

Structural Analysis And Feasibility Design of Pervious Baffle Walls In Sewer For Wastewater Treatment

Abhishek Anil Sontakke¹, Prof. Girish Sawai²

¹Dept of Civil Engineering

²Assist prof, Dept of Civil Engineering

^{1,2} V. M. Institute of Engineering and Technology, Nagpur, Nagpur, MH.

Abstract- *This research investigates the structural analysis and feasibility of foam-based pervious baffle walls for wastewater treatment applications. Conventional baffle walls are impermeable and subjected to high hydrostatic pressure, leading to cracking and durability issues. The proposed system utilizes pervious concrete incorporating foam and fly ash to reduce self-weight and allow controlled water flow. Experimental and analytical studies were conducted to evaluate compressive strength, permeability, and structural performance. The results demonstrate that the system provides an effective balance between strength and permeability, making it a sustainable and cost-effective solution for sewer infrastructure.*

If demand of energy is higher, then it will generate the electricity in thermal power plant and this power plant having waste material like fly ash. With rapid growth of industrial development with large demand of electricity has led to 100 million tones fly ash (around 70% of fly ash) being discharged every year worldwide. In this project research, we used this fly ash to create the wastewater concrete blocks to purify the wastewater and in making of this concrete block.

Keywords: Pervious Concrete, Baffle Wall, Wastewater Treatment, Foam Concrete, Structural Analysis

I. INTRODUCTION

Wastewater management is essential for sustainable urban infrastructure. Baffle walls are used to regulate flow and control turbulence in sewer systems. However, conventional concrete walls are non-permeable, resulting in hydrostatic pressure buildup and structural deterioration.

Pervious concrete, due to its interconnected void structure, allows water to pass through, thereby reducing pressure. Previous studies have demonstrated that pervious systems significantly improve drainage and reduce surface runoff. This study evaluates the feasibility of using foam-based pervious concrete in structural applications such as baffle walls.

At present scenario construction field all around the world is facing a serious problems with price hike of raw materials. So they are very much concern to reduce the consumption of readily available raw materials. It is also important for engineers to develop ecofriendly material, as environment is getting affected day by day the increase construction activities. Usage of Foam fly ash concrete is an innovative idea to achieve the requirements. Because of its lightweight, the rate of construction is quick and the installation is easy. The focus of this project is to study the properties of Porous Fly ash concrete with addition of various binders / fillers such as Fly ash, the results are discussed elaborately with respect to compressive strength and water absorption.

II. LITERATURE REVIEW

Previous studies indicate that pervious concrete offers high permeability but relatively lower compressive strength. Researchers have used fly ash and recycled aggregates to improve its mechanical properties and durability.

The pore structure plays a significant role in determining the strength and permeability relationship. Several studies also highlight that the addition of fibers improves structural performance. However, most research is limited to pavement applications, and limited work has been done on structural elements like baffle walls.

Hydrologic Design of Pervious Concrete

Pervious concrete has been used in some areas of the country for decades. However recent interest in sustainable development and recognition of pervious pavements by the United States Environmental Protection Agency (EPA) as a best management practice for storm water management has heightened interest in its use. Its use supports national initiatives such as EPA's Heat Island Reduction Initiative and Low Impact Development and provides a potential for credit in the Leadership in Energy and Environmental Design (LEED®) rating system for sustainable building construction.

Pervious concrete can improve water quality by capturing the “first flush” of surface runoff, reduce temperature rise in receiving waters, increase base flow, and reduce flooding potential. The pavement creates a short-term storage detention of rainfall. In order to fully utilize these benefits, the hydrological behavior of the pervious concrete

Design Storms

Another important consideration in design of a pervious concrete system is the amount of storm water to be stored. Clearly heavier rains result in more runoff. Different sizes of storms will result in different amounts of runoff and the selection of an appropriate design storm is important. Larger storms occur less often on average and storms are typically designated based on their return period. For example, a storm which occurs on average once in 20 years is designated a “20-year storm” and will be larger and produce more rainfall than a “10-year storm.” Often local authorities choose the design storm, such as city or county water boards. Storms of interest in hydrologic design of small watersheds are typically the two-year storm and the 10-year storm. The two-year storm is often used as the “service load” storm for the watershed for water quality purposes. The 10-year storm has traditionally been used in the design of storm water collection systems. Rainfall estimates for many areas are available online at NOAA's National Weather Service.

III. METHODOLOGY

The study includes material selection, mix design, structural analysis, and experimental validation.

