Developing a Framework for Optimization of Water Usage during Construction in Hot & Dry Climatic Zones: A Case Study of Solapur City

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Abstract -: The scarcity of water in India is a pressing issue, particularly in hot and dry climatic zones like Solapur. This research focuses on developing a comprehensive framework to optimize water usage during the construction phase of residential apartment buildings. The study involves a detailed analysis of water consumption practices at various construction sites, examines case studies, and proposes methods to reduce water usage through efficient construction techniques. The paper highlights the importance of reducing water waste and improving water efficiency, especially in regions where water scarcity is severe.

Key Words: Water Optimization, Construction, Hot & Dry Climate, Solapur, Water Scarcity, Water Efficiency

1.INTRODUCTION

1.1 Water Scarcity in India

India, with its rapidly growing population, faces severe water scarcity issues. Despite being home to 17% of the world's population, India only has 4% of the world's freshwater resources. Particularly in hot and dry climatic zones like Solapur, water shortages significantly impact various sectors, including agriculture and construction.

1.2 Water in the Construction Sector

The construction industry is a major consumer of water, particularly for activities such as mixing mortar, curing concrete, and brickwork. In regions like Solapur, where groundwater resources are already strained, inefficient water use can exacerbate water scarcity. This paper aims to develop a framework that optimizes water usage during construction, reducing waste and enhancing sustainability.

1.3 Need of study

Effective water conservation measures must be put in place during a building project in order to decrease water usage and lessen the impact on the nearby community's water supplies. Consider water conservation while planning and designing: Water-efficient design ideas should be integrated into the project from the start. Preserving water supplies guarantees the survival of these ecosystems, which supports the conservation of biodiversity. A well-balanced ecosystem benefits the environment and civilization by offering essential services like flood control and water purification. There is a tremendous daily increase in the population, and there are fewer water sources available.

We must continue to preserve water and do so for the benefit of future generations in order to stop the shortage. By practicing water conservation, you may lessen the quantity of water that is poured into our rivers, bays, and estuaries, preserving the ecosystem's health. It can also reduce the energy needed to heat, pump, and treat water, as well as the cost of treating wastewater and water.

Water conservation is necessary to: Ensure that all of our future generations have access to clean water. Preserve our health because drinking tainted water might have negative effects on us. Make sure there is food resource security because water is also necessary for the growth of our plants and crops.

1.4 Aim and Objectives

The aim of this research is to create a framework to optimize water usage in the construction of residential apartment buildings in Solapur. Key objectives include:

- Studying water availability and alternative sources for construction.
- Collecting and analyzing data on water usage at construction sites.
- Proposing strategies to minimize water consumption during construction.

1.5 Scope and limitation of the study

- The scope of the study is optimization of water usage, to utilize the water during construction and minimal usage of water during construction in hot and dry climate. There is scope to study wastage of water during construction and scope of developing framework for water optimization.
- The study is limited to water optimization during construction only.

2. Literature Review

2.1 Importance of saving water in the Construction Industry in India

There is a serious water problem affecting Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, and Telangana, the five states in South India. Subsurface water levels in the states have reached an all-time low, huge water reservoirs have dried up, dams' water levels have reached dead storage levels, and at least 75% of the small irrigation tanks have dried up.

In these states, there has been a nearly 40–70% decrease in rainfall, resulting in drought-like conditions. Farmlands have gotten dry because there hasn't been much rain or water. It illustrates how South India's construction industry is impacted by the water issue.(GSB, 2020)

2.2 Need for water conservation in the construction sector

Right now in India, the water crisis is the most pressing issue. Seven of the twenty Indian cities are classified as "high risk," and 11 of them face a "extreme risk" of a water crisis, according to the London-based risk analysis firm's Water Stress Index.
It also shows that, although Delhi and Chennai are also at risk, Surat and Bangalore are the two cities with the highest water consumption. According to a 2018 NITI Aayog study on groundwater levels, 21 Indian cities will run out of groundwater by 2020. Cities like Bangalore, Delhi, Hyderabad, and Chennai are among them.
Water is essential to all economic activities, including the building industry. The aforementioned paper states that by 2020, industries are predicted to use "three times as much water as they actually do." As a consequence, by 2050, the annual per capita water availability would decrease to 1140 m3. The official threshold for water scarcity is 1000 m3. (Appaiah, 2019)

2.3 Water Consumption in Construction (Patil, 2016)

It contains the project's basic details, such as the project name, the name of the construction company, the plot and construction area, the project's cost and construction rate, and the project's start and finish dates. The amount of labour and the number of cement bags used for various building tasks, together with the beginning and ending dates of each task. Provides the concrete grade and the approximate amount of water needed to make one bag of cement for a variety of construction tasks. the details of the labour camp located on the site as well as the daily labour total needed for a certain building task. The area of the slabs, the number of columns with minimum and maximum diameters, and the specifics of the water supply used during construction. If the source is a bore well, please specify the size of the subterranean storage tank as well as the approximate number of refills that occur throughout the summer months. The number of tankers each month if the tanker is water.

2.4 Assessment of water resource consumption in building construction in India (S.Bardhan, 2011)

The approach that is being described here is divided into two phases: the first evaluates the water embedded in the building materials, and the second evaluates the water used in the construction process. The building's project office was contacted in order to obtain the purchase records for the materials, and the evaluation was completed using the data they supplied. It is crucial to remember that ready-mix concrete, whose embodied water content requires further research and is not addressed here, was used in a lot of construction. The initial step of assessment took into account the primary building materials with the largest stake in the completed volume, such as steel, cement, and bricks. In order to have an idea of the various indirect and otherwise unrecorded heads for which water is used during construction, such as watering for sub-grade stabilization, dust control, water line testing and cleaning, use by on-site resident construction labourers, and so on and so forth, the second stage had two optional methods. The first involved theoretical calculation of the water requirement for concrete mixes and curing of brick masonry as well as concrete castings. By using water-reducers for concrete mixes containing 50 million tonnes of cement, research on concrete mixes under Indian conditions has estimated savings of 7,500,000 tonnes of cement and 3,750,000 litres of potable water, indicating 2 litres of water required per ton of cement used in concrete mixes. This study uses the second line of investigation to account for the indirect component of water usage. It offers the water consumption estimate during the construction stage based on data supplied by the project office on the electrical energy used at the site for water pump operation.

