Journal of Architectural Sciences and Applications
JASA 2024, 9 (2), 1058-1077
Research article
e-ISSN: 2548-0170
https://dergipark.org.tr/en/pub/mbud

A Guide to the Reuse of Demountable Construction Elements and Components

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Abstract

The fact that the demolition of buildings that have lost their function creates environmental pollution in the form of waste they produce makes it necessary to reuse the building elements. There are important points to be ensured as of the design stage for the implementation of building dismantling. One such point is to have a designer with sufficient knowledge in designing a demountable structure in which high-level building elements can be reused. In this study, a scoring system has been developed to guide the designer in the selection of materials during the design stage so that the elements and components in the subsystems of the structures that end their life cycles are highly demountable and reusable. With this system, the designer will be able to predict to what extent the building can be dismantled and the building elements can be reused depending on the selected material.

Keywords: *Reuse, demountable, building component, element.*

Sökülebilir Yapı Elemanları ve Bileşenlerinin Yeniden Kullanımına İlişkin Rehber

Öz

İşlevini yitiren yapıların yıkımlarının atık oluşturarak çevre kirliliği oluşturması yapı elemanlarının yeniden kullanımını gerekli kılmaktadır.Yapı sökümünün gerçekleştirilmesi için tasarım aşamasından itibaren yapılması gereken bazı önemli hususlar vardır. Bunların başında tasarımcının yüksek düzeyde yapı elemanlarının yeniden kullanılabildiği bir sökülebilir yapı tasarlayabilmesi için bu konuda bilgi sahibi olması gerekliliğidir. Çalışmada yaşam ömrünü dolduran yapıların alt sistemlerini oluşturan eleman ve bileşenlerin yüksek düzeyde sökülebilir ve yeniden kullanılabilecek düzeyde olabilmeleri için tasarım aşamasında tasarımcıya malzeme seçiminde yön gösterebilecek puanlama sistemi geliştirilmiştir. Bu sistem ile tasarımcı yapının seçilen malzemeye bağlı ne oranda sökülüp, yapı elemanlarının yeniden kullanılabileceğini öngörebilecektir.

Anahtar kelimeler: *Yeniden kullanım, sökülebilirlik, yapı bileşeni, elemanı.*

Citation: Eren, Ö. (2024). A guide to the reuse of demountable construction elements and components. *Journal of Architectural Sciences and Applications*, 9 (2), 1058-1077.

DOI: https://doi.org/10.30785/mbud.1540928

Received: *August 30, 2024 –* ***Accepted:*** *November 14, 2024*

1. Introduction

The advent of Industrial Revolutionbrought about mass production with new production methods, which gave rise to high availability and low-cost products. As a result, emissions to the environment, solid waste production and landfilling have increasingly led to severe impacts due to new consumer societies and staggering growth in industrial activities. Under these circumstances, consumption of natural resources, which increases with the growing world population, will become unaffordable in near future. In this scenario, it is not only the problem of environmental pollution that becomes acute, but also the problem of global resource scarcity (European Commission, 2016; Lieder & Rashid, 2016). In this respect, reuse of building elements becomes crucial in order to reduce material waste and ensure resource efficiency. According to the United Nations Environment Program (UNEP), the built environment annually accounts for 30% of global greenhouse gas emissions and consumes 40% of all energy (Durmisevic et. al, 2017, p. 275-280). The amount of waste generated from the demolition of buildings worldwide constitutes 50% of the total amount of waste. This figure represents 180 million tons of construction and demolition waste annually in Europe (Kibert & Kibert, 2008, p. 4-8; Kibert, 1994; Crowter, 2014, p. 1-9).

A report by the World Resources Institute predicts a 300% increase in energy and material use as world population and economic activity increase over the next 50 years (Saghafi & Teshnizia, 2011, p.854). For this reason, the construction industry has recently realized the need to be environmentally responsible and has turned to activities and processes that aim at reintroducing building materials and components into the production chain to minimize their negative impact on the environment. Studies on the construction of buildings and the reusability of end-of-life waste are among the leading topics of research in both academia and industry. Deconstruction is different from destruction. While the term demolition is used for the careless destruction of structures, the term deconstruction is used to describe a selective dismantling process with the aim of recycling or reusing materials or entire elements of demountable structures for a later application (Akinade et al. 2015, p. 167-175; Obi et. al., 2021, p.2-26). Reusing building elements recovered from demolished buildings is not innovation. Not only deconstruction and adaptability save the world's depleting energy and natural material resources, but also contribute to the preservation of cultural and historical values contained in different materials and buildings (Saleh & Chini, 2009, p.30—33).

A demountable building system involves the design of buildings to facilitate future replacement by partially or completely dismantling them for the recovery of systems, components, and materials (Guy & Ciarimboli, 2005, p.2-69; Aidonis et al., 2008, p.211-216). Architects and design engineers who want to include demountability in their designs should take this into consideration in the selection of building materials, components and fasteners beginning from the first stage of design (Akinadea et al, 2017, p. 9).

Wheaton (2017) states in his graduate thesis that the reuse rate of building elements will be approximately 1% in 2016, 10% in 2020, 45% in 2050, and 80% in 2100. He argues that the recycling rate will decrease from 69% in 2020 to 35% in 2050 and to 10% in 2100, leading to a reversal from recycling to reuse, and that reuse will increase due to environmental impacts (Wheaton, 2017, p. 17). Perhaps this process will be spontaneous due to the natural depletion of resources. The age of mass production created an understanding in which cheap products were replaced by new ones without repairing them, while the old ones were seen as waste. This understanding has recently been replaced by the concept of reuse repeatedly, for we have become more aware of our responsibility to the environment. When studies on the measures that the construction sector should take against carbon emissions started in late 1980s around the world, the clearest statement regarding reuse was made in Agenda 21 at the 1992 UNESCO conference in Rio, particularly with the article that cyclical processes should replace linear ones in order to create sustainable development (Durmisevic, 2003, p. 355).

When building elements cannot meet the desired needs, they become waste and harm the ecosystem. In order to create a sustainable future, the primary goal should be the reuse of all buildings before the demolition and reconstruction processes (Paduart et al., 2009, S. 1-6; McDonough & Braungart, 2003, p.10-30). If this is not possible to achieve, it is necessary to turn to a cyclical system in which building components and elements are reused, adapted, and reuse is maximized (Debacker & Manshoven, 2016, p.6; Ness, Field & Pullen, 2005, p.1-8).

Minimizing material waste and ensuring efficient use of resources will increase the value of the investor's business on the one hand, and have a positive impact on the country's economy on the other. The degree of demountability of the structural elements that make up each construction system is different from the other. In this study, research was conducted on the demountability of light steel construction systems. Although demountability of light steel structures is predictable, it should not be limited to carrier systems as increased demountability and durability in all systems, including carrier systems, building subsystems, and all other components, will improve dismantling performance. As Cai & Waldmann, (2019) stated, there is no detailed study on demountability or the reuse of disassembled components. This study aims to show that light steel structures suitable for demountability can be included in the life cycle by reusing a high percentage of their elements through systematic dismantling, and that it is a construction system with high environmental, economic and social performance. Disassembly cannot be limited to deciding on materials and connection types. Disassembly information management also requires defining the processes that involve design decisions. Since buildings designed for dismantling have dismantling plans, and the materials have barcodes, it will be possible to know how to utilize each material after dismantling. In this way, the cycle of material use will be closed, and it will be possible to design buildings that will help transition to a zero waste construction industry (Guy & Shell, 2006). The main aspects of demountable design are listed below.

The aim of this study is to ensure resource conservation by selecting materials during the building design phase, taking into account that the building elements and components can be reused after completing their functions. In this regard, a guide has been created to determine what method(s) should be followed in order to make the right choice among all materials.

1.1. Sustainability and Demountability of Structures

Disassembly is defined as the process by which some (or all) components of a building are selectively taken apart for the purpose of reuse (Durmisevic, 2003, p. 352-361; Durmisevic, 2019, p. 12-35). Design for disassembly is defined as a feature of a product design that enables the product to be disassembled at the end of its life cycle in a way that allows its components and parts to be reused, recycled, recovered for energy, or in some cases reused. Disassembly is the non-destructive separation of an assembled product into its component or components (BS 8887-2, 2009, p. 3.11; Durmisevic, 2019, p.12-35).

Demountable construction aims to construct buildings to reduce the consumption and waste of new materials during construction, renovation and demolition processes, to increase the life of the building in situ, and to create buildings that will be future building materials. Such an approach to material and building preservation will facilitate the recovery of their components for the next renovation, and therefore provide both economic and environmental benefits for builders, owners and occupants of these buildings, as well as for the communities in which they are located. To be able to produce buildings with such an understanding, the design process must develop assemblies, components, materials, construction techniques, and information and management systems that are suitable for this goal (Deller et al., 2005, p.2-69).

