VALUE OF SUSTAINABLE USE OF WATER IN CONSTRUCTION INDUSTRY

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Abstract

Water is abundantly available and precisely vital. However, water is a finite resource and finding freshwater is a global issue for many countries at present and the same problem faced by many others in near future. The construction industry causes significant environmental stress and environment pollution in many ways. Water is one of the resources being polluted and wasted. However, its value and importance are not realized by the stakeholders in construction sector. Basically, construction work cannot be started without water. Yet, water is one of the lesser acknowledged surprisingly by the construction sector, compared to significant effort focused on reducing energy consumption. More importantly, water is also a longer- term consequence dimension for sustainable development. Although, water is an asset for the construction sector, unfortunately, the value of water in construction project is remaining mostly unknown. Therefore, it is worth to devise a framework to provide best practice guideline to promote sustainable use of water in construction.

Since the research is at the initial stage, the paper explores the significant gaps identified through literature review and findings of preliminary survey conducted among the industry experts. Literature highlighted, water handling in construction is one of the significant areas required to be looked at and identifying the process and activities that consume more water,the extent of quantity required and also best practices for reducing water consumption during the construction is essential. Moreover, it was found that little attention had been given by previous researchers to identify the importance of water in the construction stage. As found from preliminary survey, lack of understanding of how water is used and how water is wasted are major challenges faced by the industry and suggested to have proper guidelines specific to water conservation for construction work.

Keywords: Best practices, Construction industry, Sustainable development, Water conservation

1. Introduction

Recent years have seen an upswing in the demand for potable water. As highlighted in literature freshwater shortage and water pollution are becoming one of the most critical global problems unless the present perceptions and attitudes change radically (Centre for Environmental Systems Research, 2000; Cheng, 2002; and Biswas and Seetharam, 2008). Many researchers have identified that climate change, droughts, growing population and increasing industrial demand are straining the available supplies of freshwater (Johnston, 2003; Chanan, et al. 2003; Economist, 2008; Goodrum,2008, ABB review,2011). At present, more than 100 countries currently rely on desalination for part of freshwater consumption needs (McWhinney, 2011). Certainly, saltwater cannot be used directly for drinking, irrigation and most industrial purposes including construction. The construction industry is one of the major consumers of natural resources including water (Ding, 2008). Water serves multiple purposes and it is an important input for economic development and social development of the country. Joyce (2012) argues that, the true values of water are still not reflected in all water related decision-making due to the existence of various socially constructed barriers.

Construction industry is regarded as one of the largest users of water along with energy and material resources (Guggemos and Horvath,(2006). However, amount of water consumed by the construction is unknown. Similarly, Goodrum (2008) mentioned the requirement of identifying the process and activities that consume more water, quantity of water required and also best practices for reducing water consumption during the construction. Moreover, the same author stated there has not been a considerable research effort in this area. It is true, because reviewing the past literature, considerable water researches had been done and being focusing in the field of agriculture, livestock, irrigation, household, textile, foods, manufacturing but less acknowledged in the construction sector. As stated by McCormack et al., (2007), inadequate research on policies focused on operational water consumption in construction. The Workplace Health and Safety Queensland (2007) identified, protection of environment is also identified as a key requirement during construction.

Therefore, many studies hitherto have discussed that water is one of the lesser acknowledged areas in the construction sector. At present, many people believe, the cost of water is comparatively low when compared to the total cost to be spent for a project. On the other hand assuming water quantity to be used in construction sector is relatively small and less significant. Therefore, in Sri Lanka many scholars, construction stakeholders as well as government authorities do not feel the significance of water conservation aspects in the construction sector yet. Relatively, low priority is given. At present many construction activities use potable water during the construction process and could be seen as a mere wastage and misuse of water. Water pollution and environment damage due to construction work are other negative impacts. After reviewing the extensive published literature, the need for best practice guideline to promote sustainable use of water in the future on- site construction through establishing some benchmarks was identified. Since, the research is at the initial stage, this paper will address the issue “how stakeholders realise the value of water in the construction sector?” Mainly, a comprehensive literature review and preliminary survey were used as the

research method for this paper. Key words like water efficiency, conservation, delivery, consumption, quality, sustainable, and construction were used to search literature from various sources. In addition, preliminary survey was conducted to get impartial opinions of key representatives from the construction industry.