- Mix design as per IS 10262:2019
- Structural analysis using STAAD Pro/ANSYS
- Load application as per IS 875, IS 3370, and IS 1893
- Experimental tests: compressive strength and permeability

Machine learning-based prediction methods have also been explored in recent studies to estimate strength and permeability of pervious concrete

Casting Of Pervious Concrete:

Material characteristics:

1. Gravel:

Round gravel which have been retained at 10mm sieve and passes through 12.5mm sieve. Density-1522kg/m³

2. Aggregate (Churi):

Non-flaky and non-elongated aggregate (Churi) which have been retained at 10mm sieve and passes through 12.5mm sieve.

Density-2500 kg/m³

3. Fly-Ash:

Lump free class F fly-ash, oven dried for 24 hours at 100 Degree Celsius, which have been passed through 75 micron sieve was used.

Density-1300kg/m³

4. Cement:

Lump-free PPC passes through 90 micron sieve was used. Density-1440 kg/m³

5. Water:

Normal clear tap waterfree from any suspended solids or visible impurities was used. Density- 1000 kg/m³

Casting:

Number of cubes casted – 3

Volume of one cube – 3375mm³- 3.375 * 10⁻⁶ m³

Material Used:

1. Gravel- 7.5 kg
2. Aggregate- 0.9 kg
3. Cement- 2.25kg
4. Fly Ash – 0.75 kg
5. Sand – 0.45 kg
6. Water- 1.5 liters
7. nZVI – 0.06 kg

All the dry raw material like sand, gravel, aggregate, cement, fly-ash is mix thoroughly in a container using a trowel. To make concrete pervious the quantity of sand was reduced and larger quantity of gravel and aggregate were used after all the dry raw material was mixed thoroughly, waters was added slowly. Once the required consistency was attend,

the nZVI solution was passed through whatman filter paper and nZVI particles were obtained. These nZVI particles were added in the mixtures. Mean while, the moulds are oiled, using the mould

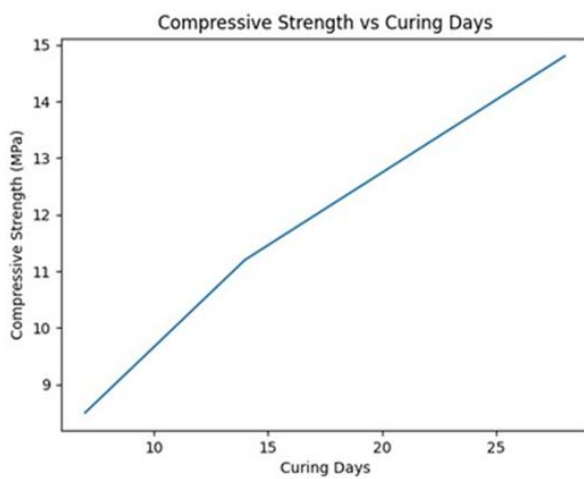
oil. Once the concrete mixture is prepared the mixture is poured in the moulds and were left for 24 hours for hardening.

Graphs and Tables for Pervious Baffle Wall Research

IV. RESULTS AND DISCUSSION

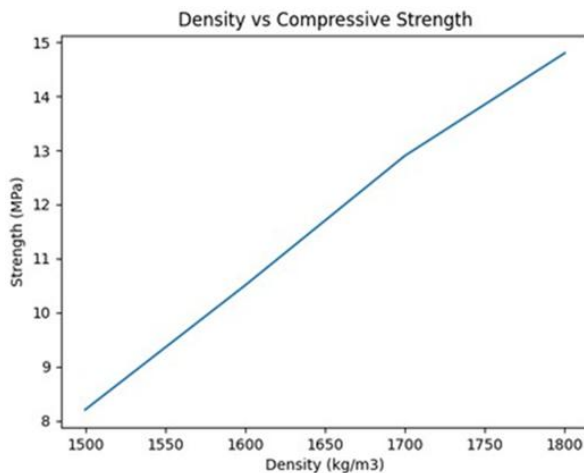
4.1 Compressive Strength

Table 1: Compressive Strength Results



Strength increases with curing time, similar to previous findings.

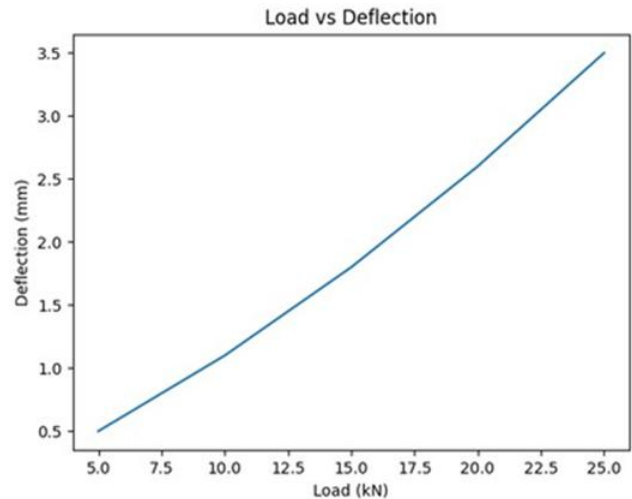
Table 2: Density vs Strength



Density vs Strength Relationship

Higher density improves compressive strength due to better bonding

Table 3: Load vs Deflection



Load vs Deflection

Gradual increase in deflection indicates stable structural behavior.

