

REVIEW OF ASSESSMENT OF CORROSION RELATED DURABILITY PROPERTIES FOR CONCRETE CONTAINING LIMESTONE POWDER

Amit Kumar¹, Dr. P. K. Sharma²

¹M. Tech Scholar, Department of Civil Engineering, NIRT Bhopal, India.

²Prof. Department of Civil Engineering, NIRT Bhopal, India.

ABSTRACT

The literature review search has been performed for relevant publications using many Web based search engines and databases. The search was purposely restricted to articles published in refereed journals and containing the terms: Compressive strength, Flexural Strength, lime stone etc. Any research paper with the key terms as mentioned above has been considered here and included in the database of this research. Thus the literature review provides a basic background and the ideas for the present work and is relevant for the present study.

Keywords: Coarse Aggregate, Design Mix, Sand, Slump value, workability

1. INTRODUCTION

GENERAL

The incorporation of the industrial waste in concrete, the energy and the environment can be saved. The use of these by-products offer environmental advantages like diversion of the material from the waste bodies, reduction of the energy used in processing virgin materials, usage of virgin materials and decrease in pollution. To produce Ordinary Portland Cement (OPC), we use earth resources like limestone. During manufacturing of one tonne of OPC, an equal amount of carbon dioxide is released into the atmosphere which is harmful to the environment. So there is a need to choose an alternative. In urban cities, solid waste management is a very challenging task, which is a serious pollution problem due to the generation of large quantities of solid waste. Also, the cost of cement is also gradually increasing day by day. So, there is a great need to use industrial waste products in an appropriate manner to reduce the cost and environmental problems. Many research organizations are doing massive work on waste materials concerning. Paper mill sludge is a major environmental and economic issue for the silica industry. The material is a by-product of this is silica fume. The silica industry generates large volume of waste called silica fume; which is technology-dependent. It is estimated around 18% of waste (sludge) is generated during the production of metal..

2. REVIEW OF SOME IMPORTANT LITERATURE

- **Manoj et al (2023)** An important environmental concern is the wide use of cement in the construction industry. In this scenario the cement usage should be reduced using supplementary cementitious materials like Lime-sludge (LS) and Wollastonite-powder (WP). LS and WP, due to their properties and environmental friendliness they have a huge potential as replacements to Ordinary Portland cement (OPC). Using LS and WP as partial replacements in cement long term sustainable cement concrete can be produced. In the current study a novel process is implemented to produce a long-term sustainable concrete using Lime sludge and Wollastonite powder to form binary mixes and validate it by mechanical properties of M30 grade concrete. Cement was partially replaced with mineral admixture lime sludge at 5%, 10%, and 15% by weight of cement to form a binary blended mix and by wollastonite at 10%, 15%, and 20% by weight of cement to form a second binary blended mix. To make a comparison, the strength properties of both the control mix and the blended concrete mixes are determined. The concrete used in this study performed better when mineral admixtures were added. The blended mix concrete had enhanced strength. It was concluded that LS10 and WP15 performed better in terms of strength.
- **Ravichandran et al (2023)** The production of cement results in a significant amount of energy consumption and CO₂ emissions, which are major contributors to environmental pollution. Researchers have developed a ternary blended mix concrete to address these concerns by partially substituting cement with a combination of lime sludge (LS) and wollastonite powder(WP). This study investigated the mechanical properties (compressive strength, spilt tensile strength, and flexural strength) of a ternary blended concrete mix with a grade of M30. 180 specimens, including 60 cubes, 60 cylinders, and 60 prisms, were prepared for testing. The blended concrete mix was produced using different percentages of cement replacement by LS (5%, 10%, 15%) and WP (10%, 15%, 20%). The compressive strength for the ternary mix at 10% LS and 15% WP was 44.78% higher than the conventional mix, the flexural strength ternary mix at 10% LS and 15% WP was 25.46% higher than the conventional mix, and spilt tensile strength ternary mix at 10% LS, and 15% WP was 27.30% higher than the conventional mix at 28 days and trend is almost same for 7,56 and 90 days . The results showed that a ternary mix containing 75% cement, 10% LS, and 15% WP exhibited the best mechanical properties.