2. Literature review

2.1 Water availability and future challenge

Water is a precious resource. Nobody can live without water even can live without energy (Luan, 2010). Global warming and depletion of natural resources like fossil fuel and water cannot be ignored by any one which is affecting to environmental degradation (Mezher, 2011). Water is by far the commonest substance on earth, but 97% of the total is seawater which is unfit for human use (Economist, 2003). The remaining 3% of the world's water resources, only about 1% is readily available for human consumption (McWhinney, 2006). Figure 1 illustrates the distribution of earth's water graphically. The distribution of water throughout the earth is not uniform. Some places have far more rainfall than others. However, the total amount of water on the earth and in its atmosphere does not change but the earth's water is always in movement. Circulation and conservation of earth's water as it circulates from the land to the sky and back again is called the 'hydrological cycle' or 'water cycle' (www.euwfd.com) which consists of five stages, namely, evaporation, transport, condensation, precipitation, groundwater and run-off.

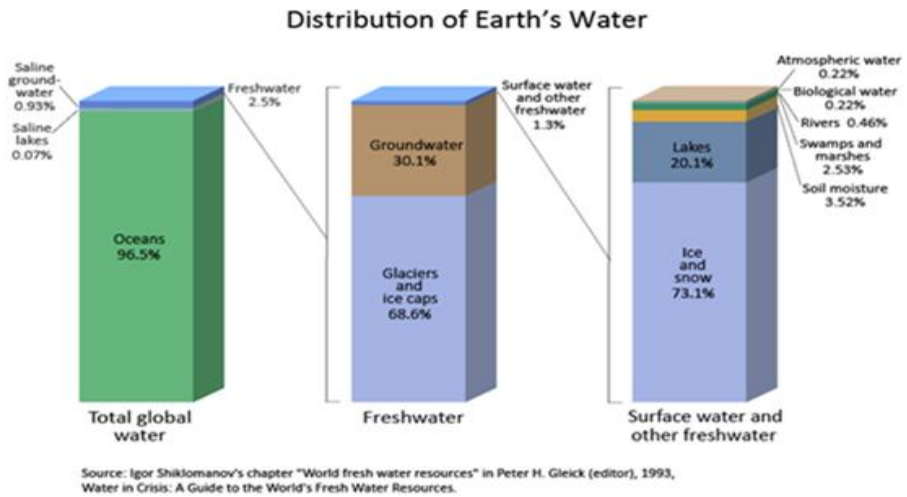

Figure 1: Distribution of earth's water (adopted from www.euwfd.com)

Moreover, many studies predicted that water is a scarce resource for many parts of the world (Economist, 2008; OECD, 2008) and availability of drinking water per capita is inadequate and shrinking (ABB Review, 2011). Countries like Australia, China and Middle East do not have enough water but countries like Canada, Ireland and Austria have more water than usage

