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Determining Water Footprint of Buildings During Construction Phase: An Activity-based Approach

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Abstract Construction activity uses water to a significant extent for many operations, materials, and on-site activities, and the availability of potable water for building construction is a matter of concern. This research work aims to determine water consumption during construction activities on-site during the construction phase of the building in the Indian context. Conventional low-rise load-bearing and Reinforcement Cement Concrete (RCC) framed buildings are considered for the calculations of materials and activities. The application of building materials and water requirements for various construction activities and methods is determined to achieve the goal. Theoretical water use for various activities on site is considered, as per water requirements for application, mixing, and curing. Based on this research, recommendations are made for potential strategies for water saving in construction activity. Water consumption in building construction is expected to increase globally, particularly in developing countries like India, because of the demand for urban development and housing for all. Hence, water efficiency in building construction is a matter of concern. This research will contribute to the addition of new knowledge to the existing database about this topic to set a benchmark. Research paves the way for energy-efficient construction techniques and the use of building materials in a sustainable manner to reduce water use in building construction.

Keywords Water Demand, Water Footprint, Water Sustainability, Building Construction, Architecture

1. Introduction

Potable water is becoming increasingly scarce; approximately two billion people lack safe access to potable water today. The scarcity of water resources is no longer merely viewed as a problem of human growth and environmental sustainability, but also as a political and security issue. By the middle of this century, about four billion people, or around 40% of the world's population, would reside in water-stressed basins [1].

Most emerging nations are experiencing rapid population development, which is accompanied by an increase in the demand for food, water, housing, and other natural resources. Since building projects are still mostly carried out using conventional methods, they come with a variety of sustainability challenges, including environmental, social, and economic issues. This is especially true when resources are being used poorly and inefficiently [2].

Most rating systems already consider water (efficiency, conservation, and resource utilization) to be a key criterion, including the Indian Green Building Council (IGBC) in India, Leadership in Engineering and Environmental Design (LEED) in the United States, Assessment Standard for Green Building (ASGB) in China, and sustainable/green interventions [3]. The concept of water footprint analysis is relatively new worldwide. The literature on the water footprint of buildings, especially during development, is scarce. Few nations have started avoiding foods and buying goods that have a disproportionately high water impact. Researchers note that several factors will alter global water consumption and pollution levels in 2050 and that we must reduce the effects of future freshwater scarcity [4]. Researchers found that reducing humanity's water footprint to sustainable levels is possible even with increasing populations, provided that consumption patterns and other drivers change.

The National Remote Sensing Center and 2019 study estimated that India's average annual water resource availability was 1,999.20 billion cubic meters (BCM). The country's usable water is thought to be 1,126 BCM due to geographical, hydrological, and other limitations [5]. The importance of water footprint is related to the need to increase public awareness about the amount of water used in producing goods and providing services, as well as the modifications that may be made to diet, market trading, and production. The crops grown for food and bioenergy are the main subject of a literature review on the water footprint of agricultural production [6].

The second largest employer in India is the real estate industry, behind agriculture. Therefore, it's critical to comprehend both the volume of freshwater required during construction and the volume that enters into building materials [7]. Water availability per person is predicted to gradually decrease, reaching 1,465 cubic meters by 2025 and 1,235 cubic meters by 2050. India might be classified as a country with a water shortage if this reduction continues and reaches 1,000–1,100 cubic meters [8]. There is a need to reduce the consumption of water in the agriculture sector. We can produce more, even with less water. Crop planning would be based on local climatic conditions, water availability, and the overall demand-supply situation. It could also assist the government in designing incentives to encourage farmers to grow the recommended crops.

The amount of water available to each individual depends on the population of the nation. In India, the country's water availability is declining per capita as a result of the rising population. The average annual water availability per person was estimated to be 1816 cubic meters in 2001 and 1545 cubic meters in 2011, respectively. This amount may further decline to 1486 cubic meters and 1367 cubic meters in 2021 and 2031, respectively [9].

