Journal of Geotechnical Engineering
Research paper
Vol 11,issue 1,2024
Receiving date:01-4-2024
Acceptance date:8-4-2024
Publication date:10-4-2024

Enhancing Compressive Strength and Durability through Optimization of Concrete Mixtures

Yash Dangi[1*], Harsh Rathore[2]

1Student ,Department of Civil Engineering, Sanjeev Agarwal Global Educational University, Bhopal. M.P. India

2Assistant professor, Department of Civil Engineering, Sanjeev Agarwal Global Educational University, Bhopal. M.P. India

Corresponding author mail I'd : Yashthakurr29@gmail.com

Abstract

This research investigates how varying cement-aggregate ratio, water-cement ratio, and slump height affect the compressive strength of concrete mixtures. Through an analysis of 36 samples, each representing different combinations of these parameters, significant insights are gained into the optimization of concrete mix designs for construction applications. The study reveals that higher water-cement ratios tend to decrease compressive strength due to increased porosity in cured concrete. Conversely, higher cement-aggregate ratios generally lead to higher compressive strengths, up to a certain point, after which excessive cement content may result in issues such as shrinkage and cracking. Additionally, the impact of slump height on compressive strength is elucidated, with higher slump heights typically associated with lower strengths due to increased water content. These findings underscore the importance of carefully balancing these parameters to achieve desired concrete performance. By optimizing mix designs based on these insights, engineers and practitioners can ensure the construction of durable and resilient concrete structures, thus advancing the field of concrete technology and improving construction practices.

Keywords: Concrete Mixtures, Compressive Strength, Cement-Aggregate Ratio, Water-Cement Ratio, Slump Height

Journal of Geotechnical Engineering
Research paper
Vol 11,issue 1,2024
Receiving date:01-4-2024
Acceptance date:8-4-2024
Publication date:10-4-2024

Introduction

Over the years, concrete has served as a fundamental material in construction projects. Traditionally, the structural design of concrete buildings has centered on factors like compressive strength and construction techniques. However, decades of field experience have revealed that concrete structures undergo a gradual degradation over time. This degradation manifests as a decline in material characteristics and properties, ultimately affecting the structure's performance and durability[1-4].

Regular maintenance is essential to address the deterioration of concrete structures and enhance their performance. Recent decades have seen a surge of interest in assessing damage and implementing maintenance strategies for concrete structures, driven by the observed decline in building performance[5-9].

The degradation of structures, whether caused by physical or chemical factors, leads to a diminishing performance over time. Physical damage may result from events like fire, abrasion, or stresses from expansion and contraction, while chemical damage can occur due to exposure to harsh environmental conditions figure 1[11-17]

Journal of Geotechnical Engineering
Research paper
Vol 11,issue 1,2024
Receiving date:01-4-2024
Acceptance date:8-4-2024
Publication date:10-4-2024

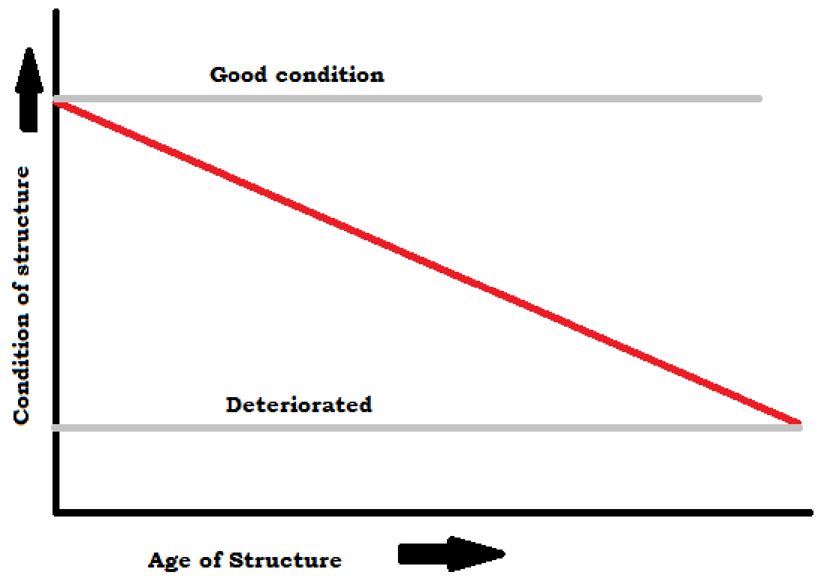


Fig. 1 -Condition of concrete

In ongoing research, the impact of factors such as cement-aggregate ratio, water-cement ratio, and the slump value of fresh concrete on the compressive strength of concrete structures is being evaluated through laboratory testing of both fresh and hardened concrete. These tests include measuring the weights of cement and aggregates, assessing the properties of both materials, proportioning ingredients, determining the water-cement ratio, evaluating workability using the slump cone method, and conducting compressive strength tests on hardened concrete blocks after 28 days of curing[18,19].