(Economist, 2003). For Australia, water is a valuable and scarce input and many studies conducted on water conservation. Horne (2012) mentioned according to Australia's approach to water policy, water needs to be priced properly and managed actively to be used effectively. Moreover, Australia's leading resource on water conservation (2005) mentioned that the construction and development industry is in a unique position to influence future water use in Australia. Moreover, identified that implementing water conservation measures, the construction and development sector can ensure that this investment delivers significant on-going dollar savings for water users now and into the future. As well as, in the UK water resources are under pressure and current levels of water abstraction are unsustainable in many places (Strategic forum for construction: water, 2012). As stated by Biswas and Seetharam (2008), social, economic and environmental future of Asia is also likely to depend on how efficiently and equitably water resource will be managed in the coming years. Hussein (2008) mentioned, future generations will continue to face serious environmental problems unless significant attention is given, and investments are made, to reverse the current state of environmental degradation, particularly with regard to water scarcity, pollution and health problems, land degradation and weak environmental institutions and legal frameworks. Because, water is not only essential for the life of humans and ecosystems, but it is also a strategic economic resource (Niccolucci et al., 2011). González-Gómez et al. (2012) stated, although agriculture is the largest consumer of water resources, per capita consumption growth, industrial activity, the use of water for energy production, the construction sector and tourism and leisure activities have all exerted additional pressure on available water resources. The reason behind this scenario is clearly explained by Joyce (2012) as 'the difference between increasing demand for water and limited water availability creates a gap that is translated into water scarcity. Johnston (2003) says that water will be the challenge of the 21st century in the way oil has been since the 20th century. This is an indication that requirement of immediate global attention on water saving.

2.2 Water challenge in Sri Lanka

Sri Lanka being a tropical Asian country, supply of water is very seasonal. The average annual rainfall in Sri Lanka is around 1900mm. However, wet zones and dry zones get irregular rain water patterns. As stated by Samad (2005) it is estimated that by 2025 most of the district in the dry zone will face severe seasonal or year round absolute water scarcity. Based on the present weather reports, wet zones will also liable to face water scarcity if not managed in a proper way. At present, pipe born water, dug well, tube well, streams, irrigation tanks and rainwater harvesting are the main sources of water supply (NWSDB, 2009). However, available quantity and quality of water vary from district to district. Pipe borne water demand is continuously increasing due to high population growth and rapid urbanization. According to the Centre for Environmental Systems Research (2000), water stress was around 40% in Sri Lanka. Based on the National water supply and drainage board (NWS&DB) annual reports and cooperate plans, at present, pipe-borne water coverage in Sri Lanka is around 39%, with the rest of the population depend on local sources such as wells, hand pumps, tube wells, small scale rural water supply schemes, rainwater harvesting tanks and surface water bodies (NWS&DB, 2012).

Converting naturally available water to drinking water involves expenditure for power, chemicals, staff, maintenance and repair (NWS&DB, 2009). Therefore, purifying water is expensive process and it should be handled with care. Figure 2 shows the water production from 2000 to 2009. It clearly shows pipe borne water demand is continuously increasing mainly due to high population growth and rapid urbanisation. Among them, western province needs higher water production which is almost equal to 60.8%. Even though presently people think water is abundantly available and consider as a cheap material in Sri Lanka, definitely this attitude will change among the individuals in near future and water topic will be a challenge to the country. Specially, supplying safe drinking water for customers will be more critical if water is not managed in a sustainable way.

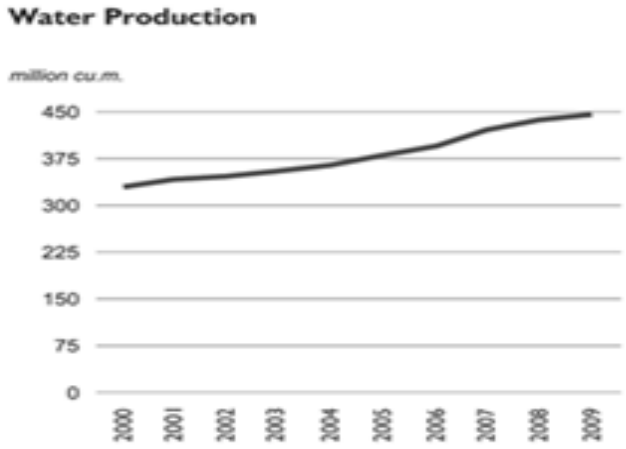

Figure 1: Water production (Annual Report: NWSDB, 2009)