(Source: https://civiconcepts.com/blog/components-of-building)

Figure 1. A typical scenario of excavation and foundation for small buildings

(Source: https://www.quora.com/What-is-the-reason-for-water-seepage-from-a-newly-casted-slab)

Figure 2. Typical RCC columns erection and curing activity

(Source: https://www.youtube.com/watch?v=Pj_HRb9zna0)

Figure 3. A general method of brickwork and curing in residential buildings

(a) (b)

(Source: https://www.youtube.com/watch?v=Q0UCHc1Y6b8)

Figure 4. (a) and (b): A general method of cement plastering on brickwork

(Source: https://www.thehindu.com/features/homes-and-gardens/proper-curing-increases-the-life-span-of-a-building/article3747192.ece)

Figure 5. Water use in the curing of brickwork and cement plaster

We are witnessing urban sprawl in the 21st century, which is associated with huge construction activity. Construction activity uses water to a significant extent for many operations, materials, and on-site activities, and the availability of potable water for building construction is a matter of concern. Consumption of water in building construction is expected to increase across the globe, particularly in developing countries like India, because of the demand for urban development and housing for all. Researchers so far have relied on the water consumption data collected on-site based on water pump operations on site, considering its flow rate and hours of operation. Information about water consumption on construction sites thus calculated cannot be considered as a benchmark because water is used in many other activities too, which are not directly related to building construction. We need to consider water use for various activities directly related to building construction, and hence a theoretical Activity-Based Approach is formulated to work out water use on site, which is realistic and can be considered as a benchmark in the region. This research work aims to showcase the state of the art and to determine water consumption during construction activities on-site during the construction phase of a building in an Indian context. For material and activity calculations, conventional low-rise load-bearing and RCC-framed buildings must be considered. The research outcome is expected to be in the form of a model (Activity Based Approach) for estimating the water footprint for construction work in an Indian scenario. Figures 1 to 7 illustrate the typical construction method and water use scenario for conventional building construction in the Indian context.

(Source: https://www.indiamart.com/proddetail/marble-floor-grinding-service-5677073091.html)

Figure 6. Marble flooring grinding activity after laying marble stone

(Source: https://www.youtube.com/watch?v=ue-1y-_SWw8)

Figure 7. Laying ceramic tiles on toilet walls

The idea of considering water use along supply chains has gained interest after the introduction of the ‘water footprint’ concept by Hoekstra in 2002. The ‘water footprint’ is an indicator of freshwater use that looks not only at the direct water use of a consumer or producer but also at the indirect water use. The scope of this research is to determine the direct water use and footprint of buildings during the construction process as per prevailing practices in the composite climatic zone of India.

Water is a challenging and important ingredient of the sustainable mission of the country and one of the most important life resources. A significant component of this resource is used in the construction sector. The quantity of water used in construction is largely unaccounted for and undocumented. Extremely high water use during construction is normal because of ignorance and lack of accountability, mainly in local areas. The use of conventional materials seems likely for at least the next 20 years (brick, concrete, stone, wood, and other alternate materials available locally). As a result, the contribution of this research work to current practices for water utilities is justified and will be extremely beneficial.

Sustainability in the context of water usage in buildings mostly concentrates on operational water use, i.e., water used in buildings after construction, hence a variety of strategies are stressed to address the problems linked to operational water demand. The difference is thought to measure the amount of net water that must be consumed and used throughout specific construction activities. Due to the wide range of construction techniques and worker skill levels, water use on construction sites may vary. According to Jain and Srivastava's calculations, a sample building's substructure required a total of 15.19 to 36.12 liters of water per square meter of the built-up area [11].

According to Australian researchers and their research, the amount of embodied water is far more than the amount of water used over the course of a building's lifetime. Hossainien used the Life Cycle Assessment methodology and the Water Footprint Network method to conduct research on the effects of structural parameters (area, height, material, slab, and the lateral load resisting system) as well as site classification on the water footprint of building construction [12]. They proposed a water footprint framework for residential building assessment by reviewing the literature, analyzing a concrete block production plant, investigating 21 construction sites, and analyzing 45 residential apartments. Researchers concluded that small buildings are preferable to large buildings in terms of the water consumption intensity of their structures.

