REVIEW ON THE IMPACT OF AIR ENTRAINTMENT ON THE PROPERTIES OF CONCRETE STRUCTURES

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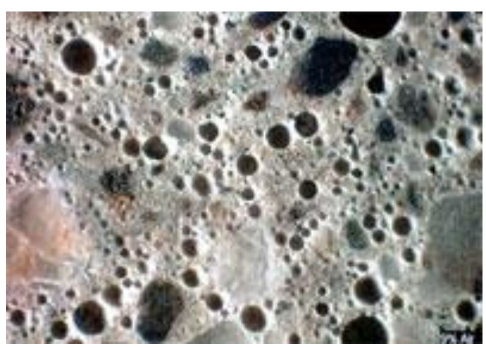
***Abstract**: When an air entraining agent is added during mixing, it causes little air bubbles to be purposefully produced in a batch of concrete. A type of surfactant that lowers the surface tension between water and particles in this situation, it enables the formation of bubbles of the desired size. These are formed when mixing the concrete, and the majority of them persist to remain in the finished product after it has dried.By including an appropriate air-entraining agent in the concrete mix, air entrained concrete can be created. For the usage of air entraining admixtures in the concrete work, many papers were being considered. The results are being compared, and research is being done to determine the best dosage of each admixture for improving workability and significant compressive strength in the concrete. For the improvement of acid resistance and workability of the concrete, paper suggests the use of various admixtures in the concrete.*

I. INTRODUCTION

Per cubic foot, air-entrained concrete has billions of tiny air cells. These air pockets create microscopic chambers for frozen water to expand into, relieving internal pressure on the concrete. air entrained Under careful engineering supervision, air-entrained concrete is made using air-entraining Portland cement or by adding air-entraining agents as the concrete is mixed on the site. Normal entrained air levels range from four to seven percent of the volume of the concrete, but they might vary depending on the circumstances.Millions of non-coalescing air bubbles are incorporated into these air entraining agents, acting as flexible ball bearings and altering the qualities of plastic concrete in terms of workability, segregation, bleeding, and finishing quality. Additionally, it changes the hardened concrete's permeability and resistance to frost action.



1.1 Effect of air entrainment on concrete

Following properties of normal concrete get modified due to air entrainment:

1) Workability of concrete increases.

2)Use of air entraining agent reduces the effect of freezing and thawing.

3)Bleeding, segregation and laitance in concrete reduces.

4)Entrained air improves the acid and alkaline resisting capacity of concrete.

5) Durability of hardened concrete increases. Unit weight of concrete decreases and permeability decreases.

6) The strength of concrete decreased, but not very substantial.

7)Air-entrainment in concrete must not be done if the site control is not good.

1.2 Type of air present in concrete

Entrained air

Entrained air is intentionally created by adding admixture specifically designed for this purpose. The goal is to develop a system of uniformly dispersed air voids throughout the concrete and present in controlled amount (void size below 0.3 mm)

Entrapped air

Entrapped air is created during improper mixing, consolidating and placement of the concrete. It is not beneficial and have negative effect on concrete even void size larger in this case (upto3 mm)

II. HISTORY OF AIR-ENTRAINMENT

It was discovered in the 1930s that some roads in the North-East States of America could withstand the impacts of freezing and thawing temperatures and the presence of salts better than other roads in the region. The less dense roads had more durable roads, according to an experimental inquiry, and the cement came from mills where beef tallow served as an air-entraining agent and improved the concrete's durability. This prompted a more cautious examination, and the New York Department of Public Works created an air-entrained concrete roadway in 1939. Since then, the effect has attracted a lot of attention. Here are some of the materials' descriptions:

2.1 Fatty Acid Salts

In order to meet requirements like performance in use and the capacity to generate stable aqueous solutions of sufficient strength, fatty acids are used as air-entrain agents. Natural oils and fats like coconut oil, which occur naturally, are employed in the form of this mixture for concrete. These fatty acids are present in a diversity of chain lengths. Fatty acid salt makes up around 20% of the weight of conventional formulations. These compounds can be combined in solution with specific lingosulphonic and hydroxyl carboxylic acid salts to create admixtures with air entraining and water lowering properties, unlike neutralised wood resins..

2.2 Alkyl-aryl Sulphonates

The alkyl-aryl sulphonates tend to find utilization in the production of light weight concrete (LWAC) and not in enhancing the freezing-thawing durability of normal concrete. The common raw material is ortho dodecyl benzene sulphone, a basic surfactant used in a variety of industrial and domestic detergents. The hydrocarbon base is petroleum derived. The sulphonation process utilized can vary from direct reaction with sulphuric acid to SO_2/SO_3 mixtures; result in some excess sulphuric acid. On neutralization a proportion of sodium sulphate is produced which is preferably kept to a minimum for admixture formulations.

