EFFECT OF MAJOR CONSTITUENTS OF URINE ON THE PHYSICO-CHEMICAL PROPERTIES OF THE HARDENED CEMENTITIOUS PRODUCTS

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THESIS

EFFECT OF MAJOR CONSTITUENTS OF URINE ON THE PHSICO-CHEMICAL PROPERTIES OF HARDENED CEMENTITIOUS PRODUCTES

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TO MY MOTHER

AND

THE SPIRIT OF

MY FATHER

A C K N O W L E D G E M E N T S

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1.1. INTRODUCTION

Because of the limited literature found on the effect of normal and pathological urine on cement and concrete, the literature review has been generalised to show the effects of the individual constituents of urine mainly its inorganic ions which are of interest to the cement system and are present in other aggressive waters such as sea-water, ground water and river water.

In this chapter research studies found about the influence of sewage and glucose on the cement system is also given.

1.1.1. Effect of aggressive waters:

A review with 66 references, the causes for the deterioration of the concrete placed in marine environment are examined and the measures to prevent it are indicated(1). Sulphates dissolved in sea-water react with the cement paste and form gypsum and ettringite. The growth of the crystals of these compounds, within the paste pores causes an expansion which in its turn, results in internal stresses. If these stresses exceed the concrete strength craking and scaling takeplace.

If chloride ions penetrate into concrete and reach the reinforcement, they destroy the steel passivation caused by the strongly alkaline environment in concrete and favour metal oxidation and corrosion. Nevertheless, it is possible to minimize these drawbacks and therefore to guarantee the integrity and durability of the concrete structures by strictly preventing and hampering the penetration of the aggressive ion and oxygen into the concrete.

The effect of an aggressive soft water containing 13 - 15 mg/l CO_2, on the durability of mortar prepared with different types of cement (Portland, slag and aluminous cements), after exposure for 15 years was also studied(2). The slag cement mortar was slightly superior to that containing portland cement. The soft water caused carbonation of the cement paste, leaching of the lime, depletion of CaO from hydrates which are less dense and resistant and the appearance of dissolution-recystion cycles. These changes resulted in the cement paste becoming porous and cracked a break down of the bonding structures and in the time disintegration of the mortar.

Supersulphate cement from granulated slag, 80 - 85 %, $CaSO_4$, 10 - 15 %, and portland cement clinker, 5 % is resistant to natural water, seawater, industrial water and waste water(3). It is more resistant to sulphate attack than sulphate-resistant cements. Thus cubic pastes cured for a period of $\lesssim$ one year in $MgSO_4$ solution or in a solution containing $MgSO_4$ and $MgCl_2$ are corroded; but cubic pastes cured in NaCl, $MgCl_2$, Na_2SO_4 solutions or in sea-water remained uncorroded. The corrosion was due to gypsum formation rather than linear expansion due to ettringite formation.

The compressive strength, elastic modulus, neutralization depth, and geometrical changes were measured on various types of concrete after immersion in sea-water for 10 years[4]. The concentration of MgO, SO_3 and Na_2O and leaching of CaO in the surface layer of the specimens were observed; for concretes from blastfurnace slag and flyash cements penetration of chloride ions in the specimens caused a weight increase for portland cement concrete. The compressive strength decreased for portland cement and increased for mixed cement concrete. Expansion in portland and mixed cement concrete specimens was explained by action of penetrated chloride ions.

Concrete specimens[5] made of normal portland cement (I), a sulphate-resistant cement consisting of SiO_2, 22.5; Al_2O_3, 3.5; Fe_2O_3, 4.5; CaO, 65.6; MgO, 1.3 and 1.9 weight percentage (II) and a sulphate resistant cement containing blastfurnace slag and consisting of SiO_2, 29.2; Al_2O_3, 11.5; Fe_2O_3, 3.0; CaO, 47.6; MgO, 4.0 and SO_3, 2.0 weight percentage (III) were soaked in sea water for a period of ≤ 5 years, and the resulting specimens were subjected to compressive strength, elastic and neutralization depth measurements, X-ray diffraction and chemical analysis. The compressive strength followed the order $I < II < III$; chloride ions in sea water penetrated to the center of specimens of I and II but concentrated in the surface layer of III. The chloride ion was present as calcium chloroaluminate in the specimen.

