0.347 mol/L and 0.363 mol/L at 10 mm, 30 mm, and 50 mm depths respectively. The depletion of hydroxyl ions towards the concrete surface could be caused by leaching of alkali content from the concrete surface (Lloyd, Provis and Van Deventer, 2010). The depletion of hydroxyl ions at the concrete surface could also be caused by the effect of carbonation. All precautions were taken to prevent carbonation which, therefore, is unlikely to be a cause of pH reduction near the surface zone. Another possible explanation for the gradual depletion of hydroxyl ions towards the concrete surface in concrete submerged in water was attributed to the outward diffusion of hydroxyl ions (Mangat and Gurusamy, 1987). Tritthart (Tritthart, 2009) proposed that under chloride exposure competition exists between OH^- and Cl^- at the adsorption sites of the hydration products. It was observed that as more chloride ions were chemically adsorbed, fewer adsorption sites were left for other ions such as OH^- which could not be absorbed simultaneously. This hypothesis was suggested as the reason for higher binding capacity for concrete with a low pH. This is unlikely for AAC because its poor binding capacity was largely due to the small amount of Friedel's salt (acid soluble chloride) or any form of crystallized salt, leaving only the kuzel's salt (water-soluble chloride) to be actively involved in the chloride binding (Mangat and Ojedokun, 2020). Luping and Nilsson (Luping and Nilsson, 1993) suggested the possibility of undissolved alkali content which is enclosed in the unhydrated slag cement to be responsible for boosting the pH of concrete pore solution especially at the inner core of concrete. AAC 2 has the highest hydroxyl ion concentration of 0.204 mol/L and 0.147 mol/L at 10 mm depth at both 180- and 270-days Cl exposure respectively but maintains the same alkalinity as AAC 1 at inner depth of 50 mm. Despite AAC 2 being 3.88% diluted with water, it produced maximum alkalinity within its pore structure relative to AAC 1 and 3. This suggests that AAC 1 has excess concentration of alkali activator which was leached into the curing solution upon sufficient wetting of its binder gel. However, the leaching was minimal at greater depths of 30 mm, showing less depletion of hydroxyl ion concentration.

Free chloride concentrations

The free chloride concentration profiles of AAC 1, 2, 3 and PC concrete at early (180 and 270 days) and later (540, 860 and 1750 days) of chloride exposure periods are shown in Figures 2a and 2b respectively. The free chloride profiles of control PC concrete are lower than AAC 1, 2 and 3 as shown in Figures 2a and 2b. For example, free chloride concentrations at 270 days exposure of AAC 1, 2, 3 and PC concrete are 0.020 mol/L, 0.023 mol/L, 0.025 mol/L, 0.022 mol/L respectively at 10mm depth. The migration of free chloride within AAC is mainly restricted by its pore structure which is directly related to alkali activator concentration. AAC 1 with the lowest dilution of alkali activator has the lowest porosity and high volume of closed pores relative to AAC 2 and 3 (Mangat and Ojedokun, 2018). These are the two distinctive pore properties that resulted in lower free chloride concentrations and have reduced the diffusion of free chloride in AAC 1 significantly.

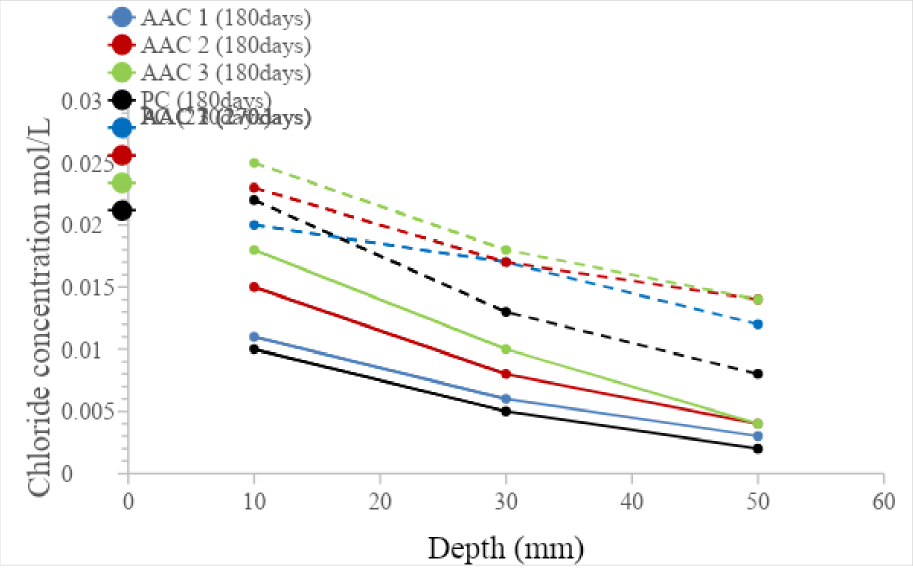

Fig. 2a. Chloride concentrations of AAC 1, 2, 3 and control PC concrete at 180- and 270-days exposure