Demountability involves the removal of a structure by dismantling its components in the reverse order of its construction. The last thing to be installed is usually the first thing to be removed respectively. The process may include manual and mechanical tools for dismantling. The main idea is to recover as much material as possible for reuse and/or recycling. In this sense, materials that can be reused should be preferred among the materials that can be recycled (Chini & Nguyen, 2003, p. 312; Condotta & Zatta, 2021, p. 318; Lopez Ruiz et al., 2020, p. 248; Rios et al., 2015, p. 1296 – 1304).

1.2. Demountable Building Materials and Reuse

In the demountable building design, the designer should use demountable joints in the structure design, therefore the use of welding and mortar should be avoided. It is important to design the structures with simple forms, to use a large number of standard products using modular grids, and to have a small number of types and connections. When choosing materials, the aging period of the products should be taken into consideration, durable products should be selected and composite materials should not be used. Another important point is to use light materials that will facilitate disassembly (Guy & Shell, 2006). Increasing awareness among designers and customers in the reuse of building elements, and providing incentives and rewards by local governments (shortening the approval period of the project, tax reduction, etc.) will increase the tendency towards the system in the first place. Technically, in order to increase the reliability of these elements, it is necessary to have standards, quality grading of reused materials, and a warranty certificate. Stocking sufficient quantities of the same product will also increase the applicability of the products (Eren, 2021).

The materials they are produced from and their quality play an important role in the reuse or recycling of building elements. Below, reuse of building elements and materials suitable for recycling are mentioned.

The main principles for the Life Cycle are described in international standards ISO 14040 and 14044. In addition, the European construction sector has specific standards: EN 15804 which applies at product level, and EN 15978 which applies at building level (The Environmental Impact of Reuse In The Construction Sector. n.d).

Although steel has been recycled for a long time, the reuse of this material is not at the desired level for certain reasons (Vares et al., 2019, p. 750-761; Winkler, 2010, p. 92). The removability of building and structural elements and their feasibility for reuse after dismantling should be considered carefully to determine their reuse potential with other materials and systems. In this respect, steel is an important material for sustainable construction as a material that is both removable and reusable (McDonough & Braungart, 2003, p. 15). There is no specific standard test developed for reusing reclaimed steel components. As long as they are not strongly stressed (inelastic) or do not show visible signs of plastic deformation, they can be reused in structural applications (Hobbs & Hurley, 2001, p. 98-125; Thormark, 2000, p. 1-20; Fujita, 2008, p. 230). For the reuse process of steel to become widespread (disassembly, refurbishment, testing, additional handling and handling, manufacturing), its cost must be less than the price difference between new steel and scrap (Dunant et. al., 2017, p.118–131). Structural steel and steel members of light steel structures may be reused as long as they are structurally adequate for the proposed purposes. There are certain requirements to reuse structural elements, such as the number of reuse, their size and shape, and the floor height of the new building. After cleaning steel beams and girdles from paint adhering to the surface, they can be cut into the desired length and reused if they have appropriate structural features. Durmisevic (2003) stated in his study that 83% of steel products are recycled, 14% are reused, and 3% are buried in landfill (Durmisevic, 2003, p.353).

Aluminum is a material that is preferred in many areas for its low density, high corrosion resistance, high conductivity and high ductility. Aluminum extrusions and rolled sheets are typically used as purlins and cladding for light industrial buildings. Therefore, they can be reused. Aluminum extrusions are also widely used in curtain walls and window frames. The electrolysis stage required to produce aluminum from ore is extremely energy intensive. This process requires 20 times more energy than is required to melt the equivalent mass of existing aluminum. For this reason, the aluminum industry supports the recycling of aluminum material because only 5% of the energy from the initial production is required for recycling (Allwood, 2014, p.471). In the recycling of aluminum ISO 14021 standards are used (Hydro CIRCAL recycled aluminium n.d.)

In order to facilitate the reuse of brick, it is important to label the products with the company name, indicate the raw material and firing properties, and to state the place and date of production to be able to determine the bricks that can be passed on to future generations. In cases where brick qualities differ more than today, product labeling becomes an important issue (Icibaci, 2019, p. 198-202).

Currently, there are no official standards controlling the quality of reclaimed bricks and blocks. Therefore, companies that supply recycled bricks can develop ISO accreditation under ISO9002 if they establish their own quality management systems to classify bricks according to their quality, such as first quality, medium quality and below quality. This type of system will allow customers to know what to expect and might increase customer satisfaction (Hobbs & Hurley, 2001, p. 98-125).

Brick waste from demolition can be reused in two ways. Historic bricks or those with an unusual character or color can be valuable when cleared from walls for reuse in the same project or resold for other purposes. To reuse bricks, the mortar on the surface must be cleaned (Winkler, 2010, p. 1-256). However, the mortar after the Second World War was so strong that bricks would break during cleaning with mortar remaining intact (Kowalczyk et al., 2000, p. 95-140). Generally, all types of bricks can be reused, except the bricks that come out of chimneys (Thormark, 2000, p. 1-20). If lime mortar or other weak mortars are used in applications, it is easier to reuse the bricks as they are easily separated from each other. Currently, clay bricks are rarely reused for several reasons. The first reason is the lack of feasible and economical methods for cleaning bricks. Another reason is the lack of non-destructive testing methods. However, methods are constantly improving (Thormark, 2000, p. 1-20; Webster et al., 2007, p. 55-67). It is thought that this practice will become widespread in the future with the availability of easy cleaning methods to remove mortar, for clay bricks and roof tiles are building materials that can easily be removed and reused.

Although wood is a natural renewable resource and therefore has a very low environmental impact, it is widely recycled and reused. If timber is graded, a label should provide information about the strength class, species group, and origin. This information can help the architect to see that the lumber meets their specifications. Non-structural wood can also be reused in non-structural applications, but it is not subject to the strict rules mentioned above. Many wood components reclaimed from existing structures contain nails and screws that must be removed or made safe for transport before being reused or recycled. In wooden elements to be used structurally, the gaps created by the diameters of the removed nails and the decrease in the capacities of the elements should be determined (Winkler, 2010, p. 1-256). For low-income families, second-hand construction markets provide the opportunity to build their own homes. Wooden floor coverings and other wooden structural elements tend to be replaced with new ones due to user change or changes in fashion trends although these elements have been used very little and are undamaged. Reusing these elements will provide great economy to second-hand users (Kowalczyk, Kristinsson & Hendriks, 2000, p. 95-140). *Incorporating reused wood elements can also present structural challenges for architects. The structural integrity of the reused wood may be compromised, requiring careful evaluation and design adjustments. Despite several challenges (such as health concerns, or special care and maintenance demands), the aesthetic appeal and sustainability-related benefits make the reuse of wood elements a trend in architecture that is likely to continue in the years to come (*Kuzman et al., 2024, p. 2).

Increasing recycling rates of PVC pipes will increase the life cycle of PVC and reduce the amount of PVC going to landfill. PVC can be recycled six to seven times. With a product life of 100 years, this means that PVC material could potentially have a lifespan of 600 years. All recycled PVC can be used in multilayer non-pressure pipes (Construction and Demolition Waste Guide-Recycling and Re-use Across the Supply Chain, n.d.).

Glass products that are removed from buildings and expected to be reused generally include windows, doors, partition walls, etc. They are plate-shaped glass products extracted from metal. While they can be used for the same purposes, they can also be used in making mosaic floors by grinding, melting and processing.

Ceramic tiles used as wall and floor coverings are difficult to remove from surface. The adhesive mortar on the back of tiles that can be removed without breaking them is cleaned, while the broken ones can be reused by creating new patterns according to the size of the pieces. Ceramic companies such as Corian Gronala Company and Vetrazzo Company produce covering tiles from used glass and ceramic products.

