HOUSE OF WASTE AND ITS IMPLICATIONS FOR PROJECT MANAGEMENT

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Introduction

- Achieving a balance between the key performance indicators of scope, time, quality and cost has always been a source of concern to project stakeholders in the construction industry.
- The manufacturing industry has traditionally been more productive than the construction industry.
- The lack of productivity in the construction sector has been attributed to the prevalence of waste (Aziz and Hafez, 2013).
- To improve the productivity of the construction sector, it has been suggested to adopt some of the tools and techniques utilized in the manufacturing sector (Koskela 1992).

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LEAN THINKING IN CONSTRUCTION

Lean thinking changes everything (Womack and Jones 2003)

How we work together

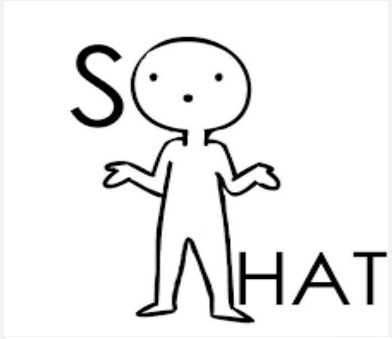
The kind of tools we develop to help with our work

The organizations we create

The nature of our projects and their linkage to each other and the society

Lean Construction

- Lean targets the removal of behaviors and activities that contribute to WASTE and Loss of PRODUCTIVITY
- Lean Construction brings the needed methodologies and culture for improvement
- The aim of LC is to minimize waste of materials and efforts in order to generate the maximum value for project stakeholders (Ballard and Howell 2004)
- It focuses on value delivery at all stages of the project (Fewnings 2013)



Problem Statement

Waste affects productivity and reduces value.

During the execution stage of construction projects

Classification, prioritization, and highlighting the interdependence of wastes to better focus intervention measures.

Literature Review

- New production philosophy and its application to construction was first discussed by Koskela (1992)

- The problem of productivity in construction is due to the absence of a general theory of production.

- Three fundamental elements (Transformation, Flow and Value) need to be added to a production theory for construction (Koskela 2000).

- Lean construction is a production system designed to reduce waste of materials, time and effort to facilitate value creation (Emmitt 2014).
- LC places emphasis on reduction of non value adding activities as a means of value improvement (Sacks et al. 2010).
- LC represents a way design production systems to discourage, minimize and eliminate waste of material, time and effort to promote value maximization (Koskela 2002).
- LC has altered the traditional view of a project by embracing the concepts of flow and value generation (Aziz and Hafez 2013).

Principles of LC

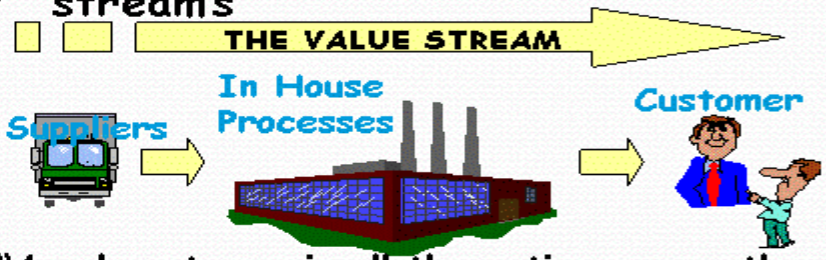
Lean Principles

1 Specifying Value

Value can only be defined by the ultimate customer

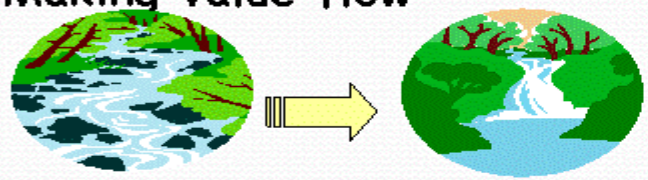
"Value is only meaningful when expressed in terms of a specific product or service which meets the customer needs at a specific price at a specific time"

2 Identify and create value streams



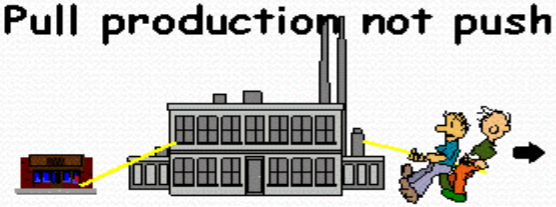
"A value stream is all the actions currently required to bring a product from raw materials into the arms of the customer"

3 Making value flow



"Products should flow through a lean organisation at the rate that the customer needs them, without being caught up in inventory or delayed"

4 Pull production not push



"Only make as required. Pull the value according to the customer's demand"

5 Striving for perfection

Perfection does not just mean quality. It means producing exactly what the customer wants, exactly when the customer requires it, at a fair price and with minimum waste.

