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(DFD) DESIGN FOR DISASSEMBLY FRAMEWORK: AN APPROACH TO ENHANCE THE DESIGN CONSTRUCTION PROCESS

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ABSTRACT

Design for Disassembly principles have become more integrated in architecture, by expressing materials, form, and structural assembly through their methods of connection and utilizing pure materials, with reuse and recycling capabilities. Therefore, the research focuses on investigating the importance of using the DFD concept to enhance the design construction process and to study how to include DFD principles in the design process's phases. The research methodology applied the quantitative method in the main survey (questionnaire), to suggest the systematic framework of DFD by including its guidelines in different design stages according to its importance.

***Keywords**:* Design for Disassembly, Construction Process, RIBA Design Process, Modular, Reuse, Assembly, Building Layers, Design for Environment" (DfE).

1. Introduction

"Design for Disassembly" DfD is a new idea for designing and constructing community and is a substantial funder to "Design for Environment" (DfE). DfD is essential to broaden the preservation of materials and create adaptable buildings to prevent building removals completely. Design for Disassembly (DfD) was a developed theme inside the fabricating constructions, and could be a smart method to put off inefficiency of the economic factors, which enhance the disposal and demolition of structures. It permits the mass-customization of solutions, by allowing the design team to provide strategic goals of 50% lower greenhouse gas emissions, 50% faster delivery, 50% progresses in exports and 33% lower costs, all by 2025 [1,2]. Thus, construction plays the main role in formulating solutions to minimize the use of resources, although a step change is needed to deliver the buildings we need in a more efficient and sustainable way. So, it is a challenge to adapt or deconstruct buildings for reusing and recycling in a profitable way. According to the "*Building Materials Reuse Association*", the most cited obstacle to deconstruction was "time to deconstruct" with "low disposal costs".

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1.1. Research problem

The United Nations expects that there will be a 33% rise in the world population by 2050, this will lead to more housing, infrastructure and commercial property. Evidently, 50% of the world's landfill waste derived from construction, 45 per % of the world's carbon emissions came from buildings and 90% of the world's hardwood used in the construction sector. So, many environmental, social and economic problems raised. In addition, previous studies did not include a methodical way for the design of disassembly systems, Therefore, DfD concept can increase the efficiency of a disassembly process by taking it into consideration within the main design stages.

1.2. Research hypothesis

The study assumed that by integrating the concept and guidelines of DFD in the design process will lead to;

- Reduce new materials consumption and waste in their construction, renovation and demolition, to expand the building's lives in situ.
- Create buildings that are supplies of future building materials.

This enabling of buildings and materials conservation that facilitate the recovery of their components for the next iteration, helping to provide both environmental and economic benefits for owners, builders and occupants.

1.3. Research objective (Authors' contribution)

The research suggests a comprehensive and systematic framework by merging the building's layers to design and execute disassembly systems to enhance the design-construction process.

2. Literature review

2.1. Previous studies

A considerable amount of literature has been published on DfD concept in architecture design from different points of view. From a product development viewpoint, a proposed methodology provides a model of the bond of components and modularity for offering a disassembly and recyclable component guideline for designers to store and swap their design information by using a cloud computing architecture or helping them in Joint design of products and production systems [3,4]

Moreover, to enhance the sustainability performance of products, by describing a metric to measure the complexity involved in assembly and disassembly tasks during its use phase for open architecture constructions. To provide a useful tool in the decision making for designers of product complexity's analysis during the design stage, [5]. And by proposing a method to assess product disassembly complexity that signifies the disassembly strains, that impacted on the product recovery and help in developing sustainable product design by achieving product recovery strategy, [6].

As well as to evaluate the material waste, by exploring the potential for the recapture of materials and components if the building was designed for such future recovery, by analyzing and recovering the embodied energy in buildings, and taking these considerations at the early design stage, [7].

Otherwise, propose a sequence design method by incorporating both assembly and disassembly system planning to determine the modular design for selective disassembly and interface type of assembly, by developing adjacency matrices to collect the sequence information for computational analysis, and considering the functions of products during assembly and disassembly operations, and factors of overcoming gaps between each assembly and disassembly sequence structure, [8]

2.2. Design for disassembly (Terms - Concepts)

Deconstruction is the dismantling and the rescue of the building' elements at the end of the building's life without damaging to be easily replaced, displaced, reconfigured, for future reuse and recycle to recuperate in the total life cycle. So, the building should be designed for disassembly, to act as a key for sustainable construction [9].

- *Disassembly*; is similar to deconstruction, but not necessarily to reuse or recycle building parts, it concerns with assembling the building in a way for efficient deconstruction to ensure the maximum reuse potential of its components [10].
- *Design for disassembly*; aid the future changes and the eventual dismantlement (in part or whole) for the recapture of components, systems and materials by improving the assemblies, components, materials, construction techniques, and information and management systems in the building. Thus, this process enables flexibility, convertibility, addition, and subtraction of whole buildings, which help in avoiding the removal of buildings and supporting all aspects of sustainable building [1,10].