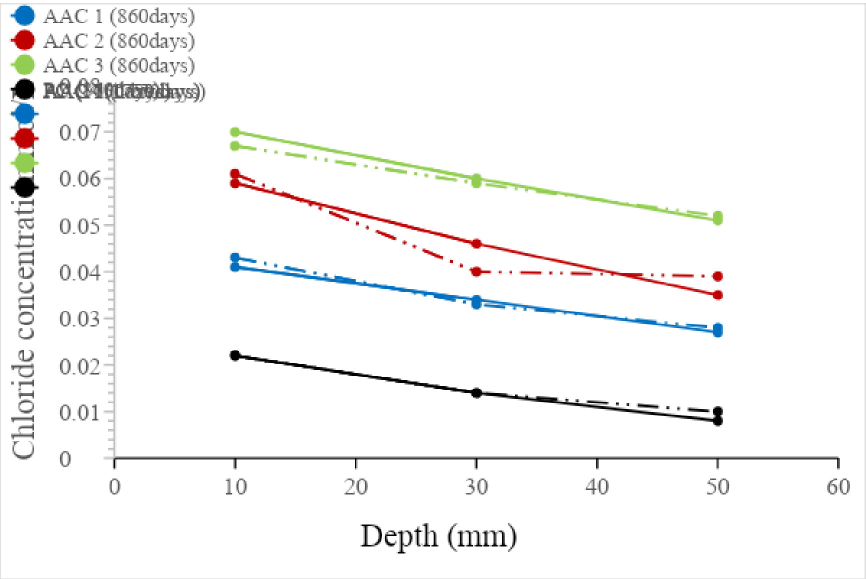

Fig. 2b. Chloride concentrations of AAC 1, 2, 3 and control PC concrete at 540, 860 and 1750 days exposure

In addition to pore structure, the chemical and physical binding of chlorides in the PC matrix influenced the reduction of free chloride concentrations (Mangat and Ojedokun, 2019, 2020) as shown in Figures 5a and 5b. Conventional PC concrete has higher total bound chloride due to the presence of C_3A and C_4AF in its PC binder relative to AAC. The unhydrated portion of aluminate (C_3A) and aluminoferrite (C_4AF) of PC binders takes up the free chloride in its pore solution during the exposure period, to form Friedel's salt ($Ca_6A_{l2}O_6.CaC_{l2}.10H_2O$) and calcium chloroferrite (Sumranwanich and Tangtermsirikul, 2004). The lack of aluminate (C_3A) and aluminoferrite (C_4AF) in the AAC compositions resulted in higher amount of free chloride concentrations in AAC. The chloride binding capacity of concrete controls its free chloride concentrations which initiate steel corrosion when their permissible limits are exceeded. There is steep decline in the free chloride concentration from the surface to the core particularly in PC concrete at 270 days exposure. This suggests that a higher amount of chlorides are physically and chemically bound to the binder gel as they migrate towards the inner core of the concrete (Mangat and Ojedokun, 2020).

Free Chloride/ Hydroxyl ion Ratio [Cl^-/OH^-]

The free chloride to hydroxyl ion concentration ratio, which is a critical threshold parameter for corrosion initiation in steel reinforcement, is shown in Figures 3a and 63b for AAC 1, 2, 3 and PC concrete at early (180 and 270 days) and later (540, 860 and 1750 days) of chloride exposure periods respectively.

