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Effect of Surfactant on Portland cement

Mr.Anoop Kumar, Ravi Rajput,Varun Kumar Singh Jadaun,Ramakant Sharma,Vaibhav Kumar Mishra

Under Graduate student of Civil Engineering and Technology,

Galgotias college of engineering and Technology (GCET), Greater Noida Uttar Pradesh

Email Id:

anoop.kumar@galgotiacollege.edu

ravirajnewidea@gmail.com varunthakur02003@gmail.com

Mishravaibhav3001@gmail.com bombayiit555@gmail.com

ABSTRACT: Cement is a kind of substance with adhesive and cohesive properties, capable of binding solid particles together to form a dense and long-lasting concrete mass. Cement kinds other than those made mostly of lime are not used in civil engineering. In civil engineering, cements are used primarily to bind sand and aggregate particles together via a chemical reaction with water known as hydration.

A combination was made by adding 2% and 4% by weight of sodium lauryl sulphate, a surfactant, to the weight of cement in order to increase the quality of the concrete. The workability, setting time, and strength of the concrete were evaluated using a battery of tests, including the Compressive Strength Test, the Initial and Final Setting Time Test, the Consistency Test, and the Slump Test.

The concrete's workability was enhanced, and the amount of water needed was decreased, thanks to the inclusion of the surfactant. As a result, the concrete's compressive strength improved. Because the surfactant lowered the water's surface tension, less water was needed to make the concrete workable. So, adding a surfactant, like sodium lauryl sulphate, can boost concrete quality by enhancing its workability and compressive strength while decreasing the amount of water required.

KEYWORDS: Surfactant, Sodium Lauryl Sulphate, Hydration

Introduction

Concrete is a popular construction material that is classified as a composite man-made substance. It is formed by combining binding materials like cement with aggregate, water, and admixture [1]. Within a concrete mixture, the cement and water work together to form a paste or matrix that fills the voids between the aggregate particles and binds them together.The addition of surfactant concretes enhances their properties, such as workability, strength, and decrease viscosity [2]. The addition of surfactants in cement concrete requires careful consideration of factors such as the type of surfactant, dosage, compatibility with other admixtures, cement composition, environmental conditions, and desired properties of the concrete. It is important to consult with experts and conduct appropriate testing to ensure the surfactants are suitable for the specific application and achieve the desired results.

Surfactants are a type of molecule that possess both hydrophobic and hydrophilicproperties, making them amphiphilic [3]. Due to their unique structure, surfactants can reduce the surface tension between two immiscible phases, such as oil and water.[4] Surfactants can be produced through chemical synthesis or by using biological materials, which are known as biosurfactants. The reduction in surface tension that surfactants provide is due to their unique molecular structure, which contains both hydrophilic and hydrophobic components.[5] Surfactants are classified as anionic, non-ionic, and cationic, depending on the nature of the hydrophilic part. Theeffect of the synthetic surfactant with non-ionic and anionic surfactants on the compressive strength of cement mortar has been studied.[6]Sodium lauryl sulphate (SLS) is an anionic surfactant that is commonly used in household cleaning products such as laundry, spray cleaners, and dishwasher detergents. It is an effective emulsifying cleaning agent [7-8]. The concentration of SLS in consumer products can be different depending on theproduct and manufacturer.Typically,cosmetic products contain 0.01%-50% SLS,while cleaning products contain 1%-30% SLS.[9-10]

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2. Experimental Program

Common Portland cement is the binder of choice for making concrete. In this experiment, M25 grade concrete was employed, and the cement-to-sand-to-aggregate ratio was 1:1:2. Various tests will be performed on the samples before and after the addition of surfactant to determine the effect of surfactant on the properties of concrete.

In all test amount of SLS percentage in taken by weight of cement.

The following experiments will be performed:

1-CONSISTENCY TEST OF CEMENT
2-SETTING TIME OF CEMENT
3-SLUMP CONE TEST OF CONCRETE
4-COMPRESSIVE STRENGTH OF CEMENT

2.1 CONSISTENCY TEST

If the plunger of a Vicat instrument can penetrate the cement paste to a depth of 5 to 7 mm from the bottom, the cement is considered to be of standard or normal consistency. This is a crucial cement measurement since it shows how much water a particular cement sample needs to reach a certain consistency. [11]The Vicat test establishes the reference consistency by measuring the depth of penetration of the Vicat plunger into a standardised cement and water paste. Cement performance may be greatly improved by properly mixing it with the right quantity of water, and this test is often used in the construction industry to assure this.

