

Advanced Developments In The Manufacturing And Performance Analysis of Precast Concrete Septic Tanks

Miss. Aishwarya Kharade¹, Dr. Shilpa Kewate²

PG Student Department of Civil Engineering, Pillai HOC College of Engineering and Technology, Rasayani, Maharashtra, India.

Associate professor, Department of civil Engineering, Pillai Hoc College of Engineering and Technology, Rasayani, Maharashtra, India

Abstract: *The growing major demand for sustainable and reliable wastewater management solutions has now a days the adoption of precast concrete septic tanks as an instead to conventional cast-in-situ systems. Common septic tanks frequently suffer from inconsistent leakage, quality control and also reduced service life due to unconfined site conditions, improper handling and Improper curing. This study emphasizes the performance assessment of precast septic tanks with reference to durability, watertightness, structural integrity and sustainability. The assessment is conducted in line with Bureau of Indian Standards (IS 9872-1981) and National Pre-cast Concrete Association (NPCA) guidelines. The Literature and technical data reviewed from national and international studies confirm that precast septic tanks exhibit greater combined strength, soil pressure, reduced permeability and better resistance to corrosion compare to cast in situ tanks. The use of optimized concrete mixes, waterproofing compound, polymer additive and protective coatings enhances performance under aggressive environmental conditions. Moreover, the controlled manufacturing process minimizes shrinkage cracks and promotes long term durability. From a sustainability perspective, precast production significantly reduces on site waste generation, time required for construction and emission of hazardous carbon materials. Overall, the study concludes that precast septic tanks represent an enhanced, durable, and ecofriendly, approach to wastewater containment, ensuring long term performance, reliability, and sustainability in modern sanitation infrastructure.*

This is the partial replacement of cement by sludge of STP. Use of natural resources in construction material helps to make construction sustainable and reduced the carbon footprint from environment, also makes environment friendly. There are many treatments which take place in STP, in that there are some chemical treatments which are done, and these chemicals improve the quality of sludge and that quality helps to make concrete as Supplementary cementitious material (SCMs). Sludge is fully waste material, so the material is free of cost. A life cycle assessment was carried out to prove the natural environmental benefits of replacing cement with sludge. Using this SCMs (STP sludge) for precast septic tank as sustainable and leakage resistance construction. In conventional means of construction like use of cement there are certain challenges like disposing of waste materials which can be reduced by use of STP.

Keywords: Precast Concrete, Septic Tank, Durability, Performance Evaluation, Leakage Resistance, Sustainability.

1. INTRODUCTION

The demand for durable, efficient, and environmentally sustainable sanitation systems is increasing rapidly with the growth of urban and rural infrastructure. Septic tanks remain one of the most widely used on-site wastewater containment systems across India due to their simplicity and cost effectiveness. However, conventional cast-in-situ septic tanks are often prone to construction defects, leakage, poor reinforcement quality, and reduced service life, primarily because of uncontrolled site conditions, variable workmanship, and inadequate curing. These discrepancies can lead to groundwater contamination and high maintenance requirements. Therefore, precast septic tanks are a valuable alternative. In this construction, standard moulds are used with enhanced designs and proper curing processes under well-monitored conditions. This results in uniform strength, dimensional accuracy, and improved watertightness, ensuring better long-term performance compared to cast-in-situ tanks. Precast systems also allow for rapid installation, reduced site disruption, and consistent quality control, making them suitable for large-scale sanitation infrastructure.

Now this STP creates huge amount of sludge on daily basis which goes waste if not treated and recycled. This highlights the importance of sludge in modern day construction. STP consists of suspended solids and sediments. It goes through stages like sedimentation, filtration and disinfection. The sludge is released in STP which leads to contamination so converting it into recyclable use has been a global concern. The main aim of this study is to analyse the properties of STP and exploring its potential as a replacement for conventional construction materials. The research as of now has been limited and has certain constraints so an analytical study of STP gives us insights about viability and benefits of adopting STP in modern construction practices. We focus on usage of sludge in precast septic tank as it better suits the requirement for the same. Precast septic tanks as a replacement for conventional tanks comes with certain modifications. It is portable and is generally installed in large housing complexes, military camps and disaster relief camps so the usage in country like India is on a very high scale. So, using conventional means are costly and time consuming so materials like STP helps to evolve the precast septic tanks and make it more environment friendly.