Some researchers at Universidad Autonoma de Madrid calculated the total water consumed by housing development in Spain [1]. They analyzed using the value focus, which ascends to 88,500 m^3. 93.1% of the latter stemmed from indirect consumption, 3.4% from consumption by service and material suppliers, and the remaining 3.5% from direct consumption during the project. All this represents approximately 5.7 m^3 of water per m^2 constructed.

However, India's material requirements, historic outlook, and context (such as its economy, people, etc.) are considerably different [17]. Massive construction activity is expected in the future, which will have a significant impact on the country's future water availability. Research undertaken on the topic is relatively new and based on lots of assumptions, too, because of prevailing construction methods in a different climatic scenario.

There are no studies that compare the water use of buildings in emerging nations or the nations with the highest water stress, like India, where some of the studies were carried out. Given that the majority of these nations heavily rely on energy-intensive desalination technology, an exhaustive evaluation of the water usage cycle of buildings in water-stressed countries can be extremely beneficial for the environment [18]. Determining the water footprint of buildings in developed and developing countries can provide insight for setting more sustainable strategies to reduce environmental impact.

In the area of the water footprint of residential building development in India, very little study has been published. At Kolkata, Bardhan analyzed a number of multi-story residential apartment structures and determined that the inherent and induced water levels were 25.6040 kl/m^2 and 2.0 kl/m^2, respectively, of floor area. As a result, the construction water footprint came to 27.6040 kl/m^2 of floor space [13]. In a different study, Bardhan examined a multi-story residential building in Kolkata and calculated the amount of embodied water to be 26.8102 kl/m^2, along with the amounts of inherent and embodied water to be 25.3897 kl/m^2 and 1.4205 kl/m^2, respectively.

The range of total WFs for construction activities is 11.84 L/USD (for Italy) to 78.12 L/USD (for India), with more developed economies showing a greater share of international WF (the average for Italy and the UK is 71.5%) than emerging economies (the average for India and South Africa is 18.5%). Therefore, the current emphasis on energy and carbon dioxide footprints risks omitting important water consequences brought on by construction operations worldwide [19].

According to recent research, Anoop stated that whereas direct water use is 3.66 kl/m^2, conventional building construction in Jammu uses 43.7 kl/m^2 of embedded water per square meter. 40.3% of the total embodied water in buildings comes through indirect water consumption [16].

The methodology, procedures, and indicators for evaluating the effects of freshwater utilization are still being developed, according to researchers. A significant breakthrough in this direction has been the idea of "water footprint" [14]. The scope of our work is limited to determining the quantity of direct water use in buildings/construction sites for the construction phase building with a new perspective using an activity-based approach. Embodied water of building materials is not taken into consideration in this work.

2. Research Methodology

To achieve the goal, water use is estimated for various activities/established practices in building construction as prevailing in the composite climatic zone in India. Broad specifications are considered for various construction and finishing materials used in the buildings for structural members as well as for wall and floor finishes. In India, conventional construction technology and methods are different from those practiced in developed countries and a list of all construction activities for the conventional construction of a building is judiciously prepared. All building work items/construction activities are enlisted in Table 1, in which water use is envisaged. For every activity water use is estimated with certain assumptions, which are mentioned with the respective activity. Water use is considered in the following broad manners for every activity/indicator.

(a) Water absorption by building materials like brick and mud/earth. It is assumed that 15% of water (by volume) will be absorbed by mud during earthwork and 15% (by volume) by bricks and cement mortar.
(b) Water is required for mixing the ingredients of various materials like mortar and concrete considering the water-cement ratio of 2:5.
(c) Water required for surface cleaning/preparation before the application is considered in the form of a thin film of water (1 mm thick for 2-time application/washing before applying the material like cement plaster).
(d) Water is required for washing the surfaces like brickwork/cement plaster/tiles/stone in the form of a thin film of water (1 mm thick for five times application including pre-fixing and post-fixing of material).
(e) Water required for curing of materials like brickwork in cement mortar, cement plaster, and concrete is considered as 10% (by volume) by bricks and cement mortar and 5% (by volume) by cement concrete for 7 to 14 days on a daily basis.
(f) Water is required for the cleaning of tools and equipment on-site daily.

