LEAN FUNCTION DEPLOYMENT

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ABSTRACT

This paper introduces and formalises a technique for minimising the share of non-value adding activities by improving the workflow reliability in AEC processes. The technique has been named Lean Function Deployment (LFD). Its framework is built upon the existing system of QFD and draws its essence from the principles of the new construction philosophy which views the construction to be composed of conversion processes and material and information flow processes. Ways to implement this technique as well as to use it for analysing the wastes has been discussed. It is proposed that LFD can play a significant role in rationalising and re-engineering the workflow processes of the AEC sector thereby allowing for preventive actions against occurrence of wastes in the flow processes.

KEYWORDS

LFD, workflow, wastes, conversion processes, flow processes

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INTRODUCTION

The inherent one-of-a-kind, fragmented and multi-disciplinary nature of AEC sector makes it a highly complex system with numerous interdependencies and constraints (resource variability, constructability problems, site location adversities etc). Fortunately, these complexities have paved way for a new way of looking at AEC processes in which the whole process is supposed to be composed of conversions and flows instead of just comprising of conversion processes, as advocated through the traditional approach based upon the activity-centred school of thought. Wastes in construction germinate from the activity-centred thinking (Howell 1999). A plethora of AEC project management tools and techniques have evolved over time but almost all of these focus on the improvement of transformation (or conversion) processes without stressing on the elimination of wastes, which is quite natural considering the one-dimensional objective of conventional management practices to improve the efficiency (or productivity) of conversion processes. Research in the field of assessing the construction wastes indicates that the wastes occurring in the AEC sector due to rework, poor quality, lack of process transparency, improper design are appreciable enough to justify use of waste reduction techniques. Non-value adding activities dominate most processes and only about 3 to 20 percent steps in these processes add value to the product (Koskela 1992). Therefore it becomes highly imperative in the context of modern construction philosophy to develop tools for minimizing the wastes occurring during flow processes; the key to which lies in improving the workflow reliability i.e. reliability of flow processes. With this objective, a technique for analyzing the wastes by/and improving the workflow reliability (Ballard 1999) is being put forward and has been named Lean Function Deployment (abbreviated as LFD). The LFD is built upon the existing system of QFD (Hofmeister et al 1989, Oswald 1992) and draws its essence from the principles of the new construction philosophy, which views the construction to be composed of conversion processes (value-adding) and material and information flow processes (essentially non value-adding, though may be contributory). The role of LFD can be best appreciated *if every process in the AEC sector is viewed as a customer of itself*. The universal "Voice of every process", considering the newly evolved philosophy, is to improve its productivity along with minimising wastes (Koskela 1999). LFD minimises the wastes occurring in the flow processes (Figure 1) thus reflecting the Voice of the Customer (or Process).

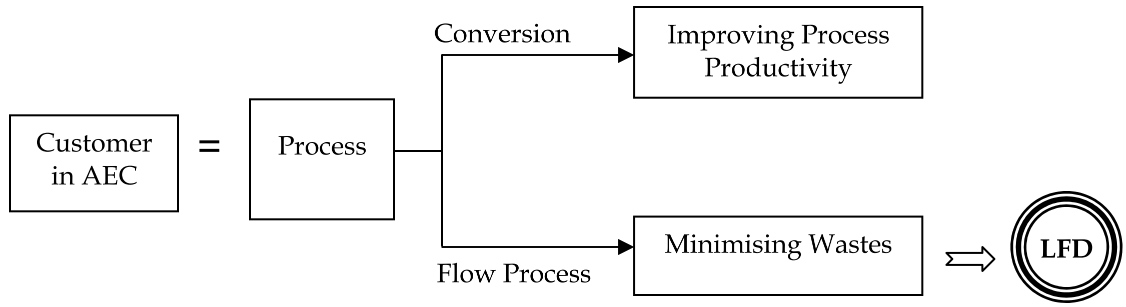


Figure 1: Role of LFD in Achieving the Voice Of The Customer (Process)

LFD technique can be applied to various AEC flow processes as shown in Figure 2.

