Wastage Potential in Construction of Building Using Fuzzy Logic

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Abstract- Construction industries are still facing numbers of contingent problems. The chronic problems of construction are well known such as low productivity, poor safety, inferior working conditions, and insufficient quality. Particularly, waste is generally associated with waste of materials in the construction processes. The construction industry Responding to those challenges imposes an urgent demand to raise productivity, quality, reducing waste and to incorporate new technologies to the industry. According to the researchers in Fuzzy Construction, the new construction production philosophy is laid on the concepts of conversion and flow process. Therefore, performance improvement opportunities in construction can then be addressed by adopting waste reduction strategies. Fuzzy rules manufacturing or fuzzy production, often simply "fuzzy", is a systematic method for the elimination of waste within a manufacturing system. Zadeh (1965) first introduced the concept of fuzzy set theory through his paper. To Examine the general perceptions of the construction industry with the fuzzy rules and practices, Wastes are classified under fuzzy techniques, Study the potential project productivity improvements by reducing and eliminating the wastes as classified under fuzzy technique.

Index Terms- Fuzzy sets; Membership Grade function; α-cut, Fuzzy rule based system, Linguistic variables, Wastage potential

I. INTRODUCTION

Construction is a key sector of the national economy for countries all around the world, traditionally it took up a big portion in nation's total employment and nation's revenue as a whole. However, until today, construction industries are still facing numbers of contingent problems that were bounded to be resolved since the past time. The chronic problems of construction are well known such as low productivity, poor safety, inferior working conditions, and insufficient quality. Particularly, waste is generally associated with waste of materials in the construction processes while non-value adding activities such as inspection, Wastages, transportation of materials and others are not recognized as waste.

Zadeh (1965) first introduced the concept of fuzzy set theory through his paper and it is generally agreed that an important point in the evaluation of the modern concept of uncertainty was the publication of his seminal paper, even though the American philosopher Max Black (1937) envisioned some ideas presented in the paper some 30 years earlier. Fuzzy rules manufacturing or fuzzy production, often simply "fuzzy" is a systematic method for the elimination of waste within a manufacturing system. Unfortunately, these fuzzy-logic concepts especially those on wastes and values most of the times are not well understood by construction personnel. If we use fuzzy techniques so that it could be benefited for rate consumption & total cost of material & it also consume the time. Sometimes it is necessary to check wastage control by using fuzzy technique as well as observed by Site Engineer & Project Manager. Fuzzy technique control wastage in construction site & it observed on the wastage things as well as it could help to complete this task. This way is the best pivotal option to use for achieved goal/complete task. This wastage has been observed by fuzzy technique & it could be possible to minimum Cost of wastage material. As the result of that, the productivity of construction industry cannot be fully optimised due narrow interpretation on the concept of waste which is currently adopted.

II. LITERATURE REVIEW

The traditional two-valued logical systems, crisp set theory and crisp probability theory are inadequate for dealing with imprecision, uncertainty and complexity of the real world. The uncertainty (predictive, prescriptive, etc.) has a pivotal role in any efforts to maximize the usefulness of systems models. Zadeh (1965) first introduced the concept of fuzzy set theory through his paper and it is generally agreed that an important point in the evaluation of the modern concept of uncertainty was the publication of his seminal paper, even though some ideas presented in the paper were envisioned some 30 years earlier by the American philosopher Max Black (1937).

A fuzzy set can be defined mathematically by assigning, to each possible individual in the universe of discourse, a value representing its grade of membership in the fuzzy set. This grade represents the degree to which that individual is similar or compatible with the concept represented by the fuzzy set. Thus, an individual may belong in the fuzzy set to a greater or lesser degree as indicated by a larger or smaller membership grade. These membership grades are very often represented by real-number values ranging in the closed interval [0, 1]. The extreme values in these intervals 0 and 1, represent, respectively, the total rejection and confirmation of the membership in a given fuzzy set. As fuzzy logic deals with values between 0 and 1, it is also multi-valued logic. In other words, fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial - truth values between "completely true" and "completely false". That is, propositions are true to a certain degree and false to a certain degree. In the extreme

case, if a proposition happens to be completely true i.e., to a maximum degree, then it cannot be false in any amount i.e., it is false to a minimum degree. As its name suggests, it is the logic underlying modes of reasoning which are approximate rather than exact. The importance of fuzzy logic derives from the fact that most modes of human reasoning and especially common sense reasoning are approximate in nature (Klir and Yuan, 2003).