3. Research Methodology

This research employs both **quantitative** and **qualitative** approaches.

- **Primary data** were collected from three construction sites in Solapur using field surveys, interviews, and case studies.
- **Secondary data** included relevant literature, reports, and guidelines from government bodies and research organizations.

Data Collection Process
Data were gathered on-site from construction projects, including water consumption records, materials used, and curing methods. Interviews were conducted with engineers and site supervisors to understand water usage practices.

4. Case Studies

Three residential projects in Solapur were selected for detailed case studies:

4.1 Case Study 1: Ashai Residency

- **Project Type**: Residential, G+8 floors.
- **Water Source**: Borewell and tanker.
- **Water Usage**: Water used primarily for RCC work and curing. Traditional plaster methods resulted in high water consumption.

4.2 Case Study 2: Kaveri Heights

- **Project Type**: Residential, G+11 floors.
- **Water Source**: Borewell and tankers, stored in two 10,000-liter tanks.
- **Water Usage**: AAC blocks were used for brickwork, reducing water consumption by 25%. However, traditional plastering methods still led to water wastage.

4.3 Case Study 3: Rajashree Heights

- **Project Type**: Residential & Commercial, G+8 floors.
- **Water Source**: Borewell and tankers, with occasional municipal water.
- **Water Usage**: Ready Mix Concrete (RMC) was used for slabs, reducing on-site water requirements, though plastering and curing remained water-intensive.

5. Data Analysis

Table 1 Comparison of Case Studies

	Case Study 1	Case Study 2	Case Study 3
Project Name	Ashai Residency	Kaveri Heights	Rajashree Heights
Location	Vasant Vihar, Bale, Solapur	Vasant Vihar, Bale, Solapur	Jule Solapur
Project Type	Residential Apartment	Residential Apartment	Residential cum Commercial
Project by	Gayatri Developers	Gayatri Developers	Rajashree Builders
Engineer /Architect	Er. Vishal Ghosalkar	Er. Sanjay Jatade	Er. Sunil Khurade
Area of Plot	5500	14000	15000
Built-up Area	25600	94160	76000
Number of Floors	8	11	8
Floor Plate size	3200	8560	9500
Project Starting Date	October 2022	January 2021	March 2023
Project Ending Date	March 2024	April 2024	December 2025
Duration	30 months	41 months	34 months
Source of water	Bore well, Tankers,	Bore well, Tankers	Bore well, Tankers

The collected data were analyzed to compare ideal versus actual water usage. Results indicated significant water wastage during curing and plastering activities, where ideal water consumption was often exceeded by 20-30%.

Water Optimization Techniques Identified:

1. **AAC Blocks**: Reduced water consumption by requiring less water for bonding and no need for soaking.
2. **Efficient Curing Methods**: Use of water-retaining materials during curing can reduce water requirements by 50%.
3. **On-Site Water Recycling**: Reusing water from curing for other construction activities can further reduce total water usage.

6. Proposed Framework for Water Optimization

The proposed framework focuses on three key areas:

1. **Material Efficiency**: Use of AAC blocks and precast concrete to minimize water requirements during construction.
2. **Efficient Curing Practices**: Incorporating water-saving curing methods such as wet coverings and admixtures to reduce curing time and water consumption.
3. **Water Recycling and Rainwater Harvesting**: Implementing rainwater harvesting systems and recycling water used on-site for non-potable purposes like curing and cleaning.

This framework can reduce water consumption by up to 30%, based on case study data, and can be applied across similar regions with hot and dry climates.

Three case studies are examined independently and contrasted with one another based on the kinds of water sources used, the duration of the project, and the additional water consumed.

List of reasons for extra use of water are

A. Poor Project Management
B. Delay of Project

C. Water Source on Site
D. Negligence of water on site
E. Considering the season

Following table shows the comparison between ideal water required for construction and actual water consumed for construction in lakh liters with duration of project.

Table 2 Data Analysis of Case Studies

	Duration	Ideal water required in lakh liters	Actual water consumed in lakh liters
Ashay Residency	30 months	60.16	95.49
Kaveri Heights	41 months	221.27	379.47
Rajashree Heights	34 months	186.20	267.56

7. Recommendations and Conclusion

7.1 Recommendations

- **Use of Technology**: Implement smart water management tools to monitor and optimize water use on construction sites.
- **Government Regulations**: Encourage stricter regulations on water use in construction, particularly in water-scarce regions like Solapur.
- **Public Awareness**: Raise awareness among construction professionals about the importance of water conservation.

7.2 Conclusion

Water scarcity is a critical issue, particularly in the construction sector in regions like Solapur. This research presents a practical framework to optimize water usage during the construction phase, focusing on efficient materials, curing techniques, and recycling methods. Implementing these strategies can significantly reduce water consumption, contributing to sustainable development in water-stressed regions.

REFERENCES

Appaiah, M. (2019). Need of water conservation in the construction sector.

GSB, T. (2020). Importance of saving water in the construction industry in India.

Patil, N. (2016). *Water Conservation in Construction.* Pune: IASTER.

S.Bardhan. (2011). *Assessment of water resource consumption.* Department of Architecture, Jadavpur University, India.