2. LITERATURE REVIEW

T.R.C Rokeby (1952) TRC Rokeby in his studies stated that higher strength and better finish is possible if precast element is manufactured under control conditions.

National Pre-cast Concrete Association (NPCA) (2005-2010) The NPCA report states that for proper staging of septic tank, reinforcement detailing and dimensional accuracy is necessary, it further states that for assurance of tank quality permeability and hydrostatic test is must.

Md Saeed Hasan (2013) in his observation mentioned in report says that this tank can last up to 50 years in compression with traditional tanks. if they can last up to 50 years in comparison with traditional tanks, if they are cured and manufactured properly as they have dense concrete matrices.

3. PRECAST SEPTIC TANK

A Concrete septic tank built of precast unit makes possible the installation of a complete home sanitation system in short time. Use of this tank eliminating mixing concrete at the job and requires no special equipment for handling units. Mass production of precast concrete tanks at central plants simplifies inspection, lowers cost and improves quality. [1]



Figure 1. Precast Septic Tank [7].

3.1 Types of precast septic tank based on shape.

- **Rectangular precast septic tanks**
Provides wider surface for solid disposal [1].
- **Cylindrical (Circular) precast septic tanks**
Common in small-scale or individual houses [2].
- **Square precast septic tank**
Used for structures where there is space constraint [1, 2].

3.2 Types of precast septic tank based on no. of chamber.

- **Single chamber tank**
Used for tiny household and temporary structures [7].

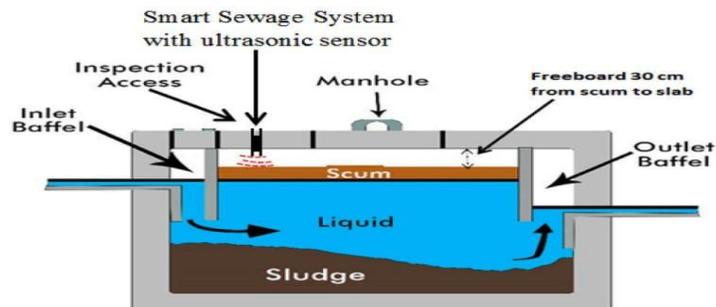


Figure 2. Single-Chamber Tanks [4].

- **Two-Chamber Tanks**
Most widely adopted [3]

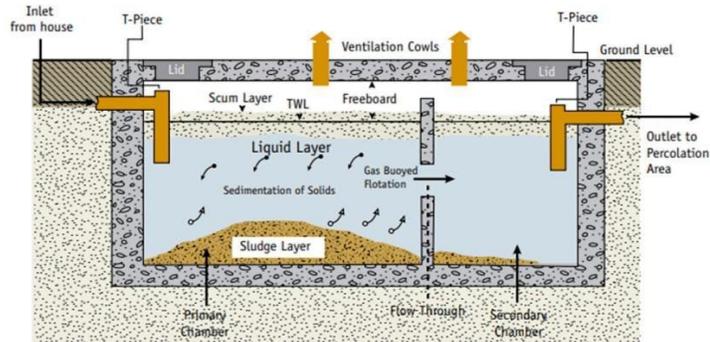


Figure 3. Single-Chamber Tanks [3]

- **Three-Chamber or Multi-Stage Tanks**
Designed for residential colonies and industries [3].

