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A Review Paper on the Effect of Sulphate Attack on Concrete Durability

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***Abstract:** Durability of concrete is a vital property that affects its serviceability. One of the factors that affect concrete durability is sulphate attack, which can result to expansion, cracking, deterioration and deformation of concrete structures. However the present study focuses on affect of sulphate on concrete durability*

In this research the findings of various research papers were studied wherein different tests were performed on different types of concrete specimens. The specimens varied in size were and subjected to multiple test settings. These different tests are compressive strength, Elastic modulus, Weight evolution, Load displacement curve, Erosion age etc. For each of the aforementioned tests the results were different for eg. The result of compressive strength tests of the specimen were found to have reduced in the beginning when the concentration of solution is increased but with the passages of time it shows an increasing trend.

***Keywords:** Sulphate attack, compressive strength, cracks*

I. INTRODUCTION

Sulphate attack is the reaction between sulphate ions in the pore solution of concrete and constituents in the concrete that result in formation of new reaction products with a relatively large molar volume. There is two type of sulfate attack.

External sulphate attack: when the sulphate ions are from an external source. Internal sulphate attack: when attack occur from an internal sources of sulphate, as in delayed ettringite formation. There is three form of reaction: Tricalcium aluminate, Gypsum and Ettringite. $Ca_3Al_2O_6$, often formulated as $3CaO \cdot Al_2O_3$ to highlight the proportions of the oxides from which It is made It does not occur in nature, but is an important mineral phase in Portland cement. Gypsum is a soft sulfate mineral composed of calcium sulfate dehydrate, with the chemical formula $CaSO_4 \cdot 2H_2O$. It is widely mined and is used as a fertilizer and as the main constituent in many forms of plaster, blackboard/sidewalk chalk, and drywall. Ettringite is the mineral name for calcium sulfoaluminate ($3CaO \cdot Al_2O_3 \cdot 3CaSO_4 \cdot 32H_2O$), which is normally found in Portland cement concretes. Gypsum and other sulfate compounds react with calcium aluminate in the cement to form ettringite within the first few hours after mixing with water.

II. LITERATURE REVIEW

A.R. Suleiman et.al [1] in the hot and arid regions concrete structure can severely suffer from salt weathering. The damage is generally of a localized nature, often the above ground portion of concrete members. This type of deterioration has been described as a physical attack. This process of weathering in these regions depends on the pore structure of the concrete surface. The soil on which the structure stands is in rich in sulphates, a typical characteristic of the soil in arid regions. The salty water rises by the capillary action. After the water has evaporated, salt crystals that are left behind grow in the concrete surface pores resulting in damage to the structure. Therefore protecting the concrete surface can enhance its durability to salt weathering.

The study was conducted using concrete cylinders made with w/c = 0.45 and 0.60, both cured and non-cured which were coated with a variety of surface treatment materials. It was revealed reducing the w/c ratio enhanced the performance of concrete exposed to physical sulfate attack. There was less salt growth through the concrete pore space leading to lesser damage.

Tiejun Liu et.al [2] This experiment uses Cathode ray tube (CRT) funnel glass either partially or totally in place of natural sand as fine aggregate in concrete. The experiment intends to investigate the durability performances of concrete using CRT funnel glass as fine aggregate in 8% sodium chloride solution, 5% sodium sulfate solution and 10% sodium sulfate solution. The test results reveal that although the compressive strength and elastic modulus first decrease with increasing content of CRT funnel glass in concrete however the long-term resistance to chloride ion penetration is enhanced by using CRT funnel glass as fine aggregate. The glass owing to its lesser porosity and water absorption capacity when compared to sand imposes a negative effect on chloride diffusion. It can be concluded in the long term the resistance to chloride ion penetration can be increased for concrete using CRT glass as fine aggregate.

It is generally accepted that the compressive strength and elastic modulus of concrete decrease with an increase of CRT content. However, the relative increase in compressive strength of concrete containing CRT glass is obviously larger than that of the control concrete under sulfate attack. The CRT concrete may degrade faster than control concrete at the advanced deterioration stage under sulfate attack.