Consequently, the design levels of the disassembly could be controlled by taking the advantage of the *BUILDING LAYERS "6S"* as follows; where the building consisted of more time-related layers which include site, structure, skin, services space plan and stuff as seen in Fig. 1, where every layer has its own service life, which could be described as; [1,11]

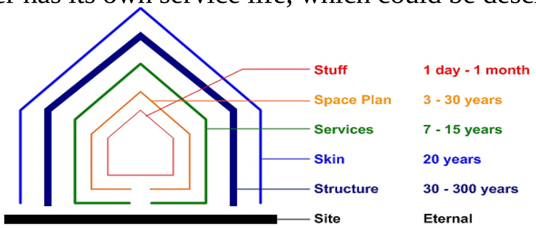

Fig. 1. Building layers and their expected lifetime [10]

- *Site;* it related to the building's surrounded urban environment, the geographical setting to deduce the expected life of the building.
- *Structure;* it is the more sustaining central layer, that involved the foundation and load-bearing elements, which could last 30-300 years.
- *Skin;* that meant the building's envelope (exterior finishes, glazing, frame, etc.) which can replace for renovation every 25 years or so.
- *Services;* act as the building's blood, (the utilities, the moving parts, HVAC systems), which may be exchanged every 7-15 years.
- *Space Plan;* It was related to the interior finishes, space division, and cabinetry, which could be repaired every three years to a much longer life.
- *Stuff;* that link up with the bared objects that modified in space and time (furniture, freestanding lamps, appliances, etc.).

Consequently, the vital difference between each layer is its lifetime, so it is essential to separate each layer from each other due to it involves different design considerations [1,11]. Therefore, what to be designed for disassembly lies on the architect to determine what and at any level the DfD must emerge by evaluating the life span of elements, which will provide adaptability and sustainability then this must be discussed with the client [12].

2.3. Design for disassembly strategies

The DfD means the multiple technologies, occupants, uses, and environmental issues during the building's life and provide disassembly and materials recovery at the end-of-life. Accordingly, the owner, the architect, the property managers and the building's facilities managers should be incorporated in the scenario-buffered planning. In this way, integrating DfD strategy will reduce the change's impacts, cost, and the friction between the original building design and alterations [11,12]. Besides, it will drive the design-thinking to consider that the "construction" of a building have a dynamic life and does not stop at the initial construction's end [1], as seen in Fig. 2.

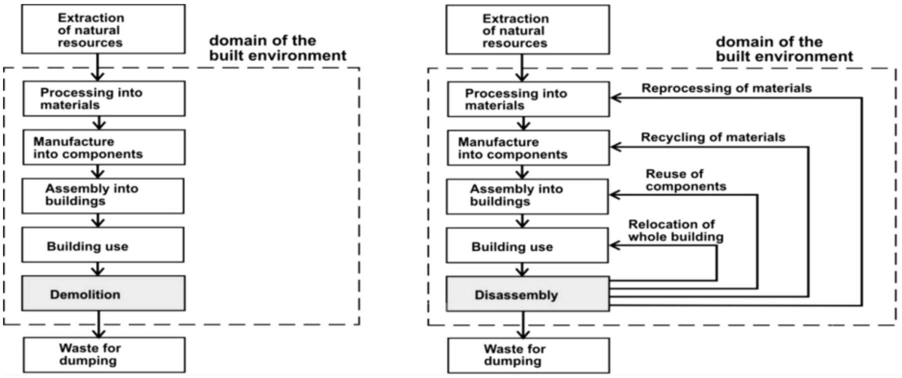

Fig. 2. Changing the life cycle from linear to cyclic model through disassembly [1]

Thus, there are many examples could illustrate this process, as in the MoMA Cellophane House, 2008, in New York, that was designed for ease of assembly, disassembly and re-assembly in a new location. They have labelled the parts, for easy lifting and transferring by a technician to conduct a site survey and plan the moves required to load the unites [13], as seen in Fig.3. Besides, the Loblolly House in Taylors Island, Maryland, 2006, was a single-family home and Off-site fabricated to be built in an entirely different way. Consequently, the joints were designed to use only simple hand means, which was detailed by parametric modelling software to confirm that the fabricated units will fit together perfectly, then built off-site. As a result, the various elements were prepared at the same time, shifting 70 % of the effort to the factory; the house was assembled in less than six weeks [14], as seen in Fig. 4.

Fig. 3. Cellophane House [13]

Fig. 4. The drawn diagram of the house's conception, and its components [14]

3. Methodology

The methodology intended to examine the main hypothesis of merging the DFD principles in the design process stages. In addition, planned to produce the DFD a framework and a guideline that would help to be a platform to enhance the construction process for designers, as seen in Fig. 5.

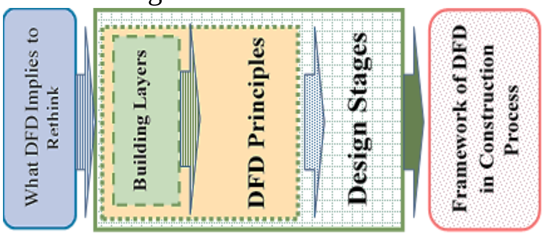

Fig. 5. the proposed Methodology [Author]

3.1. Materials/stimuli

- The main survey was a standardized questionnaire, which administered with 20 varied experienced architectural and structural engineering, to examine the extent of success in applying the DFD principles in all design stages, to accomplish the DFD Framework for enhancing the construction process.
- The statistical analysis was using the frequency analysis to investigate the relationship between principles of DFD system and the tasks of all design stages.

3.2. Variables/design of the questionnaire

The questionnaire was divided into four parts; **Part one;** represented the questionnaire's aim, the DFD concept's definition with examples, and the tasks of different design stages which adopted from the RIBA Plan of work [2] Table 1. Next **Part two;** displayed the general data of the responses, to know the specialty and the extent of the Engineer's knowledge about the subject before. Then **Part three;** consisted of closed-ended questions, that divided into five sections (each section represented the main criteria in DFD process) Table 2. Five Likert scales are designed to measure the importance of every DFD factor and criteria in the design stages. Finally, **Part four;** was a question about the barriers to applying this concept from their points of view.