Initially, water consumption is calculated for the unit quantity of building work items/ construction activity, which is presented in Table 1. A prototype of the building is considered and the Bill of Quantity / Material Take Off is calculated for the building (illustrated in Figures 8 and 9), and accordingly water use is determined for all construction items for the prototype building.

The distinction between the internal and external faces of cement plaster is not considered in this work, but water use is calculated for an item/activity regardless of internal or external. It is assumed that the curing of cement concrete, brickwork, and cement plastering work will be done using water sprinklers for optimal use. To calculate water use for an activity, the following activities and broad assumptions (as mentioned above in point (a) to point (f) are given in Table 1. The activity-wise water use in residential building construction is given in Table 2.

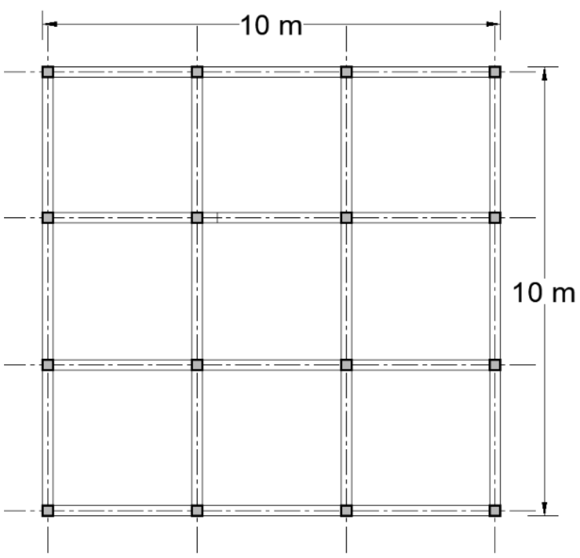
A simple case has been considered to determine the water footprint in terms of water use per m^2 of the covered area. The quantity of building materials varies from building to building, so a simple case with a square plan of a residential building is considered a prototype /base case. Figures 8 and 9 show the schematic grid layout and base case building plan, respectively. The quantity of construction items or building materials is calculated using the base case and certain assumptions or considerations as mentioned in methodology point (a) to point (f).

Table 1. Construction activities and assumptions for determining water footprint

S. No.		Activity	Unit	Estimated Water Use (Litres)	Assumptions/Remarks
1		Excavation of Earthwork	1.0 m^3	60	Hard and dry alluvial soil (with no rocks) with an absorption capacity of 15% by volume
2		Plain Cement Concrete (PCC) In Foundation (1:4:8)	1.0 m^3	12+27=39	Water used in direct mixing and absorption by the brick ballast and ~9 litres each in 03 periodic curing
3		Reinforced Cement Concrete (RCC) of ratio (1:2:4 or 1:1.5:3) work in foundation, columns, beams, slabs etc.	1.0 m^3	7.5+84=91.5	7.5 l in direct mixing and ~12 litres each in 7 periodic curing
4		Damp Proof Course at Plinth Level	1.0 m^2	6+6=12	6.0 l in direct mixing and ~2 litres each in 03 periodic curing
5		Brickwork in Foundation	1.0 m^3	40+63=103	Water used in mortar preparation, absorption by the bricks (before laying) and ~9 litres each in 07 periodic curing
6		Brickwork in Superstructure			
	(a)	230 mm thick or higher width courses	1.0 m^3	40+63=103	Water used in mortar preparation, absorption by the bricks (before laying) and ~9 litres each in 07 periodic curing
	(b)	115 mm thick partition wall	1.0 m^2	5+9=14	Water used in mortar preparation, absorption by the bricks (before laying) and ~1.25 litres each in 07 periodic curing
7		Cement Plastering on Walls and Ceiling (12 to 15 mm thick)	1.0 m^2	6+12=18	Water used in mortar preparation, wetting of brickworks/surface and ~1.5 litres each in 07 periodic curing
8		Plain Cement Concrete (PCC) in Flooring	1.0 m^3	12+27=39	Water used in direct mixing and absorption by the brick ballast and ~9 litres each in 03 periodic curing
9		Floor Finishing			
	(a)	Marble Flooring	1.0 m^2	3+2+10=15	Water used in base cement mortar, cutting-grinding and washing of stone (@2 litres for 5 times)
	(b)	Tile Flooring	1.0 m^2	3	Water used in base cement mortar, cutting and grouting
	(c)	Cement Concrete Flooring	1.0 m^2	6+6=12	Water used in cement concrete mixing and curing
10		Putty and Painting	1.0 m^2	3+3=6	Water used in surface preparation, washing and cleaning of the floor after painting
11		Mud Phuska Terracing (average 100 thick)	1.0 m^2	30	Water used in mud phuska mixing and laying
12		Plumbing Works			
	(a)	Cutting, Grooving, Chase making in walls	Built-up area of 100 m^2	30	Lump sum
	(b)	Core Drilling, Making Holes across walls, etc. (03 holes up to 150 mm each)	Built-up area of 100 m^2	30	Lump sum
	(c)	Fitting / Fixing / Jointing	Built-up area of 100 m^2	30	Lump sum