Dezhi Wang et.al [3] this paper intends to understand the durability of concrete containing fly ash (FA) and silica fume (SF) against combined freezing-thawing and sulfate attack was studied in this paper. For this purpose concretes with w/b of 0.38 and 0.33 containing FA (i.e. of 10%, 15% and 25% by weight) and SF (i.e. of 5%, 8% and 11% also by weight) as partial replacement of Portland cement (PC) were exposed to 5% and 10% sodium sulfate solution under freezing–thawing cycles. The studies revealed that when exposed to 5% sodium sulfate solution, both FA and SF can enhance concrete's resistance to sulfate attack and in comparison SF performed better than FA.

To conclude both FA and SF as the concrete admixture can enhance concrete's resistance against the combined freezing thawing and sulfate attack with 25% FA and 5–8% leading to significant improvement in concrete durability.

Mohammed Fatah Lakhdari et.al [4] the purpose of this experiment was to study the combined effect of temperature and sulfate attack on the durability of dune–alluvial sand mortar. For this, 4x4x16 mm specimens of mortar were exposed to sulfate solutions MgSo4 and solutions NaSo4 then exposed to 50 °C temperature in oven for three months. Results revealed a decrease in the mechanical strengths of the dune–alluvial sand mortars, either in compression or in tensile, with the passage of time. Dune alluvial sand mortar with super-plasticizer exhibits the best behaviour under sulfate attack.

The fall in the compressive and flexural strengths of mortars without Super-plasticizer is more than 50% for dune-alluvial sand mortars when immersed in sulfate solutions (MgS04 and NaS04) under high temperature of 50 °C for a period of 45 days. The Magnesium sulfate attack hugely impacts the strength of dune-alluvial sand mortars as compared to the Sodium sulfate attack under high temperature of 50 °C.

Jianwei Sun et.al [5] this experiment was performed to gain an understanding on the Influences of limestone powder on the resistance of concretes to the chloride ion penetration and sulfate attack with a constant water/binder ratio. The sensitivity of the properties of concrete to the early moist curing time was also explored. The results showed that under a constant water/binder ratio condition, the resistance to sulfate attack of concrete deteriorates with the increasing of limestone powder content and the resistance to chloride ion penetration decreases when the replacement ratio of limestone powder is 24%. As the early moist curing time elapses, the reducing magnitude of the properties of concrete containing limestone powder was found to be larger than that of plain cement concrete. It was found that both the crystallization of sodium sulfate and the formation of ettringite together result in the deterioration of concrete subjected to the sulfate solution.

Rim Ragoug et.al [6] The Sulfate ions in seawater or underground water can attack the cement paste resulting in expansion and strength loss. This expansion is affected by gypsum precipitation. This study throws light on the possible altered zone. It also intends to find out the mechanisms of degradation that it undergoes in such conditions. For this purpose cement pastes manufactured using CEM I with two w/c ratios (0.45 and 0.60) were used. These were exposed to sodium sulfate solutions (semi immersion at a controlled pH = 8.0 ± 0.1) that has undergone one year of curing in water. Detailed analysis of physical aspect of this phenomenon reveals that there are two modes of transfer that take place. First is the transfer of sulfate ions to the cement matrix. Second phenomenon is the leaching of calcium ions to the external solution. The analysis of the chemical composition highlights the consumption of the surface portlandite, until a total consumption after 2 months of exposure to the sulfate solution. Furthermore, the decalcification of C-S-H with significant chain extension is confirmed and validated by the 29Si NMR results. So far as the ettringite is concerned, it is formed from both AFM and aluminium incorporated in C-S-H.