Surfactants can have various effects on the consistency of cement, depending on the type and dosage of surfactant used. Here are a few possible effects:

1. Water Reduction: Surfactants, commonly known as water reducers or plasticizers, are often utilized in cement mixtures to decrease the amount of water necessary to achieve a desired consistency. These surfactants function by dispersing cement particles, enabling them to move more freely and reducing the friction between them. Consequently, a smaller quantity of water is required to attain the desired workability, resulting in a more consistent and less fluid mixture.
2. Air Entrainment: Surfactants, specifically air-entraining agents, are utilized to introduce small air bubbles into the cement mixture. These bubbles have several benefits for the concrete. Firstly, they enhance the workability and flowability of the mixture, making it easier to handle and place. Additionally, the entrained air in the concrete improves its freeze-thaw resistance by providing space for water expansion during freezing. This helps to reduce the risk of cracking and damage, especially in regions with cold climates or when the concrete will be exposed to freeze-thaw cycles.
3. Foam Formation: Surfactants can be employed to create foamed cement, a process where stable foam bubbles are generated and mixed with the cementitious material. This technique produces lightweight and low-density concrete with improved thermal insulation properties. The foam acts as a filler, reducing the overall density of the cement mixture and resulting in a more porous and lightweight consistency.
4. Set Time Modification: Some surfactants can have an impact on the setting time of cement. Retarding agents, for instance, can slow down the setting process, extending the workability time of the concrete mixture. This can be beneficial in scenarios where there is a need for longer placement and finishing times, such as when dealing with large volumes of concrete or working in hot weather conditions. On the other hand, accelerating agents can speed up the setting time, which can be advantageous when a rapid strength gain is desired for time-sensitive projects.

2.1 CONSISTENCY TEST OF CEMENT:

OBSERVATION AND TABLE

1. Weight of cement taken (g)= 400g
2. Initial percentage of water added to cement for standard consistency is 31.6%

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3. Quantity of water added to cement with 2% and 4% SLS respectively are 22% and 27%

TABLE1: WATER TO BE ADDED

SLS %	0%	2%	4%
AMOUNT OF WATER TO BE ADDED (ml)	31.6%	27%	22%

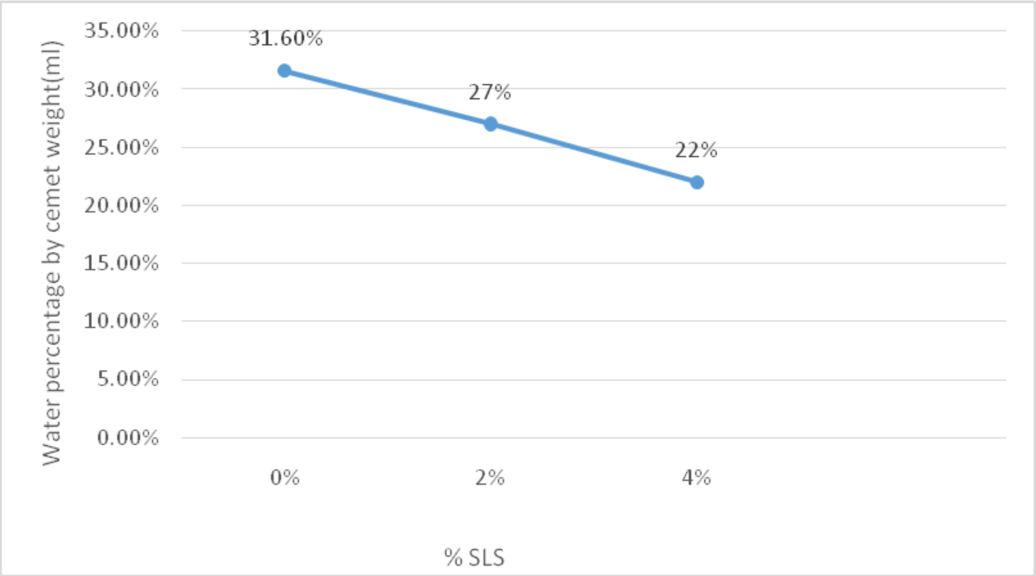

FIG 1: GRAPH BETWEEN WATER % vs SLS %

RESULTS: Percentage of water content for standard consistency is 22% and 27% with2% and 4% of SLS respectively.