Keith Hampson, Sherif Mohamed *(et al) (2002)* have studied about in this article the study of value adding (e.g. Conversion) & the non-value adding activities (e.g. Secondary Transportation) in the construction industry has been carried out. Construction managers have for a long time focused their attention on conversion processes, with little attention given to flow activities, leading to uncertain flow processes, expansion of non-value-adding activities, and reduction of output value. This paper investigates the incidence of non-value-adding activities in construction projects in Indonesia and Australia, focusing on non-residential building and infrastructure projects. A quantitative approach was adopted for this research utilising the results of a questionnaire survey involving 53 variables that relate to non-value-adding activities. The variables were then separated into two classifications: waste categories that contribute to a reduction in the value of construction productivity and waste cause variables that could be defined as factors producing waste. Statistical analysis was performed to identify the different perceptions amongst the respondents and to determine the key variables of non-value-adding activities. The paper illustrates the key waste categories, the key waste cause variables and leads the contractors to focus their attentions on these issues in order to reduce the incidence of non-value-adding activities during the construction process.

L. Y. Shen, C. M. Tam (et.al) (2004) have studied about in the existing research works and practices, and these works can be grouped largely into three areas: waste classification, waste management strategies (avoiding waste, reducing waste, reusing waste, and recycling waste) and waste disposal technologies. The examination leads to developing a waste management mapping model (WMMM) provides an alternative tool assisting in planning waste management procedures on construction sites. It can serve as a vehicle for comparing the waste management practices between construction sites, thus both good practices and weak areas can be identified.

***Glenn Ballard* &Syed M. Mohammed (2008)** *have* studied about as the Construction Industry has traditionally been one of the largest in many developing nations. While other industries have greatly increased their levels of quality and performance, the majority of construction work is based on antiquated techniques, attended by supply-chain deficiencies and high defect rates resulting in wasted labour and materials. Estimates indicate that up to 30% of construction costs are due to inefficiencies, mistakes, Wastages, and poor communications. As global competitiveness increases, so will the expectation of higher levels of quality and productivity in constructed facilities.

Salem O., *Solomon, J. (et al) (2006)* have studied about in this article comparison of the techniques is developed for lean construction with those developed for lean manufacturing. Lean manufacturing and lean construction techniques share many common elements despite the obvious differences in their assembly environments and processes. Manufacturing plants and construction sites are different in many ways that might explain why lean production theories and practices do not fully fit the construction industry. the study, a new “lean assessment tool” is proposed to quantify the results of lean implementations. The assessment tool evaluates six lean construction elements: last planner, increased visualization, huddle meetings, first-run studies, five S’s, and fail safe for quality. This paper provides a simple and comprehensive approach that is transferable to any construction project.

Sou-Sen Leu, et al., (1999) says activity duration is uncertain due to the variation in the outside environment, such as weather, site congestion, productivity level, etc. A new optimal resource-constrained construction scheduling model is proposed in this paper, in which the effects of both uncertain activity wastage and resource constraints are taken into account.

Leonhard E. & Zhang, Jing. (et.al) (2005) have studied about the traditional management approach for site operation with management philosophy that has as its sole & unifying objective the elimination of process waste. It will be demonstrated that a waste-based management philosophy creates a culture of continuous improvements & innovative progress driven by the goal to reduce wastes from injuries to unproductive work activities. Wall framing & masonry construction are used to demonstrate how the waste-based management approaches functions. This research concluded that Contrary to traditional management which focuses on setting & meeting targets (i.e., schedule, budget, etc.). waste-based management emphasizes the importance of an ongoing continuous effort that includes everyone who is in any way involved in planning, controlling, and executing the work.

III. METHODOLOGY

The modeling for Wastage analysis in the construction of building assumes greater complexity due to the involvement of human perception in the evolution of decision making process. Further, the complex human perception is subjected to the physical surrounding, social environment and also to its own household structure over and above the economic constraints.