Clean and dry insulation products can often be reused in projects. However, there are certain factors that might discourage the architect to reuse these products. One factor is the relatively high cost of storing insulation products for reuse. Also, old insulation products are usually thicker, and they do not function at desired levels, which might require additional insulation and increase the total cost. Still, if the original insulation materials meet the desired insulation value, their use will be economical. Insulation layers that are not damaged by moisture should be separated from those that are damaged. Since insulation materials are usually glued or nailed to the substrate, screw holes or other damage to the panels may occur during the removal process. The damaged parts of the insulation must be separated or repaired to increase their effectiveness. While carrying out these operations, it is necessary to ensure that there is no performance loss, there is no increase in costs, and there is no tendency towards new products (Winkler, 2010, p. 1-256). Thermal insulation products such as rigid Expanded Polystyrene (EPS), Polyisocyanurate (PIR), mineral wool and glass wool (in smaller quantities) are also available in used building products market. Particularly, insulation panels are often available on the used product market, and they are cheaper than their new equivalent products (Icibaci, 2019, p. 198-200). The change in the heat conduction coefficient of insulation materials over time should be determined by tests and technical information about the current situation should be given in detail. *EN 13501-1 for fire resistance, ISO 9221 for corrosion resistance, EN 29053 (ISO 9053) for air permeability, EN 29052-1 for acoustic applications, EN ISO 10140-1 for sound ınsulatıon, EN 16012 for durability, EN ISO for vapor diffusion 12572, EN 13859-1 for water tightness* (Thermal Insulatıon Products For Buildings With Radıant Heat Reflective Componenets. 2015 European Assesment Documents n.d). Products for mechanical and electrical services such as lamps, taps, boilers, elevators, fans, fixtures, radiators and plumbing are the best-selling materials in the reuse market (Icibaci, 2019, p. 98-200).

2. Material and Method

In this study, the scoring system that has been developed to measure the demountability and usability of the elements in building subsystems after dismantling consists of two stages. Firstly, the products to be used in all subsystems are listed and coded. These elements and components are scored on a Likert scale according to the criteria of durability, demountability and sustainability, with numerical data taken from the literature and in consultation with experts. During the design phase, each subsystem is scored according to the determined criteria. When the scores given to all the subsystems are added together, the demountability score of that structure is found. The designer can increase the degree of demountability of the structure by choosing different products during the design phase (Eren, 2021).

3. Findings and Discussion

3.1. Material Selections

Detachable light steel structure design should be made according to the characteristics of the building elements and the relationships established by the building subsystems (Table 1, Figure 1). In Table 2, the building subsystems that are planned to be used in the subsystems are grouped according to the basic materials. Materials of the elements and components that make up all the subsystems of light steel structures are then classified and coded (Table 4,5,6).

The values given according to the criteria in the selection of building elements and components determine the level of their reusability after the structure is dismantled.

This study is based on the principle of scoring the 5 subsystems of light steel structure separately. In the scoring tables, all components that make up the subsystems are scored according to the criteria determined in Table 3.

Table 1. Materials used in building subsystems (Original)

Roof Coverings	Wall Claddings	Floor Coverings	Water Insulation	Thermal Insulation
Terracotta Roof Covering Metal Roofing Cement Roof Coverings Bitumen Based Roof Coatings Polymer Based Roof Coverings Glass Coatings Stone coverings Wooden Roofing	**Exterior Wall Coverings** Cement Based CoatingMetal Based Coatings Polymer Based Coating Baked Clay Based Coating Stone Veneer Glass Coated Wood Veneer **Interior Wall Coverings** Gypsum Plaster + Paint Coating. Paper Coating Ceramic coating Wood Veneer	**Floor Coverings** Natural Stone Veneers Cement Based Coatings Wood and Wood Based Coatings Artificial Polymer Based Coatings Natural Polymer Based Coatings Glass Based Coatings Metal Based Coatings Carpet Coverings Stone Veneers **Ceiling Covering** Structural Coverage	Bitumen Based Products Plastic Based Products Special Waterproofing Boards Vapor Blocker-Moisture Blocker Vapor Balancer	Thermal Insulation Products of Plant and Animal Origin - Organic Insulation Mineral origin thermal insulation products Thermal insulation products of synthetic origin (synthetics)

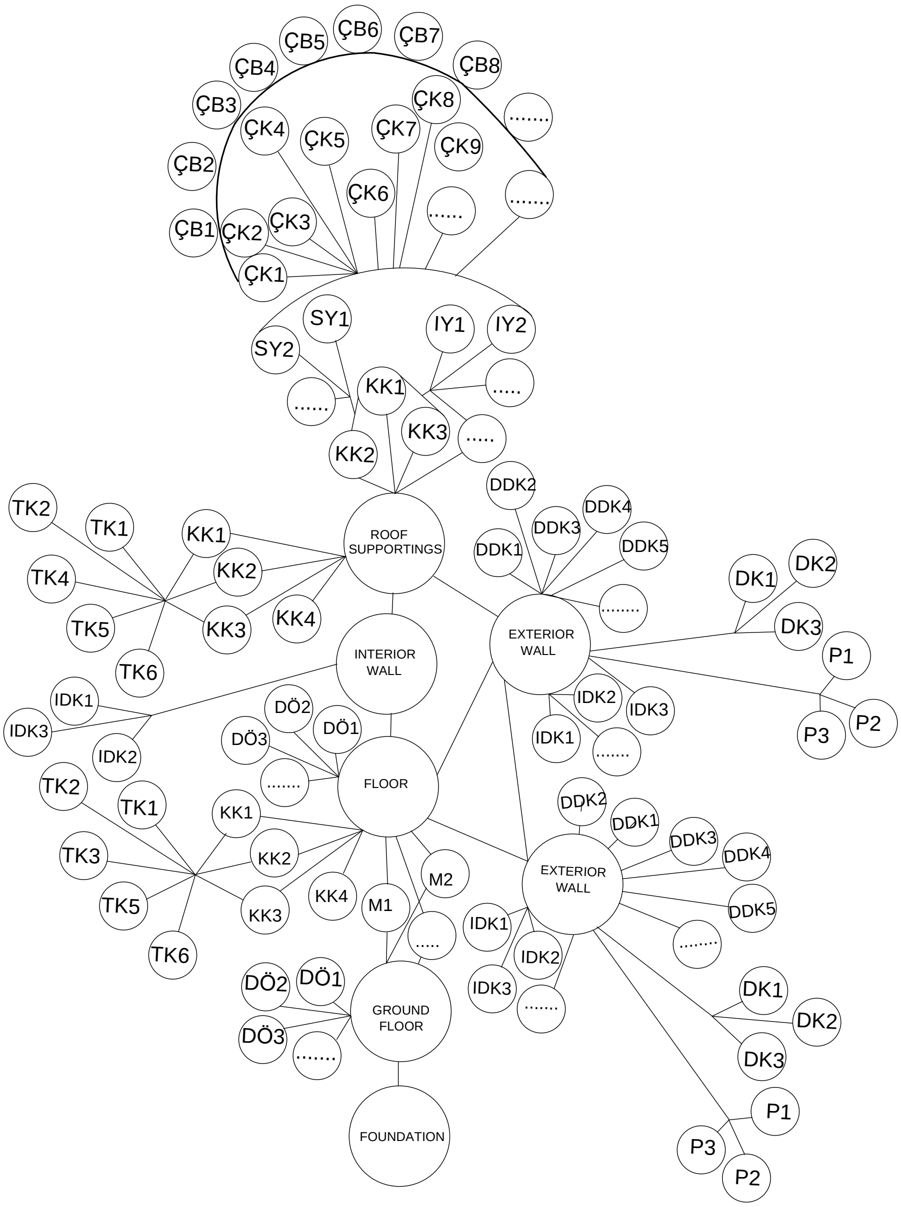


Figure 1. Relationship of detachable structural elements with the light steel carrier system (Eren, 2021)

Table 2. Demountable scoring table of light steel structure (Eren, 2021)

BUILDING ELEMENT	
1.ROOF COVERING	
2.WALL CLADDING	
3.INTERIOR WALL CLAD.	
4.FLOOR COVERING	
5.STRUCTURAL COVERING	
6.FIXING ELEMENT	
7.WATER INSULATION	
8.HEAT INSULATION	
9.ROOF FINIFHING	
10.FINISHING ELEMENT	

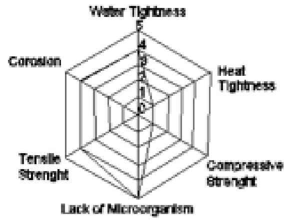
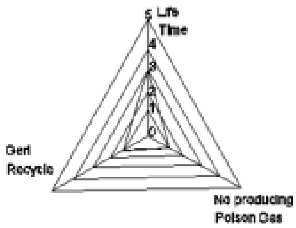
TOTAL SCORE	
MAIN SCORE	
DURABILITY	
	