2.2.SETTING TIME OF CEMENT

Obtaining the desired concrete setting qualities is crucial in the building industry.[12]This is because it facilitates the smooth running of several concrete-related processes, including moving, laying, compacting, and polishing. The rigidity of the concrete during its setting period is a major consideration when deciding when to insert it in formwork.[13]

In general, the addition of surfactants to cement can potentially increase the setting time. This effect is not always observed and can depend on the specific surfactant and its dosage. Here are a few reasons why surfactants might increase the setting time of cement:

1. Retardation Effect: Some surfactants are categorized as retarders and are specifically formulated to delay or slow down the setting time of cement. These surfactants function by adsorbing onto the surface of cement particles and impeding the hydration process. By hindering the interaction between water and cement, the surfactant effectively retards the formation of the crystalline structure, leading to an extended setting time..
2. Interference with Hydration: Surfactants have the potential to interact with the hydration process of cement, which involves the chemical reactions leading to the formation of hardened cementitious products. The presence of surfactants can interfere with the diffusion of water into the cement particles, reducing the availability of water for hydration reactions. This interference can result in a slower progression of hydration and, consequently, an increased setting time.

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3. Dosage and Compatibility: The dosage of surfactant added to the cement is a critical factor that affects the setting time. If an excessive amount of surfactant is used, it can hinder the hydration process to a significant extent, resulting in a noticeable delay in setting. On the other hand, insufficient dosage may not have a noticeable effect on the setting time.

It is important to note that the effect of surfactants on the setting time of cement can vary depending on their specific chemical properties, dosage, and interactions with the cement matrix. While some surfactants may increase the setting time, others may have an accelerating effect, causing the cement to set faster.

Therefore, it is crucial to carefully evaluate and test the surfactant in the specific cement system and desired application to understand its impact on the setting time. The dosage of the surfactant should also be controlled to ensure the desired effect is achieved without undesirable delays or accelerations in the setting process.

RESULT:-The initial of cement without surfactant is 126 minutes by applying 2% SLS by weight of cement the initial setting time increase by 8 minutes

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2.3SLUMP CONE TEST

The slump test is a standard procedure for gauging the new concrete's fluidity. Slumped new concrete's dip in height is measured to ascertain its workability. It is essential for on-site construction success that the flowability of concrete be precisely predicted throughout the concrete mixture design phase. As the complexity of building projects using concrete rises, so does the strain on material engineers to ensure that the final product is both highly workable and has the mechanical qualities called for by the design.[14]

1. Increased Workability: Surfactants, particularly plasticizers or superplasticizers, are commonly used to enhance the workability of concrete. These surfactants function by dispersing cement particles and reducing the surface tension of water. This results in increased fluidity and improved flow of the concrete, making it easier to handle and place. As a result, the slump value increases, indicating higher workability and improved ease of placement.

2. Improved Cohesion and Segregation Resistance: Surfactants have the ability to enhance the cohesion and stability of concrete mixes, reducing the risk of segregation. They achieve this by modifying the surface properties of the cement particles, facilitating better particle dispersion and reducing the tendency of particles to settle or separate. This leads to improved homogeneity and resistance to segregation, as indicated by an increased slump value.