The calculation of Wastage in the construction of building has a major bearing on the human decisions regarding the importance of the construction activities. Both the decision processes are complex with higher degree of subjectivity involved and therefore call for the analytical tools which can imitate this behavior and bring the results close to the reality.

the Fuzzy Rule Based System is developed to calculate Wastage status in the construction of building. A flow diagram of fuzzy model is developed in accordance with more understanding about present invention, features and advantages, references and detailed description accompany in flow diagram, in which:

I. Figure 1: A flow diagram of DP fuzzy model for Wastage Status in Construction of Building.

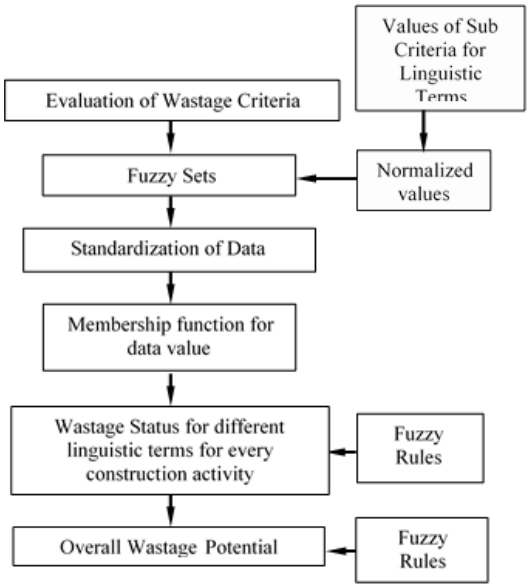

Figure 1: A flow diagram of DCWP fuzzy model for Wastage, Status in Construction of Building

In this invention, the fuzzy model DP is developed to determine Wastage potential. The Wastage status will help to decide rescheduling status of further activities.

The first step was the identification of experts. Experts were from the field of civil engineering as top level managers, Senior Civil Engineers and Professors.

To develop the Fuzzy rule base system, expert's opinion has been taken for different criteria to arrive at status of the following construction activities for defining Wastage potential of construction of building:

Excavation Wastage potential status: Excavation upto hard strata (with carting away of materials) and Dewatering
Foundation base Wastage potential status: PCC and waterproofing
Construction of Footing Wastage potential status: Formwork, Steel work and Concreting
Construction of Stub Column Wastage potential status: Formwork, Steel work and Concreting
Construction of Sub- Structure Wastage potential status: Excavation, Foundation base, Construction of Footing and Construction of Stub-Column
Construction of Plinth Beam Wastage potential status: Anti termite, PCC, Formwork, Steel fixing and concreting
Construction of Grade slab/ PCC Wastage potential status: Anti termite, Polythene sheet, Formwork, Steel fixing and concreting
Construction of Plinth Work Wastage potential status: Construction of Plinth Beam and Construction of Grade slab/ PCC
Construction of Column Wastage potential status: Formwork, Steel work and Concreting
Construction of RCC wall Wastage potential status: Formwork, Steelwork, Concreting
Construction of Beam & Slab Wastage potential status: Formwork, Steel work and Concreting
Construction of Flat Slab Wastage potential status: Formwork, Steel work, Laying of Tendons and Concreting
Construction of OHWT/ LMR Wastage potential status: Construction of Column, Construction of bottom slab, Construction of Column & RCC wall and Construction of top slab
Construction of Parapet wall Wastage potential status: Formwork, Steel work and Concreting
Construction of RCC work Wastage potential status: Construction of Plinth beam, Construction of Grade slab/PCC, Construction of Column, Construction of RCC wall, Construction of Beam & Slab, Construction of flat slab, Construction of OHWT/LMR and Construction of Parapet wall**.**
Construction of wall Wastage potential status: BBM, Plumbing & Electrical conduicting and internal Plaster
Waterproofing Wastage potential status: Toilets & Balconies