SUSTAINABLITY	
	
DISASEMBLY	

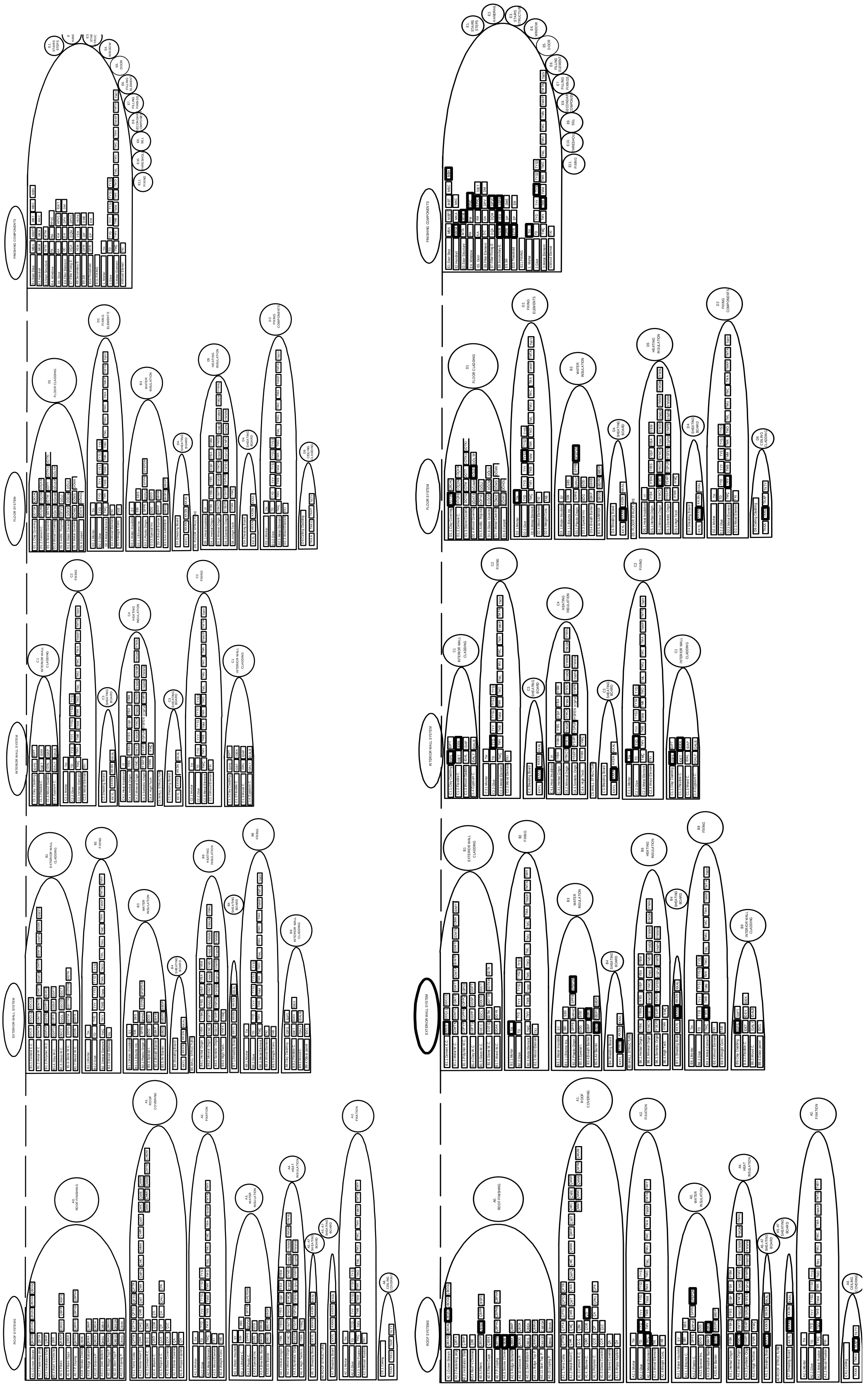
Table 3. Main and sub-criteria (Eren, 2021)

Main Criteria	Sub-criteria
Durability	Waterproofness Thermal expansion Compressive strength Tensile strength Microorganism growth Corrosion formation
Demountablity	
Sustainability	Life span Does not emit toxic gas Recyclability

Table 4. Classification of the elements and components that make up the building subsystems by coding them according to materials (Eren, 2021)