Table 1 illustrate the RIBA (The Royal Institute of British Architects) plan of work for design stages, that was developed through seven stages. Each stage had basic consideration that must take into account during design process, that influenced on the next one.

Table 2 displayed the deduced the used criteria in DfD method, which was categorized into; components/structure, joints, materials, structure/construction techniques and documentation/information management system.

Table 1.

RIBA Design Stages

	RIBA STAGES
RIBA Work Stages 	**Description of key tasks**
Stage 1: **Preparation and Brief**	Develop Project Objectives, including Quality Objectives and Project Outcomes, Sustainability Aspirations, Project Budget, other parameters or constraints and develop Initial Project Brief. Undertake Feasibility Studies and review of Site Information.
Stage2: **Concept Design**	Prepare Concept Design, including outline proposals for structural design, building services systems, outline specifications and preliminary Cost Information along with relevant Project Strategies in accordance with Design Program. Agree alterations to brief and issue Final Project Brief.
Stage 3: **Developed Design**	Prepare Developed Design, including coordinated and updated proposals for structural design, building services systems, outline specifications, Cost Information and Project Strategies in accordance with Design Program.
Stage 4: **Technical Design**	Prepare Technical Design in accordance with Design Responsibility Matrix and Project Strategies to include all architectural, structural and building services information, specialist subcontractor design and specifications, in accordance with Design Program.
Stage 5: **Construction**	Offsite manufacturing and on-site Construction in accordance with Construction Program and resolution of Design Queries from site as they arise.
Stage 6: **Handover Construction and Close Out**	Handover of building and conclusion of Building Contract.
Stage 7: **In Use**	Undertake In Use services in accordance with Schedule of Services.

Table. 2.
The used DFD Criteria modified from [1]

DFD CRITERIA	
Main factors	• **Sub Criteria**
Components/ Structure	• Maximize standardization of component variations. • Separate working components into modular sub-assemblies • Provide clear identification of replacement/repair modules • separate non-recyclable, non-reusable and non-disposal items, such as mechanical, electrical and plumbing • design simple structure and forms that allow the standardization of components and dimensions. • Make the most reusable parts most accessible
Joints	• Minimize the number and types of fasteners used • Use joining technologies and methods which enable easy separation of components and materials • Standardize the use of fasteners • Use mechanical connections rather than chemical ones • Design joints and connectors to withstand repeated use • Provide access to all parts and connections of the building • Provide realistic tolerances to allow for movement during disassembly
Materials	• Reduce number of material types • Choose recycling-compatible materials • Avoid composite materials employing adhesives • [Avoid secondary finishing] • Select materials with similar component life. • Use recycled materials • Provide standard identification of material types • Avoid using materials which require separating before recycling
Structure/Construction Techniques	• Separate mechanical, electrical and plumbing (MEP) systems. • Disentangling MEP systems from the assemblies that host them makes it easier to separate components and materials for repair, replacement, reuse and recycling. • Use Simple open-span structural systems, simple forms, and standard dimensional grids for ease of construction and deconstruction. • Use assembly technologies that are compatible with standard building practice • Use prefabricated subassemblies and mass production system
Documentation/Information And Management Systems	• Code or otherwise identify parts and materials to facilitate recycling and audit trails • Document materials and methods for deconstruction, (As-built drawings, labeling of connections and materials) • Use a "deconstruction plan" in the specifications all contribute to efficient disassembly and deconstruction. • Allowing for movement and safety of workers, equipment and site access • Provide spare parts and on site storage for custom parts • Use a hierarchy of disassembly related to expected life span of the parts • Allow for parallel disassembly rather than sequential disassembly

4. Results and discussions

4.1. Sample's demographic analysis

The sample consisted of academics and practitioners, 80% of the sample were familiar with the disassembly's concept. Their sources of knowledge were varied; 60% due to general and specialized reading.

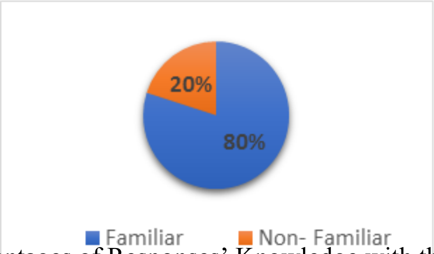

Fig. 6. Percentages of Responses' Knowledge with the DFD [Author]

4.2. Importance of DFD criteria in different design stages

By analyzing the questionnaire responses on the importance of DFD standards at each stage of the design, the following choices were extracted:

4.2.1. Importance of components/structure criteria at each design stage

Table 3 shows that: **1)** The importance of the standard (*Maximize standardization of component variations*) was shown in the early design's stages, while its importance increased and was needed to use it in (*Developed design, technical design and construction stage*); **2)** The standard (*Separate working components into modular sub-assemblies*) one of the criteria that was becoming increasingly important in the first five stages, started from; *Preparation and Brief, Concept Design, Developed Design, Technical Design and Construction Stage;* **3)** The standard of (*Providing Clear Documents*) is particularly important in two phases; *Developed Design and Construction Stage*, for easy replacement and repair of units; **4)** The criterion for (*Separating Non-Recyclable Elements*) was becoming increasingly important from the second phase *Developed Design;* for easy handling in the rest of the design stages; **5)** The criterion of (*Designing Simple Structural Structures*) is increasingly important in two phases; *Concept Design and Construction*. **6)** The standard of (*Making the Most Reusable Parts Easy to Access*) is one of the basic principles that should be taken into account in the design's early stages, and then its importance was increased at the rest of the stages to facilitate maintenance and disassembly.