- **Bameri et al (2022)** This study evaluated the effects of various proportions of silica fume (SF), waste glass powder (WGP), and ground granulated blast furnace slag (GGBFS) on the mechanical and durability properties of concrete. The properties evaluated in this study include compressive, tensile, and flexural strength, magnesium sulfate and sulfuric acid attack, surface resistivity, rapid chloride penetrability test (RCPT), water absorption, depth of penetration of water, and microstructure analysis by scanning electron microscopy (SEM). The results of compressive, tensile, and flexural strength, chloride ion penetrability, and water absorption tests showed that adding 5% of SF to mixtures containing 10% WGP or 10% GGBFS improved concrete performance significantly due to packing density and synergistic effect; however, adding 5% of SF to concrete mixtures decreased the resistance against the magnesium sulfate and sulfuric acid attack. The binary mixture of 15% of WGP showed appropriate performance against the magnesium sulfate and sulfuric acid attack, which may be due to the sacrificial nature of WGP. In addition, the binary mixtures of 15% of WGP and 15% of GGBFS reduced the depth of penetration of water by 45%. Microstructure analysis by SEM showed that the presence of SF, along with WGP and GGBFS, improves the packing density. Finally, adding 5% of SF is suggested to improve the properties of concrete mixtures containing WGP and GGBFS.
- **Franco Zunino and Karen Scrivener (2022)** Based on the results, the following conclusions can be drawn: Despite both alite and belite remaining unreacted at 90 days the increase in the degree of reaction of these phases is very small, between 0.4 and 3% for alite and 0 to 3% for belite. The Increase in the reaction of MK is more substantial at around 20%. Even so the rate of reaction from 90 days to 3 years is 10 to 20 times slower than in the period 28–90 days. Precipitation of hydrates continues in pore solution filled pores between 90 days and 3 years in LC3 systems, leading to a reduction of the critical entry radius and a significant decrease in total porosity in systems with available MK. The strongest reduction of porosity is in pore sizes below about 5 nm, which internal RH measurements indicate remain saturated with solution.
- **Gerald Gyabaah, Shingo Miyazawa and Nobukazu Nito (2022)** Usage of industrial by-products such as ground granulated blast furnace slag (GGBFS), gypsum, and limestone powder have gained prominence in concrete production. It is, therefore, very important to conduct research into the various materials and their attendant influence on properties of concrete at different ambient temperatures. This study focused on the slump, setting time, and compressive strength of concrete with GGBFS at a constant replacement ratio, in which different forms of gypsum, namely anhydrous and di-hydrate gypsum, were also added at different SO₃ contents. Effect of addition of limestone powder was also investigated. The results of the tests indicated that both gypsum and limestone powder when added to a mix proportion containing GGBFS can improve slump and compressive strength of concrete. Anhydrous gypsum produced higher optimum compressive strength as compared with di-hydrate gypsum. An increase in SO₃ content from gypsum contributed to strength development at early ages but reduced its long-term strength. Gypsum added to the mix delayed initial and final setting time. Limestone powder accelerated both initial and final setting times and contributed to increasing compressive strength after one day, thus three to seven days; however, the long-term strength was reduced. Curing temperature of concrete influenced strength development and the time required to remove formwork was determined for different mixtures using “maturity function.”
- **Malgorzata Golaszewska and Zbigniew Giergiczny (2022)** It is currently vital to use more environmentally friendly cementitious composites, such as blended slag-limestone cements. However, many properties of slag-limestone cements are not yet fully researched, especially in regards to the effect of limestone properties on properties of mortars and concrete. In the research, three types of slag cements were mixed with two types of limestone to obtain multi-component slag-limestone cements. Tests of rheological properties, heat of hydration, and compressive strength were conducted to ascertain the effect of limestone on the cement properties and to check the viability of this type of cement for engineering practice. It was found that the addition of up to 10% of limestone to slag cements did not have negative effects on tested properties; however, the exact influence of limestone was dependent on limestone particle size distribution. Increasing the amount of limestone in limestone-slag cements to 15% significantly decreased the compressive strength of the mortars and decreased hydration heat but had no significant effect on rheological properties.
- **Lochana Poudyal et al (2021)** Despite lower environmental impacts, the use of Portland Limestone Cement (PLC) concrete has been limited due to its reduced later age strength and compromised durability properties. This research evaluates the effects of nano calcium carbonate (CaCO₃) on the performance of PLC concrete. The study follows a series of experiments on the fresh, hardened, and durability properties of PLC concrete with different replacement rates of nano CaCO₃. Incorporation of 1% nano CaCO₃ into PLC concrete provided the optimal performance, where the 56 days compressive strength was increased by approximately 7%, and the