Feng Xu et.al [7] in this study the concentration distributions of the total and free chloride ions in the cracked concrete are tested to evaluate the influences of sulfate and cracks on the chloride diffusivity of concrete material. The observations that were made revealed that the presence of crack resulted in a 2-D chloride diffusion in concrete. Also the width of the crack has a good enough relation to the chloride diffusion rate. It is found that the presence of sulfate ion decelerated the chloride diffusion in cracked concrete. Also a lower concentration of both free and total chloride ions was noted. With a passage of time the influence of sulfate ion on the chloride diffusion was found to be more pronounced. Furthermore, the chloride binding capacity of concrete material was found to have decreased by the action of sulfate ion in solution. The results were validated by evaluating of corrosion products by X-ray diffraction (XRD) during the erosion process. As a result, the lower water/binder ratio concrete specimen has a lower permeability or higher resistance for the chloride diffusion in concrete material

Ramasamy Gopalakrishnan et.al [8] this study sets out the aim to enhance the resistance of Portland cement mortar to a combined chloride and sulfate attacks by the partial replacement of cement with nano and micro Pozzolanic Material.

The durability of the OPC mortar mixes is investigated using Pozzolans, Fly Ash (FA), Metakaoline (MK), and Slag with nano additives namely, Nano silica (NS), Nano Titania (NT) and Nano alumina (NA) separately and in combined form. After proper curing, they are treated with aggressive chemicals 5%NaCl, 5% Na2SO4 and 5% NaCl–5%Na2SO4 and tested their compressive strength for shorter and longer duration (7–180 d).Sulfate resistance studies are undertaken by keeping samples in a solution of Sodium Sulfate, or Magnesium Sulfate or a mixture of the two for a prolonged time.

This study captures in detail, the ternary mixes behaviour of OPC blended with nano materials of silicious (NS), aluminate (NA) species, and refractive tiania (NT) as well as the compound form of all nano additives. It can be concluded that the Increase in the utilization of micro and nano materials for the replacing cement partially in producing durable mortars will greatly contribute to increasing the life time of the construction products.

Renan P. Salvador et.al [9] External sulfate attack (ESA) is a complex phenomenon that plays an important role in assessing the long-term durability of cement-based materials exposed to a sulfate-rich environment. The objective of this study is to evaluate how accelerator type and dosage influence the durability of sprayed concrete exposed to a sulfate solution External sulfate attack in concrete consists of a series of interdependent processes resulting from the interaction of sulfate ions from the external environment and cement phases. This results in matrix degradation. To obtain a sulfate-resisting matrix, the water/cement ratio must be controlled. The accelerator type and dosage and the interaction between cement and accelerator are important factors that control sprayed concrete strength. Therefore it has a direct influence on the durability of the matrix. Sprayed concrete produced with accelerators shows a lower durability against ESA as compared concretes that do not contain accelerators. The immersion of concrete in the sodium sulfate solution leads to portlandite leaching and gypsum formation, which further leads to AFM conversion into ettringite.

Ahmed M. Diab et.al [10] The effect of nanomaterial, represented by Nano-SiO2 (NS) and NanoMetakaolin (NMK), on the absorption, total porosity, magnesium sulfate resistance and acid resistance of High Strength Concrete (HSC) and High-Performance Concrete (HPC).

This study was performed on three grades of concrete (55 MPa, 80 MPa and 90 MPa) with cement content of 350, 450 and 600 kg/m3 and water/binder ratio of 0.45, 0.29 and 0.24 respectively. The magnesium sulfate and acids resistance were evaluated in terms of compressive strength loss, expansion strain, weight loss, and Ultrasonic Pulse Velocity (UPV) loss. The relation between compressive strength loss and each of expansion strain, weight loss and UPV loss were also studied. The results revealed that addition of NS or NMK to HSC and HPC enhances the resistance to magnesium sulfate. In terms of compressive strength loss, the use of NS of 55 MPa concrete grade showed 18.6% reduction in the compressive strength loss after 360 days when exposed to 10% magnesium sulfate. The use of NMK resulted in 41.4% fall in compressive strength loss as compared to the concrete mix without nanomaterials.

