SUSTAINABLE USE OF WATER IN CONSTRUCTION PROJECTS: THE CASE OF SRI LANKA

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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ABSTRACT

One of the major constraints for sustainable development is the limited quantity of freshwater available. However in construction projects, water is one of the poorly acknowledged resources as far as its efficiency and conservation are concerned. The waste and the misuse of water in construction sites have been identified as critical problems, although there is a high potential for saving water during the construction stage by adopting various water efficiency measures. Nevertheless, this aspect has not been explored sufficiently in current body of knowledge as per exiting literature. This induced the need for the research on sustainable use of water in construction. Therefore, the aim of this research was to develop a framework for improving sustainable water use practices in construction projects, from a Sri Lankan perspective.

Within a pragmatic philosophical view, a triangulation based mixed method approach was adopted for data collection and analysis. Four (04) case studies were carried out into building construction projects located in Colombo to explore the efficient water use practices that are being adopted. Concurrently, a questionnaire survey was administered among experienced construction professionals to identify important measures which can ensure efficient water use.

One of the key findings that emerged from the study was that water efficiency practices are strongly influenced by conditions prevailing within the operational environment of a project. However, some measures for improvement that go beyond on-site project level which have industry-wide support and intervention at policy level are required for these measures to be successful. This study revealed and clearly favoured ‘soft’ measures such as changes in the behaviour of workers as opposed to ‘hard’ measures which were primarily technology-based, for achieving water efficiency. The study also identified that the attitudes and behaviour of the parties that influence efficient water use in construction sites. The experience and commitments of the parties are also identified as an influential factor for the efficient use of water. The main barrier for achieving water efficiency was the low priority assigned to water management by the top managements of the relevant organisations due to their heavy engagements with other managerial functions.

The research findings introduced three new dimensions namely, Regulation, Responsibility, and Reward that could extend the existing 6R water hierarchy in a more effective manner. This led to the introduction of a novel 3R.6R extended water hierarchy model that can be applied to achieve the efficient use of water in the construction industry.

Among on-site construction activities, ‘site cabins and sanitation’ taken together was identified as consuming the highest volume of water and also as an activity that causes water wastage. It was revealed that indirect construction activities approximately consume more than two thirds of the amount of water used in a site. As a result, water wastage has become rampant among these indirect construction activities although in contrast it is minimal in direct construction activities. Therefore, the efficient use of water could be improved further by implementing the ‘soft’ measures in this study rather than implementing technology oriented ‘hard’ measures. Based on the results of the study, a framework has been proposed which provides the best practice guidelines on implementing sustainable water use during the construction stage of a project.

Keywords: 3R.6R Extended Water Hierarchy, Framework for Sustainable Water Use, Water Management, Water Efficiency, Construction Projects
I dedicate this piece of research to my loving husband and son who have always stood by me, endured my absences on many occasions with a smile.
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The best paper award was received on paper title “Water efficiency techniques and strategies for sustainable use of water during construction phase of building projects” in the 4th World Construction Symposium June 2015 awarded by The Ceylon Institute of Builders (CIOB).

**RESAERCH PUBLICATIONS**

**Referred Index Journal**


**Referred Journal**

Referred Conference Publications


Symposium and Other publications


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Display Posters on the Site to Save Water at Bathing Area

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Total Water Volume per Day

Mix Concrete

Vegetable Cultivation

Cognitive Map for Water Usage During the Construction Stage of

Cumulative Water Usage

Participants’ Response on Highly Applicable Measures under AB

3R.6R Extended Water Hierarchy Model for Construction Industry

Three Levels for Enhancing Efficient Water Management Practices during Construction Phase

BSR Norms

Water Requirement for 1:2:4 Concrete Mix based on Site Practice and Water Consumption Pattern

Water Requirement for 2

Volume of Water Consumed by Non-Construction - Case Study 3

Water Consumption Pattern

Total Water Volume per Day

Columns Covered with Gunny Bags to Reduce Water Evaporation

Trays For Mixing Mortar and Concreting

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University of Moratuwa, Sri Lanka. Electronic Theses & Dissertations. www.lib.mrt.ac.lk
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<th>Description</th>
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<tbody>
<tr>
<td>AB</td>
<td>Attitudes and Behaviour</td>
</tr>
<tr>
<td>AC</td>
<td>Alternative Construction</td>
</tr>
<tr>
<td>BOQ</td>
<td>Bill of Quantities</td>
</tr>
<tr>
<td>BEAM</td>
<td>Building Environmental Assessment Method</td>
</tr>
<tr>
<td>BREAM</td>
<td>Building Research Establishment’s Environmental Assessment Method</td>
</tr>
<tr>
<td>BRS</td>
<td>Building Rating System</td>
</tr>
<tr>
<td>BSR</td>
<td>Building Schedule of Rates</td>
</tr>
<tr>
<td>CE</td>
<td>Civil Engineer</td>
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<tr>
<td>CEA</td>
<td>Central Environment authority</td>
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<tr>
<td>CIDA</td>
<td>Construction Industry Development Authority</td>
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<tr>
<td>CIRIA</td>
<td>Construction Industry Research and Information Association</td>
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<tr>
<td>EIA</td>
<td>Environmental Impact assessment</td>
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<tr>
<td>EMS</td>
<td>Environmental management system</td>
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<tr>
<td>ET</td>
<td>Efficient Technologies</td>
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<tr>
<td>GBCSL</td>
<td>Green Building Council, Sri Lanka</td>
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<tr>
<td>GRIHA</td>
<td>Green Rating for Integrated Habitat Assessment</td>
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<tr>
<td>ICTAD</td>
<td>Institute of Construction Training and Development</td>
</tr>
<tr>
<td>LEED</td>
<td>Leadership in Environmental and Energy Design</td>
</tr>
<tr>
<td>MC</td>
<td>Municipal Council</td>
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<tr>
<td>M &amp; E</td>
<td>Mechanical and Engineering</td>
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<tr>
<td>NAM</td>
<td>Norm Activation Model</td>
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<tr>
<td>NBRO</td>
<td>National Building Research Organization</td>
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<tr>
<td>NCPC</td>
<td>National cleaner Production Centre</td>
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<tr>
<td>NGOs</td>
<td>Non-Government Organizations</td>
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<tr>
<td>NRBV</td>
<td>Natural Resource Based View</td>
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<tr>
<td>PP</td>
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<tr>
<td>Acronym</td>
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<td>Waste and Resources Action Program</td>
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