Assessing the impact of Waste Management and Effective Reutilization in Construction Industry

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Abstract—The purpose of the study is to investigate the waste assessment and effective reutilization in construction industry. The researchers used interview schedule method for collecting data from the respondent. The study was conducted during the period from October – 2014 to March - 2015 thrissur district, Kerala. The study identifies ten antecedents of waste management, they are designing phase, construction phase, implementation difficulties, time and cost, modern trends, contract and training, management techniques, onsite measures, beneficiaries, support and responsibilities. Furthermore the study examines the relationship between various antecedents of waste management and design managers satisfaction, support and responsibilities. The study will help the policy makers in framing suitable policies with regard to utilization of construction waste for some other purpose.

Key words: Implementation Difficulties, Modern Trends, Management Techniques, Onsite Measures, Beneficiaries, Support and Responsibilities

I. INTRODUCTION

The term construction is generally used to describe the activity of the creation of physical infrastructure, superstructure and related facilities (Wells, 1985). Construction is also referred to as all types of activities associated with the erection and repair of immobile structures and facilities (Nam and Tatum, 1988).

Even though there is widespread recognition across the world of the importance of moving towards sustainability, the construction industry is “notorious for producing huge amounts of construction and demolition waste” (Kwan et al., 2003). The Building Research Establishment (1982, cited in Skoyles and Skoyles, 1987) defines construction waste as the difference between the purchased materials and those used in a project. According to Hong Kong Polytechnic (1993) construction waste is the “by-product generated and removed from construction, renovation and demolition work places or sites of building and civil engineering structures”. Further, construction waste has been defined as “building and site improvement materials and other solid waste resulting from construction, re-modeling, renovation, or repair operations” (Harvard Green Campus Initiative, 2004). Although resource optimization is one of the main objectives of any organization, less attention is paid to construction waste minimisation even though it makes a great contribution to the aforesaid objective. This is due to the perception regarding waste, which “has no value and which the junkman can take away” (Leenders et al., 1990).

A. Construction Waste in the Context of the Indian Construction Industry:

Sustainable waste management (SWM) encourages waste minimization – the reduction, re-use or recycling of waste – and promotes the more efficient use of materials and broader incorporation of recycled materials into building construction. SWM offers several benefits for the SSC industry: firstly, it reduces the environmental impact(s) of the construction process through reducing dependence on raw resources and reducing pollution associated with the production of materials, transportation and landfill (Tam and Tam, 2006); secondly, it has been shown to incur substantial financial savings for construction firms (Begum et al., 2006; McDonald and Smithers, 1998); and thirdly, SWM creates new opportunities for employment in secondary materials markets (Kofoworola and Gheewala, 2009).

A number of studies have investigated the role of human behavior in waste generation. The earliest studies were conducted in Australia by Lingard et al. (2000) and Teo and Loosemore (2001) and more recently, studies have been carried in the UK (Dainty and Brooke, 2004; Saunders and Wynn, 2004). The outcome of this research effort is recognition that, whilst construction industry participants recognise the impact(s) of their actions, there is reluctance within the industry to implement waste minimisation initiatives. Furthermore, despite recognition that human attitudes have major influence on waste generation, there has been little research into the role of human attitudes in waste generation on SSC projects, despite these comprising 99% of all work undertaken in the construction sector (Teo and Loosemore, 2001)

II. REVIEW OF LITERATURE

Catarina Thormark(2001) In a study of recycling nationally produced building waste identified the potential energy saving through recycling was about 50% of the embodied energy and when reused materials were used energy decreased about 45% .He also subdivided recycling into reuse, material recycling and combustion with energy recovery. Chandani Kansara, et al., (2007) concluded that the objective of the study is to derive the reasons contributing to the amount of material wasted on residential building sites which needs to be brought down substantially by devising suitable methods under study are material management, project management, planning, stores and housekeeping and method of execution of works. Derek S. Thomson, et al (1998) has suggested that reusable building services components will increase the adaptability of both new and existing services installations. In Florence Yean Yng Ling, et al.,(2013) noticed the waste management strategies can be categorized into: procurement; management of subcontractors and the workforce; training
and supervision; material handling and control; and communication and documentation and the barriers to implementing waste management are the value chain, from clients who do not expect waste management, to subcontractors not implementing, to workers who adopt wasteful practices, to project managers who lack in implementing waste management.