Concept and Application of Lean Thinking

- Reduction and eventual elimination of waste.

- Lean thinking creates a means for specifying value helps in the sequential arrangement of value-adding activities (Womack and Jones 2010)

Transformation-Flow-Value Theory

- This theory facilitates the application of the principles of lean thinking in construction (Koskela 2002, Winch 2006) .

Description	Transformation view	Flow view	Value generation view
Conceptualization of construction as production	As a direct transformation of construction inputs into outputs	As a flow of materials composed of procurement, inspection, moving, waiting and transformation	Process of creating value for the client by fulfilling his stated requirements
Main principles	To ensure that the construction process is more efficient	Elimination and/or reduction of all non-value adding activities (waste)	Ensuring that the best functional worth alternative is selected to reduce/eliminate value loss
Procedures	Work breakdown structure, materials requirement planning, organizational responsibility chart	Last planner system to facilitate pull production and continuous flow of work	Value stream mapping, quality function deployment
Contribution to construction process	Ensure that what has to be done is done	Ensures that what is unnecessary is done as little as possible	Ensures client requirements are met in the best possible manner with the least possible cost for the stated quality requirement

- The TFV model provides an important criterion for LC.

- Using the TFV approach however requires a close monitoring of the interaction between flows to ensure reduction of waste and process variability (Tezel 2011).

- The peculiarities of the construction sector makes it very challenging in creating continuous flow (Koskela 2000)

Construction Wastes

- Waste in the construction industry has generated a lot of interest and research over the years.
- However, material waste has been the focus of these interests and research (Aziz and Hafez 2013).
- This is because material waste is tangible and therefore easy to see and measure (Formoso et al. 2002).
- The focus of LC is on intangible waste. However, this type of waste is difficult to measure.

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T-F-V Theory ??

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- Classification of wastes based on the TFV model was first performed by Alarcon (1997).

- He classified the wastes associated with LC as controllable wastes associated with Transformation, flows and values.

Lean Wastes

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D	Defects
O	Overproduction
W	Waiting
N	Non-Utilized Talent
T	Transportation
I	Inventory
M	Motion
E	Extra-Processing

	Type	Examples
D	Defects	• Incorrect information on drawings • Rework • Inspections to reduce/remove defects, • Production of defective work, not meeting specifications
O	Over-production	• Producing items earlier than needed or beyond specification • Producing more than is required • Generating waste through over-staffing
W	Waiting	• Equipment downtime • Documents awaiting approval, updating or processing • Workers unable to do value creating work • Waiting time between processes or for capacity to take the next step
N	Non-utilized talent	• People working one or two levels below their true capability • Lack of knowledge learned from one project transferred to another • Losing time and ideas, skills improvement and learning opportunities
T	Transportation	• Moving work in progress from one place to another • Moving temporary site facilities from one location to another • Delivering equipment, incomplete orders • Moving material to and from storage
I	Inventory	• Excess raw material, WIP or finished goods causing longer lead times, damaged goods, transportation/storage costs and delays • Too much material compromising the workspace • Large site storage of materials
M	Motion	• Unnecessary movement of people and equipment that does not add value • Walking between workplace and welfare facilities, manual paperwork processing • Unnecessary movement of personnel and equipment at site
E	Extra-processing	• Taking unnecessary steps • Providing higher quality products than necessary and produced to standards beyond specifications • Inefficient processing, especially due to poor design or work planning causing

Methodology

- The design science research methodology was adopted.
- Design science is not concerned with action itself, but with knowledge to be used in designing solutions (Aken, 2004).
- This method involves two main activities (Lukka 2003, Saunders et. al, 2009)
  - Creation of new knowledge through design of novel things or processes.
  - Analyzing what has been created through reflection and/or abstraction