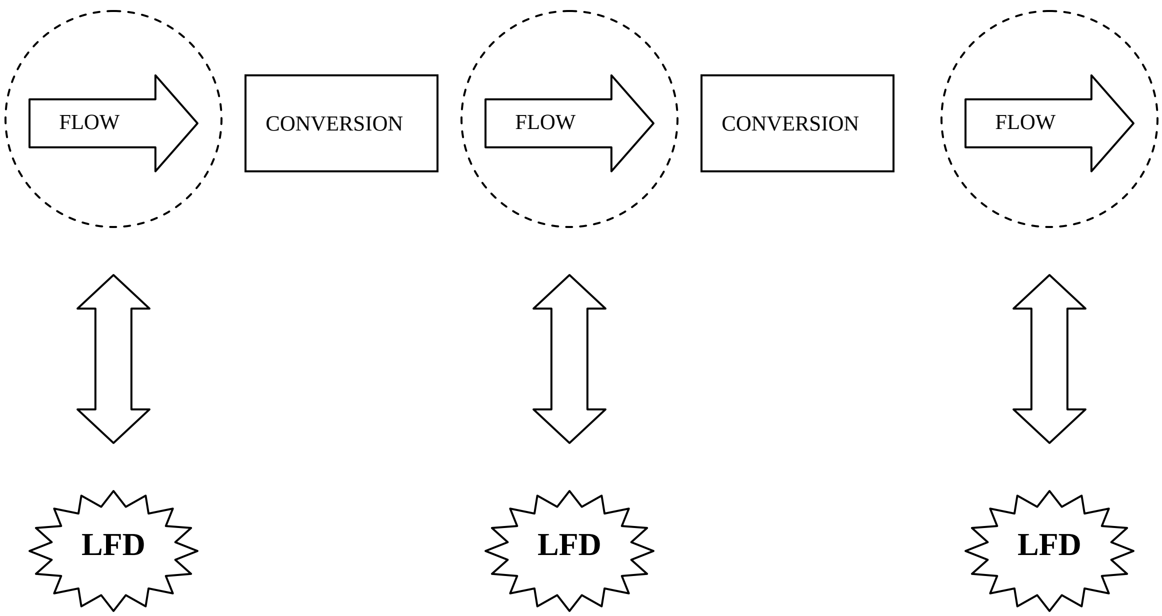


Figure 2: Coupling of LFD with the AEC flow processes

DESCRIPTION

The LFD comprises of a chart with various parameters clinging to it. It may also be referred to as "House Of Leanness" with various rooms as shown below in Figure 3.