Khairulzan Yahya, et al.,(2006) stated that sustainable waste management encourages the generation of less waste, and the reuse, recycling and recovery of waste and the various form of impact are air or water pollution, and its associated energy usage. He also noted that material waste occurs as result of project operation and external factors such as theft and vandalism. Lukumon O. Oyedele, et al.,(2011) simplified and identified the chief sources of waste in construction are generated during design, operational, material handling and procurement (material). Causes of waste are rampant throughout the construction process, from inception to demolition. Mohammed Arif, et al.,(2011) key findings are waste quantification, waste segregation, and the implementation of 3Rs (reduce, recycle, and reuse). He also proposed a list of 11 practices: standardization of design, stock control to minimise over ordering, environmental education to the work force, provision of recycling and waste disposal companies as part of the supply chain, on time/just in time deliveries, penalties for poor waste management, incentives and tender premiums for waste minimisation, waste auditing, increased use of off-site techniques, use of on-site compactors, reverse logistics for minimization of waste.

In the study carried out by Nicholas Chilse, et al.,(2013) states that refurbishment as opposed to demolition was identified as a viable option for achieving sustainability and cost, and time, remains key drivers in refurbishment. Fast, reliable and predictable refurbishment saves money and reduces local impacts associated with refurbishment work. Peter A. Bullen(2007) revealed the concept of adaptation is supported by building owners and there is a strong intuition/perception that adaptive reuse serves the key concepts of sustainability and it enhances the longer-term usefulness of a building and more sustainable option than demolition and rebuilding. Peter A. Bullen, et al.,(2008) noticed the ability to make commercial buildings attractive to developers as viable reuse projects relied heavily on the use of legislation that reduces code and zoning requirements and offers substantial financial incentives in the form of tax concessions. Peter A. Bullen, et al.,(2011) concluded that adaptive reuse also conserves the architectural, social, cultural and historical values and he also suggests that the outcomes of adaptive reuse include improvements in material and resource efficiency (environmental sustainability), cost reductions (economic sustainability) and retention (social sustainability). Studies carried out by Roy S Webb, et al.,(1997) suggested that by utilizing reusable services components, facilities managers may be able to increase the adaptability of both new and existing buildings and reduce the financial impact of change and correctly utilized, reusable services components will provide to satisfy client demands for adaptable buildings by enabling facilities managers to effectively co-ordinate space use in the resultant more adaptable buildings.

According to Shivashish Bose(2012) the methodology for the restoration included surveying and documenting the existing structure; examining old materials and methods of construction and earlier repairs and the suitability of matching existing and new materials; analysing structural and physical strengths; defects and their causes; prescribing remedial measures; estimating and tendering, appointing contractors; allocating funds for restoration; supervision and monitoring of the works. Sugiharto Alwi Keith, et al.,(2004) concluded that through measurements, it is possible to initially reduce the cost of waste and every action to reduce waste should focus on measurable and actionable improvement. Thormark, C (2000) studies states recycling is here used as an overall concept for reuse, material recycling and combustion with heat recovery and the main benefits of recycling are saving of natural raw materials, saving of energy, decrease of harmful emissions and reduction in space needed for landfills. Udayangani Kulatunga, et al.,(2006) synthesized on the attitudes and perceptions of the construction workforce can influence the generation and implementation of waste management strategies and the reasons behind this lack of practice of waste management applications are other priorities during the pre- and post-construction stages, such as profit, time, cost, etc.

### III. RESEARCH GAP

Although several studies have been conducted with regard to construction waste management practices in the construction industry, most of the studies have been conducted in western perspective. Only few studies have been conducted in Indian context. Therefore the researcher would like to fill the gap by way of studying the construction waste management and the various possibilities of reusing the same in order to reduce the total construction cost.

### IV. PROPOSED RESEARCH MODEL

This study is approached with the following proposed research model:

![Fig. 1: Proposed Research Model](image-url)
V. OBJECTIVE OF THE STUDY
The study is confined with the following objectives:
- To identify the various antecedents of waste assessment in construction industry.
- To measure the impact of various antecedents of waste assessment in construction industry with design managers satisfaction

VI. PROJECT HYPOTHESIS
1) H1: There is no significant impact on designing phase and design management satisfaction.
2) H2: There is no significant impact on construction phase and design management satisfaction.
3) H3: There is no significant impact on implementation difficulties and design management satisfaction.
4) H4: There is no significant impact on time and cost and design management satisfaction.
5) H5: There is no significant impact on modern trends and design management satisfaction.
6) H6: There is no significant impact on contract and training and design management satisfaction.
7) H7: There is no significant impact on management techniques and design management satisfaction.
8) H8: There is no significant impact on onsite measures and design management satisfaction.
9) H9: There is no significant impact on beneficiaries and design management satisfaction.
10) H10: There is no significant impact on support and responsibilities and design management satisfaction.