Table 3.
Importance of components/structure criteria [Author]

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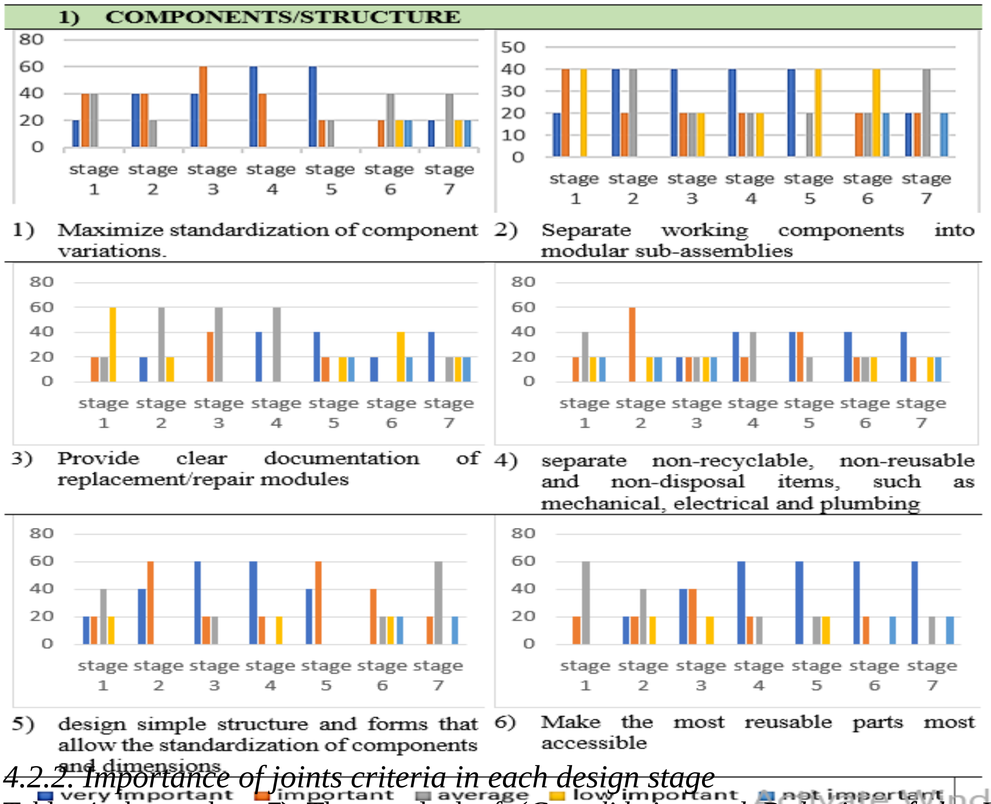
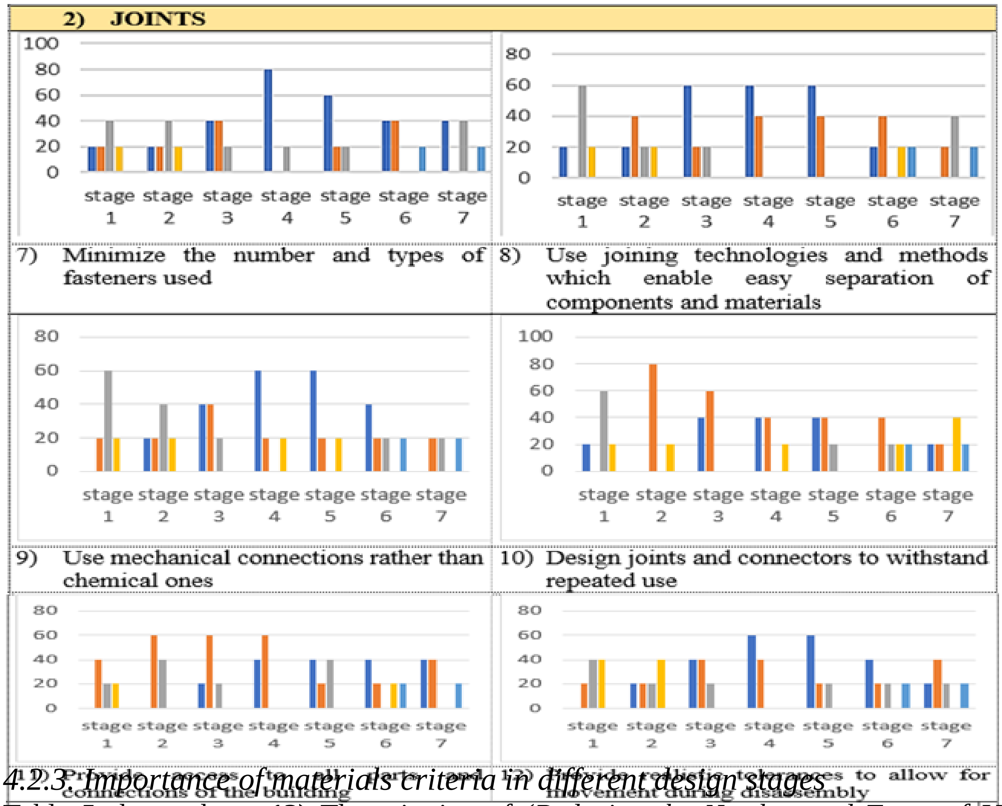