Zhongya Zhang et.al [11] this experiment was performed to provide a deeper understanding on the possible alteration of the mesoscopic pore structures in concrete caused by chemical sulfate attack (CSA) and physical sulfate attack (PSA). It was carried out by using a non-destructive testing technology. Results reveal that during early stages of sulfate exposure (0–3 months), the sulfate attack reaction products fill most categories of mesoscopic pore structures (most categories of pores and pore throats) in concrete specimens exposed to CSA. During the course of experiment it was revealed that deterioration on concrete when exposed to sulfate attack begins with significant expansive forces generated at the narrow mesoscopic pore-level. However, the corresponding mesoscopic deterioration characteristic of concrete under different types of sulfate exposure remains uncertain.

The evolution of mesoscopic pore structures in concrete specimens exposed to sulfate attack was significantly influenced by sulfate exposure condition. During full-immersion condition (CSA, Exposure-I), the mesoscopic pore structures in concrete were filled with sulfate attack reaction products such as ettringite at an early stage, resulting in the decrease of volume of these pores.

Juntao Dang et.al [12] this experiment explored the use of recycled brick aggregates to tackle the shortage of natural. It also investigated the possibilities in reducing the construction waste by producing more sustainable concrete. For this purpose the sand aggregates (SA) were replaced by recycled brick aggregates (rBA) at 0%, 50%, and 100%, and the additional water included in the mix proportion to represent the different moisture states of rBA (oven-dry, partial-dry, saturated-surface-dry) on the microstructure and durability of the concrete.

The results revealed that the replacement of SA by rBA reduces the chloride migration But an increase in the water absorption, water sorptivity, drying shrinkage and carbonation was observed. It was found that the water absorption, water sorptivity and carbonation could be minimized by lowering the additional water content. The microscopy results revealed that the pore structure of concrete deteriorated with an increase in the replacement levels. It can be attributed to the porous structure of Rba.

Syed Minhaj Saleem Kazmi et.al [13] the structural use of recycled aggregate concrete (RAC) on account of its inferior durability performance is limited. The primary focus of this study is to investigate the effect of different RA treatment techniques on the durability properties of RAC. For this purpose, five different RA treatment methods such as immersion in acetic acid, immersion in acetic acid with rubbing, accelerated carbonation, immersion in acetic acid with accelerated carbonation and immersion in lime with accelerated carbonation were considered during course of the study.

Different durability tests such as water absorption, permeability, chloride ingress, acid attack and carbonation were carried out to investigate the effect of different RA treatment techniques on the durability properties of RAC. RAC having treated RA was found to perform better than RAC having untreated RA so far as improved resistance against water absorption, chloride penetration, carbonation, and acid attack is concerned. The results revealed that for more durable performance of RAC, immersion in lime with accelerated carbonation and immersion in acetic acid with rubbing techniques can be used. It is also more environmentally sustainable.

D. Ambika et.al [14] High Strength Concrete (HSC) and High-Performance Concrete (HPC) have been widely/prolifically used in the building projects. HSC and HPC is not merely a simple mixture of cement, water and aggregates. HSC and HPC contribute to achieve the maximum compressive strength of 120 to 150 MPa.

At this intensity the coarse aggregate becomes the weakest link in concrete. The strength and durability of concrete can be improved by removing the coarse aggregate. Using the mineral admixtures and steel fibres is the methodology to develop Reactive Powder Concrete (RPC). The development of Reactive Powder Concrete (RPC) incorporated with GGBS with several mineral admixtures and micro steel fibre was studied and investigated. Four different mineral admixtures namely fly ash, ground granulated blast furnace slag (GGBS), Quartz powder and silica fume were added in RPC. The micro steel fibres were also used.

Self-cured concrete was found to have less water absorption and mass loss standards as compared to fully cured concrete. Also it was found to be less porous compared to the other two types of curing and have only less deterioration.