VII. METHODOLOGY
A. Scope:
The scope of the study is confined to the design managers who had made use of the old demolished construction materials as an alternative for the new construction material in and around Thrissur district, Kerala.

B. Questionnaire Development and Content Analysis:
After formulating questionnaire the researcher constituted a committee which consist of one engineer who has more than 20 years of experience in construction industry and one engineering faculty who teaches construction oriented subjects for 10 years. Based on their opinion suitable modification has been made in the existing questionnaire.

C. Data Collection Methods:
The data collection was carried out by means of questionnaire method. The first part of the questionnaire consist of the demographic profile of the respondent. The second part of the questionnaire deals with the experience of the correspondence on using the construction waste as an alternative. The third part of the questionnaire points to the satisfaction level of the design engineers on work done.

D. Sampling:
The researcher used snowball sampling method for collecting the questionnaire from the respondent. The researcher used interview schedule method for collecting data from the respondent.

E. Period of Study:
The period of study was conducted during the period of October 2014 to March 2015.

F. Descriptive Statistics:
The demographic profile in the questionnaire features the experience of the design managers towards the implementation of construction waste as an alternative for new materials in construction industry. The total survey was conducted in 120 out of whom only 88 questionnaires could be collected. The response rate of the survey was 73.33 percent. Among the survey conducted, 51 were designing engineers and 37 were site executing engineers. Among 51designing engineers 39 were engineers in the private sector and 12 were public sector engineers.

VIII. ANALYSIS AND DISCUSSION
A. Measure Construction:
One of the objectives of the research was to construct a scale that measures antecedents of designing phase, construction phase, implementation difficulties, time and cost, modern trends, contract and training, management techniques, onsite measures, beneficiaries, support and responsibilities.

B. Specification of Domain and Generation of Sample Items:
In this step the domain of interest i.e.” Waste assessment and effective reutilization in construction industry” was clarified and a total of 27 items were generated. Literature review and discussions with experts and academics of the construction industry team were carried out.

C. First Data Collection and Measure Purification:
The items were measured on a five point Likert scale and were included in the questionnaire collected by interview scheduled method. Data collection is used in order to purify the measure. Measure purification includes basically the elimination of those items that do not correlate highly with the total score of the overall measure.

D. Reliability Analysis:
There is a number of different methods towards assessing reliability of a scale. In this study the method employed is cronbach’s reliability. Cronbach’s α is the most commonly used procedure to estimate reliability. It is highly accurate and has the advantage of only requiring a single application of the scale. Hence cronbach’s α was obtained and found to be of adequate magnitude. Cronbach’s α calculated at this point was initially found to be rather satisfactory (0.69) (Nunnally 1978; Hair et al., 1998)

E. Determinants for A Successful Quality Management Implementation:
In order to identify some broad determinants of waste assessment and effective reutilization in construction industry implementation, factor analysis was utilized on 27 variables created as mentioned previously. Kaiser-Meyer-Olkin measure for sampling adequacy was of an acceptable magnitude (KMO 0.600). Moreover, Bartlett’s sphericity test gave a significance level of 0.000. Hence, all assumptions for carrying out factor analysis are met. The
extraction technique chosen was principal components and the rotation method was varimax. 

<table>
<thead>
<tr>
<th>Kaiser-Meyer-Olkin Measure of Sampling Adequacy.</th>
<th>.600</th>
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<tbody>
<tr>
<td>Approx. Chi-Square</td>
<td>429.369</td>
</tr>
<tr>
<td>Bartlett's Test of</td>
<td>Df 351</td>
</tr>
<tr>
<td>Sphericity</td>
<td>Sig. .000</td>
</tr>
</tbody>
</table>

Table 1: KMO and Bartlett's Test
Initially all the 27 variables were used. After rejecting those items that have insufficient loadings, researchers deduced to 10 factors. Factor analysis converged after nine iterations. The identified factors explain 64.666 percent of total variance. The cut-off point for accepting sufficient loading was 0.4. The factors are names as follows:
- Designing Phase
- Construction Phase
- Implementation Difficulties
- Time and Cost
- Modern Trends
- Contract and Training
- Management Techniques
- Onsite Measures
- Beneficiaries
- Support and Responsibilities