Objectives

The objectives of this research endeavor are multifaceted, aiming to comprehensively investigate the intricate relationship between key parameters in concrete mixtures and their influence on compressive strength and durability. Firstly, the study seeks to analyze the effect of varying cement-aggregate ratios on the compressive strength of concrete samples, elucidating the optimal ratio range for maximizing strength while mitigating potential drawbacks such as shrinkage and

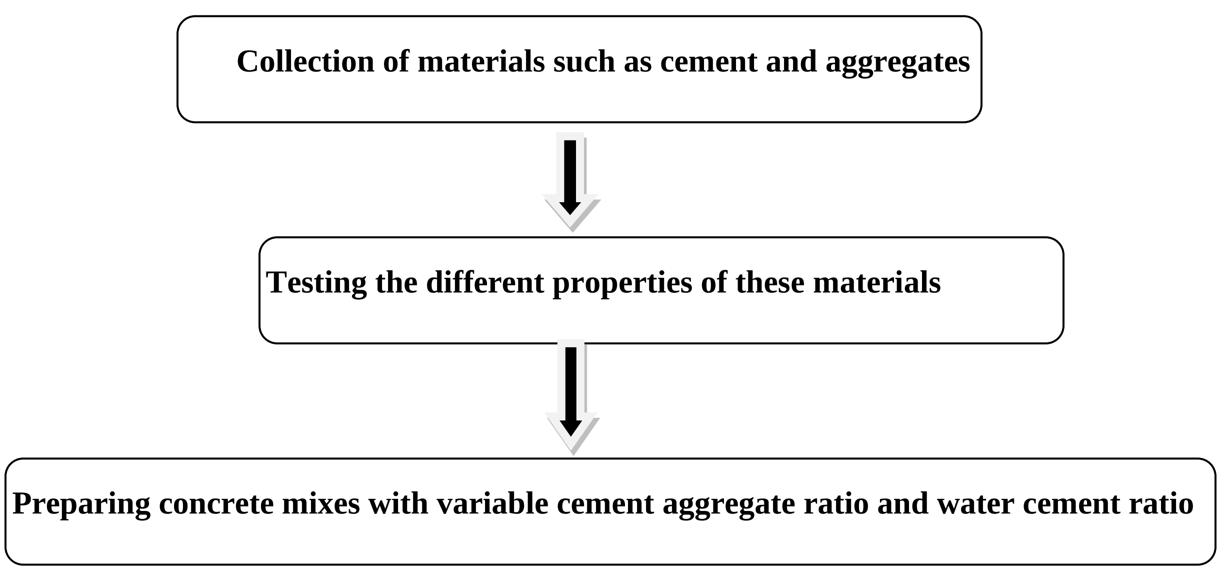
Journal of Geotechnical Engineering
Research paper
Vol 11,issue 1,2024
Receiving date:01-4-2024
Acceptance date:8-4-2024
Publication date:10-4-2024

cracking. Secondly, the research endeavors to explore the impact of water-cement ratios on both compressive strength and durability, investigating how differing ratios affect porosity and overall performance. Additionally, the study aims to assess the role of slump height in concrete workability and its consequent effect on compressive strength, providing insights into achieving a balance between workability and strength. By achieving these objectives, the research aims to contribute to the optimization of concrete mix designs, facilitating the construction of durable and resilient structures while advancing the field of concrete technology.

Material

The cement utilized in this study adheres to the standards outlined in IS 8112, constituting 43 grade ordinary Portland cement. The quality of cement is assessed based on its adherence to the performance criteria specified in the Indian standard specification. Similarly, the aggregates employed meet the stipulated requirements of Indian codes. Specifically, 20mm is the maximum size of aggregates used in this research. To ensure precision, coarse and fine aggregates are batched separately and then amalgamated to form a unified unit figure 2.

Figure 2:Methodology



Journal of Geotechnical Engineering
Research paper
Vol 11,issue 1,2024
Receiving date:01-4-2024
Acceptance date:8-4-2024
Publication date:10-4-2024

Performing tests over these prepared concrete mixes

Determining the compressive strength

Examining the effect of cement/ aggregate, water/cement and workability on Compressive strength

Result and Discussion

A total of 36 concrete samples have been prepared by adjusting the cement-aggregate ratio and water-cement ratio. The aim is to investigate the impact of fresh concrete properties on compressive strength and to analyze how the tested parameters vary concerning water-cement ratio and cement-aggregate ratio. The detailed findings are summarized in Table 1, where the variations in these parameters are recorded and analyzed.