Kirill Shuldyakov et.al [15] Low durability of reinforced concrete structures and constructions is among major problems in modern concrete science. It is particularly true in harsh climatic conditions and saturated with marine or mineralized water. Existing standards guide designers and builders to increase the density of concrete with increasing degree of aggressive impact, as well as through cyclical freezing of concrete structures, which taken as the main indicator of durability, air entrainment is mandatory.

The deterioration of concrete that occurs during cyclical freezing occurs not only due to the formation of ice in the pores of concrete, but also as a result of temperature stresses in concrete with ice. The washing out of portlandite and aging of the cement gel is also one of the reasons for deterioration – the main structural element of hardened cement paste. The durability of the concrete can be enhanced by maintaining the finely dispersed structure of the hardened cement paste. Preventing crystallization of the gel from external influences or increasing its basicity is an effective way of checking the deterioration.

III. CONCLUSION

A. The change law of compressive strength of the concrete with different strength grade attacked by sulfate with semi-immersion form is different. The compressive strength of different grade concrete decreases with increase of concentration of sulfate solution, however, the corresponding change law of another grade of concrete first increases and then decreases.

B. Concrete specimen prepared with different grade of concrete and curing water with different PH values

C. These specimens of different grades would then go under test for different no. of days

D. Rate of deterioration would then be calculated for each specimen on each interval.

REFERENCES

[1] A.R. Suleiman et.al Effect of surface treatment on durability of concrete exposed to physical sulfate attack http://dx.doi.org/10.1016/j.conbuildmat.2014.10.006

[2] Tiejun Liu et.al Experimental investigation on the durability performances of concrete using cathode ray tube glass as fine aggregate under chloride ion penetration or sulfate attack http://www.elsevier.com/locate/conbuildmat

[3] Dezhi Wang et.al Durability of concrete containing fly ash and silica fume against combined freezing-thawing and sulfate attack http://dx.doi.org/10.1016/j.conbuildmat.2017.04.172

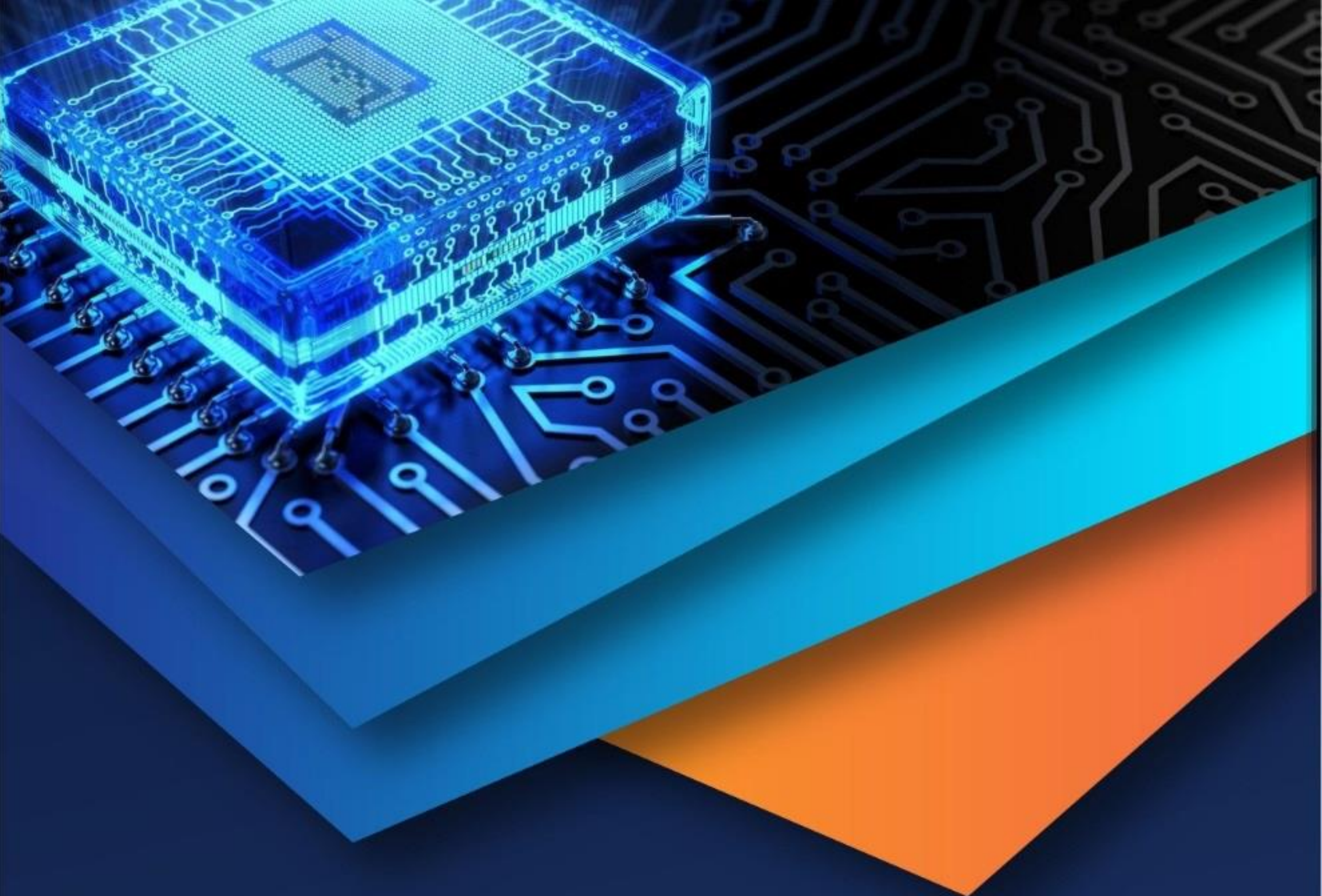
[4] Mohammed Fatah Lakhdari et.al Combined Effect of Temperature and Sulfate Attack on the Durability of Repair Mortar Based on Mixture of Dune-Alluvial Sand http://www.sciencedirect.com/