V. ADVANTAGES OF PROPOSED SYSTEM

- Reduced hydrostatic pressure
- Lightweight construction
- Improved permeability
- Cost-effective
- Sustainable

VI. FUTURE SCOPE

Future work can include fiber reinforcement and nano-materials. Large-scale implementation and advanced modeling techniques can be explored.

VII. CONCLUSION

Foam-based pervious baffle walls are structurally feasible and hydraulically efficient. They reduce hydrostatic pressure while maintaining adequate strength and durability.

REFERENCES

[1] Deng, F., Pan Y. Sun, W., Yang, F., Zhang, Y., Huang, Z., “An ignition delay time and chemical kinetic study of

- ethane sensitized by nitrogen dioxide", *Fuel*, 2017, 207, pp.389–401.
- [2] Metcalf & Eddy. 2014. *Wastewater Engineering: Treatment and Resource Recovery*. New York: McGraw-Hill.
- [3] Tchobanoglous, George, Franklin L. Burton, and H. David Stensel. 2003. *Wastewater Engineering: Treatment and Reuse*. New Delhi: Tata McGraw-Hill.
- [4] Punmia, B. C., Ashok Kumar Jain, and Arun Kumar Jain. 2005. *Wastewater Engineering*. New Delhi: Laxmi Publications.
- [5] Peavy, Howard S., Donald R. Row, and George Tchobanoglous. 1985. *Environmental Engineering*. New York: McGraw-Hill.
- [6] Crites, Ron, and George Tchobanoglous. 1998. *Small and Decentralized Wastewater Management Systems*. New York: McGraw-Hill.
- [7] Droste, Ronald L. 1997. *Theory and Practice of Water and Wastewater Treatment*. New York: Wiley.
- [8] Hammer, Mark J., and Mark J. Hammer Jr. 2012. *Water and Wastewater Technology*. New Jersey: Prentice Hall.
- [9] Davis, Mackenzie L. 2010. *Water and Wastewater Engineering: Design Principles and Practice*. New York: McGraw-Hill.
- [10] Qasim, Syed R. 1999. *Wastewater Treatment Plants: Planning, Design, and Operation*. Boca Raton: CRC Press.
- [11] Spellman, Frank R. 2013. *Handbook of Water and Wastewater Treatment Plant Operations*. Boca Raton: CRC Press.
- [12] Kadlec, Robert H., and Scott Wallace. 2009. *Treatment Wetlands*. Boca Raton: CRC Press.
- [13] Henze, Mogens, Mark van Loosdrecht, George Ekama, and Damir Brdjanovic. 2008. *Biological Wastewater Treatment*. London: IWA Publishing.
- [14] Mara, Duncan. 2004. *Domestic Wastewater Treatment in Developing Countries*. London: Earthscan.
- [15] Metcalf & Eddy/AECOM. 2013. *Wastewater Engineering: Treatment and Resource Recovery*. New York: McGraw-Hill.
- [16] Von Sperling, Marcos. 2007. *Wastewater Characteristics, Treatment and Disposal*. London: IWA Publishing.
- [17] Grady, C. P. Leslie, Glen T. Daigger, and Nancy G. Love. 2011. *Biological Wastewater Treatment*. Boca Raton: CRC Press.
- [18] Benefield, Larry D., and Clifford W. Randall. 1980. *Biological Process Design for Wastewater Treatment*. Englewood Cliffs: Prentice Hall.
- [19] Rittmann, Bruce E., and Perry L. McCarty. 2001. *Environmental Biotechnology: Principles and Applications*. New York: McGraw-Hill.
- [20] APHA. 2017. *Standard Methods for the Examination of Water and Wastewater*. Washington, DC: American Public Health Association.
- [21] Metcalf & Eddy. 2007. *Water Reuse: Issues, Technologies, and Applications*. New York: McGraw-Hill.
- [22] IS 456. 2000. *Plain and Reinforced Concrete – Code of Practice*. New Delhi: BIS.
- [23] IS 3370. 2009. *Concrete Structures for the Storage of Liquids*. New Delhi: BIS.
- [24] IS 800. 2007. *General Construction in Steel*. New Delhi: BIS.
- [25] IS 1893. 2016. *Criteria for Earthquake Resistant Design of Structures*. New Delhi: BIS.
- [26] IS 875. 1987. *Code of Practice for Design Loads*. New Delhi: BIS.
- [27] Neville, A. M. 2011. *Properties of Concrete*. London: Pearson.
- [28] Hibbeler, R. C. 2017. *Structural Analysis*. New Jersey: Pearson.
- [29] Wang, Chu-Kia, and Charles G. Salmon. 2008. *Reinforced Concrete Design*. New York: Wiley.
- [30] McCormac, Jack C., and Russell H. Brown. 2015. *Design of Reinforced Concrete*. New York: Wiley.
- [31] Bansal, R. K. 2010. *Strength of Materials*. New Delhi: Laxmi Publications.
- [32] Rajput, R. K. 2006. *Strength of Materials*. New Delhi: S. Chand.
- [33] Garg, S. K. 2015. *Environmental Engineering*. New Delhi: Khanna Publishers.
- [34] Peavy, H. S., and D. R. Row. 1985. *Environmental Engineering*. New York: McGraw-Hill.
- [35] Mihelcic, James R., and Julie B. Zimmerman. 2014. *Environmental Engineering: Fundamentals*. New York: Wiley.
- [36] Metcalf & Eddy. 1991. *Wastewater Engineering: Treatment, Disposal and Reuse*. New York: McGraw-Hill.
- [37] Tchobanoglous, George. 2015. *Wastewater Engineering: Treatment and Resource Recovery*. New York: McGraw-Hill.
- [38] Spellman, Frank R. 2008. *Water & Wastewater Infrastructure*. Boca Raton: CRC Press.
- [39] Arceivala, S. J., and Shyam R. Asolekar. 2007. *Wastewater Treatment for Pollution Control*. New Delhi: McGraw-Hill.
- [40] Fair, Gordon Maskew, John Charles Geyer, and Daniel A. Okun. 1968. *Water and Wastewater Engineering*. New York: Wiley.
- [41] Steel, Ernest W. 1960. *Water Supply and Sewerage*. New York: McGraw-Hill.