External & Internal Plaster Wastage potential status: Single Coat & Double coat
Tiling Wastage potential status: Dado & Flooring
Painting Wastage potential status: Internal & External Painting
Tremix Wastage potential status: Internal & External Tremix
Finishing Items Wastage potential status: Construction of wall, waterproofing, external & Internal Plastering, Tiling, Painting and Tremix
Plumbing Wastage potential status: Internal & External Plumbing
Electrical work Wastage potential status: Internal & External electrical work
HVAC Wastage potential status: Internal & External HVAC work
Firefighting Wastage potential status: Internal & External firefighting work
MEP Wastage potential status: Plumbing, Electrical work, HVAC and Firefighting work
Overall Civil Construction Wastage potential status: Construction of Sub-Structure, Construction of plinth work, Construction of RCC work, Finishing items and MEP**.**
Perception of experts, about the linguistic description for the above selected sub criteria for Civil construction, Electrification and mechanical work for Overall Wastage potential of construction of building, was obtained on the basis of their views through a questionnaire. The fuzzy sets like less, average, much and very much are developed.
*a) **Membership Grade:***
The next step is the determination of membership grade at α- CUT. For this, first normalization of field data is required. The field data can be normalized with respect to considerable limits. Then membership grade for respective Wastage or cost or wastage potential at α-CUT can be calculated.
b) **Fuzzy Rules for Wastage Potential of Construction of Building***:*
After obtaining the fuzzy numbers with their corresponding α- CUT the rule base for the system is to be defined. A set of rules is required to be constructed for the Wastage potential in construction of buildings. Each rule has an antecedent proposition connected together using AND operator, resulting in some consequence. The assertions related to its antecedent part be obtained from the experts, are imprecise or fuzzy. Thus a fuzzy rule based system can be developed for the knowledge representation or reasoning process. Here, the partial matching is allowed and the analyst can estimate the extent to which the assertion satisfies the antecedent part of the rule contrary to the rule based system which examines as to whether the antecedent part is satisfied or not.
A hierarchical structure is developed for Wastage potential in construction of building resulting out of a set of rules.
Excavation, Foundation base, Construction of Footing and **Construction of Stub Column Wastage potential status** can be judged in the first hierarchical level of knowledge base to arrive at **Construction of Sub- Structure Wastage potential status**.
Construction of Plinth Beam and Construction of Grade slab/ PCC Wastage potential status can be judged in the second hierarchical level of knowledge base to arrive at **Construction of Plinth Work Wastage potential status.**
Construction of Plinth beam, Construction of Grade slab/PCC, Construction of Column, Construction of RCC wall, Construction of Beam & Slab, Construction of flat slab, Construction of OHWT/LMR and Construction of Parapet wall Wastage potential status can be judged in the third hierarchical level of knowledge base to arrive at **Construction of RCC work Wastage potential status.**
Construction of wall, waterproofing, External & Internal Plastering, Tiling, Painting and Tremix Wastage potential status can be judged in the fourth hierarchical level of knowledge base to arrive at **Finishing Items Wastage potential status**.
Plumbing, Electrical work, HVAC and Firefighting Work Wastage potential status can be judged in the fifth hierarchical level of knowledge base to arrive at **MEP Wastage potential status**.
The final level characterizes Construction of Sub-Structure status, Construction of plinth work, Construction of RCC work status, finishing items status and MEP Wastage potential status to arrive at the Potential of Wastage in **Overall Civil Construction as highly tolerable, tolerable, just tolerable and not tolerable.**

IV. RESULTS AND DISCUSSION

For the determination of membership grade (Fuzzy Number: FN) at α-CUT, first the field data were normalized on the basis of considerable limits. Then membership grade for respective Wastage potential at α-CUT was calculated.

Table 1 Fuzzy number of Field Data of Excavation

Scheme	Sub Criteria	Linguistic Terms			
		Less	Average	Much	Very Much
1	Excavation	0	0	0.8	0
	De-watering	0	0.6	0	0

Similarly, for all the activities the α-CUT were calculated.
The degree of certainty, of linguistic terms, less, average, much and very much for all the activities was calculated on the basis of Min-Max rules. To develop the fuzzy rule base, experts' opinions have been taken for all the generated activities.