2.3 Water use in construction industry

According to the UN world water report (2003), political changes, population growth, agricultural demand, economic growth and industry, technological changes, lifestyle, and, climate change worsen the water crisis. Water is a raw material for many industries including construction. However, water handling in construction industry rarely acknowledged by the construction stakeholders as well as the relevant government authorities in Sri Lanka as well as many studies highlighted significant gaps in terms of water consumption at site level. As described earlier, supply of portable water is a big challenge faced by many parts of the world. According to the NWS&DB sources, still Sri Lanka is not capable to supply potable water to meet the required demand. In Sri Lanka, many industries use pipe-bone water including the construction industry. According to the NWS&DB data source, water consumption used by the construction industry is grouped under the industry category. Therefore, total potable water quantity consumed only by the construction sector is unknown. Figure 3 elaborates the service charge for the industry category per unit during the last three decades charged by the NWS&DB. When consider total construction cost of a project, the unit rate is almost subsidiary rate for many parties. Therefore, real value of water is unrealized by many parties who are specially involved in the construction sector. Most of the construction firms consider water as

an unlimited resource and consume water more than the required quantity. Therefore, significant wastage and misuse of water could be observed in many construction sites.

Figure 3: Unit rate industrial/construction work (Based on NWS&DB, Sri Lanka)

During the last two decades with speedy industrialisation and population growth there is upsurge rapid demand for construction activities both in the building and civil engineering sub-sectors. It is obvious that without water no construction work can be started. Chen (1998) argued that there could be no economic activity without construction. Construction industry is a major contributor to economic growth (Chan, 2009). It has strong linkages with other sectors of the economy (Chen 1998; Rameezdeen et al., 2008). According to the Central Bank Report (2012), construction industry contributes around 7-8 % to the Gross Domestic Product of the country. As mentioned earlier, construction sector consumes significant natural resources including water. During construction, water is used for several purposes and not limited to mixing mortar and concrete, curing work, dust controlling, soaking materials, vegetation establishments, geotechnical borings, pipe flushing and pressure testing, washing and cleaning (The Workplace Health and Safety Queensland, 2007; Green roads TM manual V1.5(n.d) ; Utraja, 2010). The strategic forum for construction (SFfC) water subgroup has identified that dust suppression, cleaning, commissioning and testing are the main water wasting activities (McNab et al., 2011). According to the Green roads^{TM} manual V1.5(n.d), typical water sources for construction include natural water bodies, potable water supply pipelines, non-potable water from storm water , and reused water from wastewater treatment plants. Among them, large volume of potable water is commonly used in road construction but inadequate studies conducted to quantification of water usage. Moreover, the same report highlighted that water withdrawal from these facilities may or may not be regulated by the government jurisdiction. Meanwhile, some research studies identified that there is a very good relationship with water conservation and energy saving (Cheng, 2002; Cheng, 2003). Raising public awareness of water conservation can also achieve significant energy saving Cheng (2002).

Quality and quantity of water also has much effect on the strength of mortar and concrete in construction work (Utraja, 2010). Moreover, the same author emphasised, water should be cleaned and free from injurious quantities of alkalis, acid, oils, salt, sugar, organic materials,

vegetable growth and other substances that may be deleterious to bricks, stone, concrete or steel. Chloride contamination is a major source of concrete deterioration (Link et al. 1994). In general, potable water is generally considered satisfactory for concrete mixing. As depicted in literature, the best practice is testing the water before use it. When compare with the total cost spend on the project, little amount paid for testing. In Sri Lanka, specially the construction projects going on arid zones where water availability is less, brings water from bowsers and gets from river, lakes, streams, canals etc. On the other hand quantity of water is also impact on the strength of some construction activities like concrete and mortar. Utraja (2010) explained additional water weakens not only the strength of cement paste but also adhesive quality. Furthermore, elaborated, approximate water quantities to be used in concrete mix 1:2:4 and 1:1.5: 3 as 32 and 30 litres respectively for one bag mix. However, at present measuring water quantity exactly is not practiced and ignored in many construction projects when mixing mortar and concrete at site level. Moreover, type of sources, consumption, handling, storage, transport, disposal, policies and alternative sources of water at the project site is required to analyze in proper way for sustainable use of water. In addition it is required to establish benchmarks which are specific to the construction phase. All these facts emphasize water source will be a critical resource for construction as well as it is essential to protect and practice sustainable way by identifying its real values as in construction industry, water is one of the essential raw materials used to produce a value added product at the end.