TABLE 2: RESULTS OF SLUMP CONE TEST

SLS PERCENTAGE	0%	2%	4%
SLUMP VALUE(mm)	45mm	142mm	193mm

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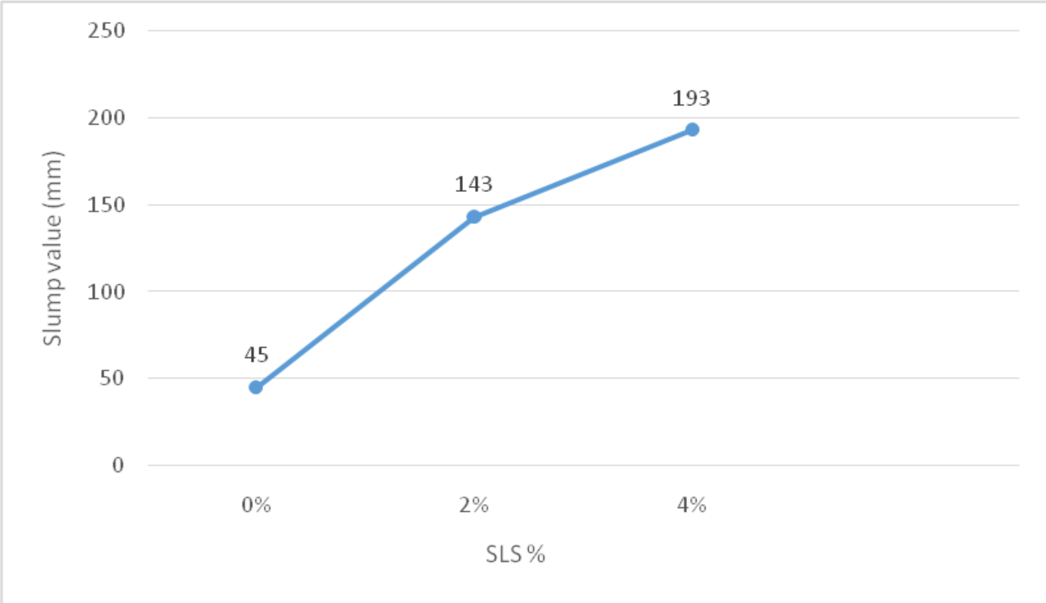


FIG 2: GRAPH BETWEEN SLUMP VALUE vs SLS%

2.4 COMPRESSIVE STRENGTH

The IS Code was used to calculate the compressive strength of concrete specimens with dimensions of 150 millimetres by 150 millimetres by 150 millimetres. Three examples per age and kind of concrete were tested at 7 and 28 days.[15] Concrete mixes containing 4% Sodium Lauryl Sulphate (SLS) and without surfactant were compared to determine surfactant's impact on compressive strength.

1. Improved Particle Dispersion: Surfactants, particularly water-reducing agents or superplasticizers, play a crucial role in enhancing the dispersion of cement particles. These surfactants reduce the surface tension of water, enabling better wetting and coating of the cement particles. As a result, the cement particles are more uniformly distributed throughout the mixture, leading to improved hydration and a denser concrete matrix. The increased density and improved particle packing contribute to higher compressive strength of the concrete.

2. Water-to-Cement Ratio Reduction: Surfactants, particularly water-reducing agents, allow for a reduction in the water-to-cement ratio while maintaining the desired workability of the concrete mixture. By lowering the water content in the mixture, the surfactant helps to achieve a more optimal cement hydration process. This reduction in the water-to-cement ratio leads to increased strength development and improved overall mechanical properties, including higher compressive strength of the hardened concrete.

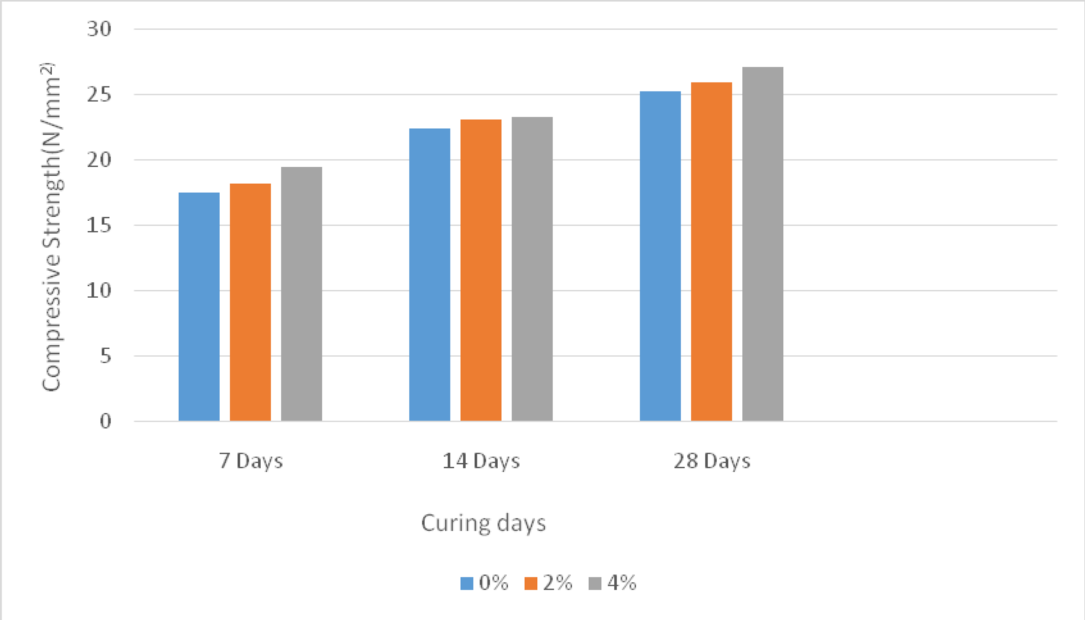
3. Enhanced Cement Hydration: Surfactants have the ability to promote the hydration of cement by facilitating the penetration of water into the cement particles. By reducing the surface tension of water, surfactants enable it to more effectively penetrate the cement particles and participate in hydration reactions. This enhanced hydration process ensures a more complete and efficient cement hydration, resulting in increased strength development of the concrete.