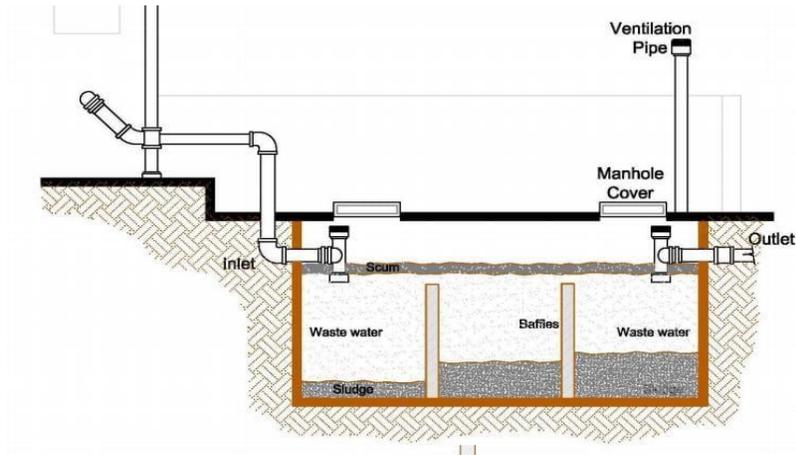


Figure 4. Three - Chamber or Multi-Stage Tanks [11].

3.3 Types of precast septic tank based on load bearing and installation condition.

- **Light-Duty Tanks**
Suitable for residential areas with low external load from soil or vehicles [2].
- **Medium-Duty Tanks**
Used in light vehicle access zone [8].
- **Heavy-Duty Tanks**
It is used in parking zones and car drives [9]

4. TYPES OF PRECAST SEPTIC TANKS BASED ON CONSTRUCTION MATERIAL.

4.1 RCC (Reinforced Cement Concrete) Precast Septic Tanks.

RCC is widely used material for precast septic tanks because of it is high combined strength, and capacity to resist soil pressure. These tanks are produced under factory-controlled conditions with M20 or higher-grade concrete, ensuring superior durability and watertightness [1,2]

Advantages: long shelf life and simple Installation.

4.2 FRP/GRP (Fiber-Reinforced Plastic/Glass-Reinforced Plastic) Tanks.

FRP or GRP septic tanks are lightweight, corrosion resistant composite units made from fibre-reinforced polymer resins. These tanks provide excellent chemical resistance and are suitable for marine, industrial or saline [3].

Advantages: Transportation easy to carry.

4.3 HDPE (High-Density Polyethylene) Septic Tanks.

For temporary sanitation setups one-piece moulded structure like HDPE are used [3].

Advantages: Lightweight and easy to transport

4.4 Hybrid/Smart Precast Septic Tanks.

Hybrid which uses FRP coating and RCC shells with linear enhance durability and reduced permeability [3].

Advantages: water tight performance with improve durability.

5. CONVENTIONAL AND PRECAST SEPTIC TANK.

5.1 Disadvantages of Conventional septic tank

- Because of above condition the conventional tanks are not aesthetic to look at.
- Open chamber and leakage of the water lead to bad smell.
- Unhygienic conditions act as breeding ground for Mosquitos which can be health hazardous
- In Rainy season this kind of septic tank are overflow because of collapsed open chamber, so rain water can flood the same and create water Logging.
- Construction is time consuming

5.2 Advantages of Precast septic tank

- This tank is available in circular, rectangular and square shape.
- Single, double and multi-chamber tanks are available.
- Easy and fast installation.
- Fully packed tank.

5.3 Objective of STPs Sludge Replacement in Concrete material

- Study the current construction scenario to find the scope of improvement.
- Analyse the possibility of using water treatment sludge (STP) as a partial replacement of concrete.
- Analyse the strength of a concrete block, made by partially replacing concrete (up to 10%) with sludge for potential use in a precast septic tank to study the enhancement in strength.
- Analyse scope of improvement with the help of results and find environmentally friendly and economically sustainable options which can be considered as partial replacements for concrete.

Table no 1. Problems And Solution of Septic Tank.

5.4 Problems of conventional septic tank	5.5 Solution
<ul style="list-style-type: none"> • Issues related to leakage • Improper quality control • High project cost • Difficult in maintenance and care • No uniform standard guidelines 	<ul style="list-style-type: none"> • Use precast RCC septic tank • Control and monitoring of quality • Precast tank reduced material wastage • Preapproved engineering drawings and quality certification • Addition of sludge gives more durability and sustainability



Figure 5. Cracks In Wall Resulting In Shrinkage [Source. Author].



Figure 6. Dealignment of Bricks [Source. Author].