4.2.2. Importance of joints criteria in each design stage

Table 4 shows that: **7)** The standard of (*Consolidation and Reduction of the Used Connection's Number and Types*) is increasingly important in two phases; *Technical Design and Construction Stage;* **8)** The importance of linking techniques and means that make it easy to separate materials and components was increased in stages; *Developed Design, Technical Design and Construction.* **9)** The use of mechanical connections rather than chemical connections is progressively important in two phases; *Technical Design And Construction Stage;* **10)** Design joints to withstand the repeated use were starting from phase; *Concept Design and Developed Design;* **11)** From the first four stages; *Preparation and Brief, Concept Design, Developed Design and Technical Design*, the standard of accessibility to all parts and connections of the building is progressively more essential; **12)** It is more important to provide adequate clearance for movement easily during disassembly in stages; *Technical Design and Construction Then Handover Construction and In Use Stages.*

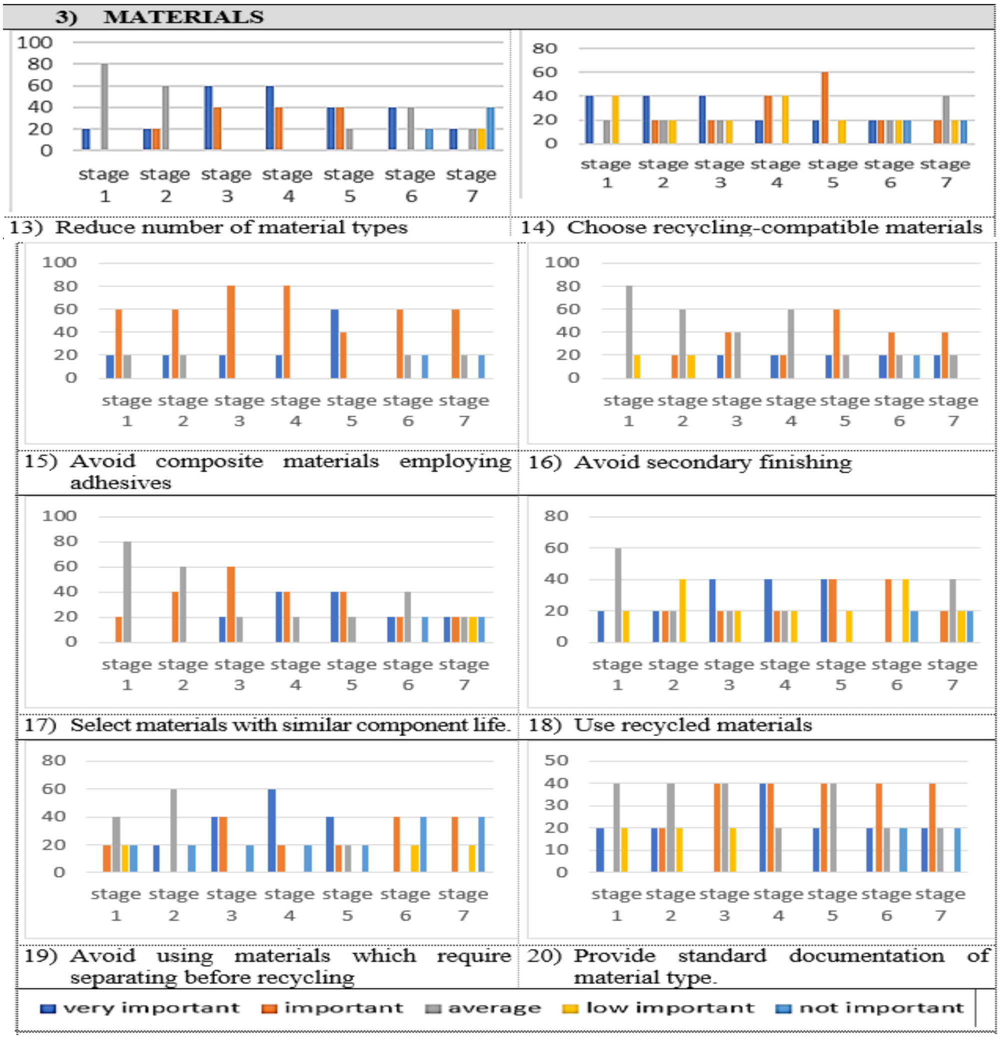
Table 4.
Importance of joints criteria [Author]



4.2.3. Importance of materials criteria in different design stages.

Table 5. shows that: **13)** The criterion of (*Reducing the Number and Types of Used Materials*) is becoming ever more important in stages; *Developed Design, Technical Design and Construction;* **14)** The selection of compatible materials are progressively vital in the construction phase, by taking into account at the beginning of two phases; *Developed Design and Technical Design.* **15)** The status of the standard (*Avoiding The Use of Composite Materials from The Design Stages*) is ultimate in both stages; *Developed and Technical Design;* **16)** Avoidance of secondary adjuvants standard is increasingly important at the *Construction* stage; **17)** The criterion of (*Selecting Materials and Units with A Similar Default Age*) was important in two phases; *Developed and Technical Design;* **18)** Starting from; the Developed, Technical, Construction and Handover Construction stages, the usage of recycled materials was progressively imperative; **19)** It is progressively more important to avoid using materials that required separation before recycling in stages; *Developed, Technical and Construction;* **20)** The provision of standards' documentation for types of the used materials is important at all stages of design.