4. Reduced Microscopic Voids and Porosity: Surfactants play a crucial role in minimizing the formation of microscopic voids and porosity within the concrete matrix. By improving particle dispersion, reducing water content, and enhancing hydration, surfactants help to mitigate the development of voids and air pockets. This reduction in voids and porosity contributes to a more compact and dense concrete structure, which is associated with higher compressive strength and improved overall durability.

It's important to note that the specific effect of a surfactant on the compressive strength of concrete will depend on various factors, including the type of surfactant, dosage, cement composition, aggregate properties, curing conditions, and other mix design parameters. The selection and dosage of the surfactant should be carefully considered to optimize the compressive strength while maintaining other desired properties of the concrete. Proper testing and evaluation should be conducted to ensure the surfactant's compatibility with the specific concrete mixture and to verify its effect on compressive strength.

TABLE 3: COMPARISION OF COMPRESSIVE STRENGH WITH AND WITHOUTSLS

MIX	COMPRESSIVE STRENGTH(N/mm^2)		
	CURING DAYS		
	7 DAYS	14 DAYS	28 DAYS
M0	17.5	22.44	25.33
M1	18.22	23.11	26
M2	19.55	23.77	27.11



GRAPH3: COMPARISON OF COMPRESSIVE STRENGHT

M0=MIX WITH 0% OF SLS
M1=MIX WITH 2% OF SLS
M2=MIX WITH 4% OF SLS

3.Conclusions

Based on the above test study, following conclusion can be drawn

The addition of surfactants to cement concrete can result in significant improvements in its properties. Surfactants, such as water-reducing agents or plasticizers, play a crucial role in enhancing the workability of concrete by dispersing cement particles and reducing the surface tension of water. This leads to increased fluidity, improved flow, and higher slump values, making the concrete easier to handle and place.

1. The amount of water to be added in normal mixture is more than the mixture in which surfactant is added. Thus the amount of water required for concrete mix is decreased.