Figure 7. Chamber Slab In Damaged State [Source. Author].



Figure 8. Open Sewer Line [Source. Author].



Figure 9: Precast Septic Tank
[Source. Author]

6. SUSTAINABLE MATERIAL FOR SPETIC TANK WHICH CAN BE USE WHILE MAUFACTURING.

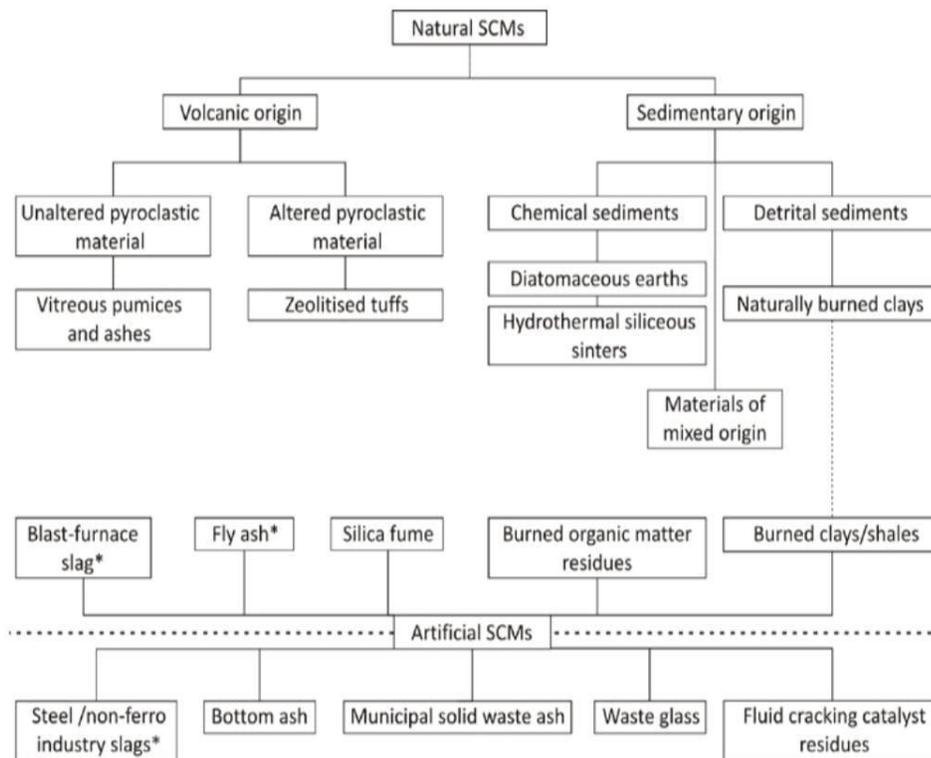


Figure 10. Sustainable Materials Flow chart [5].

7. MATERIAL USED FOR PRECAST SEPTIC TANK.

Cement: ordinary Portland Cement (OPC) 53 grade.

Fine aggregate: Manufactured sand or sand passing through river 4.75mm

Coarse Aggregate: Granite (crushed) aggregates of 10mm & 20 mm normal size, angular in shape to enhance bond.

Water: potable water requirements

Admixtures: plasticizers or superplasticizer to improve workability and gain low water cement ratio

sludge: Replacement of fine aggregate in concrete

Joint Sealing Materials: Rubber/PVC gasket and epoxy sealants for watertight joints [1,6]



Figure 11. Cement
[Source Author]



Figure 12. Crushed Sand
[Source Author]



Figure 13. Coarse
[Source Author]



Figure 14. KIM Admixture
[Source Author]



Figure 15. KP200
[Source Author]

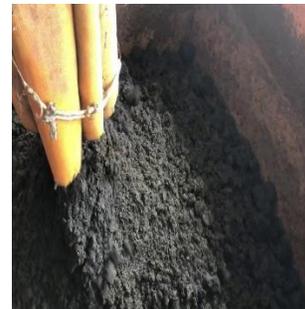


Figure 16.STP Sludge
[Source Author]

8. CONCRETE TEST FOR PRECAST SEPTIC TANK

CompressiveStrength

Flexural Strength Test

Water Absorption Test

Permeability test [1,6]

Below graphs shows the replacement of sand (fine aggregate) by STP sludge material replacement of concrete in different proportion can achieve strength after 3, 7 and 28 days. CC- Shows the pure concrete without sludge percentage.