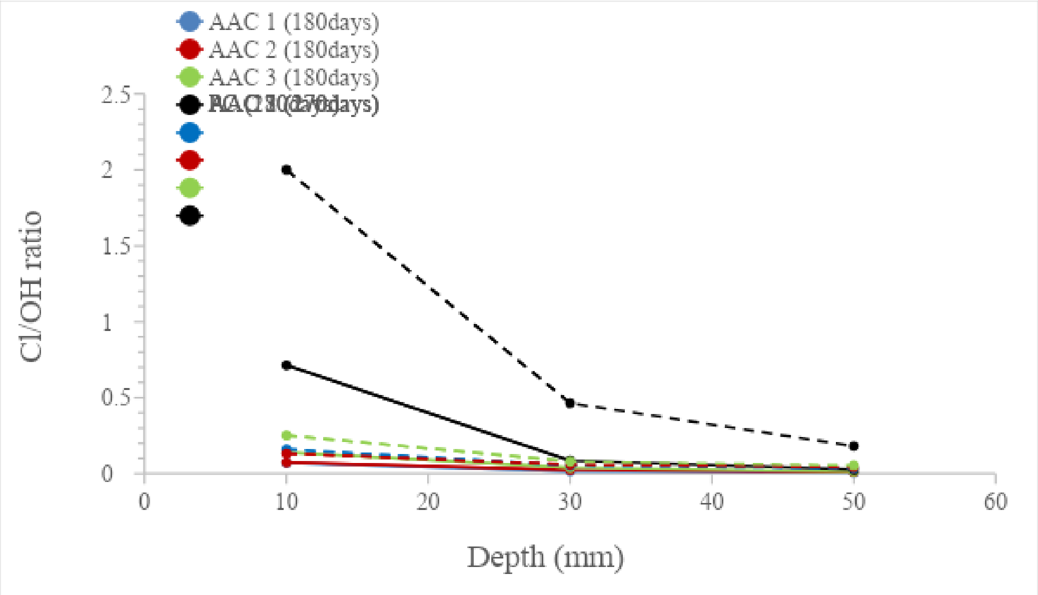

Fig. 3a. Cl^-/OH^- ratios of AAC 1, 2, 3 and control PC concrete at 180- and 270-days exposure

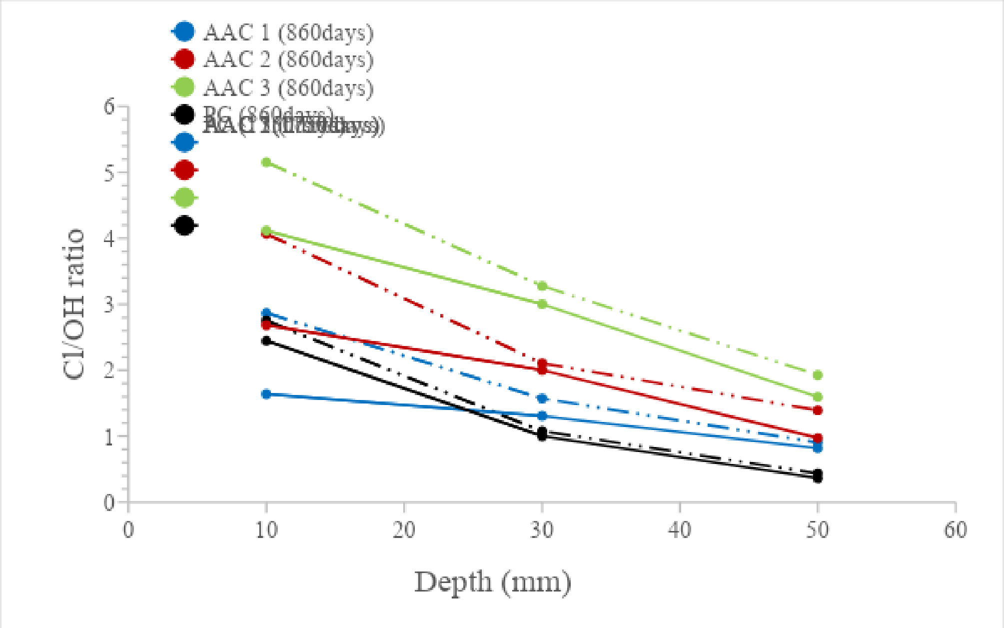

Fig. 3b. Cl^-/OH^- ratios of AAC 1, 2, 3 and control PC concrete at 860 and 1750 days exposure

Cl Exposure period

Figure 1a shows that at early age (180 and 270) days of exposure to the chloride solution, the hydroxyl ion concentration of the AAC concrete is much higher than the PC concrete while Figure 2a shows the converse result regarding chloride diffusion. However, the hydroxyl ion concentration dominates its influence on the Cl^-/OH^- ratios which remain much lower for PC concrete relative to AAC. Figures 1b and 2b show a reversal of the Cl^-/OH^- ratios with the AAC concrete having much higher values of Cl^-/OH^- than PC concrete, this is caused by a reduction in the differential of chloride and hydroxyl concentration between PC and AAC at the later ages due to chloride binding. A gradual decline in the Cl^-/OH^- ratio from 10mm to 50mm depths is observed for all AAC mixes at 180- and 270-days Cl exposure as shown in Fig. 3aa. The impact of low alkalinity in PC concrete relative to AAC as shown in Fig. 1 resulted in a high value of Cl^-/OH^- ratio. Also, a sharp decline of Cl^-/OH^- ratio is observed between 10mm to 30mm depths, especially in PC concrete (Fig. 3). The physical and chemical binding of free chloride, particularly for PC concrete at 30mm depth, played a major role in the reduction of Cl^-/OH^- ratio. The significant reduction of hydroxyl concentration particularly at 10 mm depths of PC concrete at 270 days of Cl exposure contributed significantly to the increased Cl^-/OH^- ratio over time. For example, the Cl^-/OH^- ratio at 10mm depths of AAC 1, 2, 3 and PC are 0.16, 0.13, 0.25 and 2.0 at 270 days exposure. The Cl^-/OH^- ratio of AAC is an order of magnitude lower than the PC concrete. The effect of high alkalinity in AAC accounts for the significant reduction in Cl^-/OH^- ratio.