[5] Jianwei Sun et.al Influences of limestone powder on the resistance of concretes to the chloride ion penetration and sulfate attack http://www.sciencedirect.com/science/journal/

[6] Rim Ragoug et.al Durability of cement pastes exposed to external sulfate attack and leaching: Physical and chemical aspects https://doi.org/10.1016/j.cemconres.2018.11.006

[7] Feng Xu et.al Experimental investigation on the effect of sulfate attack on chloride diffusivity of cracked concrete subjected to composite solution http://www.sciencedirect.com/science/journal/09500618

[8] Ramasamy Gopalakrishnan et.al The effects on durability and mechanical properties of multiple nano and micro additive OPC mortar exposed to combined chloride and sulfate attack https://doi.org/10.1016/j.mssp.2019.104772
[9] Renan P. Salvador et.al Influence of accelerator type and dosage on the durability of wet-mixed sprayed concrete against external sulfate attack http://www.sciencedirect.com/science/journal/09500618
[10] Ahmed M. Diab et.al Effect of nanomaterials additives on performance of concrete resistance against magnesium sulfate and acids https://doi.org/10.1016/j.conbuildmat.2019.03.099
[11] Zhongya Zhang et.al Understanding of the deterioration characteristic of concrete exposed to external sulfate attack: Insight into mesoscopic pore structures https://doi.org/10.1016/j.conbuildmat.2020.119932
[12] Juntao Dang et.al Durability and microstructural properties of concrete with recycled brick as fine aggregates http://www.sciencedirect.com/science/journal/09500618
[13] Syed Minhaj Saleem Kazmi et.al Effect of recycled aggregate treatment techniques on the durability of concrete: A comparative evaluation http://www.sciencedirect.com/science/journal/09500618
[14] D. Ambika et.al An exploration on the durability properties of reactive powder concrete http://www.sciencedirect.com/science/journal/22147853
[15] Kirill Shuldyakov et.al Stable microstructure of hardened cement paste – A guarantee of the durability of concrete http://www.sciencedirect.com/science/journal/22145095



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