2.4 Value of water as a sustainable resource

As stated by the UN world water report (2003), water is indispensable recurrent natural resource. According to Khalfan (2002) limited freshwater is a major constraint on sustainable development. Horne (2012) stated sustainable development is an important input for economic development and social development of the country. It is clear, sustainable development has emerged as the universally agreed goal in the development field over the past decade (Imran and Low, 2005) which is not a new practice and it has developed over the period of time and will continue to change in the future (Shah, 2007). As stated by Khalfan (2002), one of the most important aspects of sustainable development is sustainable construction. This will enable construction players to be more responsible to the environment protection needs without neglecting the social and economic needs in striving for better living (Abidin,2009). Hussein (2008) mentioned future generations will continue to face serious environmental problems unless significant attention is given, and investments are made, to reverse the current state of environmental degradation, particularly with regard to water scarcity, pollution and health problems, land degradation, weak environmental institutions and legal frameworks. Because, Niccolucci et al., (2011) mentioned water is not only essential for the life of humans and ecosystems, but it is also a strategic economic resource. As depicted in literature, many green building assessment systems like Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM) including Sri Lankan green building rating system (GREENSL) are discussed and identified protection and conservation of water is one of the fundamental principles concerning sustainable construction.

However, Economist (2003) stated that over the past century, water has been 'ill-governed', and colossally under-priced especially, wilful refusal to treat water as an economic commodity. Moreover, the wrong location and man's extravagantly wasteful misuse of water are identified as two big obstacles stand in the way of delivery of water to people. Birol et al., (2010) state the economic benefits generated by environmental goods and services should be quantified in monetary units, and weighted against the costs of conserving or providing such commodity and services. IWMI (2010) stated that charging for water is one way of making people more aware of its value and encouraging them to use it wisely because unfortunately today many people in the world do not know the real value of water. Howard (2003) identified value of water has three components namely existence value, aesthetic and environmental value, and economic value. According to the Article 9 of the EU Water Framework Directive (WFD) the financial costs, environmental costs and resource costs should constitute the total costs of water services (Heinz,(2005). Hence, protection and conservation of water is one of the fundamental principles concerning sustainable construction. Promoting sustainable practices ensures positive impact on communities throughout the nation. As stated by Boyd and Kimmet (2001), if performance in the built environment is not measured against human satisfaction, then appropriate benchmarks/indicators need to be developed, tested and applied. Benchmarking allows an industry or an individual entity to measure own performance against similar site nationwide and useful method to assess any improvements and reduce the water use with cost effective measures (Alberta water council, 2007; Corr, and Adams, 2009). Many researches conducted on key performance indicators (KPIs) and benchmarks for building operations with regard to water conservation aspects (Waggett and Arotsky, 2006; Queensland Government, 2012) which are very useful to track water consumption, measure performance associated with an activity or process, identify changes in water consumption and possible leaks, and compare with past use and similar business (Queensland Government, 2012). For Joyce (2012) achieving an efficient and equitable water allocation requires a shift from the current practices that place water as a 'separate sectorial box' to a 'holistic approach' which integrate water as part of the wider social and economic development.

3. Findings of preliminary survey

Preliminary survey was conducted to get impartial opinions from key representatives who have more experience and representing different disciplines from the construction industry before initiating the detail research. Qualitative interviews conducted via face to face and telephone to collect data. Six voices representing four different disciplines including engineering, quantity surveying, project management and environmental economics involved with the unstructured interviews to elicit views and opinions. Sample consists of two engineers, two quantity surveyors, a project manager and an environmental economist. Basically the following open-ended questions were asked from them. "What are the current practices of water conservation during construction and any specific issues with water handling so far?' and "Individual opinion about identifying the value of water as a construction commodity and is it worth to conduct research on this area since the construction industry is rarely acknowledged in water related researches conducted so far".