<table>
<thead>
<tr>
<th>Loadings</th>
<th>Initial eigenvalues</th>
<th>Variance explained</th>
<th>percent of Variance</th>
<th>Cumulative percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designing Phase</td>
<td>Waste Reduction During Design 0.171 2.893 10.516 7.692 7.692</td>
<td></td>
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<tr>
<td>Advise Client For Waste Reusage 0.213</td>
<td></td>
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<td></td>
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<tr>
<td>Designing Measures Aimed Reusing Construction Waste 0.166</td>
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<tr>
<td>Construction Phase</td>
<td>Effectiveness Limited Construction phase 0.428 2.269 8.404 7.206 14.898</td>
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<tr>
<td>Competitive Market 0.748</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Complicated Subcontracting 0.826</td>
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<td></td>
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<tr>
<td>Expectation from Client 0.836</td>
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<tr>
<td>Implementation Difficulties</td>
<td>Difficulties Enforcement 0.154 2.115 7.832 7.081 21.980</td>
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<tr>
<td>Difficulties Forecasting 0.107</td>
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<tr>
<td>Time and Cost</td>
<td>Increase Cost Time 0.414 2.027 7.509 6.983 28.963</td>
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<tr>
<td>Lack of Awareness 0.725</td>
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<tr>
<td>Low Incentives 0.662</td>
<td></td>
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<tr>
<td>Modern Trends</td>
<td>Applying I.T 0.578 1.605 5.944 6.701 35.664</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Appropriate Layout 0.693</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Associate Available Recycling 0.558</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Prefabricated Compound 0.615</td>
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<tr>
<td>Contract and Training</td>
<td>Contracts With Subcontractors 0.591 1.553 5.750 6.529 42.193</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training Education 0.891</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management Techniques</td>
<td>Environmental Management 0.462 1.488 5.513 6.444 48.637</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Purchase Management 0.738</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onsite Measures</td>
<td>Recyling Onsite 0.578 1.327 4.913 5.684 54.320</td>
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<td></td>
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<tr>
<td>Sorting Onsite 0.399</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Beneficiaries</td>
<td>Environmental Benefit 0.488 1.173 4.346 5.196 59.516</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Meets Planning 0.518</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduce Disposal Cost 0.541</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Support and Responsibilities</td>
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</table>
The first factor labeled “Designing Phase” includes implementing waste reduction during design, advice client for waste re-usagand designing measures aimed reusing construction waste. In the design process even if the project is small and the requirements were simple, there is still a mental design process that occurs in between understanding the requirements and starting to construct. Design becomes more and more important as the project becomes larger and more complex. The alternatives include the tools and technology you will you utilize, the scalability of the solution, and the structure of the components you will build.

The second factor labeled “Construction Phase” consists of notions like effectiveness limited construction phase, competitive market, complicated subcontracting and expectation from client. Construction Phase is the process of preparing for and forming buildings and building systems. Construction starts with planning, design, and financing and continues until the structure is ready for occupancy. Those involved with the design and execution of the infrastructure must consider the requirements, the environmental impact of the job, the successful scheduling, budgeting, construction site safety, availability and transportation of building materials, logistics, inconvenience to the public caused by construction delays and bidding, etc.

The third factor labeled “Implementation Difficulties” includes the critical areas like difficulties enforcement and difficulties forecasting. The four challenges, barriers and issues faces by the construction industry are the nature of the construction process, implementing too many parties, non-standardization, culture of the employees (Peter Hoonakker et al., 2012).

The fourth factor labeled “Time and Cost” includes applying IT, appropriate layout, associate available recycling and prefabricated compound. Delays in final completion can result in an erosion of profits, or even losses the determination of the least cost construction schedule can maximize a contractor's profit. A methodology has been presented to find the minimum cost schedule with a variety of compression procedures to determine the time versus direct cost curve.

The fifth factor labeled “Modern Trends” includes the notion like contracts with subcontractors and training and education. Construction Industry Trends all over the world show a rise in its rate of growth. This industry is composed of many components including construction of heavy and civil engineering (highways, bridges, railway tracks, airports, etc.), real estate (both residential as well as commercial) development, and specialized construction products (such as architectural products, electrical connections, decorative items, etc.). All these segments cannot be expected to show similar trends and in fact are showing differential growth pattern all over the world.

The sixth factor labeled “Contract and Training” includes contracts with subcontractors and training education. The contract in the sense the return documents that are required for the effective completion of the project and the various training sessions that are carried out to the work force regarding the construction sequence together constitute error free construction.

The seventh factor labeled “Management Techniques” includes environmental management and purchase management. Project management is the process and activity of planning, organizing, motivating, and controlling resources, procedures and protocols to achieve specific goals in scientific or daily problems. A project is a temporary endeavor designed to produce a unique product, service or result with a defined beginning and end (usually time-constrained, and often constrained by funding or deliverables) undertaken to meet unique goals and objectives, typically to bring about beneficial change or added value.