Table 1 Experimental Result

S.No.	Weight (kg) of			Cement/ Aggregate (r1)	Water/ Cement (r2)	Slump height (h) in mm	Compressive strength (s) in MPa
	Cement	Aggregate (Fine + coarse)	Water				

Journal of Geotechnical Engineering
Research paper
Vol 11,issue 1,2024
Receiving date:01-4-2024
Acceptance date:8-4-2024
Publication date:10-4-2024

1	1	2	0.4	0.50	0.4	90	27.4
2	1	2	0.44	0.50	0.44	94	27.3
3	1	2	0.48	0.50	0.48	97	27.1
4	1	2	0.52	0.50	0.52	101	26.5
5	1	2	0.56	0.50	0.56	106	26.4
6	1	2	0.6	0.50	0.6	110	26.1
7	1	3	0.4	0.33	0.4	92	25.1
8	1	3	0.44	0.33	0.44	97	24.8
9	1	3	0.48	0.33	0.48	99	24.6
10	1	3	0.52	0.33	0.52	105	24.2
11	1	3	0.56	0.33	0.56	107	23.9
12	1	3	0.6	0.33	0.6	111	23.7

Journal of Geotechnical Engineering
Research paper
Vol 11,issue 1,2024
Receiving date:01-4-2024
Acceptance date:8-4-2024
Publication date:10-4-2024

13	1	4.5	0.4	0.22	0.4	72	19.8
14	1	4.5	0.44	0.22	0.44	75	19.5
15	1	4.5	0.48	0.22	0.48	75	19.2
16	1	4.5	0.52	0.22	0.52	79	19.2
17	1	4.5	0.56	0.22	0.56	87	19
18	1	4.5	0.6	0.22	0.6	91	18.9
19	1	6	0.4	0.17	0.4	78	14.8
20	1	6	0.44	0.17	0.44	82	14.6
21	1	6	0.48	0.17	0.48	85	14.6
22	1	6	0.52	0.17	0.52	87	14.3
23	1	6	0.56	0.17	0.56	91	14.2
24	1	6	0.6	0.17	0.6	97	14.1

Journal of Geotechnical Engineering
Research paper
Vol 11,issue 1,2024
Receiving date:01-4-2024
Acceptance date:8-4-2024
Publication date:10-4-2024

25	1	9	0.4	0.11	0.4	52	9.9
26	1	9	0.44	0.11	0.44	55	9.7
27	1	9	0.48	0.11	0.48	56	9.6
28	1	9	0.52	0.11	0.52	56	9.5
29	1	9	0.56	0.11	0.56	58	9.5
30	1	9	0.6	0.11	0.6	58	9.3
31	1	12	0.4	0.08	0.4	35	4.8
32	1	12	0.44	0.08	0.44	36	4.7
33	1	12	0.48	0.08	0.48	38	4.7
34	1	12	0.52	0.08	0.52	38	4.6
35	1	12	0.56	0.08	0.56	40	4.6
36	1	12	0.6	0.08	0.6	42	4.5

Journal of Geotechnical Engineering
Research paper
Vol 11,issue 1,2024
Receiving date:01-4-2024
Acceptance date:8-4-2024
Publication date:10-4-2024

The results sheds light on how varying cement-aggregate ratios and water-cement ratios influence the compressive strengths of concrete mixtures. Notably, higher water-cement ratios tend to decrease compressive strength due to increased porosity, while higher cement-aggregate ratios often yield higher strengths, though excessive cement content can lead to issues like shrinkage.

Slump height, indicating concrete's workability, also impacts compressive strength. Higher slump heights usually mean better workability but can lead to lower strengths due to increased water content. However, slump height alone isn't a definitive indicator of concrete quality; it must be considered alongside other factors like cement-aggregate and water-cement ratios.

Compressive strengths in the dataset range from 4.5 MPa to 27.4 MPa. Lower water-cement ratios and higher cement-aggregate ratios typically result in higher strengths, whereas higher water-cement ratios and lower cement-aggregate ratios lead to lower strengths.