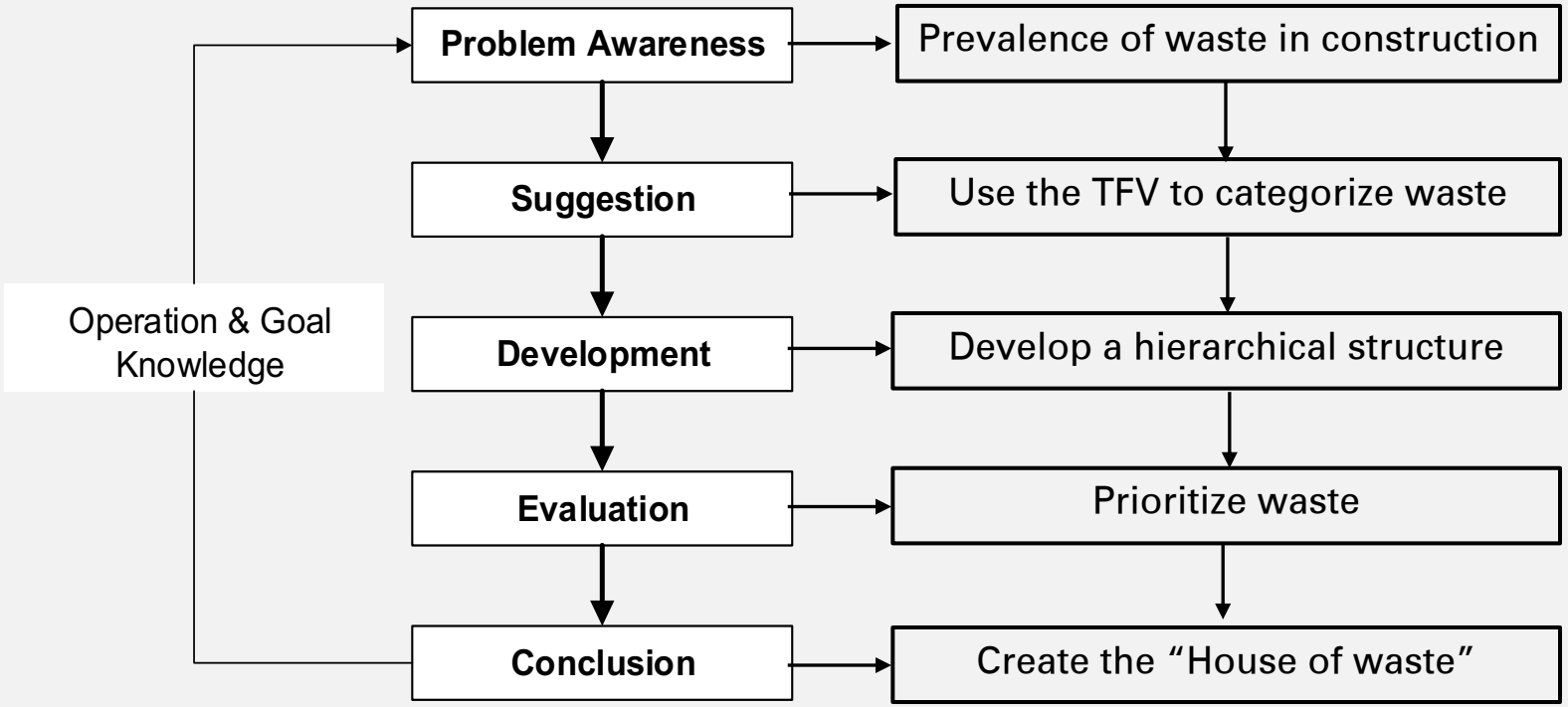


Fig 1: Methodology flow chart

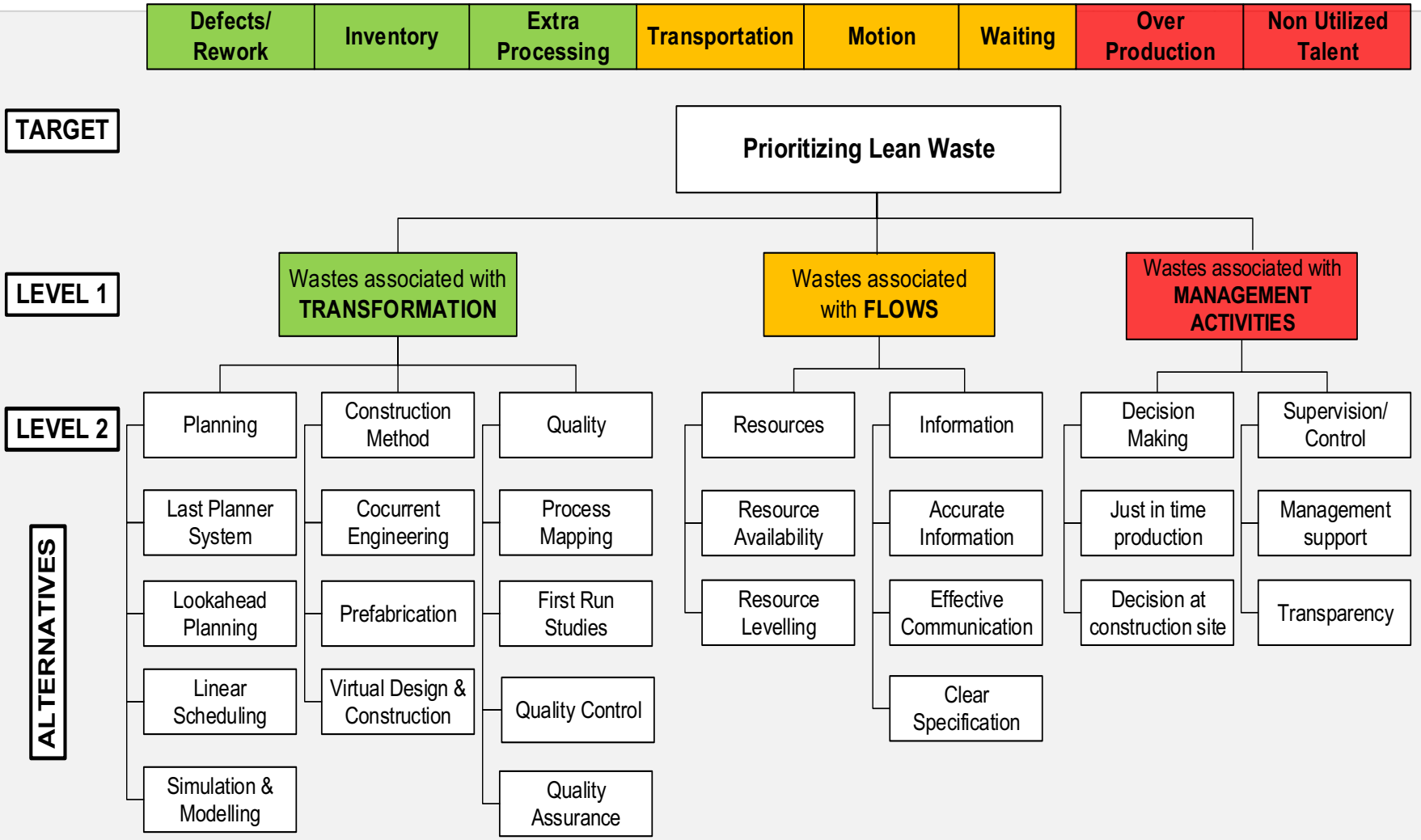


Fig 2: AHP for prioritizing lean wastes

Data Collection