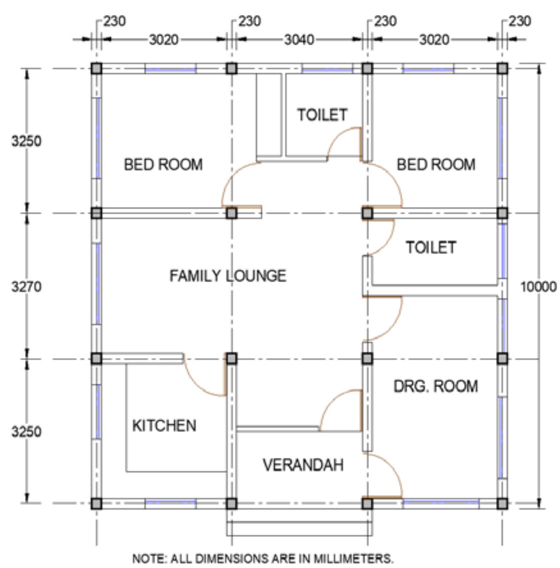
Table 1. Continued

13		Electrification Works			
	(a)	Cutting, Grooving, Chase making in walls	Built-up area of 100 m^2	30	Lump sum
	(b)	Conducting and Board Fixing	Built-up area of 100 m^2	30	Lump sum
	(c)	Wiring and Switching	Built-up area of 100 m^2	30	Lump sum
14		Carpentry Works (Door Window Making)	Built-up area of 100 m^2	30	Lump sum
15		Fabrication Works			
	(a)	Steel Fabrication	Built-up area of 100 m^2	30	Lump sum
	(b)	Aluminium Fabrication	Built-up area of 100 m^2	30	Lump sum
	(c)	Glazing and Hardware Fixing etc.	Built-up area of 100 m^2	30	Lump sum
16		Cleaning of Equipment / Utensils / Machinery	Built-up area of 100 m^2	4500	Water use @30 litres daily for 150 days
17		Manpower on Site (Average 03 person on-site daily for 150 days) for hand washing etc. only. (Not for residential purposes)	Built-up area of 100 m^2	20250	Water use @ 45 litres per head per day daily for 150 days
18		Miscellaneous Activities (Site Clearing and Levelling, Layout, Shuttering, Reinforcement, Making Temporary Water ponds, Earth Filling and Compaction, Wall Tiles Pasting etc.)	Built-up area of 100 m^2	900	Water use @ 15 litres daily for 60 days Lump sum



(Source: The Authors)

Figure 8. Indicative structural grid configuration of base case building



(Source: The Authors)