2.3 Alkyl Sulphates

These products are also compatible with a number of water reducing agents to produce air-entraining agents which can be further used in the production of air entraining concrete.

2.4 Phenol Ethoxylates

Since phenol ethoxylates are non-ionic materials, they are unique. Although they are not frequently employed, solutions of 2 to 4% by weight in water work well at low dosage levels and they are particularly effective at low addition levels.

Nonylphenolethoxylate is the most widely used substance, and the few research that have been done on it suggest that the higher value is the most effective.

III. LITERATURE REVIEW

Qi Liu (2020) : It is commonly acknowledged that the air void size distribution plays a crucial role in air-entrained cementitious materials. It is still unclear, nevertheless, how characteristics like the molecular structure of air-entraining agents (AEAs), the kind of solid particles used, or the chemical environment of the pore solution in fresh mortars affect the air-entraining behaviour. Additionally, there are few ways to evaluate how AEAs and cement particles interact. Thus, the air-entraining behaviours of three different surfactant types (cationic, anionic, and nonionic) were investigated in this study. By using zeta potential and attenuated total reflectance-Fourier transform infrared (ATR-FTIR) spectroscopy, the general functioning mechanisms of these surfactants were investigated. According to the results, the strong electrical contact between the cationic surfactant's air bubbles and negatively charged cement particles causes the cationic surfactant to entrain inappropriate coarse air gaps. Anionic surfactants attract finer air spaces by interacting with the positively charged portion of cement particles. The nonionic surfactant entrains the finest and most uniform air spaces because the interaction between the nonionic surfactant and cement particles is so minimal.

Abdulkader EL MIR, Salem G. NEHME (2017) : Due to its special characteristics, self-compacting concrete has obtained a broad variety of uses. With the right choice of raw ingredients, it may provide a high strength and durable type of concrete. This study's objective was to demonstrate how using a large dosage of air entraining admixture affected the characteristics of self-compacting concrete. The resistance of conventional and air-entraining self-compacting concrete that contains slag-blended cement and additional cementitious elements to frost-salt scaling was experimentally investigated. To obtain an objective comparison between air and non-air entrained self-compacting concrete mixtures, additional fresh and hardened properties tests, such as slump flow, V-funnel, compressive strength, splitting tensile strength, air void characteristics, and water absorption tests, were carried out. To further this inquiry, the automated image analysis process was used to assess the air void properties. The results show that the air entraining admixture significantly reduced the compressive strength by up to 52% and that metakaolin, as opposed to silica fume, was the dominant additional cementitious material in terms of scaling resistance and water absorption.

J Holan, J Novák and R Štefan (2019): Only a small number of studies have examined the mechanical characteristics of air-entrained concrete at high temperatures, despite decades of research into the fire response of concrete. The experimental examination of the impact of air entrainment on concrete's compressive strength at varied high temperatures is presented in this work as early findings. On reference and air-entrained concrete specimens, heat treatments and compression tests have been carried out as part of this investigation. The analysis of the experiment's data reveals that when subjected to high temperatures for an extended period of time, air entrainment appears to have a negative impact on the concrete's compressive strength.

Mohammed Hefni, **Ferri Hassani (2021)** : The experimental study described in this paper examines the impact of cement and entrained air dosages on mine backfill unconfined compressive strength (UCS), fresh density, and dry density as part of an extensive research programme exploring the potential benefits of using air-entraining admixtures in mine backfill. Silica sand, regular Portland cement, water, and an entrained air admixture were used to create backfill specimens. To create predictive mathematical models and evaluate the findings, an experimental design using response surface approach was used. The findings showed that a 3.5% entrained air dosage could increase the UCS of the mine backfill due to greater cement particle dispersion. The UCS as well as the fresh and dry densities were yet decreased by an additional dose increase of about 200 and 120 kg/m3, respectively. According to study findings, utilising air-entraining admixtures may improve mine backfill flowability and lower density, leading to safer and more environmentally friendly working conditions in an underground mining setting.

Hamid Eskandari, Anis Ghanei (2016) : Sulfates, carbonates, and chlorides affected the attack on reinforced concrete buildings. Chloride attack is the primary cause of reinforced concrete structure corrosion, and corrosion of the reinforcing steel is avoided by lowering chlorides in the concrete at the proper thickness, which also regulates the permeability of the concrete coating layer. In order to investigate the properties of corrosion and water absorption, test samples were prepared using a 5 mix with various air entraining admixtures on a cylindrical sample along with a 15 mm reinforced bar. Results reveal that concrete's water absorption and electrical resistivity are significantly impacted by air entraining.