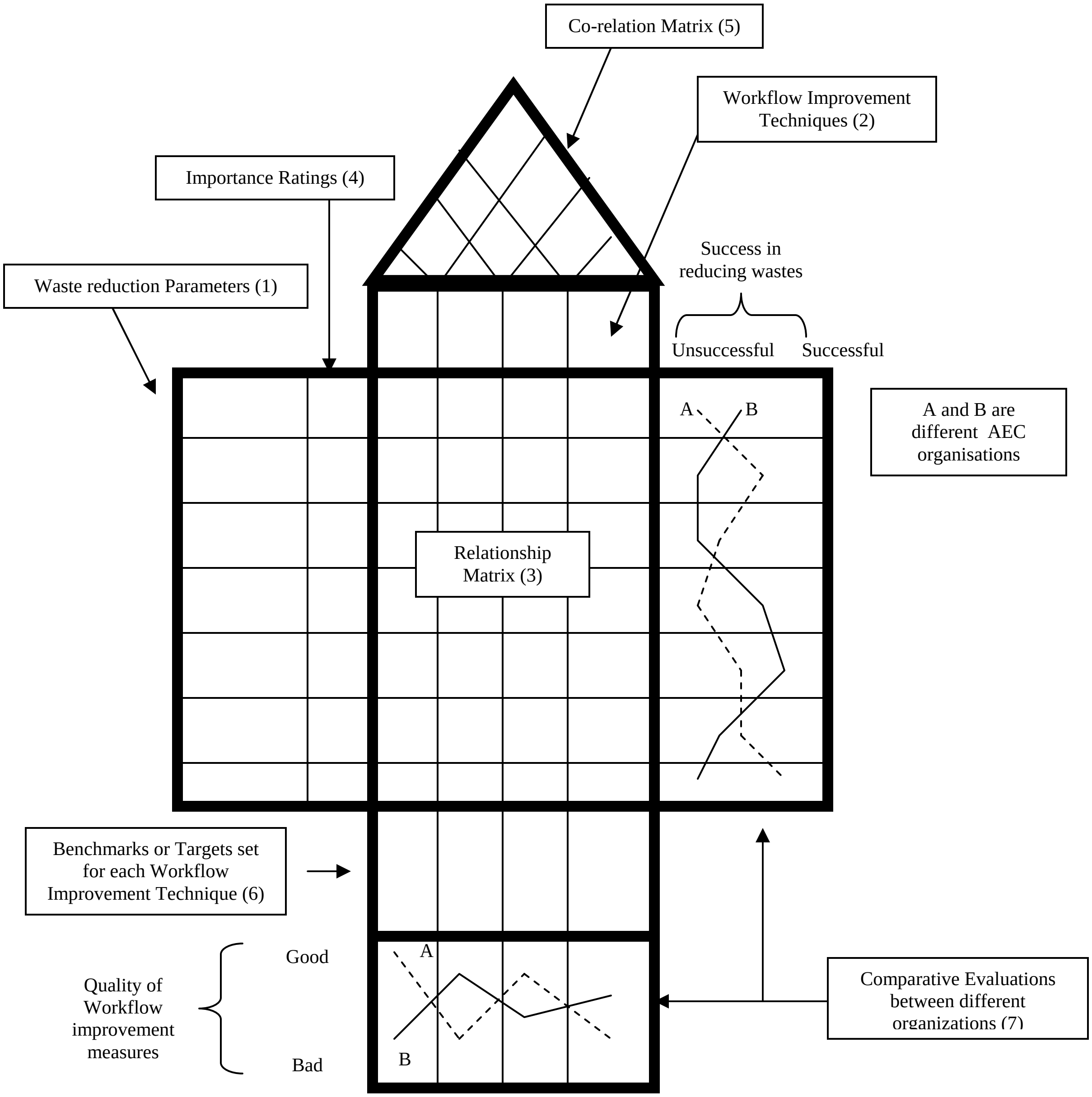


Figure 3: "House of Leanness" with all its rooms

The chart has a set of Waste Reduction Parameters (1) and a corresponding set of Workflow Improvement Techniques (2). The strength of relationship between (1) and (2) is expressed in a Relationship matrix (3). The Importance Ratings (4) of Waste Reduction Parameters can be set either through judgment or by using Analytic Hierarchy Process (Chua et al 1999) and takes into account the relative dominance of wastes in the process, as perceived by the process owner. The co-relation among the various workflow improvement techniques is mapped in a Co-relation matrix (5). The measurable targets for workflow improvement techniques (6) are described at the bottom of the Relationship matrix. Finally, Comparative evaluation charts (7) are placed opposite workflow improvement measures and waste reduction parameters.

IMPLEMENTATION

LFD is applicable to any process (or sub-process) by the process owner (the person responsible for the process). Steps for its implementation are:

a) To begin with, the various categories of wastes occurring in a process, which have to be minimised are listed vertically. This constitutes the category of WHATS i.e. what are the process objectives w.r.t minimizing wastes and are termed as Waste Reduction Parameters. The WHATS may include reduction in overproduction, avoidance of irrational substitution of resources for accomplishing tasks, reduction of waiting time, minimization of waste due to unnecessary or excessive transportation of materials on site, minimization of inventories, minimization of unnecessary movement of crew on site, minimization of rework, be it at the site or during the design process (Formoso et al 1999). The waste reduction parameters are process-specific and are set by the process owner.

b) Next, the ways and methods to improve workflow reliability for checking these wastes are listed horizontally. These may be referred to as HOWS and include several measures like organisational hierarchy reform, process improvement through analysis of process for inefficiency, systematic consideration of the succeeding customer process at the downstream, reduction of variability, simplification of processes, increase of output flexibility, achieving greater transparency, maintaining adequate safety standards, paying attention to the whole process, implementation of IT to the processes, automation of certain construction tasks (Koskela 1992). These measures, again, are dependent on the process and may vary from process to process.

c) The relationship between the WHATS and HOWS can then be plotted inside the Relationship Matrix. The relationships are assigned weights of 9,3 or 1 as in QFD, with 9 indicating a strong relation.