2. Initial and final setting of concrete mixture is increased in which surfactant is added.

3. The workability of concrete is enhance by the addition of surfactant.

4. The compressive strength of concrete is increased in which surfactant is added.

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4.REFERENCE

1. A Singh, S Singla, R Garg, Performance analysis of Papercrete in presence of Rice husk ash and Fly ash, IOP Conference Series: Materials Science and Engineering 961 (1), 012010, 2020
2. Aldrees, Ali, Mohd Sayeed Ul Hasan, Abhishek Kumar Rai, Md Nashim Akhtar, Mohammad Amir Khan, Mufti Mohammad Saif, Nehal Ahmad, and Saiful Islam. "On the Precipitation Trends in Global Major Metropolitan Cities under Extreme Climatic Conditions: An Analysis of Shifting Patterns." Water 15, no. 3 (2023): 383.
3. Alfaisal, Faisal M., Shamshad Alam, Raied Saad Alharbi, Kiranjeet Kaur, Mohammad Amir Khan, Mohammad Faraz Athar, and Saima Ahmed Rahin. "Application of an Optimization Model for Water Supply Chain Using Storage Reservoir Operation for Efficient Irrigation System." Discrete Dynamics in Nature and Society 2023 (2023).
4. Alharbi, Raied Saad, Shaminee Nath, O. Mohammed Faizan, Mohd Sayeed Ul Hasan, Shamshad Alam, Mohammad Amir Khan, Sayantan Bakshi, Mehebub Sahana, and Mufti Mohammad Saif. "Assessment of Drought vulnerability through an integrated approach using AHP and Geoinformatics in the Kangsabati River Basin." Journal of King Saud University-Science 34, no. 8 (2022): 102332.
5. Cara AM Bondi, Julia L Marks, Lauren B Wroblewski, Heidi S Raatikainen, Shannon R Lenox, and Kay E Gebhardt, Human and Environmental Toxicity of Sodium Lauryl Sulphate (SLS): Evidence for Safe Use in Household Cleaning Products.
6. Clear, C.A., Harrison, T. A. 1985. Concrete pressure on formwork, in CIRIA report R 108, Londan.
7. Deb, Plaban, Barnali Debnath, Murtaza Hasan, Ali S. Alqarni, Abdulaziz Alaskar, Abdullah H. Alsabhan, Mohammad Amir Khan, Shamshad Alam, and Khalid S. Hashim. "Development of eco-friendly concrete mix using recycled aggregates: Structural performance and pore feature study using image analysis." Materials 15, no. 8 (2022): 2953.
8. Effects of Surfactants on the Properties of Mortar Containing Styrene/Methacrylate Superplasticizer El-Sayed Negim,1,2 Latipa Kozhamzharova,3 Jamal Khatib,1 Lyazzat Bekbayeva,1,4 and Craig Williams1
9. Experimental investigation on the effect of Nano-silica on the silica fume-based cement composites, DP Bhatta, S Singla, R Garg, Materials Today: Proceedings 57, 2338-2343, 2022
10. GM Fani, S Singla, R Garg, Investigation on Mechanical Strength of Cellular Concrete in Presence of Silica Fume, IOP Conference Series: Materials Science and Engineering 961 (1), 012008, 2020
11. Gupta, Tripti, Khalid Ansari, Dilip Lataye, Mahendra Kadu, Mohammad Amir Khan, Nabisab Mujawar Mubarak, Rishav Garg, and Rama Rao Karri. "Adsorption of Indigo Carmine Dye by Acacia nilotica sawdust activated carbon in fixed bed column." Scientific Reports 12, no. 1 (2022): 15522.
12. Haribabu, A., Raviteja Surakasi, P. Thimothy, Mohammad Amir Khan, Nadeem A. Khan, and Sasan Zahmatkesh. "Study comparing the tribological behavior of propylene glycol and water dispersed with graphene nanopowder." Scientific reports 13, no. 1 (2023): 2382.
13. Hasan, Mohd Sayeed Ul, Abhishek Kumar Rai, Zeesam Ahmad, Faisal M. Alfaisal, Mohammad Amir Khan, Shamshad Alam, and Mehebub Sahana. "Hydrometeorological consequences on the water balance in the ganga river system under changing climatic conditions using land surface model." Journal of King Saud University-Science 34, no. 5 (2022): 102065.
14. Hasan, Mohd Sayeed Ul, Mufti Mohammad Saif, Nehal Ahmad, Abhishek Kumar Rai, Mohammad Amir Khan, Ali Aldrees, Wahaj Ahmad Khan, Mustafa KA Mohammed, and Zaher Mundher Yaseen. "Spatiotemporal Analysis of Future Trends in Terrestrial Water Storage Anomalies at Different Climatic Zones of India Using GRACE/GRACE-FO." Sustainability 15, no. 2 (2023): 1572.
15. J.J. Brooks, M.A. Johari, M. Mazloom Effect of admixtures on the setting time of high strength concrete Cement Concrete. Compos., 22 (4) (2000), pp. 293-301
16. K Kumar, M Bansal, R Garg, R Garg, Mechanical strength analysis of fly-ash based concrete in presence of red mud, Materials Today: Proceedings 52, 472-476, 2022
17. Khan, Mohammad Amir, Nayan Sharma, Giuseppe Francesco Cesare Lama, Murtaza Hasan, Rishav Garg, Gianluigi Busico, and Raied Saad Alharbi. "Three-Dimensional Hole Size (3DHS) approach for water flow turbulence analysis over emerging sand bars: Flume-scale experiments." Water 14, no. 12 (2022): 1889.
18. Li Y, Lee JS. Staring at protein–surfactant interactions: fundamental approaches and comparative evaluation of their combinations: a review. Anal Chim Acta. 2019; 1063:18–39.
19. Momin, Asif Iqbal A., Aijaz Ahmad Zende, Rajesab B. Khadiranaikar, Abdullah H. Alsabhan, Shamshad Alam, Mohammad Amir Khan, and Mohammad Obaid Qamar. "Investigating the Flexural Behavior of a Two-Span High-Performance Concrete Beam Using Experimentally Derived Stress Block Parameters." ACS Omega (2023).