- Data was collected from industry experts and academic practitioners in LC through a questionnaire survey

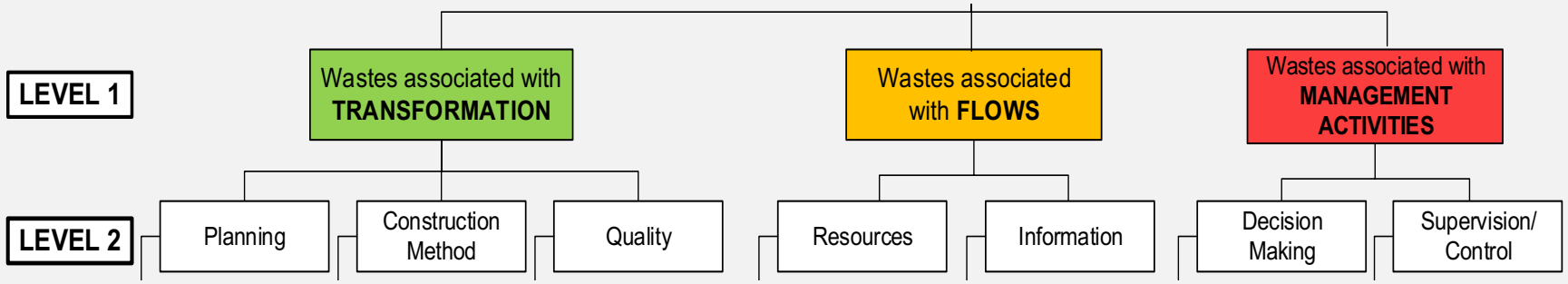
experts (3 from academia and 4 from Industry) provided feedback for analysis