d) The waste reduction parameters are ranked in order of their relative impact on the Process Flow Efficiency i.e. a waste category with maximum rating indicates that the reduction of this waste is important for reducing the wastes occurring in the flow process under consideration. These Importance Ratings may have any suitable range.

e) The co-relationships among the HOWS are then plotted in a Correlation Matrix, which is a roof like triangular table. The co-relations are weighted as strong positive, positive, negative and strong negative.

f) Workflow Improvement Technique Benchmarks (measurable or objective targets) are set for the tools to be used to improve workflow reliability. These may be referred to as HOW MUCH. The measurable targets for various workflow improvement tools can be expressed in % or time units e.g. reduction of cycle time by 10% or by 2 days can be one form of target. However, only a subjective assessment of targets may be feasible for certain workflow improvement measures like process simplification. Setting of measurable targets in this manner provides an objective way of assuring that workflow improvement (or waste reduction) requirements have been met.

g) Finally, relative abilities of different AEC organizations in minimizing the various wastes is plotted along with the relative evaluation of quality (engineering quality) of the various waste reduction techniques (or workflow improvement measures) employed by different AEC organizations. This kind of *comparative evaluation* may be quite challenging because it will require an in-depth understanding of flow processes of various organizations. It may be noted that an absence of comparative evaluations is not counter-productive to the cause of LFD, however, its presence complements LFD.

The LFD can be used serially (as shown in Figure 4) within a process to arrive at a precise set of objectives for reducing flow process wastes. During its serial implementation only critical workflow improvement parameters are passed on to the next phase of LFD.

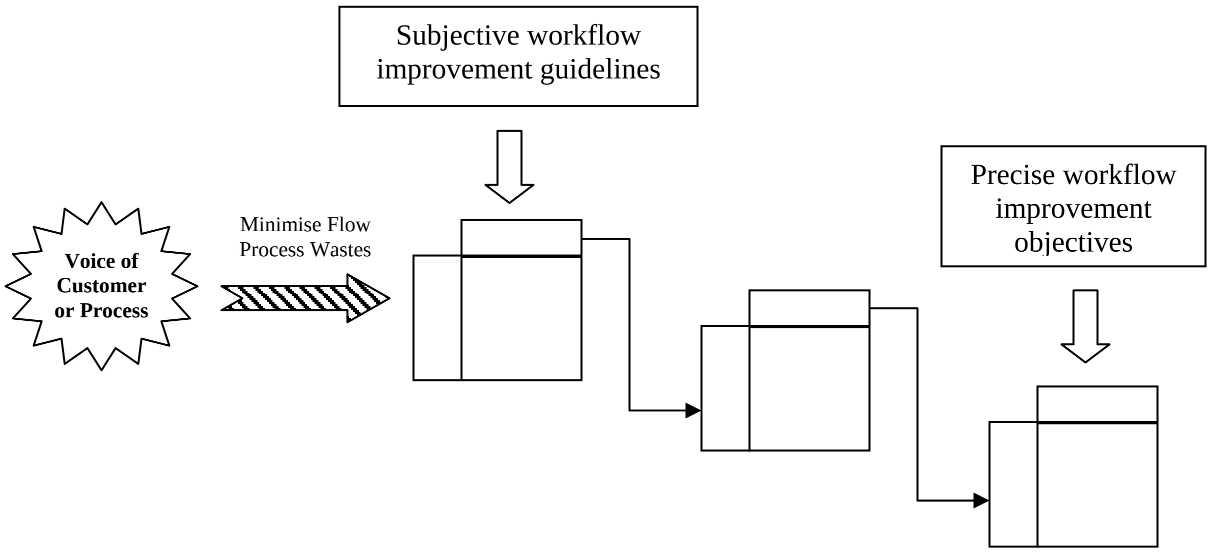


Figure 4: Serial implementation of LFD to arrive at precise workflow improvement measures

ANALYSIS USING LFD

RELATIONSHIP MATRIX

It gives an idea of the strength of relationship that exists between the Waste Reduction Parameters (WHATS) and the Workflow improvement techniques (HOWS) and helps to visually depict and easily interpret highly complex relationships between them. Moreover, if the rows or columns in this matrix are blank, it suggests that our interpretation of waste reduction parameters and workflow reliability is inadequate.