CONSTRUCTION MATERİALS	KOD
1.ROOF COVERINGS	**ÇT**
Terracotta Roof Coverings	
Marseille Tile	Ç$_{PTM}$
Ottoman Tile	Ç$_{PTA}$
Corrugated Tile	Ç$_{PTD}$
Roman Tile	Ç$_{PTR}$
Metal Roof Coverings	
Single Layer Roof Coverings	
Bullet	Ç$_{MK}$
Zinc	Ç$_{MÇ}$
Copper	Ç$_{MB}$
Titanium	Ç$_{MT}$
Aluminum	Ç$_{MA}$
Stainless Steel	Ç$_{MPÇ}$
Corten Steel	Ç$_{MC}$
Metal Tile	Ç$_{MMK}$
Insulated Metal Roof Coverings Sandwisch	
Two Sided Metal Sandwich Panel	
Polurethane Insulated Panel	Ç$_{MIP}$
Rockwool Insulated Panel	Ç$_{MIT}$
Glasswool Insulated Panel	Ç$_{MIC}$
EPS	Ç$_{MIE}$
Membran Sandwich Panels	
Sandwick Panels Made on Site	
Two sided Metal Sandwich Panels	Ç$_{MYM}$
Top Face Membrane Systems	Ç$_{MÜM}$
Cement Based Roof Coverings	
Fiber Cement Based Corrugated Sheet	Ç$_{LÇ}$
Concrete Tile	Ç$_{BK}$
Bitumen Based Toof Coverings	
Bitumen Sheets	Ç$_{BÖ}$
Corrugated Bitumen Sheets	Ç$_{OB}$
Asphalt Shingle	Ç$_{S}$
Polymer Based Roof Coverings	
Glass Fiber Reinforsed Polyester (GFR)	Ç$_{CE}$
PolikorbanAT (PC) Sheets	Ç$_{P}$
Acrylic based Roof Coverings	Ç$_{A}$
Polivinil Chloride (PVC) Sheets	Ç$_{PKL}$
Plastic Tiles	Ç$_{PK}$
Glass Coatings	
Glass Tile	Ç$_{CK}$
Laminated Glass	Ç$_{LC}$
Stone Veneers	
Slate	Ç$_{A}$
Wooden Roof Coverings	
WoodenHartama (bedavra)*	Ç$_{H}$
2.WALL CLADDİNGS	**DDK**
Cement Based Coating	
Plaster	DD$_{ÇS}$
Fiber Cement Board	DD$_{ÇLÇ}$
Glass Fiber Reinforced Concrete Panel	DD$_{ÇCE}$
Metal Wall Claddings	
Single Layer Claddings	
Bullet	DD$_{MTK}$
Zinc	DD$_{MTÇ}$
Copper	DD$_{MTB}$
Titanium	DD$_{MTT}$
Aluminum	DD$_{MTA}$
Stainless Steel	DD$_{MTP}$
Corten Steel	DD$_{MTC}$
Composite Claddings	
Sandwich Panels made on Site	
Polymer Based Facade Claddings	
Vinyl Polymer Facade Cladding-PVC	DD$_{PVP}$
PMMA-Acrylic Sheet	DD$_{PPM}$
PC Panel	DD$_{PPC}$
Glass Fiber Reinforced Polyester Sheet	DD$_{PCE}$
Clay Facade Claddings	
Brick	DD$_{PTU}$
Plaque	DD$_{PP}$
Ceramic Tile	DD$_{SP}$
Teracotta	DD$_{PT}$
Glass Claddings	
Glass Composite PVB	DD$_{CC}$
Laminated Glass	DD$_{CL}$
Prestressed Glass	DD$_{CÖ}$
Tempered Glass	DD$_{CT}$
Stone Claddings	
Granit	DD$_{TG}$
Marble	DD$_{TM}$
Travertine	DD$_{TTR}$
Sandstone	DD$_{TKM}$
Limestone	DD$_{TK}$
Wood Claddings	
Wood Composite	DD$_{MK}$
Weather boarding	DD$_{MK}$
3. THERMAL INSULATION	
Herbal Origin	
Hemp	IYB$_{K}$
Sheep Wool	IYB$_{KO}$
Cellulose	IYB$_{S}$
Cooton	IYB$_{P}$
Wood Wool Board	IYB$_{A}$
Mushroom	IYB$_{M}$
Mineral Origin Thermal Insulation	
Glass Wool	IYM$_{CY}$
Rock Wool	IYM$_{TY}$
Expanded Perlite	IYM$_{GP}$
Glass Foam	IYM$_{CK}$
Calcium Silicate	IYM$_{KS}$
Ceramic Wool	IYM$_{SY}$
Elastomeric Rubber	IYM$_{EK}$
Melamin Foam	IYM$_{MK}$
Expanded Vermiculite	IYM$_{EK}$
Wood Fiberboard	IYM$_{MK}$
Syntehetic Origin Thermal Insulation	
Ekspanded Polystytene Foam (EPS)	IYS$_{EPS}$
Ekstrude Polystytene Foam (XPS)	IYS$_{XPS}$
Polyurethane Foam (PUR)	IYS$_{PUR}$
Phenol Foal	IYS$_{FEN}$
Polyvinylchloride Foal (PVC)	IYS$_{PVC}$
Polethylene Foam (PE)	IYS$_{PE}$
Poloefin Foam	IYS$_{PK}$
Woold Wool Composite (WW)	IYS$_{WW}$
Advanced Technology Thermal Ins	
Aerojel	IY$_{MK}$
Vakum Insulated Panel	IY$_{MÇ}$
4. INTERIOR WALL CLADDINGS	**İDK**
Clay Based Claddings	
Ceramic	İD$_{PS}$
Teracotta	İD$_{PT}$
Flexible Claddings	
Textile	İD$_{ET}$
Vinyl	İD$_{EV}$
Paper	İD$_{EK}$
Wooden Wall Claddings	
Wood Panel	İD$_{AL}$
Wooden Board	İD$_{AP}$
Plaster Based Claddings	
Green Plasterboard	İD$_{ALY}$
White Plasterboard	İD$_{ALB}$
Glass Claddings	
Sheet Glass	İD$_{CL}$
5.FLOORING COVERINGS	**DK**
Terracotta	
Ceramic Tile	DÖ$_{TSK}$
Ceramic Mozaic	DÖ$_{TSM}$
Cement Based Coatings	
Concrete Screed	DÖ$_{ÇBŞ}$
Cast Mozaik	DÖ$_{ÇDM}$
Tile mozaik	DÖ$_{ÇKM}$
Stone	
Granit e	DÖ$_{TG}$
Marble	DÖ$_{TM}$
Travertine	DÖ$_{TT}$
Sandstone	DÖ$_{TKU}$
Limestone	DÖ$_{TKI}$
Wood	
Wood panel	DÖ$_{ATK}$
Parqued	DÖ$_{AMP}$
Laminated Panel	DÖ$_{LEP}$
Laminate Panel	DÖ$_{LTP}$
Artifcial Polyemer	
PVC Coatings	DÖ$_{PVC}$
Linoleum	DÖ$_{LI}$
Glass Coatings	
Glass Parquet	DÖ$_{CP}$
Glass Mozaic	DÖ$_{CM}$
Laminated Glass	DÖ$_{LC}$
Metal Coatings	
Grill Coatings	DÖ$_{MIZ}$
Metal Sheet	DÖ$_{MS}$
Metal Ceramic ve Mozaik	DÖ$_{MK}$
Carpet	
Artificial Fiber	DÖ$_{HYL}$
Natural Fiber	DÖ$_{HDL}$
6.CEILING COVERINGS	**TK**
Paper	TK$_{KA}$
Tekstile	TK$_{KU}$
Plasterboard	TK$_{AP}$
Rock Wool Panel	TK$_{TY}$
Metal Panel	TK$_{MP}$
7.STRUCTURAL COVERINGS	**KK**
OSB-particleboard	KK$_{YL}$
Plywood	KK$_{KN}$
Hatdboard	KK$_{SN}$
Plasterboard	KK$_{AL}$
8.FIXİNG ELEMENTS	**TE**
Mortar	
Natural adhesive	
Semi synthetic	T$_{YD}$
Synthetic polimer	T$_{YY}$
Termoset yapıştırıcılar	T$_{YS1}$
Akrilik polimerler	T$_{YS2}$
Termoplastik yapıştırıcılar	T$_{YS3}$
Vinil polimerler	T$_{YS4}$
Metal Fasteners	
Nail	T$_{MÇ}$
Screw	T$_{MV}$
Bolt	T$_{MB}$
Metal Clamp	T$_{MM}$
Bracket	T$_{MK}$
Omega Profile	T$_{MO}$
L profile	T$_{ML}$
U profile	T$_{MU}$
C profile	T$_{MC}$
Agraf profile	T$_{MA}$
Perforated Corner Profile	T$_{MKP}$
Ceiling Suspention Profile	T$_{MTA}$
Thermal Insulation Fixing Dowel	T$_{MIY}$
Wooden Compenet	
Frame, slat	T$_{KL}$
Gravity Concrete	T$_{AB}$
9.WATER INSULATION	**SY**
Bitumen Based Insulation	SBI
Organic Bituminous Product	SBS
Synthetic Bituminous Product	
Plastic Origin Insulatiom	SP$_{PE}$
PolYethylene (PE)	SP$_{PVC}$
Polyvinlychloride (PVC)	SP$_{PIB}$
Polyisobitulene (PIB)	SP$_{EPDM}$
Synthetic Rubber- Ethylene Propylene Diene Terpolymer(EPDM)	
Special Insulation Products	SÖ$_{G}$
Geotextiel-Separating Layer	SÖ$_{D}$
Dranage Boards	
Vapor Barier	SBK$_{P}$
Polymer	SBK$_{B}$
Bituminous	
Vapor Balance	SBD$_{B}$
Bitumen Based Products	SBD$_{PO}$
Polymer Bitumen	SBD$_{P}$
Plastic Bitumen	
10.ROOF FINISHING	**ÇBE**
Gutter-Groove	
Hanging Gutter	ÇB$_{OAB}$
Copper	ÇB$_{OAÇ}$
Zinc	ÇB$_{OAG}$
Galvanized Steel	
Hidden Groove	ÇB$_{OGG}$
Galvanized Steel	ÇB$_{OGÇ}$
Zinc	
Fixing Strip	ÇB$_{TA}$
Ventilation Chimney	ÇB$_{HP}$
Membrane Ventilation Chimney	ÇB$_{MG}$
Sloping Roof (Shingle) Ventilation Chimney	ÇB$_{E}$
Strainer	
Stteep Drop Pipe	
PVC	ÇB$_{SDP}$
Galvanized Sheet	ÇB$_{SDG}$
Parapet Outlet	
PVC	ÇB$_{PP}$
Galvanized Sheet	ÇB$_{SPG}$
Stainer Covers – Stainless Steel Sheet	ÇB$_{SK}$
Parapet harpuşta	ÇB$_{PHA}$
Alūminum	ÇB$_{PHG}$
Galvanized Steel Sheet	ÇB$_{PHB}$
Prekast Concrete	ÇB$_{PHP}$
Stone Sheet	ÇB$_{DB}$
Smoke Chimney	
Ridge Bottom Profile	ÇB$_{MA}$
Alūminum	ÇB$_{MP}$
Stainless Steel	
Gutter Edge Profile	ÇB$_{OG}$
Galvanized Painted Profile	ÇB$_{OA}$
Aluminum	
Bottom Profile	ÇB$_{EG}$
Galvanized Painted Sheet	ÇB$_{EA}$
Aluminum	
Ridge Top Profile	ÇB$_{MÜG}$
Galvanized Painted Sheet	ÇB$_{MÜA}$
Aluminum	
Top Profile	ÇB$_{EÜG}$
Galvanized Painted Sheet	ÇB$_{EÜA}$
Aluminum	
Coping Profili	ÇB$_{HG}$
Galvanized Painted Sheet	ÇB$_{HA}$
Aluminum	
11.STAIRS AND FINISHINGH COMPONENT	**ME**
Stairs by Supporting System	
Wood	MT$_{A}$
Metal	MT$_{M}$
Stair Step Covering	
Wood	MB$_{A}$
Ceramic	MB$_{PT}$
Stone	MB$_{T}$
Glass	MB$_{C}$
Carpet	MB$_{H}$
Railing Types	
Metal Railing	MK$_{M}$
Wood Railing	MK$_{A}$
Glass Panel Railing	MK$_{C}$
Window and Exterior Door Joirney Frame	
EWood	P$_{A}$, K$_{A}$
Metal-Aluminum	P$_{M}$, K$_{M}$
PVC	P$_{PV}$,K$_{PV}$
Filling Component	
Glass	D$_{C}$
Wood panel	D$_{A}$
PVC panel	D$_{PV}$
Metal panel	D$_{M}$
Fill Component Fixing	
Slat	D$_{ÇA}$
Wood	D$_{ÇM}$
Metal	D$_{ÇV}$
Nail, Screw	D$_{ÇIV}$
Secondary Components	
Hinge	YE$_{M}$
Door and Window Handle	YE$_{K}$
Blinds, Shutters	D$_{PR}$
Sill and Threshold Types	
Precast	E$_{PR}$
Stonel Panel	D$_{P}$, E$_{P}$
Metal	D$_{P}$, E$_{M}$

Table 5-6. Material selection table (Eren, 2021)



Building subsystems are scored based on the following scoring system: according to durability, sustainability, and demountability criteria (Eren, 2021).