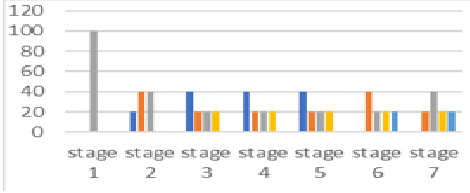
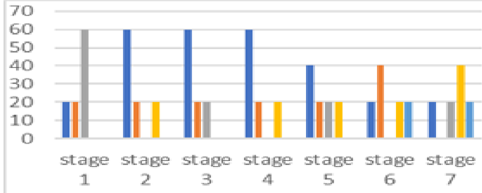
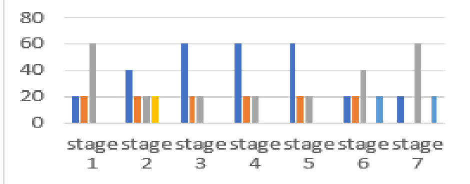
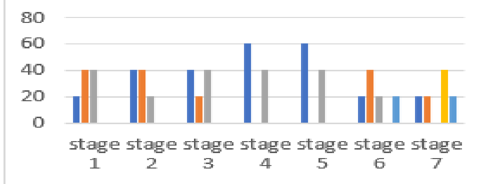
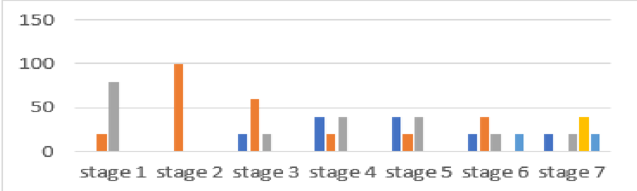
Table 5.
Importance of materials criteria [Author]



4.2.4. Importance of structure/ construction techniques criteria in different design stages

Table 6 shows that: **21)** Separation of mechanical and electrical systems is important at all stages started from the first stage; *Preparation and Brief*, then becomes more important in the stages; *Developed Design, Technical Design, Construction and Handover Construction and Close Out;* **22)** The use of *Simple Structural Systems* is increasingly important in; *Concept Design, Developed Design and Technical Design*, then *Construction Phase;* **23)** Usage of compatible-systems assembly techniques were more important in stages; *Developed Design, Technical Design and Construction*; **24)** Mass production system and usage of formerly manufactured components is becoming increasingly important in stages; *Technical Design, Construction, And Handover Construction and Close Out;* **25)** The components and material's design in a suitable size is becoming significant in both phases; *Developed and Technical Design*

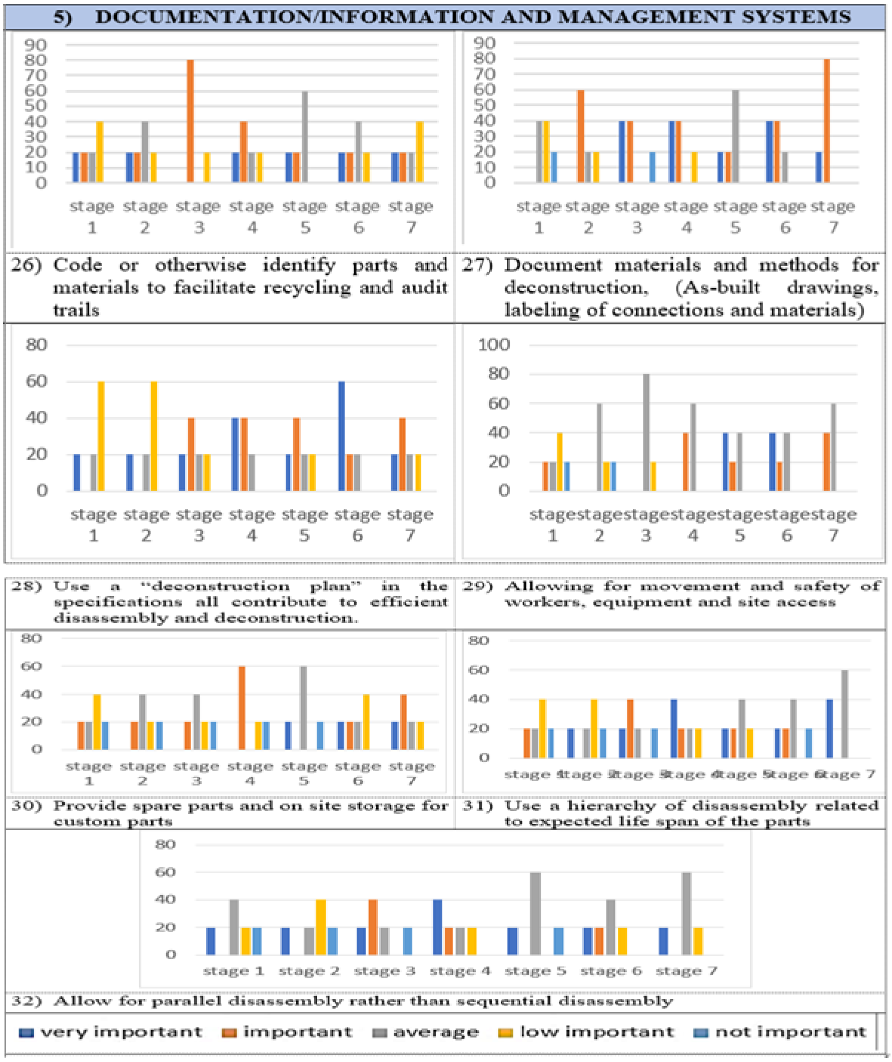
Table 6.
Importance of structure/ construction techniques criteria [Author]

4) STRUCTURE/CONSTRUCTION TECHNIQUES	
	
21) Separate mechanical, electrical and plumbing (MEP) systems. for repair, replacement, reuse and recycling.	22) Use Simple open-span structural systems, simple forms, and standard dimensional grids for ease of construction and deconstruction.
	