Table 2: Fuzzy Rules

Excavation Wastage status	Dewatering Wastage status	Excavation Wastage Potential Status
Less	Less	Less
Less	Average	Less
Less	Much	Average
Less	Very Much	Much
Average	Less	Less
Average	Average	Average
Average	Much	Average
Average	Very Much	Much
Much	Less	Average
Much	Average	Much
Much	Much	Much
Much	Very Much	Very Much
Very Much	Less	Very Much
Very Much	Average	Very Much
Very Much	Much	Very Much
Very Much	Very Much	Very Much

Table 3: Fuzzy Rules with linguistic terms values

Excavation Wastage status(FN)	De-watering Wastage status (FN)	Excavation Wastage potential status (Min. of 1 and 2)
Less (0)	Less (0)	Less (0)
Less (0)	Average(0.6)	Less (0)
Less (0)	Much (0)	Less (0)
Less (0)	VeryMuch (0)	Less (0)
Average (0)	Less (0)	Less (0)
Average (0)	Average (0.6)	Average (0)
Average (0)	Much (0)	Average (0)
Average (0)	Very Much (0)	Much (0)
Much (0.8)	Less (0)	Much (0)
Much (0.8)	Average (0.6)	Much (0.6)
Much (0.8)	Much (0)	Much (0)
Much (0.8)	Very Much (0)	Very Much (0)
Very Much (0)	Less (0)	Very Much (0)
Very Much (0)	Average (0)	Very Much (0)
Very Much (0)	Much (0)	Very Much (0)
Very Much (0)	Very Much (0)	Very Much (0)

From **Table3,** maximum value of the degree of certainty for linguistic terms Less, Average, Much, Very Much is 0, 0.6, 0 and 0 respectively.

The maximum value of the degree of certainty of linguistic terms Less, Average, Much, Very Much of Excavation potential for scheme 1 is as shown in **Table 4**

Table 4 Excavation Wastage Potential

Scheme	Excavation Wastage Potential			
	Less	Average	Much	Very Much
1	0	0.6	0	0

Similarly, Wastage potential of different activities of sub-structure were calculated and shown in Table 5 to 7.

Table 5 Foundation Base Wastage Potential

Scheme	Foundation Base Wastage Potential			
	Less	Average	Much	Very Much
1	0	0	0.7	0

Table 6 Construction of Footing Wastage Potential

Scheme	Footing Wastage Potential			
	Less	Average	Much	Very Much
1	0	0	0.8	0

Table 7 Construction of Stub Column Wastage Potential

Scheme	Stub column Wastage Potential			
	Less	Average	Much	Very Much
1	0	0.2	0.6	0

On the basis of Wastage potential of Excavation, foundation base, footing and stub-column, the sub-structure Wastage potential was calculated (Table 8).

Table 8 Construction of Sub-Structure Wastage Potential

Scheme	Sub-Structure Wastage Potential			
	Less	Average	Much	Very Much
1	0	0	0.7	0

Similarly, the Wastage potential for other activities was calculated. From the study the following points were observed:

i) Wastage status of Substructure shows much Wastage potential with degree of certainty 0.5, 0.5 and 0.7 respectively for scheme1, 2 & 3.
ii) Wastage status of Plinth beam base shows much Wastage potential with degree of certainty 0.9, 0.6 & 0.8 respectively for scheme1, 2 & 3.
iii) Wastage status of RCC work base shows average Wastage potential with degree of certainty 0.8, 1&0.7 respectively for scheme1, 2 & 3.
iv) Wastage status of finishing items shows much Wastage potential with degree of certainty 1, 0.9 &1 respectively for scheme1, 2 & 3.
v) Wastage status of MEP work base shows much Wastage potential with degree of certainty 0.8, 0.8 &0.8 respectively for scheme1, 2 & 3.
vi) Wastage status of Overall Civil Construction work base shows much Wastage potential with degree of certainty 0.7, 0.6 &0.7 respectively for scheme1, 2 & 3.

V.FURTHER SCOPE OF THE WORK

The wastage potential can be calculated from this study. Further, on the basis of results it would be possible to optimize the wastage potential of every construction activity. On the basis of optimized values, it can be decided that which activity wastage material can be recycled with quantity and that same can be linked to profit margin study.

VI.CONCLUSION

From the analysis of the results of the present study the following conclusions have been drawn:

i) Application of fuzzy approach for Wastage status in construction of building is found to be more appropriate compared to the current crisp approach.
ii) From the Fuzzy Rule–Based System (FRBS) results, it is possible to classify Wastage potential.

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