Durability Criteria include water impermeability, thermal expansion, compressive strength, tensile strength, microorganism growth and corrosion sub-criteria (Table 7, 8, 9, 10, 11).

The water permeability (%) values of the materials are calculated first in the scoring of water absorption. The water permeability values of the examined materials range from 0 to 30 and above. These values are scored on a 5-point Likert scale. According to the scoring system that has been established based on expert opinion, if the water impermeability value is 0, it will receive 5 points; between 0.1-5, it will receive 4 points; between 5-10, it will receive 3 points; between 11-29, it will receive 2 points, and if it is 30 and above, it will receive 1 point (Table 7).

Thermal expansion (cm / cmºC x10^{-6}) ***:*** It has been determined that the thermal expansion values of the materials (Arpacıoğlu, Ü., Diri C. 2009). that can be used in buildings are between 0 and 80 and above. Accordingly, it has been decided to give 5 points to products with a value between 0-10, 4 points to a value between 10.1-20, 3 points to a value between 20.1-59.9, 2 points to a value between 60-80, and 1 point to a value of 80 and above (Table 8).

Compressive Resistance **(N/mm^2)*:*** Compressive strength of the used components is scored between 0 and 1200. Values of 0-49 receive 1 point, 50-199 2 points, 200-499 3 points, 500-899 4 points, and 900-1200 receive 5 points (Table 9).

Tensile Strength **(N/mm^2)*:*** Tensile strength of the used components range from 0 to 800 and above. According to the 5-point Likert scale, 1 point is given to tensile strength values between 0-99, 2 points to 100-199, 3 points to 200-499, 4 points to 500-799, and 5 points are given to values of 800 and above (Table 10).

Corrosion resistance scores are given according to whether the material is metal or not, and if it is, according to its corrosion properties. For each product, the durability score is obtained by adding up the scores given to the sub-criteria under the durability criterion (Table 11). Since the evaluation of corrosion in non-metallic materials is made on a 3-point Likert scale on the Karasus Company's website, corrosion properties are evaluated according to this scale in this study, too. However, since the 5-point Likert scale has been used in this study and the materials evaluated are not limited to metal only, the three-point scale is converted into a 5-point Likert scale based on expert opinion. Accordingly, 1 (good) in Karsus's table has been converted to 5 in the evaluation table of this study; 2 (be careful) to 3 (not useful-medium), and 3 (not useable-medium) to 1. In the evaluation table of this study 5 stands for excellent and 2 for very precautionary.

Resistance to Microorganism Growth: Resistance of the components against the production of microorganisms has been scored based on expert opinion. Experts were asked to answer a set of questions with the following descriptive answers: excellent, good, average, bad, and very bad. These answers were then converted into numerical values by giving a number from 5 to 1 respectively (Table 12).

Sustainability criterion The sustainability criterion is evaluated in 3 stages according to the sub-criteria of the ***life span of the elements*** (Table 13), ***recyclability*** (Table 14) and whether they ***emit toxic gases*** (Table 15) or not. + values get the highest score of 5 points, medium +- 3 points, and - values get the lowest 1 point.

The demountability criterion has been established according to the 5-point Likert scale by taking expert opinion on the demountability levels of building elements and components.

Table 7. Water impermeability (%) (Eren, 2021)

Water absorption value	0	0.1-5	5-10	11-29	30 and above
Weighting-scoring according to 5-point Likert Scale	5	4	3	2	1

In the evaluation made on a 5-point Likert scale, 5 represents the best option and 1 represents the worst option.

Table 8. Thermal expansion (cm / cmºC $x10^{-6}$) (Eren, 2021)

Thermal expansion value	0-10	10.1-20	20.1-59.9	60-80	80 and above
Weighting-scoring according to 5-point Likert Scale	5	4	3	2	1

T

Tablo 9. Compressive Strength **(N/mm^2)** (Eren, 2021)

Compressive strenght value	500-1200	499-200	199-50	49-20	19-0
Weighting-scoring according to 5-point Likert Scale	5	4	3	2	1

Tablo 10. Tensile Strength **(N/mm^2)** (Eren, 2021)

Tensile Strenght	0-99	100-199	200-499	500-799	800 and above
Weighting-scoring according to 5-point Likert Scale	1	2	3	4	5

Table 11. Corrosion Resistance (Eren, 2021; Corosion Durability, n.d.)

Corrosion resistance	Perfect	Good	Modarete	Bad	Worse
Weighting-scoring according to 5-point Likert Scale	5	4	3	2	1

Tablo 12. No microorganism growth (Eren, 2021)

Lack of growth of microorganisms	Perfect	Good	Modarete	Bad	Worse
Weighting-scoring according to 5-point Likert Scale	5	4	3	2	1

Table 13. Life time of elements and components (Eren, 2021)

Life span	0-9	10-29	30-49	50-99	>100 and above
Weighting-scoring according to 5-point Likert Scale	1	2	3	4	5

In the evaluation made according to 5-point Likert performance, 5 represents the best option and 1 represents the worst option

Table 14. Recyclability of elements and components (Eren, 2021)

Recycle	Excellent	Fair	Bad
Weighting-scoring according to 5-point Likert Scale	5	3	1

In the recycling of coatings, + is given for those that can be recycled, - for those that cannot be recycled, and +- for those that are partially recycled.

Tablo 15. Emit toxic gases (Eren, 2021)

No toxic gas emissions	Excellent	Fair	Bad
	5	3	1

In the recycling of coatings, + is given for those that can be recycled, - for those that cannot be recycled, and +- for those that are partially recycled.

The total demountability score of the building is obtained by scoring each system of the building, consisting of roof system, exterior wall system, flooring system and finishing elements, according to its own material. When the worst items are selected from the list of materials in Table 4, the structure's score is 870; when the best materials are selected , on the other hand, the structure recevies a maximum score of 1084. The structure can be scored in 5 categories. Scores 870 and below are considered as the worst, 871-930 as bad, 931-1000 as medium, 1001-1083 as good, and 1084 and above as very good. In order to improve the scoring of the structure, the selection of elements in each subsystem must be changed.

3.2. Implementation of the Recommended System on Roof Covering

The proposed system was applied to the roof covering of a light steel structure. After the structural covering and insulation layers etc that make up the roof system are scored in the same way, the score of the entire roof system is obtained. When the roofing shingle material is selected, it is seen that it receives a total of 26 points. Each layer forming the structure is scored in this way and the total dismantling score of the building is found. The demountability score of the structure can be increased by changing the materials (Figure 2, Table 16,17,18,19,20).