B. Łaźniewska-Piekarczyk (2013) : In the research, it is investigated how a particular type of viscosity modifying admixture (VMA) affects the air-content and workability of air-entrained high performance self-compacting concrete (HPSCC). The aim of this study was to investigate the effects of cement ratio, type and volume of aggregate, and volume of cement paste on the porosity and pore size distribution of HPSCC with constant water. Investigations are also conducted into the toughened HPSCC's air gaps and frost resistance properties. The findings in this paper showed that, despite their apparent similarity in chemical makeup, admixtures from diverse sources cannot be employed interchangeably.

Bo Chen A. Ghani Razaqpur (2022) : There is insufficient knowledge regarding how air entrainment affects chloride diffusivity and binding in partially frozen concrete, despite the fact that in some places concrete is partially frozen for several months per year. To address this problem, total and free chloride concentrations were measured in concrete that had no air entrained and had air entrained under continuous exposure temperatures of +5, 0, 5, and 15 °C. When the concrete evaporable water was either unfrozen or nearly entirely frozen, the entrained air decreased chloride diffusivity by 18%, but it only did so when the concrete evaporable water was only partially frozen. Under every test temperature, air-entrained concrete demonstrated lower binding capacity than non-air-entrained concrete. The impact of temperature after freezing on the diffusivity of concrete.

Xu-li Lan, Xiao-hui Zeng (2022) : Through in-situ tests, this work aims to examine the properties of the pore structure of air-entrained concrete at low atmospheric pressure (0.7P0 = 0.7 atm) and standard atmospheric pressure (P0 = 1 atm). The surface fractal dimension in various pore size regions is estimated using the results from the mercury intrusion porosimetry (MIP) test and linearly regressed using a thermodynamic model. According to the findings, low atmospheric pressure significantly affects the fractal characteristics of pores and pore volume. Surface fractal dimensions of pores generated at 0.7P0 are 4.5%–27.6% smaller than those prepared at P0 for pores smaller than 10 nm, and 4.5%–13.6% larger than P0 for holes larger than 1000 nm. In comparison to P0, the volumes of pores smaller than 10 nm and larger than 1000 nm are 9.4%–38.9% and 38.5%–66.7% smaller, respectively, whereas the volumes of pores between 10 and 1000 nm are 19.8%–41.8% larger. Discussion of the mechanisms underlying the anomalous pore structure at 0.7P0 is done from the angles of cement hydration and air bubble mechanical equilibrium.

IV. MECHANISM OF AIR ENTRAINTMENT

Air-entraining agents (AEA) stabilised air bubbles rather than creating them. The reciprocal attraction between the separated water molecules was lessened as the air-entraining agent molecules were inserted between neighbouring water molecules at the water's surface. Surface tension was reduced to sustain the bubbles against mechanical deformation and rupture, facilitating bubble formation. The smaller bubbles, which had a higher internal pressure, merged to form larger bubbles in the absence of an air-entraining agent, which had a greater propensity to escape to the surface and rupture. At the bubble's surface, absorbed AEA molecules form an end-to-end film with their polar heads in the water phase. If the molecule had a charge, the bubble also did (Dodson,1990). The ends of the AEA molecules that protruded into the water were also attracted to cement grains.

V. ADVANTAGES OF AIR ENTRAINMENT IN CONCRETE

- Workability of concrete increases.
- Use of air entraining agent reduces the effect of freezing and thawing.
- Bleeding, segregation and laitance in concrete reduces.
- Entrained air improves the sulphate resisting capacity of concrete.
- Reduces the possibility of shrinkage and crack formation in the concrete surface.

VI. CONCLUSION

Concrete that has been purposely infused with tiny air bubbles in order to introduce air in controlled proportions is known as air-entrained concrete. While some of the air entrainment concrete's results are still useful for future applications, others make the use of AEAs problematic. While listing the benefits of the review research, it became clear that there had been a considerable shift in workability, which had reduced the amount of time and vibrations needed for proper consolidation. Utilizing AEAs also resulted in a reduction in the need for cement and water. The durability of concrete, the workability of the mix, the ability to save materials like cement, the reduction of capillary water passage, the reduction of temperature rise in concrete, etc. are all significantly improved by entrained air.

The main issue with the use of AEAs is the decreased strength of concrete. Therefore, the practical application of AEA utilisation can be explained by how much structural strength can be sacrificed in order to maximise AEA usage. Therefore, it is advised to use AEAs in accordance with the criteria of workability, strength, and durability requirements. The criteria for utilising AEA should be based on the acceptable level of strength loss and the necessary workability improvement. Additionally, further research should be done on how utilising AEA affects different classes of concrete, split tensile strength, and other concrete durability skin qualities like water absorption, sorptivity, etc.

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