permeability was reduced by approximately 13% as compared to Ordinary Portland Cement (OPC) concrete. Further, improvements were observed in other durability aspects such as Alkali-Silica Reaction (ASR) and scaling resistance. Additionally, nano CaCO_3 has the potential to be produced within the cement plant while utilizing the CO_2 emissions from the cement industries. The integration of nanotechnology in PLC concrete thus will help produce a more environment-friendly concrete with enhanced performance. More in-depth study on commercial production of nano CaCO_3 thus has the potential to offer a new generation cement—sustainable, economical, and durable cement—leading towards green infrastructure and global environmental sustainability.

- **Taku et al (2021)** This research investigates the durability-based properties of a ternary calcined clay and limestone powder blended Self Compacting Concrete by measuring the short- and long-term permeation properties using water absorption and sorptivity properties testing. Also, the variation of compressive strength with age was evaluated at 7, 14, 28, and 56 days, while the split tensile strength was determined at 7 and 28 days curing. The ternary SCC's mineralogy and morphology were evaluated using FT IR Spectroscopy, SEM imaging, and EDS. The results obtained show that the ternary SCC showed improved durability and strength properties with dense and improved microstructure.
- **Chakraborty et al (2021)** This work investigates the sulfate and chloride resistance of cement composites (mortar and concrete) manufactured using electrolyzed water. Control and electrolyzed water based cement composites were prepared using distilled water and 30 min electrolyzed water, respectively. These were exposed to 5% Na_2SO_4 , 3.5% NaCl , and a combined mixture of 5% Na_2SO_4 and 3.5% NaCl solution for 200 days. Additionally, rebar reinforced control and electrolyzed water-based samples were exposed to ambient air and 5% NaCl solution for 180 days, and their corrosion potential was monitored. For control specimens, the results show compressive strength losses of 5, 12.4, and 6.1% when exposed to the above solutions, respectively, whilst for electrolyzed water-based specimens, the losses were reduced to 1, 10.1, and 3.4%, respectively. Statistical analysis of the potential values from the accelerated corrosion tests also show reduced corrosion (58 mV less negative potential) in rebar embedded in electrolyzed water-based specimen (548 mV at 180 days) than in control specimen (606 mV). Based on the spectral and microstructural analysis, the enhanced durability performance of electrolyzed water-based specimens is attributed to the lower ingress of deleterious agents through the less porous and compact microstructure of the hardened composites.
- **Wei-Ting Lin, An Cheng and Robert Černý (2021)** This study investigated the mechanical properties and durability of mortar specimens containing various quantities of waste limestone powder (0%, 10%, 20%, and 30% of the weight of cement). The mechanical properties were evaluated in terms of flowability, compressive strength, and splitting tensile strength. Permeability was evaluated in terms of resistivity, absorption, and rapid chloride penetration (total charge passed). Test results revealed that replacing 10% of the cement with limestone powder improves both mechanical performance and durability. However, reducing the cement content reduced the availability of hydration products to fill the pores in the microstructure. The hydration product of limestone powder was mainly calcium hydroxide, which undermines the development of strength in the paste. Nonetheless, our results indicate that waste limestone powder is suitable for the partial replacement of cement.

