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Sustainable Use of Water in Construction Practices

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A B S T R A C T

Water is potentially useful to humans. This article encompasses detailed study on the relation of water with construction industry including its characteristics, suitability, availability, necessity and management of the same to avoid its wastages as well as incorporating new research and development works that are being carried on it. Construction involves a highly resource intensive activities making use of materials, land, energy and water. To meet the demand of large number of housing facilities for rapidly growing population of any developing countries like India in order to fulfill the primary need of shelter for everyone the process of building construction is unavoidable..

Keywords: Sustainable Use of Water, Water in Construction Industry, Water Management

1. Introduction

Water is important because it is needed for life to exist. Many uses of water include agricultural, industrial, household, recreational and environmental activities. Virtually all these human uses require fresh water. Here, our concern is about uses of water in construction industry in different activities. Water is one of the most vital natural resources, and is extensively consumed in the building sector.

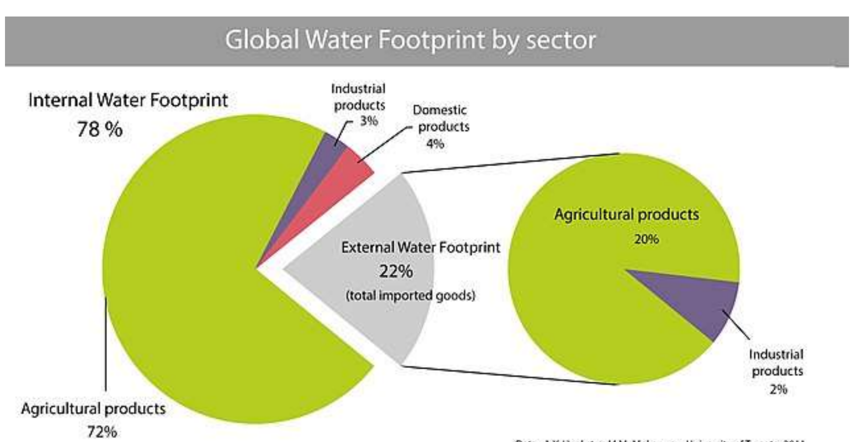

Fig 1. Global average numbers and composition of all national water footprints, internal and external [1]

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2. Water and its Characteristics

2.1 Water

Water is an inorganic, transparent, tasteless, odorless, and nearly colorless chemical substance, which is the main constituent of Earth's hydrosphere and the fluids of most living organisms. It is vital for all known forms of life, even though it provides no calories or organic nutrients.

2.2 Characteristics

Major physical properties of water can be listed as follows [2]:

Water has a high specific heat. Specific heat is the amount of energy required to change the temperature of a substance. Because water has a high specific heat, it can absorb large amounts of heat energy before it begins to get hot. It also means that water releases heat energy slowly when situations cause it to cool. Water's high specific heat allows for the moderation of the Earth's climate and helps organisms regulate their body temperature more effectively.

Water in a pure state has a neutral pH. As a result, pure water is neither acidic nor basic. Water changes its pH when substances are dissolved in it. Rain has a naturally acidic pH of about 5.6 because it contains natural derived carbon dioxide and sulfur dioxide.

Water is a good conductor of heat as compared to any other liquid except mercury. This fact causes large bodies of liquid water like lakes and oceans to have essentially a uniform vertical temperature profile.

Water molecules exist in liquid form over an important range of temperature from 0 - 100° Celsius. This range allows water molecules to exist as a liquid in most places on Earth.

Water is a universal solvent. It is able to dissolve a large number of various chemical compounds. This characteristic also enables water to carry solvent nutrients in runoff, infiltration, groundwater flow, and living organisms.

Water exhibit high surface tension. In other words, it is adhesive and elastic, and tends to aggregate in drops rather than spread out over a surface as a thin film. This phenomenon also causes water to stick to the sides of vertical structures despite gravity's downward pull. Water's high surface tension allows for the formation of water droplets and waves, allows plants to move water (and dissolved nutrients) from their roots to their leaves, and the movement of blood through tiny vessels in the bodies of some animals.