average experience of respondents

ex-pert
n.
A person with high degree of skill in or knowledge of a certain subject
adj.
Having, involving, or demonstrating skill in or knowledge of a certain subject

- A decision hierarchy was constructed to derive priorities for the criteria based on a pilot questionnaire survey and the results were analyzed using the AHP

- The goal of the AHP in this research is to obtain priority weights for the sub-criteria (Level 2) of the developed framework



- The AHP is a decision-making strategy used to compare alternatives on given criteria based on assigning priority weighing to the alternatives (Saaty 1980)

Procedure for AHP

1. Pairwise comparison is determined for each level of the AHP by constructing a matrix for the pairwise elements.

2. The values in each column of the pairwise matrix are summed, thereafter, each element of the matrix is divided by its column total to generate a normalized pairwise matrix.

3. When all the normalized pairwise comparison is made, the relative priority vectors also known as the criteria weight ***w*** are calculated by finding the row averages

4. The consistency of comparison is determined by using the eigenvalue (λ_{max}) to calculate the consistency index (CI), [CI= (λ_{max}-n)/(n-1)] where n = No of criteria.

5. The consistency ratio (CR) is then calculated by dividing the CI with the appropriate value of the random index (RI).

6. If CR does not exceed 0.10, it is acceptable but if it does, the judgment matrix is inconsistent and should be reviewed and improved (Saaty 1980; Al-Harbi 2001).

Table 1: Table of relative scores

Value of a_{jk}	Interpretation
9	j is extremely more important than k
8	
7	j is strongly more important than k
6	
5	j is more important than k
4	
3	j is slightly more important than k
2	
1	j is equally important as k

- To compute the weights for the different criteria, an *m x n* matrix designated as matrix A is constructed.

$$\text{Matrix } A_{jk} = \begin{matrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{matrix}$$

If $a_{jk} > 1$, then the *j*th criterion is more important than the *k*th criterion.

if $a_{jk} < 1$, then the *j*th criterion is less important than the *k*th criterion.

If two criteria have the same importance then the entry a_{jk} is 1.

Table 2: Level 2 comparison matrix

	Planning	Construction method	Quality
Planning	1.00	2.00	6.00
Construction method	0.50	1.00	4.00
Quality	0.17	0.25	1.00
Total	1.67	3.25	11.00

- The normalized pairwise comparison matrix (A_{norm}) is computed

$$\overline{a}_{jk} = \frac{a_{jk}}{\sum_{l=1}^{m} a_{lk}}.$$

Table 3: Level 2 normalized matrix (A_{norm})

	Planning	Construction method	Quality
Planning	0.60	0.62	0.55
Construction method	0.30	0.31	0.36
Quality	0.10	0.08	0.09

- The criteria weight ***w*** is built by averaging the entries on each row of A_{norm}

$$w_j = \frac{\sum_{l=1}^{m} \bar{a}_{jl}}{m}.$$

Table 4: Criteria Weight (*w*)

	Planning	Construction method	Quality	w
Planning	0.60	0.62	0.55	0.59
Construction method	0.30	0.31	0.36	0.32
Quality	0.10	0.08	0.09	0.09

- The consistency is obtained

$$CI = \frac{\lambda \max - n}{n-1} = \frac{3.01 - 3}{3-1} = 0.0046$$

- The consistency ratio (CR) is computed by comparing it with the random index (RI)

$$CR = \frac{CI}{RI} = \frac{0.0046}{0.58} = 0.008 < 0.1$$

Table 5: Random index (RI) values

Size of matrix (n)	1	2	3	4	5	6	7	8	9	10
Random consistency	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Summary of results