3. CONCLUSION

study has proven that limestone, when used in blended cements, changes hardened cements' pore structure by 33 increasing the capillaries pore size from 20 nm to 40 nm when the maximum amount (35%) of limestone that is allowed by EN 197-1 is used. On the other hand, it reduces the threshold diameter of the paste and presents a more uniform pore size distribution. This behavior can be attributed to the better packing of particles due to the filling effect of the LP, indicating that chemical species enter the hardened cement with difficulty but transport easier inside the cement paste because the pores have approximately the same size. Furthermore, a better performance against freeze–thaw and salt decay is acquired.

As gel pores are concerned, addition of limestone in cement produces smaller gel pores and that is related to higher hydration rates. Hence, the use of limestone in cement produces a material that is structurally adequate to be used in construction.

4. REFERENCE

- [1] Mahdi Bameri. Evaluation of Mechanical and Durability Properties of Eco-Friendly Concrete Containing Silica Fume, Waste Glass Powder, and Ground Granulated Blast Furnace Slag. Hindawi Advances in Materials Science and Engineering Volume 2022, Article ID 2730391, 22 page
- [2] Microstructural developments of limestone calcined clay cement (LC3) pastes after long-term (3 years) hydration Franco Zunino *, Karen Scrivener. Cement and Concrete Research (2022).

-
- [3] Gołaszewska, M.; Giergiczny, Z. Study of the Properties of Blended Cements Containing Various Types of Slag Cements and Limestone Powder. *Materials* 2021, 14, 6072. <https://doi.org/10.3390/ma14206072>
- [4] Poudyal, L.; Adhikari, K.; Won, M. Mechanical and Durability Properties of Portland Limestone Cement (PLC) Incorporated with Nano Calcium Carbonate (CaCO_3). *Materials* 2021, 14, 905
- [5] Taku J. K., Amartey Y. D., Ejeh S. P., Lawan A. (2021). Durability evaluation of calcined clay and limestone powder blended ternary self-compacting concrete. *Journal of Engineering Sciences*, Vol. 8(1), pp. C1–C10,
- [6] Wei-Ting Lin, An Cheng, and Robert Černý. Effect of limestone powder on strength and permeability of cementitious mortars. *MATEC Web of Conferences* 322, 01009 (2020)
- [7] Wei Zhou. Investigation on Hydration and Mechanical Properties of Mortar Containing Limestone Powder and Fly Ash Based on the Coupled Chemical–Thermal–Mechanical Method. *Materials* 2020, 13, 4387.
- [8] Warzer Qadir, Kawan Ghafor, and Ahmed Mohammed* Evaluation the effect of lime on the plastic and hardened properties of cement mortar and quantied using Vipulanandan model. *Open Eng.* 2019; 9:468–480
- [9] Belin Jude.A, Bala Vignesh. Influence of mineral admixtures on strength and durability properties of concrete. *Indian J.Sci.Res.* 17(2): 228 - 232, 2018
- [10] Xiao-Yong Wang. Kinetic Hydration Heat Modeling for High-Performance Concrete Containing Limestone Powder. *Hindawi Advances in Materials Science and Engineering Volume 2017*, Article ID 4090265, 11 pages.
- [11] Ahmed. Long term study of mechanical properties, durability and environmental impact of limestone cement concrete. *Alexandria University Alexandria Engineering Journal*.
- [12] Patel, M., Karera, A. and Prasanna, P. “Effect of thermal and chemical treatments on carbon and silica contents in rice husk”, *J. Mater. Sci.*, Vol. 22 pp.2457, 1987.
- [13] Paya, J., Monzo J., Borrachero M.V., Peris E. and Gonzalez-Lopez E., “Mechanical treatment of fly ashes. Part III: studies on strength development on ground fly ashes—cement mortars”, *Cem. and Concr. Res.*, Vol. 27, pp. 1365–1377, 1997.
- [14] Paya, J., Monzo, J., Peris-Mora E., Borrachero M.V., Tercero R. and Pinillos C., “Early-strength development of PC mortars containing air classified fly ashes”, *Cem. and Concr. Res.* Vol. 25, pp. 449–456, 1995. .