Water molecules are the only substance on Earth that exist in all three physical states of matter: solid, liquid, and gas. Incorporated in the changes of state are massive amounts of heat exchange. This feature plays an important role in the redistribution of heat energy in the Earth's atmosphere. In terms of heat being transferred into the atmosphere, approximately 3/4's of this process is accomplished by the evaporation and condensation of water.

The freezing of water molecules causes their mass to occupy a larger volume. When water freezes it expands rapidly adding about 9% by volume. Fresh water has a maximum density at around 4° Celsius. Water is the only substance on this planet where the maximum density of its mass does not occur when it becomes solidified.

Density: 997 kg/m³
Boiling point: 100 °C
Formula: H_2O
Molar mass: 18.01528 g/mol
IUPAC ID: Water, Oxidane

3. Uses of Water in Construction Industry in Various Activities

In construction practices water is used in several activities. As we all know construction industry plays a vital role in infrastructure development of a country. Water plays an important role in the production of cement concrete as it governs hydration of cement, workability, microstructure, strength and overall durability of concrete. Hydration of cement is exothermic reaction therefore; proper curing is required to achieve desired strength and durability.

Durability of concrete is one of the most important properties of sustainable concrete. Curing plays a major role in developing micro-structure and pore structure of concrete, which ultimately governs its important properties. [3]

4. Quality and Type of Water Used in Construction Industry

Water used for manufacturing as well as curing of concrete should be clean and free from oils, acids, alkalies, salts, organic materials and any substances which hamper the hydration process, strength and durability of concrete

Water used for mixing and curing shall be clean and free form injurious amounts of oils, acids, alkalies, salts, sugar, organic materials etc. Potable water is preferable. The pH value of water shall be not less than 6. Sea water is not recommended because of presence of harmful salts in se water. Water found satisfactory of mixing is also suitable for curing of concrete. [5]

IS 3025[6] recommended that, testing of water play an important role in controlling the quality of cement concrete work. Systematic testing of the water helps to achieve higher efficiency of cement concrete and greater assurance of the performance in regard to both strength and durability. Water is susceptible to being changed due to physical, chemical or biological reactions which may take place between at the time of sampling and analyzing. Hence it is necessary to test water before used for cement concrete production. Samples should be collected, as far as possible, from midstream at mid depth, Sites should be selected such that marginal changes in water observed with naked eyes, where there are major river discharges or obstructions occurred, sample from 100maway of the discharge point in downstream side is taken for small streams. In case of long river there should be at least three fixed sampling locations along the cross-section. Sampling locations can be fixed with reference to significant features In case of waste water form sewer sand narrow effluent channels, samples should be drawn from one third water depths from the top without skimming the top or scrapping the bottom. Velocity of flow at the sampling point should be sufficient to prevent the deposition of solids. Sample should be drawn gently without causing aeration or liberation of dissolved gases. In most cases, sewage flows are intermittent and hence collection of sample at every hour is necessary. Waste waters usually decompose rapidly at room temperature, therefore, certain test setups, such as dissolved oxygen, sulfides, residual chlorine, nitrite and pH should be fixed at site. For certain other tests, preservatives should be added immediately to individual sample.

AS 1379[7] recommended that, mixing water shall be drawn from a source of acceptable quality. Acceptable quality of water is, water from ready mix concrete plant in washout operations, may be used as mixing water if it is stored such as to prevent contamination by deleterious matters to concrete and the water drawn from the storage outlet. Acceptable quality is identified from past service records

ASTM C94[8] recommended that, mixing water comprises, water and ice added to the batch, water occurring as surface moisture on the aggregates and, in the case of truck mixers, any wash water retained in the drum for use in the next batch of concrete. Water shall conform to ASTM C1602, which defines sources of water and provides requirements and testing frequencies for qualifying individual or combined water sources. In any case where the requirements of the owner differ from the specifications, the owner‘s specification shall be provided. ASTM C94 permits the use of non-potable water or water from concrete production operation in ready mix concrete plant, the limits qualified to meet the requirements and optional limits summarized in code. The levels of impurities permitted in the wash water should be below the maximum concentration criteria provided in standard

EN 1008[9] recommended the requirements for water, suitable for making concrete conforming to EN 206-1 and describes methods for assessing its suitability. This standard considers, the use of potable water, water recovered from processes in the concrete industry, water from underground sources, natural surface and industrial waste water for reinforced concrete, and seawater or brackish water for production of concrete without reinforcement or with other embedded metal. Sewage water is not suitable for production of concrete. The requirements for water are summarized in standard comprising preliminary evaluation, chemical properties, setting time and strength development. Standard provides specific requirements for the use of water recovered from processes in the concrete industry.