The eight factor labeled “Onsite Measures” includes the critical area recycling onsite and sorting onsite. The critical steps taken in site during the construction process which trends to change the entire process due to the particular step plays the key role in the effective implementation of the construction process. Sorting the materials wasted and reusing the same in proper way reduces the total construction cost.

The ninth factor labeled “Beneficiaries” includes environmental benefit, meets planning and reduce disposal cost. The various profit arises due to the implementation of the waste reusage in the construction industry aims to produces the factors like reduction in the disposal cost and thus lowering the total cost and also influencing the environment.

The tenth factor labeled “Support and Responsibilities” includes the notion like top management support and social responsibilities. For carrying out a process successfully support from all angle is necessary in such cases the responsibilities will be divided among the coworkers. If these roles are systematically carried out the final outcome will be smooth and will pay towards the project excellence.

IX. HYPOTHESIS TESTING OF PROPOSED MODEL

This section focuses on the investigation of possible relationship between waste assessment and effective reutilization in construction industry and the identified factors for successful implementation that might affect the satisfaction level. Based on the discussion it is expected that attitude towards work completion will affect both the construction work frequency and the system of quality within the construction industry. Moreover it is supposed that the existence of a stronger financial support, effective official interaction, a suitable organizational strategy and administrative support within company will lead to a higher standards of waste assessment and effective reutilization in construction industry.

<table>
<thead>
<tr>
<th>Top Management Support</th>
<th>0.633</th>
<th>1.064</th>
<th>3.939</th>
<th>5.150</th>
<th>64.666</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Responsibilities</td>
<td>0.187</td>
<td></td>
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</tr>
</tbody>
</table>

Table 2: Antecedents of Waste Assessment and Effective Reutilization in Construction Industry
Table 3: Impact of Different Dimensions of Waste Assessment and Effective Reutilization in Construction Industry

**Significant at 1 percent level

<table>
<thead>
<tr>
<th>Del</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td>-1.669</td>
<td>-1.333</td>
</tr>
<tr>
<td>Designing Phase</td>
<td>.006</td>
<td>.098</td>
</tr>
<tr>
<td>Construction Phase</td>
<td>-.005</td>
<td>-.128</td>
</tr>
<tr>
<td>Implementation Difficulties</td>
<td>.119</td>
<td>.251</td>
</tr>
<tr>
<td>Time and Cost</td>
<td>.031</td>
<td>.736</td>
</tr>
<tr>
<td>Modern Trends</td>
<td>-.010</td>
<td>-.318</td>
</tr>
<tr>
<td>Contract and Training</td>
<td>.064</td>
<td>1.437</td>
</tr>
<tr>
<td>Management Techniques</td>
<td>-.056</td>
<td>-.172</td>
</tr>
<tr>
<td>Onsite Measures</td>
<td>-.036</td>
<td>-.648</td>
</tr>
<tr>
<td>Beneficiaries</td>
<td>.042</td>
<td>1.067</td>
</tr>
<tr>
<td>Support and Responsibilities</td>
<td>.564</td>
<td>8.860</td>
</tr>
<tr>
<td>R square</td>
<td>.568</td>
<td></td>
</tr>
<tr>
<td>Adjusted R square</td>
<td>.512</td>
<td></td>
</tr>
<tr>
<td>F statistics</td>
<td>10.135</td>
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</tr>
<tr>
<td>Significant level</td>
<td>0.000</td>
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</tr>
</tbody>
</table>

**X. CONCLUSION**

This study identified ten dimensions of waste assessment and effective reutilization in construction industry. These are the ten dimensions: designing phase, construction phase, implementation difficulties, time and cost, modern trends, contract and training, management techniques, onsite measures, beneficiaries, support and responsibilities. Based on factor analysis classification multiple regressions have been administered. The results of different dimensions of waste assessment and effective reutilization in construction industry indicates that R square = 0.568. This indicates that 56.8 percent of the variance in different dimensions of quality management practices is explained by independent variables. F statistics is 10.135 which are significant at 5 percent level. The result shows that happiness of work β=.703, t = 8.860, p< 0.001 percent. This study proves that there is a significant impact of support and responsibilities on design manager’s satisfaction. The study also confirmed that there is no significant impact between designing phase, construction phase, implementation difficulties, time and cost, modern trends, contract and training, management techniques, onsite measures, beneficiaries on satisfaction.

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