Conclusions

- Cement-aggregate and water-cement ratios significantly affect compressive strength.
- Higher water-cement ratios reduce strength due to increased porosity.
- Excessive cement can cause issues like shrinkage and cracking.
- Slump height impacts workability and strength, but other factors also play roles.
- Compressive strengths vary widely across the dataset.
- Lower water-cement ratios and higher cement-aggregate ratios generally yield higher strengths

In conclusion, optimizing concrete mixtures for strength and durability necessitates a nuanced understanding of the interplay between these key parameters. By striking a balance between workability and strength while maintaining appropriate ratios, concrete structures can meet performance requirements and withstand the demands of their intended applications effectively

Journal of Geotechnical Engineering
Research paper
Vol 11,issue 1,2024
Receiving date:01-4-2024
Acceptance date:8-4-2024
Publication date:10-4-2024

References

1. Yeh, I. C. (2020). Modeling of strength of high-performance concrete using artificial neural networks. *Cement and Concrete research*, *28*(12), 1797-1808.
2. Topcu, I. B., & Sarıdemir, M. (2016). Prediction of compressive strength of concrete containing fly ash using artificial neural networks and fuzzy logic. *Computational Materials Science*, *41*(3), 305-311.
3. Lee, S. C. (2014). Prediction of concrete strength using artificial neural networks. *Engineering Structures*, *25*(7), 849-857.
4. Uysal, M., & Tanyildizi, H. (2012). Estimation of compressive strength of self compacting concrete containing polypropylene fiber and mineral additives exposed to high temperature using artificial neural network. *Construction and Building Materials*, *27*(1), 404-414.
5. Naderpour, H., Kheyroddin, A., & Amiri, G. G. (2010). Prediction of FRP-confined compressive strength of concrete using artificial neural networks. *Composite Structures*, *92*(12), 2817-2829.
6. Bilgehan, M., & Turgut, P. (2010). Artificial neural network approach to predict compressive strength of concrete through ultrasonic pulse velocity. *Research in Nondestructive Evaluation*, *21*(1), 1-17.
7. Trtnik, G., Kavčič, F., & Turk, G. (2009). Prediction of concrete strength using ultrasonic pulse velocity and artificial neural networks. *Ultrasonics*, *49*(1), 53-60.

Receiving date:01-4-2024
Acceptance date:8-4-2024
Publication date:10-4-2024

8. Özcan, F., Atiş, C. D., Karahan, O., Uncuoğlu, E., & Tanyildizi, H. (2009). Comparison of artificial neural network and fuzzy logic models for prediction of long-term compressive strength of silica fume concrete. *Advances in Engineering Software*, *40*(9), 856-863.

9. Bilim, C., Atiş, C. D., Tanyildizi, H., & Karahan, O. (2009). Predicting the compressive strength of ground granulated blast furnace slag concrete using artificial neural network. *Advances in Engineering Software*, *40*(5), 334-340.

10. Prasad, B. R., Eskandari, H., & Reddy, B. V. (2009). Prediction of compressive strength of SCC and HPC with high volume fly ash using ANN. *Construction and Building Materials*, *23*(1), 117-128.

11. Altun, F., Kişi, Ö., & Aydin, K. (2008). Predicting the compressive strength of steel fiber added lightweight concrete using neural network. *Computational Materials Science*, *42*(2), 259-265.

12. Öztaş, A., Pala, M., Özbay, E., Kanca, E., Çagˇlar, N., & Bhatti, M. A. (2008). Predicting the compressive strength and slump of high strength concrete using neural network. *Construction and Building Materials*, *20*(9), 769-775.

13. Zarandi, M. F., Türksen, I. B., Sobhani, J., & Ramezanianpour, A. A. (2008). Fuzzy polynomial neural networks for approximation of the compressive strength of concrete. *Applied Soft Computing*, *8*(1), 488-498.

14. Hoła, J., & Schabowicz, K. (2007). Application of artificial neural networks to determine concrete compressive strength based on non-destructive tests. *Journal of civil Engineering and Management*, *11*(1), 23-32.

Journal of Geotechnical Engineering
Research paper
Vol 11,issue 1,2024
Receiving date:01-4-2024
Acceptance date:8-4-2024
Publication date:10-4-2024

15. Pala, M., Özbay, E., Öztaş, A., & Yuce, M. I. (2007). Appraisal of long-term effects of fly ash and silica fume on compressive strength of concrete by neural networks. *Construction and Building Materials*, *21*(2), 384-394.

16. Kewalramani, M. A.,& Gupta, R. (2006). Concrete compressive strength prediction using ultrasonic pulse velocity through artificial neural networks. *Automation in Construction*, *15*(3), 374-379.

17. Kasperkiewicz, J., Racz, J., & Dubrawski, A. (1995). HPC strength prediction using artificial neural network. *Journal of Computing in Civil Engineering*, *9*(4), 279-284.

18. Ghaboussi, J., Garrett Jr, J. H., & Wu, X. (1991). Knowledge-based modeling of material behavior with neural networks. *Journal of Engineering Mechanics*, *117*(1), 132-153.

19. Prediction of compressive strength of concrete by neural networks. *Cement and Concrete Research*, *30*(8), 1245-1250.