5. Water in Crisis/ Water Scarcity

With a varied population that is three times the size of the United States but one-third the physical size, India has the second largest population in the world. As per the report of the World Bank, India has taken significant steps to reduce poverty but the number of people who live in poverty is still highly inconsistent to the number of people who are middle-income, with a combined rate of over 52% of both rural and urban poor.

Although India has made improvements over the past decades to both the availability and quality of municipal drinking water systems, its large population has stressed planned water resources and rural areas are left out. In addition, rapid growth in India's urban areas has stretched government solutions, which have been compromised by over-privatization.

In spite of of improvements to drinking water, many other water sources are contaminated with both bio and chemical pollutants, and over 21% of the country's diseases are water-related. Furthermore, only 33% of the country has access to conventional sanitation.

One concern is that India may lack overall long-term availability of replenish able water resources. India's aquifers are at present associated with replenishing sources, the country is also a major grain producer with a great necessity for water to support the commodity. As with all countries with large agricultural output, excess water consumption for food production leads to problem of water table depletion.

Several rural communities in India who are situated on the outskirts of urban sprawl also have little choice but to drill wells to access groundwater sources. However, any water system adds to the overall depletion of water. There is no easy answer for India which must tap into water sources for food and human sustenance, but India's overall water availability is running dry.

India's water crisis is often attributed to lack of government planning, increased corporate privatization, industrial and human waste and government corruption. In addition, water scarcity in India is expected to worsen as the overall population is expected to increase to 1.6 billion by year 2050. To that end, global water scarcity is expected to become a leading cause of national political conflict in the future, and the prognosis for India is no different.

On a positive note, some areas of India are fortunate to have a relatively wet climate, even in the most arid regions. However, with no rain catchment programs in place, most of the water is displaced or dried up instead of used. In these areas, rain harvesting could be one solution for water collection. That water can be immediately used for agriculture, and with improved filtration practices to reduce water-borne pathogens, also quickly available for human use.

Whatever the means, India needs solutions now. Children in 100 million homes in the country lack water, and one out of every two children are malnourished. Environmental justice needs to be restored to India so that families can raise their children with dignity, and providing water to communities is one such way to best ensure that chance. [4]

6. Water Saving Strategies

Adopting following strategies wastages of water can be minimize and reduced to zero [10]

1. Don’t ignore leaks: An unfixed leak can be the most significant water use on site. Leaks can come from damaged washers in taps, worn valves and corroded or damaged pipework.

2. Fit triggers to gun hoses: Hoses left running when not in use waste a lot of water in a short time. Fit robust trigger guns to hoses so that flow can be controlled at the point of use.
3. Dust suppression vehicles: Most suppression techniques are very water inefficient. A hydraulic spinning system can be 90% more water efficient than a splash plate provided mains-quality water is available. Chemical additives are an option to assist in reducing the volume of water needed
4. Wheel washing: Some drive through wheel washers don't recycle water. Use a closed loop wheel wash to reuse the water for the process. Waterless systems are another innovative option that use angled steel grids to clean debris from tyres.
5. Washing out concrete wagons: Mains pressure hoses with basic spray patterns are water inefficient. Use a high pressure low volume efficient spray pattern to reduce water use. Using a specially designed sock to cover the chute can be an option to minimize water use, reduce spills and eliminate pollution. Wash out water could be re-used at concrete batching plants.
6. Flushing toilets: Toilets can use more water in a flush than is needed. If water is constantly running adjust or replace the inlet valve. Put a displacement device in larger cisterns over 6 liters volume. Modern low flush cisterns of 4.5 liters are another option.
7. Urinal flushing: Urinals often flush at regular intervals regardless of use. Consider the installation of a hydraulic valve or motion sensor to control flushing based on actual usage. Waterless urinals are another option.
8. Running taps: Flow from taps is often more than is needed. Consider adapting taps by either fitting a flow regulating or aerating tap insert. Changing the tap is another option. Turn taps off.
9. Demolition dust suppression: High capacity rain guns used in demolition are water inefficient. A fan misting system is a mains fed electrically powered efficient alternative.
10. Commissioning water use: High volumes of water are used during building envelope and services commissioning and testing. Plan for these activities considering water recirculation and minimization. The water used for flushing building services should be isolated as soon as possible after the flush water turns clear.