23) Use assembly technologies that are compatible with standard building system	24) Use prefabricated sub-assemblies and mass production system
	
25) Design components and materials with a suitable size for the used means during disassembly	
very important · important · average · low important · not important	

4.2.5. Importance of documentation/information and management systems criteria in different design stages

Table 7 shows that: **26)** Increasing the importance of cadres coding, in stage; *Developed Design;* **27)** Documentation of materials and methods for disassembly is increasingly important in phase; Concept Design and In Use, then in Developed Design, Technical Design Handover Construction; **28)** Using a disassembly plan is progressively important at the stage; *Handover Construction and Close Out*, then followed in importance; *Developed, Technical Design, Construction and In Use;* **29)** The criterion; *Allow Movement and Worker Safety* is more and more important in; *Technical Design* and *In Use* stages; **30)** Providing of spare parts is ever more important in two phases; *Technical Design* and *In Use*; **31)** The using of the hierarchy process was increased in; *Developed Design* and *Technical Design* stage; **32)** The permitting of parallel disassembly is becoming progressively essential in; *Developed Design*, *Technical Design* and *Handover Construction* and *Closeout.*

Table 7.
Importance of documentation/information and management systems criteria [Author]



4.3 The barriers in applying DFD strategy in Egypt

Initially, through the analysis of the sample answers, the research found that most of the sample 80% confirm that the financial and time constraints, lack of information about the parts, as well as the loss of craft skill to produce joints and site requirements or storage is the main obstacles for application in Egypt. Then, it followed by obstacles such as; negative awareness of using the building's parts, performance's risks, absence of the expected corrosion visibility, and lack of markets for the building's reconstructed parts, as seen in Fig. (7).

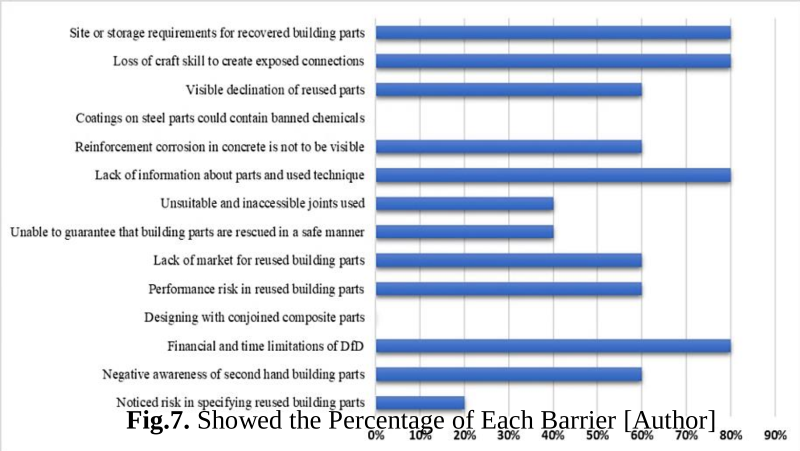


Fig.7. Showed the Percentage of Each Barrier [Author]

5. Conclusion and recommendation

As a result, with the design goals, DfD effects on construction efficiency and should be considered in each design stage. Thus, Design for Disassembly methods redefining the role of the design parties (User, Owner, Designer, and Consultant) through facilitating the enough information's task about the used techniques.

Accordingly, the final framework was deduced from the previous analysis, consistent with its importance's percentages in each design stage. That framework connects the required design considerations that attained from the design stages and DFD principles provided for each building's layer, to reach a level of design for disassembly with a very methodic and precise procedure aiding in the interaction among the different building layers and the boundaries between the architect, structural and mechanical engineers in order to do a better and smarter design.

So, the research recommended taking into consideration the deduced framework for designing and implementing different types of projects, as shown in Table.9.

Table 9.
The Final Framework of DFD In Design Stages [Author]