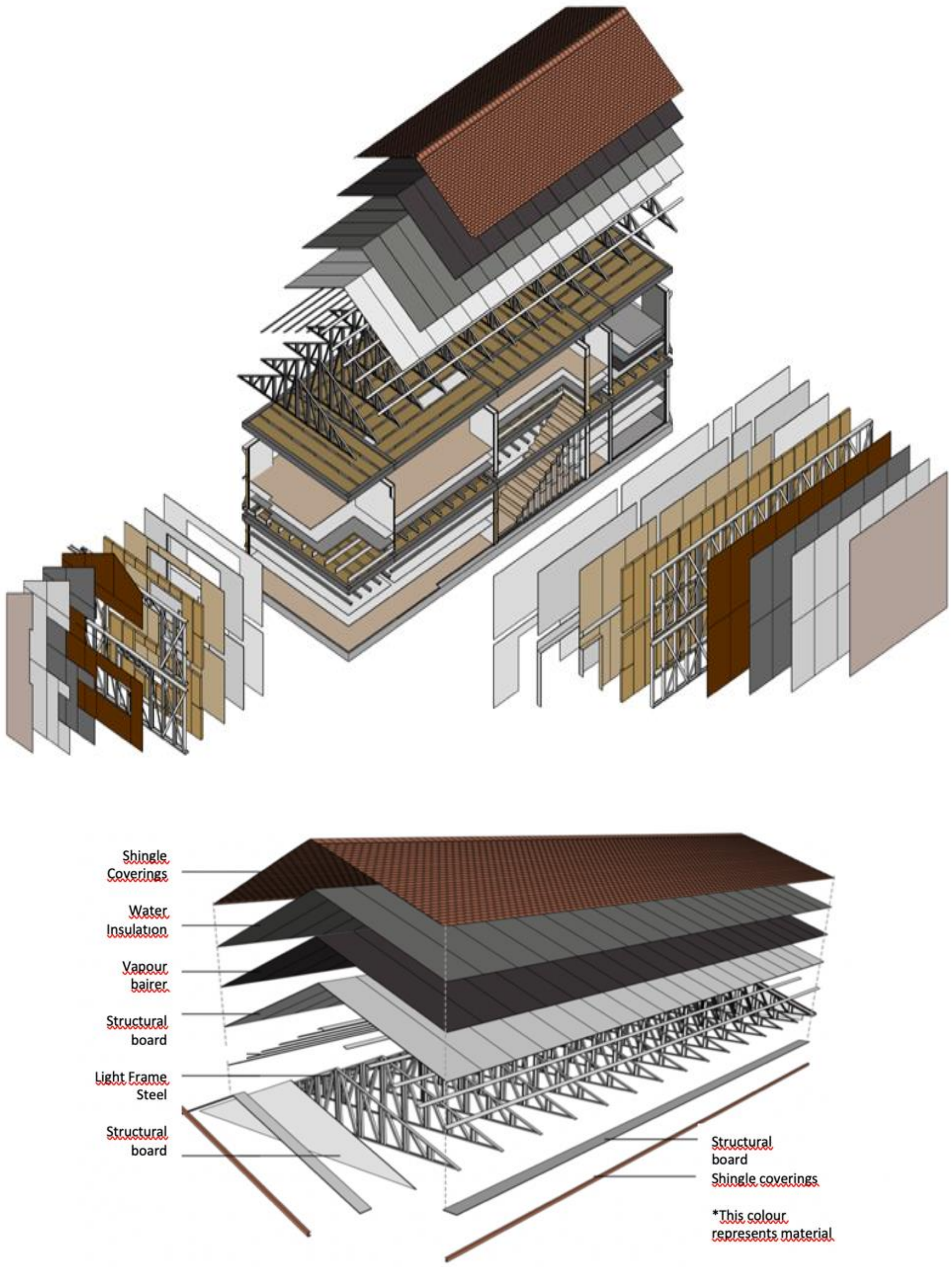


Figure 2. Separation of materials used in building subsystems into layers (Eren, 2021)

Table 16. Giving durability criterion scores of roof coverings (Anonymus, n.d.; İzo Birlik, n.d.; Cyprus Environmental Enterprises, n.d. a; Cyprus Environmental Enterprises (n.d. b); Çatı Kaplama Malzemeleri, n.d.; Almanac, n.d.; Cam Çatı Kaplamaları, (n.d.); Metal Kiremitler için Arduaz Granülleri. (n.d.); Fibercement Nedir? (n.d.); Erdem & Yatağan, 2014; Eren, 2021). Cam Elyaf Takviyeli Beton. (n.d.); Izocam Tekiz. (n.d.); Özan et al., 2017, Eren, 2021).

ROOF COVERING Main Group	Sub- Group	Code	*Waterproofing %*	SCORE	*Coefficient Thermal Expansion cm / cm°C x10⁻⁶*	SCORE	*Corrosion score*	*Microorganism Upbringing* SCORE	Compressive Strenght N/mm²	SCORE	Tensile Srenght N/mm²	SCORE	TOTAL SCORE
Clay Claddings	**Marseille Tile**	ÇPTM	10.37	3	5	5	4	4	28	2	12	1	19
	Ottoman Tile	ÇPTA	10.37	3	5	5	4	4	28	2	12	1	19
	Flat Tile	ÇPTD	10.37	3	5	5	4	4	28	2	12	1	19
	Corrugated Tile	ÇPTO	10.37	3	5	5	4	4	28	2	12	1	19
	Roman Tile	ÇPTR	10.37	3	5	5	4	4	28	2	12	1	19
Metal Wall Cladding	Lead Roofing	ÇMK	0	5	29	3	5	5	300	4	70	1	23
	Zinc Roof Coating	ÇMÇ	0	5	35	3	5	5	166	3	170	4	25
	Copper Roofing	ÇMB	0	5	16	4	5	5	350	4	230	2	25
	Titanium	ÇMT	0	5	9	5	5	5	28	2	69	1	23
	Aluminum	ÇMA	0	5	24	3	5	5	40	2	200	2	22
	Stainless Steel Galvanized S.	ÇMPÇ	0	5	12	4	5	5	515	5	860	1	25
	Metal Tile	ÇMMK	0	5	12	4	5	5	40	2	480	2	23
	Corten Steel	ÇMC	0	5	12	4	3	5	515	4	860	1	22
	Two sided metal sandwich p. Polyurethane	ÇMİP	0	5	23	3	5	5	40	2	480	2	22
	Rockwool.	ÇMİT	0	5	23	3	5	5	40	2	480	2	22
	Glasswool	ÇMİC	0	5	23	3	5	5	40	2	480	2	22
	EPS	ÇMİE	0	5	23	3	5	5	40	2	480	2	22
	Membranlı Sandwich P. Polyurethane	ÇMMP	0	5	23	3	5	5	40	2	480	2	22
	Rockwool.	ÇMMT	0	5	23	3	5	5	40	2	480	2	22
	Glasswool	ÇMMC	0	5	23	3	5	5	40	2	480	2	22
	EPS	ÇMME	0	5	23	3	5	5	40	2	480	2	22
	On-site bothe sides metal s.	ÇMYM	0	5	23	3	5	5	40	2	480	2	22
	Top Face Membrane S.	ÇMÜM	0	5	23	3	5	5	40	2	480	2	22
Cement Coating	Fiber Cement Based Corrugated	ÇLÇ	1-3	4	23	3	4	4	1000	5	300	2	22
	Concrete Tile	ÇBK	7	3	15	3	4	4	50	3	3	1	18
Bitumen Coating	Bituminous cover roof c.	ÇBÖ	0	5	121	1	4	5	0.35	1	800	1	21
	Corrugated bitumen roof c.	ÇOB	12	2	121	1	4	5	40	2	300	3	17
	Asphalt shingle	ÇS	1.5	4	121	1	4	5	0.30	1	600	4	19
Polymer Coating	Glass Fiber Polyester-CTP	ÇCE	0.16	4	25	3	5	5	63	3	132	2	22
	Polikorbanat -PC Based C.	ÇP	0.16	4	70	2	5	5	79.3	3	23.7	1	20
	Acrylic based roofing c.	ÇA	0.16	4	75	2	4	5	80	3	120	2	20
	Polivinil Chloride-PVC c.	ÇPKL	0.1-2	4	20	4	4	5	60	3	90	1	21
	Polyamide Plastic Tile	ÇPK	0.1-2	4	5	5	4	5	60	3	90	1	22
Glass Coating	Glass Tile	ÇCK	0	5	8	5	5	5	410	4	90	1	25
	Laminated Glass	ÇLC	0	5	8	5	5	5	1200	5	90	1	26
Stone Coating	Slate Tile	ÇA	3	4	9 l.par. 50 l.dik	3	5	5	100	3	90	1	21
Wood Coating	Wooden Hartama	ÇH	30-80	1	3.7	5	3	2	Lif.a10.000 Lif.d 300	4	130	2	17

Table 17. Scoring of sustainability criteria for roof coverings (Eren, 2021)