7. Tools and Techniques for Water Management

7.1 Water Management Hierarchy

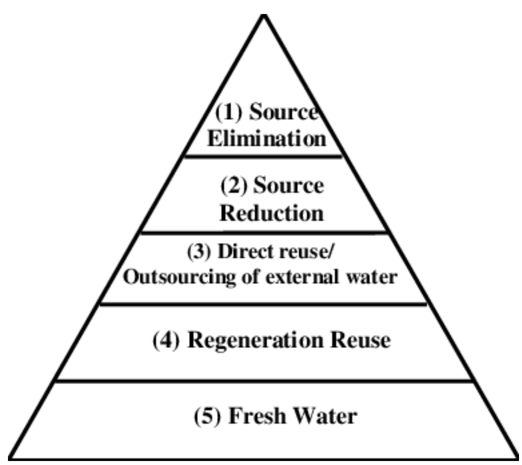

Fig 2. Water Management Hierarchy

Water Management Hierarchy (WMH) [11] is a hierarchy of water conservation priorities. Levels of the hierarchy from the highest to the lowest in terms of the priority for water conservation include elimination, reduction, outsourcing/reuse and regeneration. The most preferred option is elimination, followed by reduction of water demand. After that, direct reuse/recycling and water outsourcing through method such as rainwater harvesting are preferred. This is followed by regeneration or treatment of wastewater before being reused. Freshwater will only be used when all water-saving options have been explored.
The WMH was used as an effective screening tool in cost effective minimum water network methodology to stretch the limits of water savings beyond those achievable using conventional pinch analysis approach.

7.2 Water Pinch Analysis

Water pinch analysis (WPA) originates from the concept of heat pinch analysis. WPA is a systematic technique for reducing water consumption and wastewater generation through integration of water-using activities or processes. WPA was first introduced by Wang and Smith. [12] Since then, it has been widely used as a tool for water conservation in industrial process plants. Water Pinch Analysis has recently been applied for urban/domestic buildings. [13] It was extended in 1998 by Nick Hallale at the University of Cape Town, who developed it as a special case of mass exchange networks for capital cost targeting.

Techniques for setting targets for maximum water recovery capable of handling any type of water-using operation including mass-transfer-based and non-mass-transfer based systems include the source and sink composite curves (Nick Hallale (2002). A New Graphical Targeting Method for Water Minimisation. Advances in Environmental Research. 6(3): 377–390) and water cascade analysis (WCA). [14] The source and sink composite curves is a graphical tool for setting water recovery targets as well as for design of water recovery networks. [15]

8. Conclusion

At the end one can easily conclude that due to the vitality of water and its survival necessity for human and other living beings water wastages and thefts must be eliminated or reduced to zero level. As well as water management tools and techniques must be incorporated in various activities involved not only in construction industry but also in other industries where water consumption and utilization is significantly higher. As we have discussed about the water crisis it is a global challenge not only in India the whole world is in trouble which can become a giant in the near future if suitable planning and implementation not performed in time with adequate management and monitoring models, tools and techniques for this problem. Steps taken at Government level and policies formed for this problem in legislature is not just sufficient to tackle such a severe problem the implementation and regulation of prepared framework for the policies and laws are essential so as to achieve the desired result and target and the most importantly co-operation and contribution of people as an individual as well as in groups is also very essential to resolve the problem related to discretionary use of water.

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