Level 1	Level 2	Relative Weights
Transformation	Planning	0.21
	Construction method	0.04
	Quality	0.04
	Total	***0.29***
Flows	Resources	0.19
	Information	0.16
	Total	***0.35***
Management Activities	Decision making	0.24
	Supervision/control	0.12
	Total	***0.36***

House of waste

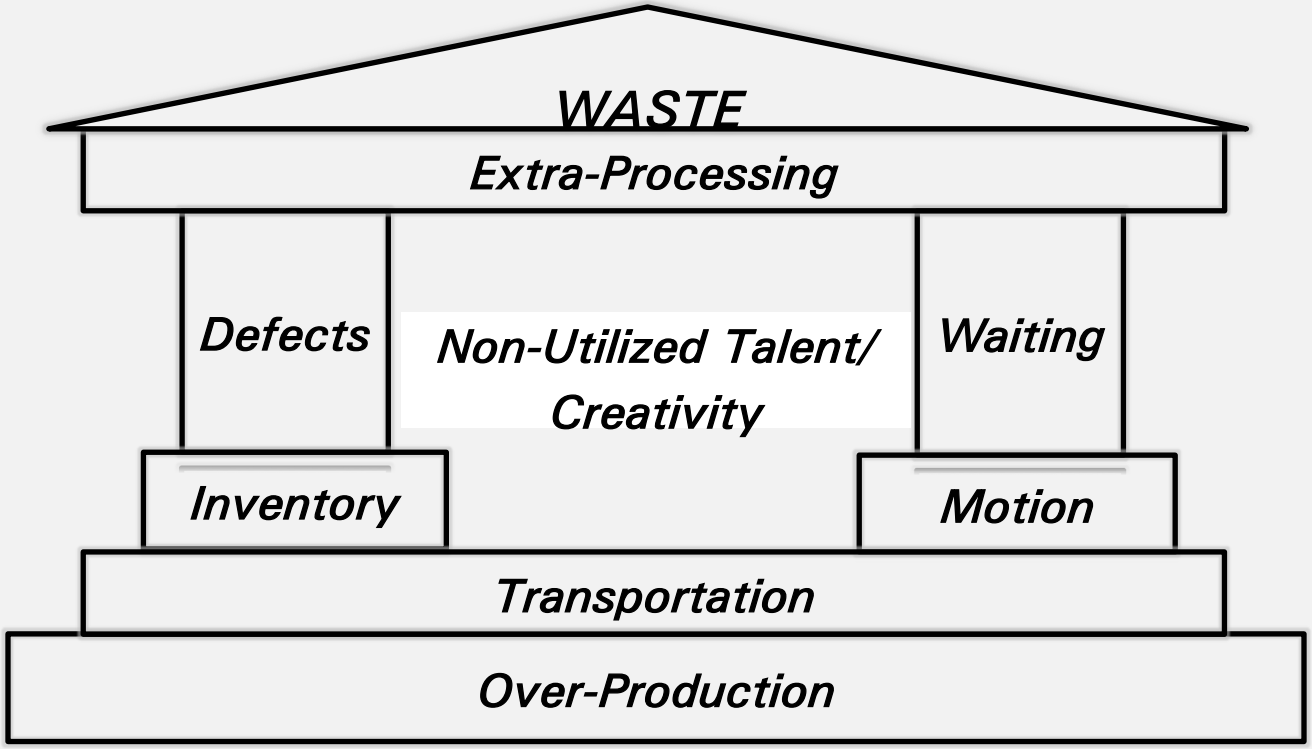


Figure 3: House of waste (adapted from house of lean)

Conclusion

- Lean thinking in construction provides an excellent opportunity for reducing waste.
- This study focused on prioritizing lean wastes based on a categorization system adopted from the TFV model.
- The essence of this prioritization is to facilitate the understanding of intervention measure
- The "House of waste' was introduced to explain the interdependency of the lean wastes.

Limitation

- The focus of the AHP was in prioritizing only level 2 criteria.
- Prioritizing the criteria alternatives was not considered.
- The study also did not provide any consideration / solutions on how to reduce the effects of the prioritized waste.

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thank you!

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