Effect of Activator Dilution

The influence of activator dilution on the free Cl^-/OH^- ratio of AAC 1, 2 and 3 is less pronounced at 180 and 270 days of chloride exposure as shown in Figure 3a than at 860 and 1750 days as shown in Fig 3b. The activator dilution has a negative influence on the free Cl^-/OH^- ratio.

The high hydroxyl ion content in AAC resulted in low Cl^-/OH^- ratios after the exposure period of 180 and 270 days compared with PC concrete as shown in Figure 3 PC concrete had the highest free Cl^-/OH^- ratio of 2 at 10 mm depth compared to AAC 1, 2 and 3 which have 0.16, 0.13 and 0.25 respectively at 270 days chloride exposure. Similar trend is observed at 180 days Cl exposure and at all depths (30 and 50mm). Even with the lowest free chloride content, a higher free Cl^-/OH^- ratio is observed in PC concrete. On the other hand, AAC has higher free chloride content but a lower free Cl^-/OH^- ratio due to its higher hydroxyl concentration which has a dominant influence in reducing Cl^-/OH^- ratios. The Cl^-/OH^- ratio is considered important for the corrosion initiation of steel in concrete.

Reinforcement Corrosion

The impact of Cl^-/OH^- ratio on the corrosion initiation of steel reinforcements in PC concrete is well documented in literature (Lambert, 2002) which is not the case for AAC. In addition to Cl^-/OH^- ratio facilitating the corrosion of steel reinforcements in AAC concrete, the presence of elemental sulfur at the steel surface has significantly impeded the propagation of corrosion (Mangat, Ojedokun and Lambert, 2021). It would have been expected that a higher corrosion activity would occur in steel reinforced AAC due to its very high Cl^-/OH^- ratios relative to PC concrete after long term chloride exposure (Figure 3b). However, this is not the case as shown in Fig. 4. The Cl/OH ratios at 30mm depth from the surface (cover provided to the reinforcement bars) in AAC 1, 2, 3 and PC concrete after 1750 days of Cl exposure are 1.57, 2, 3.28 and 1 respectively (Fig. 3b). The extraction of steel reinforcements embedded at 30mm cover in AAC and PC concrete submerged in 5% NaCl solution up to 1750 days revealed that ACC 1 and 2 showed no sign of corrosion activity. However, AAC 3 showed some signs of corrosion activity but much less than the PC concrete as shown in Fig. 4. The critical threshold Cl/OH ratio for corrosion initiation in AAC is between 2 and 3.28, whereas it is < 1 for PC concrete.

PC

Figure 4. Corrosion of steel reinforcement in AAC 3
and PC concrete after 1750 days exposure

Elemental Sulfur observed on steel reinforcements in AAC provided extra protection against corrosion activity, similar to $Ca(OH)_2$ forming thin film around reinforced steel concrete (Mangat, Ojedokun and Lambert, 2021). The primary source of sulfur content in AAC is from GGBS binder which reacts during geopolymerization to form various oxides such as H_2S, Sn^{2-}, SO_3^{2-}, $S_2O_3^{2-}$ and SO_4^{2-}. Elemental Sulfur decreases the amount of dissolved oxygen concentration in the pore solution of AAC leading to highly reducing redox environment (Vollpracht *et al.*, 2016). The Cl^-/OH^- ratio in PC concrete is controlled by the removal of chloride ions from the pore solution by chloride binding and simultaneously replaced by OH^- through the buffering effect of hydration product Ca $(OH)_2$, thereby limiting absorption sites for further chloride ingress. There is no similar buffering effect in AAC, however, its corrosion activities are greatly influenced by the presence of sulfides which regulate the cathodic reaction causing steel corrosion.

CONCLUSIONS

The following conclusions can be drawn from this study based on the results presented; the hydroxyl ion concentration of AAC exposed to a 5% chloride solution is higher than PC concrete. The differential is very high at early exposure period (up to 270 days) but decreases with longer term exposure. The free chloride concentration of AAC is much higher than PC concrete due to the high chloride binding capacity of the latter. The Cl^-/OH^- ratios of PC concrete are higher than AAC at early periods of chloride exposure (up to 270 days) but suffer a reversal at later periods (over 560 days) due to the much higher chloride binding capacity of PC concrete. The critical threshold Cl/OH ratio for corrosion initiation in AAC is between 2 and 3.28, whereas it is < 1 for PC concrete. The Steel reinforcement embedded in AAC remains free from chloride induced corrosion for a longer period and up to higher Cl^-/OH^- ratios than PC concrete due to the presence of elemental Sulphur (sulfides) on the steel surface in AAC.

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