Figure 9. Schematic floor plan of a small residential building, as a base case

Table 2. Activity-wise water use in residential building construction

S. No.		Construction / On-Site Activity	Consideration for 100 m^2 Built Up Area		
			Estimated Quantity	Water Use in Unit Quantity	Total Water Use in Activity (Litres)
1		Excavation of Earthwork	54 m^3	60	3240
2		PCC in Foundation (1:4:8)	7.8 m^3	39	304.2
3		RCC (1:2:4) works in foundations, columns, beams and slabs etc.	20.1 m^3	90	1809
4		Damp Proof Course	18 m^3	12	216
5		Brickwork in Foundation	12.4 m^3	103	1277.2
6		Brickwork in Superstructure			
	(a)	230 mm thick or higher width courses	15.6 m^3	103	1606.8
	(b)	115 mm thick partition wall	54 m^2	14	756
7		Cement Plastering on Walls and Ceiling (12 to 15 mm thick)	450 m^2	18	8100
8		PCC in Flooring	14 m^3	39	546
9		Floor Finishing			
	(a)	Marble Flooring	100 m^2	15	1500
	(b)	Tile Flooring	m^2	3	0
	(c)	Cement Conc. Flooring	m^2	12	12
10		Painting	450 m^2	6	2700
11		Mud Phuska Terracing (Average 100 thick)	93 m^2	30	2790
12		Plumbing Works			
	(a)	Cutting, Grooving, Chase making in walls	1	30	30
	(b)	Core Drilling, Making Holes across walls etc. (03 holes up to 150 mm each)	1	30	30
	(c)	Fitting / Fixing / Jointing	1	30	30
13		Electrification Works			
	(a)	Cutting, Grooving, Chase making in walls	1	30	30
	(b)	Conducting and Board Fixing	1	30	30
	(c)	Wiring and Switching	1	30	30
14		Carpentry Works (Door Window Making)		30	30
15		Fabrication Works			
	(a)	Steel Fabrication	1	30	30
	(b)	Aluminium Fabrication	1	30	30
	(c)	Glazing and Hardware Fixing etc.	1	30	30
16		Daily / Periodic Cleaning of Equipment / Utensils / Machinery	1	4500	4500
17		Manpower residing on Site (Average 03 people on site daily for 150 days)	1	20250	20250
18		Miscellaneous activities as mentioned in Table 1	1	900	900
		Total Water Use in Construction			**50765.2**

3. Results and Discussion

An attempt has been made to determine the actual water footprint (direct water use) of a low-rise RCC-framed residential building using an Activity-Based Approach, involving construction methods and techniques as per prevailing practices in the composite climate of India while mentioning considerations, quantities, and assumptions. A building's water footprint during construction is calculated to be 507 liters per square meter of built-up area, which is regarded as direct water use for building construction. In earlier works by other researchers, considerations, quantities, and assumptions were not mentioned in the publications, so it is difficult to compare the results, a comparison of which is presented in Table 3.

There is a significant difference between the results of other researchers and ours. Bardhan [13] has mentioned the direct water use as 2.0 kl/m^2, whereas Anoop has mentioned direct water use as 3.6 kl/m^2 [16]. As per our calculations, direct water use in building construction is theoretically determined as 0.507 kl/m^2, which may be considered a maximum of 0.6 kl/m^2, as an acceptable figure considering other miscellaneous uses and the wastage. We have tried to determine actual water use on-site, whereas Bardhan [15] and Anoop have considered the actual water consumption/water drawn from the ground table based on the flow rate and operational hours of the water pump installed on site. According to estimates, there is a chance to conserve a sizeable amount of water on-site throughout the building's development.

As per the estimation, the water footprint in the substructure is calculated as 50.38 litres, which seems on the higher side than the finding in the work of Jain and Srivastava, who estimated the water footprint in the substructure as 36.10 litres for the RCC framed structures. Item-wise, water consumption (highest to lowest order) is mentioned in Table 3. By studying this table, inferences or strategies for adopting appropriate construction materials can be derived to save water in the building construction phase.