20. Nhat-Duc Hoang and Anh-Duc Pham, Estimating Concrete Workability Based on Slump Test with Least Squares Support Vector Regression,
21. Otzen DE. Biosurfactants and surfactants interacting with membranes and proteins: same but different? Biochim Biophys Acta. 2017; 1859:639–649.
22. Pandey, Manish, Jaan H. Pu, Hanif Pourshahbaz, and Mohammad Amir Khan. "Reduction of scour around circular piers using collars." Journal of Flood Risk Management 15, no. 3 (2022): e12812.
23. Parveen Berwal, Arun Kumar et al. "A Comparative Study of Micro Silica Based Concrete Mix Design Using IS & DOE Method" Lectures notes in Civil Engineering. September 2022. pp 821-29.
24. Parveen Berwal, Praveen Aggarwal, Rajesh Goel, "Utilization of Recycled Aggregate in Wet Mix Macadam" International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-9 Issue-1, November 2019.
25. Parveen Berwal, Sombir "A Laboratory Study on Use of Waste Glass Powder as Partial Replacement of Cement in Concrete Production" International Journal of Advanced Research, Idea and Innovation in Technology, ISSN: 2454-132X, (Volume3, Issue1) 2017
26. R Garg, M Bansal, Y Aggarwal, Split Tensile Strength of Cement Mortar Incorporating Micro and Nano Silica at Early Ages, Int. J. Eng. Res 5 (04), 16-19, 2016
27. R Garg, R Garg, B Chaudhary, SM Arif, Strength and microstructural analysis of nano-silica based cement composites in presence of silica fume, Materials Today: Proceedings 46, 6753-6756, 2021
28. R Garg, R Garg, NO Eddy, Influence of pozzolans on properties of cementitious materials: A review, Advances in nano research 11 (4), 423-436, 2021
29. R Garg, R Garg, NO Eddy, MA Khan, AH Khan, T Alomayri, P Berwal, Mechanical strength and durability analysis of mortars prepared with fly ash and nano-metakaolin, Case Studies in Construction Materials 18, e01796, 2023
30. RD Singh, R Garg, Spectroscopic analysis of crown ether-surfactant inclusion complexes in aqueous media, Asian journal of research in chemistry, 8 (4), 555, 2009
31. RD Singh, R Garg, Study of Micellar Behavior of Crown Ether and Tetraethylammonium Bromide in Aqueous Media, E-Journal of Chemistry 7 (2), 578-582, 2010
32. Santhosh, N., B. A. Praveena, Reema Jain, Mohd Abul Hasan, Saiful Islam, Mohammad Amir Khan, Abdul Razak, and Md Daniyal. "Analysis of friction and wear of aluminium AA 5083/WC composites for building applications using advanced machine learning models." Ain Shams Engineering Journal (2022): 102090.
33. SK Mehta, R Jain, S Sharma, KK Bhasin, Interaction of poly (ethylene glycol)-400 with tetraethylammonium bromide in aqueous media, Journal of molecular liquids 122 (1-3), 15-20, 2005
34. Sritam swapnadarshi, Indu SivaRanjani Gandhi, Studies on influnce of characteristic of surfactant and foam onconcrete behaviour.
35. The Influence of Some Surfactants on Porous Concrete Properties Modestas KLIGYS", Antanas LAUKAITIS, Marijonas SINICA, Georgijus SEZEMANAS.
36. Verma, Deepak, Parveen Berwal, Mohammad Amir Khan, Raied Saad Alharbi, Faisal M. Alfaisal, and Upaka Rathnayake. "Design for the Prediction of Peak Outflow of Embankment Breaching Due to Overtopping by Regression Technique and Modelling." Water 15, no. 6 (2023): 1224.
37. Warade, Harshal, Khalid Ansari, Kul Bhaskar, Zeba Naaz, Mohammad Amir Khan, Nadeem A. Khan, Sasan Zahmatkesh, and Mostafa Hajiaghaei-Keshteli. "Optimizing the grass bio methanation in lab scale reactor utilizing response surface methodology." Biofuels (2023): 1-12.
38. Zende, Aijaz Ahmad, Asif Iqbal A. Momin, Rajesab B. Khadiranaikar, Abdullah H. Alsabhan, Shamshad Alam, Mohammad Amir Khan, and Mohammad Obaid Qamar. "Mechanical Properties of High-Strength Self-Compacting Concrete." ACS Omega (2023).