Based on the individual opinions, it was found that the importance of this topic is not realized by many parties both in the construction and for the relevant government authorities. Moreover, many of them believed that limited researches related to water resource conducted in the construction sector. Environmental economist stated that '*this is very important area, where really construction parties are not worried about water pollution and damage to the eco system due to construction activities. For example,in dry and rural areas, even for road construction water is taken from rivers, lakes, streams and transport through bowsers, after considerable period lands close to rivers, streams and road ways turn to muddy areas, then affect the ground water system due to consumption of unlimited water, and disposal of construction waste without having proper management. So it is necessary to provide specific rules and regulations for construction work and enclose in the contract documents and implement such strict policies specially, because even if there are formulated rules there is no body following the rules'.*

One of the engineer stated that '*nobody consider water as one of the critical factors when making decision to start some projects. Few months ago, one project could not start due to unavailability of water resource'.* One of the quantity surveyors shared experience at Middle East that *water is being big issue, where almost most of the water is supplied through bowsers for many construction projects. And there is no issue with quality as well as no impact to the environment like Sri Lanka. Because authorised places are available to fulfil the industry requirements. While transporting ready-mix concrete, ice is used to maintain the required temperature and this is huge water quantity used in construction work. 'Wild air' is another area where more water is used for operation of temporary A/C before handing over to the project. Apart from those water conservation techniques like use of cladding for the external walls, precast panels is being adopted,* Moreover, interviewee stated *pressures grouting of work in infrastructure projects, like bridges, tunnels etc disturb the catchment areas.* Another important fact revealed by a quantity surveyor *is there was a claim that, the project was delayed due to unavailability of water. Even though these things rarely occur, we cannot expect same weather patterns all the time due to global issues. As well as, water handling, measuring quality and usage alone are inadequate in the existing documentation. Many sites get water from pipe-born especially in the urban areas. Misuse and unlimited use of water could be seen many times. Especially water wastage due to leaks, and proper conservation methods are rarely practiced at site.* Apart from that the project manager highlighted that *construction stakeholders, and workforce behaviour and attitudes greatly affect on the sustainable use of water on-site construction. Especially in road construction dust controlling is must and conditions already inserted in the contract, for example pour water three times a day. However, no conditions enclose to control the source of water and minimize damage to the environment, as well as sustainable aspects even today developments more towards sustainable construction.*

Considering survey findings , lack of understanding of how water is used and how water is wasted are major challenges faced by the industry. Even rainwater harvesting is identified as the alternative source of water, through preliminary survey it was found that rarely rainwater harvesting is practiced as an alternative source of water for construction work. Due to the limited space, and poor quality of water of alternative sources available many construction

projects depend on the public main specially around the urban areas. As found from the preliminary survey, the volume of water used for the construction sites is currently unknown and no best practices are evolved about water usage on construction sites. Moreover, it was identified, water pollution and damage to the eco system due to construction activities are essential to be addressed. All these critical areas will be addressed in the research as the next step.

4. Conclusions

Water is identified as a global issue and many studies predicted that there can be a water shortage in year 2025-2030 for many countries including Sri Lanka. It was found, proper benchmarks, performance indicators, guidelines and practices are specially designed for water conservation during the construction stage are rarely addressed. There is a big impact of quantity and quality of water used on strength of products during the construction. As found from preliminary survey, lack of understanding of how water is used and how water is wasted are major challenges faced by the industry. On the other hand the volume of water used for the construction sites is currently unknown and no best practices are evolved about water usage on construction sites. Moreover, less attention is given on water pollution and damage to the environment due to construction activities at present.

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