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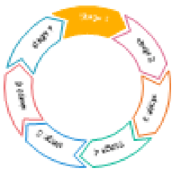
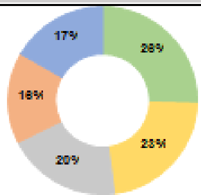
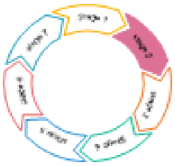
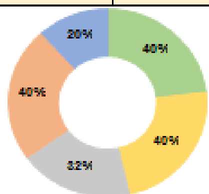
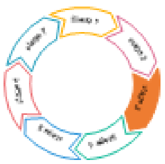
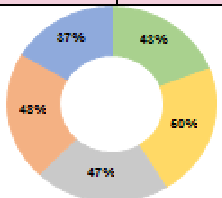
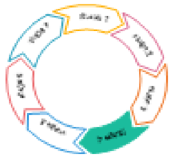
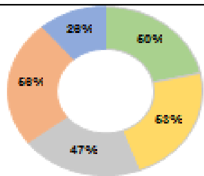
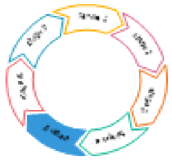
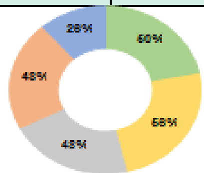
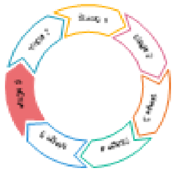
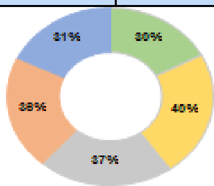
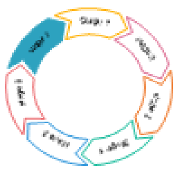
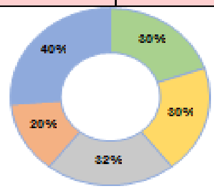
components/structure; joints; materials; structure/construction techniques; documentation/information and management systems			Importance Of DFD Factors	Design For Disassembly Requirements In Construction Stages	Building layer in design stages
Preparation and Brief	Design Stages	STAGE 1 		The Initial Project Brief should include a requirement for DfD principles to be adopted as follow; encourage the design team to involve the approach in design. When assembling; the design team the client should intend to consider the importance of components/structure, joints and materials factors respectively, that will help in assessing the design team's ability to provide the user of DfD.	Site, Structure Skin; Services; Space Plan; Stuff
	design	Develop Project Objectives, including Quality Objectives and Project Outcomes, Sustainability Aspirations, Project Budget, other parameters or constraints and develop Initial Project Brief. Undertake Feasibility Studies and review of Site Information.			
	Roles of Design Parties	Consultant	Designer	Owner	User
			√	√	
Concept Design	Design Stages	STAGE 2 		Many aspects of DfD need to be 'hard-baked' into the design at Stage 2, based on modular components with a degree of repeatability. So, for successful and sustainable Stage 2 Construction Strategy, the designer should consider applying equally: Components/structure, joints and structure/construction techniques factors during this stage. So, DfD required a Construction Strategy that is focused on more efficient ways of assembling buildings.	Structure Skin; Services
	Tasks of design stages	Prepare Concept Design, including outline proposals for structural design, building services systems, outline specifications and preliminary Cost Information along with relevant Project Strategies in accordance with the Design Program. Agree alterations to brief and issue Final Project Brief			
	Roles of Design Parties	Consultant	Designer	Owner	User
		√	√		
Developed Design	Design Stages	STAGE 3 		Coordination of elements designed with prefabrication in mind, particularly with the increased use of multi-functional components, to eliminate duplication and reduce costs. Early gaining of factory-manufactured models will help the design team to improve designs before mass production, reducing the tricky details to install on site and allowing the visual aspects to be fine-tuned. So, the factors joints, structure/construction techniques then the material should be coming first in this stage.	Structure Skin; Services; Space Plan
	design	Prepare Developed Design, including coordinated and updated proposals for structural design, building services systems, outline specifications, Cost Information and Project Strategies in accordance with the Design Program.			
	Roles of Design Parties	Consultant	Designer	Owner	User
		√	√	√	

Table 9. (Cont.)

	Design Stages			Design stage			Consultant	Designer	Owner	User
Technical Design	STAGE 4			Prepare Technical Design in accordance with the Design Responsibility Matrix and Project Strategies to include all architectural, structural and building services information, specialist subcontractor design and specifications, in accordance with the Design Program.	At Stages 2 and 3, the building components are progressively developed and coordinated. Stage 4 should contain the produced design-intent information from the design team and the follow-on development of fabrication information. In situations where the design team, the contractor has worked together previously, short cuts may be feasible. That appeared obviously with; structure/construction techniques, joints, components and materials respectively.	Skin; Services	√	√		
Construction	STAGE 5			Offsite manufacturing and onsite Construction in accordance with the Construction Program and resolution of Design Queries from site as they arise.	The site will be turned into a manufacturing or consolidation center. Prefabricated units can be delivered to site for erection. Such as; Pre-cut boards and studs, tested wiring looms, prefabricated services units, electrical distribution board and ventilation unit. That clearly appeared in the following factors; joints, components then material and construction techniques in that order.	Site, Services; Space Plan; Stuff	√	√		
Handover Construction	STAGE 6			Handover of building and conclusion of the Building Contract.	Verifying the 'As-built' information is vital at Stage 6, for available excellent data during the building's life to maintain it. This information including how the building might be disassembled at the end of Stage 7. So, it is essential to take into consideration the material, joints and structure/construction techniques factors which helped in forming the required as-built documentation.	Structure Skin; Services; Space Plan	√	√	√	
In Use	STAGE 7			Undertake in Use services in accordance with Schedule of Services.	Evaluating a building's performance in 'real time' will progressively become regular. This will allow the client and design team to receive Feedback on a building's performance, for further improvement in its performance; a circular process, where Stage 7 to Stage 0 activity reveals value. Maintenance concerns that related to the DfD, can be collected and fed back to the contractor and their supply chain. Therefore, the importance of documentation/ information and management systems factor has appeared in this stage.	Site, Structure Skin; Services; Space Plan; Stuff		√	√	√

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إطار عمل التصميم للتفكيك: منهج لتعزيز إجراءات تصميم البناء

الملخص العربى:

أصبحت مبادئ التصميم للتفكيك أكثر اندماجا في الهندسة المعمارية وذلك بالحد من استهلاك المواد، والتركيز على شكل التجميع الهيكلي، مع قدرات إعادة الاستخدام وإعادة التدوير. وبالتالي، يركز هذا البحث على دراسة أهمية استخدام مفهوم DFD في تعزيز عملية تصميم البناء. وقد اقترح البحث إطارا منهجيا لـ للتصميم للتفكيك من خلال إدراج مبادئه في مراحل التصميم المختلفة.