ROOF COVERINGS Main Group	Sub Group	Code	*Life Time*	SCORE	*Do not emit toxic gas*	SCORE	*Recyclability*	SCORE	Total SCORE
Clay Cladding	**Marseille Tile**	ÇPTM	150	5	+	5	+	5	15
	Ottoman Tile	ÇPTA	150	5	+	5	+	5	15
	Flat Tile	ÇPTD	150	5	+	5	+	5	15
	Corrugated Tile	ÇPTO	150	5	+	5	+	5	15
	Roman Tile	ÇPTR	150	5	+	5	+	5	15
Metal Wall Cladding	Lead Roofing	ÇMK	>100	5	+	5	+	5	15
	Zinc Roof Coating	ÇMÇ	>100	5	+	5	+	5	15
	Copper Roofing	ÇMB	70	4	+	5	+	5	14
	Titanium	ÇMT	>100	5	+	5	+	5	15
	Aluminum	ÇMA	>100	5	+	5	+	5	15
	Stainless Steel Galvanized S.	ÇMPÇ	50	3	+	5	+	5	13
	Metal Tile	ÇMMK	>100	5	+	5	+	5	15
	Corten Steel	ÇMC	>100	5	+	5	+	5	15
	Two sided metal sandwich p.	ÇMİM	70	4	_	1	+	5	10
	Membranlı Sandwich P.	ÇMMS	20	2	_	1	+-	3	6
	On-site bothe sides metal s.	ÇMYM	>50	4	+	5	+	5	14
	Top Face Membrane S.	ÇMÜM	20	2	_	1	+-	3	6
Cement Coating	Fiber Cement Based Corrugated	ÇLÇ	45	3	+	5	-	1	8
	Concrete Tile	ÇBK	100	5	+	5	+-	3	13
Bitumen Coating	Bituminous cover roof c.	ÇBÖ	35	3	_	1	-	1	5
	Corrugated bitumen roof c.	ÇOB	40	3	_	1	-	1	5
	Asphalt shingle	ÇS	25	2	_	1	-	1	4
Polymer Coating	Glass Fiber Polyester-CTP	ÇCE	35	3	_	1	+	5	9
	Polikorbanat -PC Based C.	ÇP	35	3	_	1	+	5	9
	Acrylic based roofing c.	ÇA	35	3	_	1	+	5	9
	Polivinil Chloride-PVC c.	ÇPK	35	3	_	1	+	5	9
	Polyamide Plastic Tile	ÇPK	35	3	_	1	+	5	9
Glass Coating	Glass Tile	ÇCK	>50	4	+	5	+	5	14
	Laminated Glass	ÇÖC	>50	4	+	5	+	5	14
	Slate Tile	ÇTC	>50	4	+	5	+	5	14
	Wooden Hartama	ÇLC	>50	4	+	5	+	5	14
Stone Coating	Fiber Cement Based Corrugated	ÇA	50	4	+	5	+	5	14
Wood Coating	Concrete Tile	ÇH	40	3	+	5	+	5	13

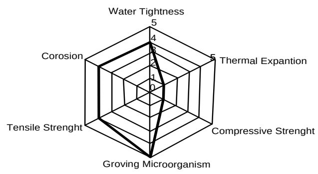
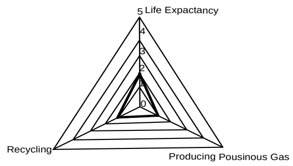
Table 18. Scoring of disassembly criteria for roof coverings (Eren, 2021)

ROOF COVERING Main Group	Sub Group	Code	Total SCORE
Clay Cladding	Marseille Tile	ÇPTM	5
	Ottoman Tile	ÇPTA	5
	Flat Tile	ÇPTD	5
	Corrugated Tile	ÇPTO	5
	Roman Tile	ÇPTR	5
Metal Wall Cladding	Lead Roofing	ÇMK	4
	Zinc Roof Coating	ÇMÇ	5
	Copper Roofing	ÇMB	5
	Titanium	ÇMT	5
	Aluminum	ÇMA	5
	Stainless Steel Galvanized S.	ÇMPÇ	5
	Metal Tile	ÇMMK	5
	Corten Steel	ÇMC	5
	Two sided metal sandwich p.	ÇMİM	5
	Membranlı Sandwich P.	ÇMMS	4
	On-site bothe sides metal s.	ÇMYM	5
	Top Face Membrane S.	ÇMÜM	3
Cement Coating	Fiber Cement Based Corrugated	ÇLÇ	4
	Concrete Tile	ÇBK	4
Bitumen Coating	Bituminous cover roof c.	ÇBÖ	3
	Corrugated bitumen roof c.	ÇOB	4
	Asphalt shingle	ÇS	3
Polymer Coating	Glass Fiber Polyester-CTP	ÇCE	5
	Polikorbanat -PC Based C.	ÇP	5
	Acrylic based roofing c.	ÇA	5
	Polivinil Chloride-PVC c.	ÇPK	5
	Polyamide Plastic Tile	ÇPK	5
Glass Coating	Glass Tile	ÇCK	5
	Laminated Glass	ÇÖC	5
	Slate Tile	ÇTC	5
	Wooden Hartama	ÇLC	5
Stone Coating	Fiber Cement Based Corrugated	ÇA	5
Wood Coating	Concrete Tile	ÇH	3

Table 19. Total score of roof coverings according to the determined criteria (Eren, 2021)

ROOF COVERINGS Main Group	Sub Group	Code	Total SCORE
Clay Cladding	Marseille Tile	ÇPTM	39
	Ottoman Tile	ÇPTA	39
	Flat Tile	ÇPTD	39
	Corrugated Tile	ÇPTO	39
	Roman Tile	ÇPTR	39
Metal Wall Cladding	Lead Roofing	ÇMK	42
	Zinc Roof Coating	ÇMÇ	45
	Copper Roofing	ÇMB	44
	Titanium	ÇMT	43
	Aluminum	ÇMA	42
	Stainless Steel Galvanized S.	ÇMPÇ	43
	Metal Tile	ÇMMK	43
	Corten Steel	ÇMC	42
	Two sided metal sandwich p.	ÇMİM	37
	Membranlı Sandwich P.	ÇMMS	32
	On-site bothe sides metal s.	ÇMYM	41
	Top Face Membrane S.	ÇMÜM	33
Cement Coating	Fiber Cement Based Corrugated	ÇLÇ	34
	Concrete Tile	ÇBK	39
Bitumen Coating	Bituminous cover roof c.	ÇBÖ	30
	Corrugated bitumen roof c.	ÇOB	31
	Asphalt shingle	ÇS	26
Polymer Coating	Glass Fiber Polyester-CTP	ÇCE	36
	Polikorbanat -PC Based C.	ÇP	36
	Acrylic based roofing c.	ÇA	32
	Polivinil Chloride-PVC c.	ÇPK	35
	Polyamide Plastic Tile	ÇPK	31
Glass Coating	Glass Tile	ÇCK	38
	Laminated Glass	ÇÖC	41
	Slate Tile	ÇTC	39
	Wooden Hartama	ÇLC	39
Stone Coating	Fiber Cement Based Corrugated	ÇA	40
Wood Coating	Concrete Tile	ÇH	38

Table 20. Demountable scoring table of light steel structure (Eren, 2021)

BUILDING COMPONENTS		TOTAL SCORE	
1.ROOF COVERING Asphalt Shingle	26	SCORING OF MAIN CRITERIA	
2.WALL CLADDING		DURABILITY	19
3.INTERIOR WALL CLAD.			
4.FLOOR COVERING			
5.STRUCTURAL COVERING			
6.FIXING TYPE		SUSTAINABLITY	4
7.WATER INSULATION			
8.HEAT INSULATION			
9.ROOF FINISHING			
10.FINISHINGS		DISASSEMBLY	3

4. Conclusion and Suggestions

The outcomes of the study are listed below (Eren, 2021).

1. Elements such as doors and windows are widely reused. This study has revealed that how the second-hand market for all building elements and components apart from these elements should be regulated is another issue that needs further investigation.
2. Changing the material selection according to the determined criteria will lead to changes in the demountability of the same structure.
3. It is crucial to have a thorough understanding of the properties of the materials used in this study, which aim to provide suggestions for the minimum waste/zero waste target in building dismantling processes, to make sure that elements produced from recyclable materials that do not contain toxic substances are used in construction, and the last layer of the building elements are more durable against weather conditions or they are not covered with synthetic substances for aesthetic reasons.
4. Economic and environmental benefits can be achieved by designing demountable structures and creating material stock for future structures. By adopting this principle, considerable amount of energy can be saved in production processes, starting from the process of obtaining materials from resources. It is important to have sufficient amount of the same elements in order to reuse them.
5. Protecting the material with coatings that can easily be separated from the surface is also important for easy cleaning of that material for further use.
6. In order to prevent waste generation by reusing building elements in the construction sector and to increase the level of reuse, certain criteria should be taken into consideration such as durability, demountability, sustainability, etc. (Eren, 2024, p. 40-56).
7. Each layer must also be classified according to their wearing time. There are also different levels of durability between the outer surface of the facade cladding and its lower layers. All technical operations must be recorded in detail including the time of the application. The same type of elements should be classified according their duration of usability: it is crucial to note whether some of them have been changed and others have been used for a longer time, which will affect the subsequent use of building elements.

In order to spread the understanding of reusability in the construction sector, courses on this subject should be designed in undergraduate education and for local governments. Government incentives should be put into effect, such as tax reductions, so that more actors in the construction sector adopt this understanding. It should be the mission of building designers to ensure that every building system is designed in a way that it will create minimum or no waste to the environment at the end of its life.

Acknowledgements and Information Note

This article was produced from the project titled 'Light Steel Construction System Waste Management Planning Map' numbered 2021/05, supported by Mimar Sinan Fine Arts University. The article complies with national and international research and publication ethics. Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

The article was written by a single author. There are no conflicts of interest.

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