CO-RELATION MATRIX

This establishes the co-relation among the various workflow improvement techniques and thereby aids in taking trade-off decisions regarding their application to the process. A strong negative co-relation between two workflow improvement techniques indicates the presence of a potential trade-off between the two. Such trade-offs must be resolved to be able to accomplish the reduction of wastes of all types. The resolution of trade-offs can be done by reconfiguring or adjusting the workflow improvement technique benchmarks.

WORKFLOW IMPROVEMENT TECHNIQUE BENCHMARKS

As stated earlier, they provide an objective way of assuring that workflow improvement requirements have been met. Moreover, they provide targets for further process flow improvements.

COMPARATIVE EVALUATION

This can yield very interesting results by bringing out conflicts between the quality of workflow improvement measures and the success achieved in reducing the wastes. If there is a conflict, say, the waste reduction program implemented by a particular organization (as compared with other organization's similar process) for a particular waste is unsuccessful while the relative engineering quality of the workflow improvement technique used by that organisation is very good, then it can be inferred that either the workflow improvement technique is not suitable for that particular waste reduction or the applicability of the workflow improvement technique has not been assessed appropriately.

CASE STUDY

A case study was done at a construction site of a Cultural centre in Singapore, to assess the suitability of LFD technique to the AEC processes. One such process, that of erection of formwork, was chosen for study. Physical layout of the work area is shown in Figure 5.

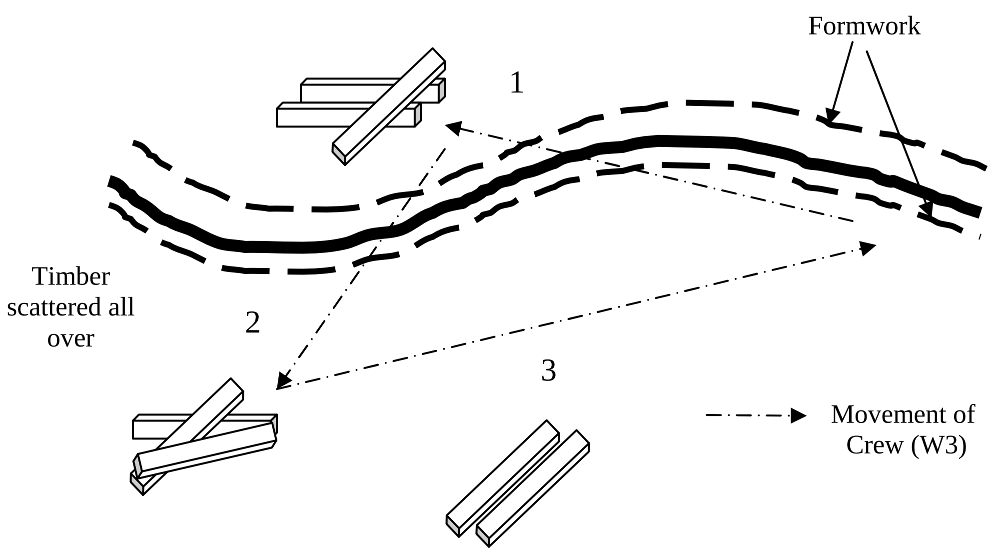
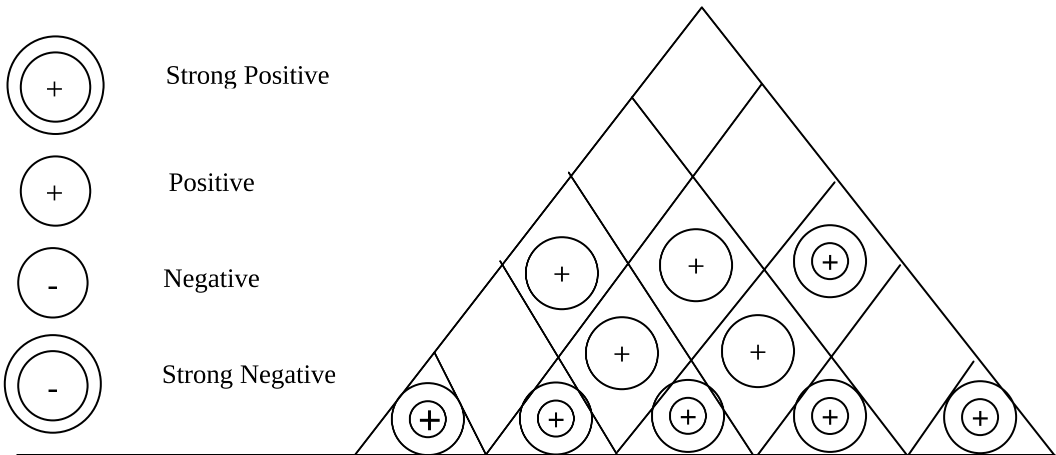