Microbiological activity[6] from sulphate - reducing bacteria can make a significant contribution to the corrossive nature of a stagnant sea water environment on concrete[7]. Degradative mechanisms were established and concrete durability was determined by several analysis methods.

sulphide production by the bacteria in the presence of crude oil or its water - soluble fraction under aerobic conditions and sulphide production and pH changes in aerobic and anaerobic microbian growth oil as the sole C-source were studied . The corrosion resistance of concrete prepared from a sulphate - resistant ferric Portland cement , pozzolanic cement and slag cement in sodium sulphate solutions with 3.5 % SO_3 was studied as a function of superplasticizer contents, water/cement ratio , cement weight in the concrete , and chloride penetration . The favorable effects obtaind by decreasing the amounts of mixing water for equal rheolobehavior were followed more completely .

The chemical resistance[8] of sewage pipes which are made from aluminous cement and are precured and autoclaved was studied. These pipes were found to have a good resistance to H_2S (in domestic sewage and industrial wastes), to dairy wastes, and to organic acids from a food canning factory.

The effect of the pH of water[9] used for preparing cement paste on the binding and hardening rate of portland cement was investigated. The kinetics of structure formation were examined. The pH region in which a considerable strength increased in the range 6.5 - 9. The buffer solutions used were suitable for obtaining gypsum-free rapid-hardening cements. The effect of H^+ and OH^- ions on accelerating of cement hydration and hardening was considered.

Ground water levels increased in a direct proportion to increased use of ammonia fertilizations[10]. This increase in nitrates in drinking water has led to an increase in methemoglobinemia. Agricultural areas are prodominatly affected. Ammonia is also injurious to human tissues, eyes, (especially the cornea), ears, and respiratory tract.

1.1.2 Effect of sewage water and humic substances:-

Domestic sewage[11] is weakly aggressive to sewage systems using cement-based, and the introduction of industrial waste water to the system only rarely causes an increase to Austrian aggressivity class 2 (i.e. strongly aggressive) as was shown by experiments where in slug-doses of HCl, HCOOH, H_2SO_4 and NaOH were added at various concentration to tap-water at various flow rates through a 50 m pitch-coated sewage pipe.

A review with 41 references on the determination of humic substances in natural water is also reported in the literature[12],

1.1.3. Effect of chlorides: -

Cement pastes and mortars intially cured for different periods when subjected to a limited number of wetting and drying in the presence of NaCl solutions of different concentrations produced significant changes in compressive and flexural strengths[13] . The loss in flexural strength was, however, more than the loss in compressive strength for all the specimens in any solution. The specimens cured in 4 % NaCl solution had the lowest loss of strengths and those in saturated solution, the most. A change in hydration mechanism and the formation of microcracks inside the specimens are thought to have influenced the mechanical properties of these specimens.

The mechanical behavior and microstructure of cement paste specimens was studied in sodium chloride environments[14]. Alternate freeze/thaw cycles in different solutions of sodium chloride were applied to estimate the deterioration of the cement paste. SEM and high-pressure porosimetry were used to study the microstructure and morphological changes of the specimens. The water/cement ratio used for the cement pastes and mortars was 0.4 and the solutions of sodium chloride used were 3 % , 4 % and saturated solution. The specimens were initially cured in fresh water for various periods before being subjected to freeze/thaw cycles. The compressive as well as flexural strength of the cement paste deteriorated in different solutions though the mode of deterioration was not similar. The loss of flexural strengths was significantly greater than the loss of compressive strengths for the same specimens . This behaviour, however, depended on the intial curing period of the specimens, concentration of sodium chloride in the solutions, and the duration of exposure to different test programs. The SEM micrographs revealed different morphology of cement paste for different test conditions. The porosimetry test also indicated redistribution of pores in the paste specimens. But all these changes were again dependent on the sodium concentration and intial curing periods.

The free chloride and hydroxide ions concentrations of the pore electrolyte phase in mature hydrated cement pastes containing equivalent quantities of chloride ions, introduced into the mixing water as sodium