Table 3. Comparison of Direct Water Use quantity determined by various scholars

S. No.	Researcher	Direct Water Use (kl/m^2)	Remarks
1	Bardhan [13]	1.42	Determined total water made available on-site through pumps (based on flow rate and number of hours of operation) and water tankers (for all activities including the residential purpose of construction workers)
2	Anoop [16]	3.3 to 3.6	
3	Jain and Srivastava [11]	0.36	Determined only for the substructure of the building
4	Report (Housing Development in Spain) [1]	0.39	Construction materials and methods are very different in Spain from those practiced in India and onsite water use is very less
5	Our Research	0.5 to 0.6	Determined direct water (which actually/ideally should be used in building construction) on-site through an activity-based approach

Table 4. Item-wise water consumption (highest to lowest) on the construction site

S. No.	Item/Construction Activity	Indicative Water Consumption (Litres)
1	Manpower Residing on the Site (Average 3 people on-site daily for 150 days)	20250
2	Cement Plastering on Walls and Ceiling (12 to 15 mm thick)	8100
3	Cleaning of Equipment / Utensils / Machinery	4500
4	Excavation of Earthwork	3240
5	Mud Phuska Terracing (average 100 thick)	2790
6	Distempering / Painting	2700
7	RCC (1:2:4) works in foundations, columns, beams and slabs etc.	1809
8	230 mm thick or higher width brickwork	1606.8
9	Marble Flooring	1500
10	Brickwork in Foundation	1277.2
11	Miscellaneous activities	900

Table 4. Continued

12	115 mm thick partition wall	756
13	PCC in Flooring	546
14	PCC In Foundation (1:4:8)	304.2
15	Damp Proof Course	216
16	Cutting, Grooving, Chase making in walls	30
17	Core Drilling, Making Holes across walls, etc. (03 holes up to 150 mm each)	30
18	Fitting / Fixing / Jointing	30
19	Cutting, Grooving, Chase making in walls	30
20	Conducting and Board Fixing	30
21	Wiring and Switching	30
22	Steel Fabrication	30
23	Aluminium Fabrication	30
24	Glazing and Hardware Fixing etc.	30

4. Conclusions

According to the US Environmental Protection Agency, there are two types of water efficiency practices: (i) engineering practices, which are based on alterations to plumbing, fixtures, or water supply operating procedures, and (ii) behavioral practices, which are based on altering water use behaviors and methods [19].

In conventional construction methods as prevailing in India, there is a huge difference in actual water consumed at a construction site (2.0 to 3.6 kl/m^2) and actual water required for various construction activities on site (0.5kl/m^2). Wastage of water on construction sites is evident if we compare the actual water supplied on site with the actual water consumed only in construction activities, which is a significant amount, i.e. 2.5 kl/m^2. Water shortage makes direct water use accounting studies extremely valuable for environmental sustainability; nonetheless, there has been little global progress in recognizing water consumption in building construction through research.

The indirect water component of the overall water footprint is the subject of earlier studies on the water footprints of buildings. The direct water footprint for the building's construction has not yet been taken into account in the Indian scenario. The researchers appear to be making few efforts to determine the water footprint of buildings. An effort has been made through this research to work out the water footprint of low-rise residential buildings as conventionally constructed in a composite climatic zone in India. Results indicate that there is significant scope for water saving on construction sites.

4.1. Future Research Potential

Through this research, it is determined that the water footprint of conventional low-rise residential buildings is to the order of 0.5 to 0.6 kl/m^2. However, a few more efforts are required so that an average figure is established as a benchmark water footprint for such construction.

Previous studies on the water footprints of buildings have focused on the indirect water component of the overall water footprint. In the case of India, the direct water footprint for building construction has not yet been considered for residential, commercial, high-rise, RCC framed etc. in various geographical locations of the world. It would also be interesting to compare the water use in various components of buildings like core, shell, finishing, substructure, superstructure etc. Such efforts by the researchers will lead to formulating water-saving strategies in building construction.

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