- [42] Kampa M., Castanas E., “Human health effects of air pollution”, *Environ. Pollut.* 2008, 151, pp.362–367.
- [43] Bernstein J.A., Alexis N., Barnes C., Bernstein I.L., Nel A., Peden D., Diaz-Sanchez D., Tarlo S.M., Williams P.B., “Health effects of air pollution”, *J. Allergy Clin. Immunol.* 2004, 114, pp.1116–1123.
- [44] Zheng N., Liu J., Wang Q., Liang Z., “Health risk assessment of heavy metal exposure to street dust in the zinc smelting district northeast of China”, *Sci. Total Environ.* 2010, 408, pp.726–733.
- [45] Ahmaruzzaman M., “A review on the utilization of fly ash”, *Prog. Energy Combust. Sci.* 2010, 36, pp.327–363.
- [46] Jun Cong Ge, Sam Ki Yoon and Nag Jung Choi, “Application of fly ash as an adsorbent for removal of air and water pollutants”, *Appl. Sci.* 2018, 8, 1116, pp.1-24.
- [47] Yao Z., Ji X., Sarker P., Tang J., Ge L., Xia M., Xi Y., “A comprehensive review on the applications of coal fly ash”, *Earth Sci. Rev.*, 2015, 141, pp.105–121.
- [48] Bouzoubaa N., Lachemi M., “Self-compacting concrete incorporating high volumes of class F fly ash: Preliminary results”, *Cem. Concr. Res.*, 2001, 31, pp.413–420.
- [49] Abbas S., Saleem M.A., Kazmi S.M., Munir M.J., “Production of sustainable clay bricks using waste fly ash: Mechanical and durability properties”, *J. Build. Eng.*, 2017, 14, pp.7–14.
- [50] Kumar S., “Fly ash–lime–phosphogypsum hollow blocks for walls and partitions”, *Build. Environ.*, 2003, 38, pp.291–295.
- [51] Dilmore R.M., Neufeld R.D., “Autoclaved aerated concrete produced with low NO_x burner/selective catalytic reduction fly ash”, *J. Energy Eng.*, 2001, 127, pp.37–50.
- [52] X. Bai et al., 'Compressive strength, permeability...,' *Sustainability*, 2024.
- [53] F. Yu et al., 'Predicting permeability...,' *Scientific Reports*, 2025.
- [54] H. Zhu et al., 'Permeability of recycled aggregate...,' *Materials*, 2020.
- [55] R. Liu et al., 'Influence of pore structure...,' *Springer*, 2020.
- [56] S. Mehta et al., 'Compressive strength of pervious concrete,' *IJERT*, 2016.
- [57] M. Ranjithkumar et al., 'Pervious concrete with fly ash,' 2021.
- [58] G. Ramesh, 'Pervious concrete: A review,' 2024.
- [59] *Results in Engineering*, Elsevier.