Figure 5: Physical layout of the work area

LFD chart has been developed for the activity (shown in Figure 6). The most important waste reduction parameter, as judged by the in-charge was the unnecessary movement of crew (hence the importance rating of 10). Quite reasonably, this can be curtailed by proper site layout through work area redesign and thus the relationship between unnecessary crew movement and work area redesign is set to 9 i.e. strong relationship.



	Importance Ratings (1-10)	Reduction in Variability of Available Timber	Crew Redesign	Simplification of Process (Alteration)	Training Of Crew	Work Area Redesign
Rework	5	0	3	1	9	1
Unnecessary crew movement	10	1	3	1	3	9
Idle Time	7	3	3	9	1	1
Waiting Time	3	9	1	3	0	3
		58	69	87	82	***111***

Figure 6: LFD Matrix for Erection of formwork

Analysis of the LFD chart indicates that work area redesign with an overall weight of 111(obtained by multiplying the importance ratings with relationship strengths) must be stressed upon to be able to reduce the wastes in the process.

The deduction from the LFD chart is supported by the Work Sampling results, obtained from time-based productivity studies for the process. One of the members of the formwork erection crew (denoted by W3) was responsible for fetching timber logs close to the place of formwork erection before the timber was adequately sized and formwork prepared. Owing to the disorderly arrangement of logs on the worksite, most of W3s time was spent in unnecessary movement to and from the different stacks of logs to find the appropriate one. 64 percent of W3s work time was wasted, as is depicted in Figure 7. The results derived from LFD are, thus, in phase with those from Work Sampling studies.

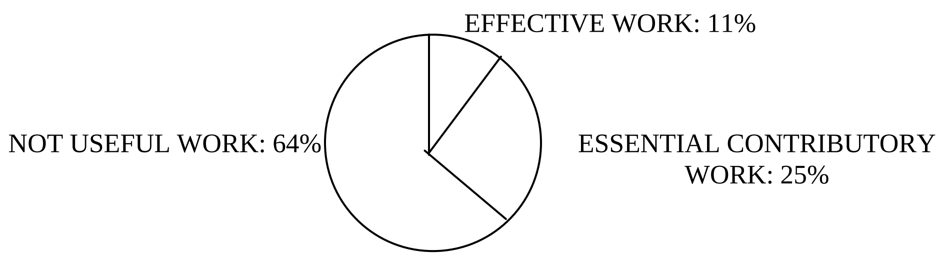


Figure 7:Work Sampling Result for crewmember W3

It can also be observed from the LFD matrix that process simplification and work area redesign have a strong co-relation among them and both are crucial for reduction of wastes (with final weights of 87 and 111,respectively). Thus, work area redesign may be treated as a representative measure for both and should be concentrated upon, instead of diverting efforts towards other measures.

CONCLUSION

LFD, with lean principles embedded in it (Dale 1999), has the potential of being a very effective tool for a planner to evaluate a process in terms of wastes, provided the numbers put in it, are logically judged. The LFD matrix is simple to use and draws together all the waste reduction parameters (or wastes) along with highlighting the key measures to be aimed for while trying to reduce the wastes. This, in turn, helps to plan in advance (by facilitating examination, cross-checking and analysis of various parameters in LFD), any process where share of non-value adding activities is high. However, it may be appreciated that LFD is not a panacea for flow related problems. This tool is introduced with a view to bring to limelight the importance of wastes occurring in the flow processes in the AEC sector which consume lot of precious resources and to encourage its use as an industry wide standard for rationalising workflows.

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