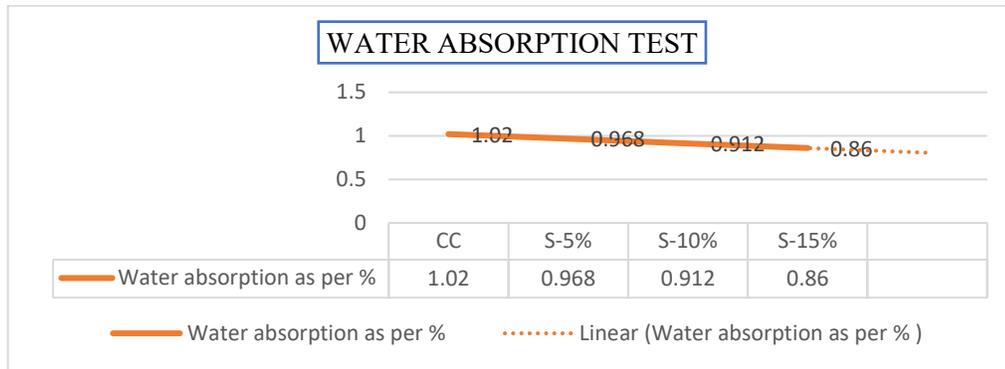


Figure 17. Water Absorption Test [6].

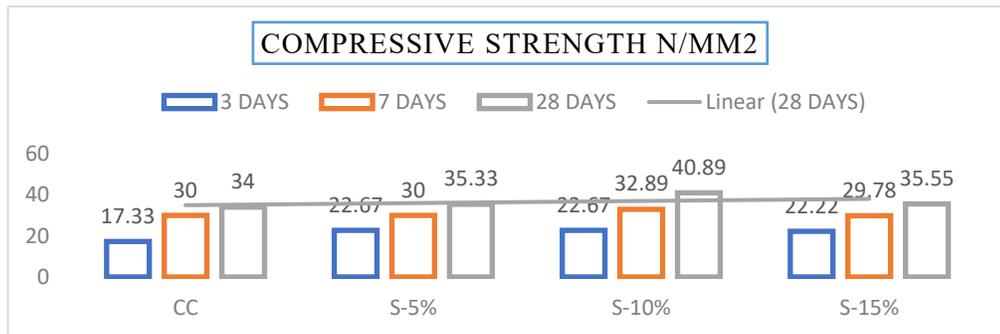


Figure 18. Compressive Strength [6].

9. RESULT

The above graph indicates that a 10% replacement of sludge yields the best performance compared to 5% and 15% replacement levels. At 28 days, the 10% sludge replacement achieved a compressive strength of 40.89 N/mm², whereas the 5% and 15% replacements attained comparatively lower strength values.

Table 2. Compression Test of Concrete N/mm2 [6].

MIX ID	3 Days N/mm2	7 Days N/mm2	28 Days N/mm2
CC	17.33	30.00	34.00
S-5%	22.67	30.00	35.33
S-10%	22.67	32.89	40.89
S-15%	22.22	29.78	35.55

Table 3. Water Absorption % [6].

MIX ID	24 Hr water Absorption %
CC	1.02
S-5%	0.968
S-10%	0.912
S-15%	0.86

10. CONCLUSION

- Due to strict quality control and compaction in vibration it helps to provide higher flexural and compressive strength in precast septic tank system as compared to traditional septic tank. Also 20 % strength increases in 28 days
- It removed leakage problems which result durability and watertightness which is not observed in traditional tank.
- Uniform stress distribution as well as cracking is reduced as factory curing is done in controlled manner with accurate reinforcement placement.
- Lifecycle based cost analysis helps in long term economic and environmental gains.
- 3% reduction of material cost of concrete.

11. ACKNOWLEDGEMENT

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