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THE SUSTAINABLE BUILDINGS E-LEARNING PROGRAM

Module 4

SUSTAINABLE CONSTRUCTION AND DEMOLITION PRACTICES

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TÜRKİYE SUSTAINABLE BUILDINGS NETWORK

The Türkiye Sustainable Buildings Network was established as part of the “Türkiye Sustainable Buildings Network Project,” which is co-funded by the European Union under the Civil Society Action towards European Green Deal Grant Scheme. The project is coordinated by WRI Türkiye, in partnership with the Zero Energy and Passive House Association (SEPEV) and with the support of the Danish Green Growth Network (DGGN).

The network operates with the aim of supporting climate action in the building and construction sector, promoting green transformation, enhancing the technical knowledge and skills of sector stakeholders, and mainstreaming the concept of sustainable buildings.



As part of this effort, the Sustainable Buildings E-Learning Program has been developed to serve as a comprehensive knowledge resource for all stakeholders in the building sector. The program consists of 10 training modules designed to contribute to the sector's sustainability, energy efficiency, and low-carbon transition goals.

Module 1: Overview of Sustainable Buildings

Module 2: Decarbonization in the Building Sector and the Whole Life-Cycle Approach

Module 3: Sustainable Building Materials

Module 4: Sustainable Construction and Demolition Practices

Module 5: District Heating and Cooling Systems

Module 6: Innovative Building Technologies

Module 7: Financing Instruments for Sustainable Buildings

Module 8: Emissions Trading Systems and the Building Sector

Module 9: Energy-Efficient and Passive Building Design

Module 10: The European Green Deal and the Building Sector

For more information about the Türkiye Sustainable Buildings Network and to access other modules, please visit [the link](#).



MODULE OBJECTIVES

The objectives of the module are as follows:

- *Learning the fundamental concepts of sustainable construction and demolition practices,*
- *Understanding the requirements of demolition practices prior to sustainable building construction,*
- *Grasping the key principles of the sustainable construction process,*
- *Implementing circular economy principles during the construction phase,*
- *Reducing the impact of construction on human health and examining best practices.*

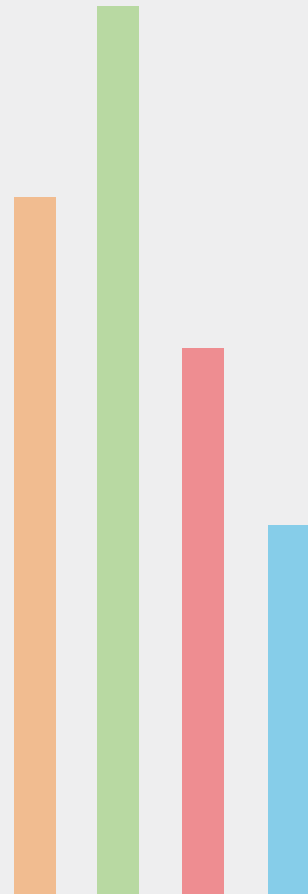


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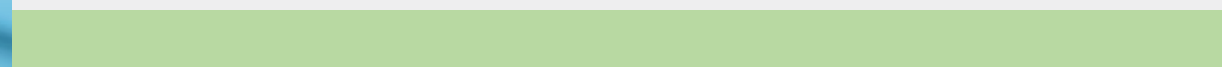
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Section 1

INTRODUCTION TO SUSTAINABLE CONSTRUCTION AND DEMOLITION PRACTICES



1.1. The Importance of Sustainable Construction and Demolition

Environmental, Social, and Economic Impacts of Conventional Construction and Demolition Practices: Construction and demolition practices that do not take environmental, recycling, and health-related considerations into account are referred to as conventional construction and demolition practices. The construction and demolition of buildings using conventional methods have extensive environmental, social, and economic impacts. Due to high natural resource consumption, waste generation, and the use of carbon-intensive materials, the conventional construction and demolition practices threatens environmental sustainability. These processes increase greenhouse gas emissions, accelerating climate change and negatively impacting ecosystems. [1]

- **Environmental Impacts:** The conventional construction and demolition practices generate significant amounts of waste and lead to adverse effects such as soil, air, and noise pollution. It involves environmentally harmful practices, including high energy consumption, unplanned transportation, the use of construction materials with a high carbon footprint, and the failure to separate waste properly.
- **Social Impacts:** The conventional construction and demolition practices processes are often non-participatory and can negatively affect communities by causing noise and air pollution, reducing overall quality of life, and leading to adverse health and social consequences.
- **Economic Impacts:** The conventional construction and demolition practices process negatively impacts the economic life of cities and regions. The social and health-related consequences impose financial burdens on national and regional economies and can also lead to higher construction costs.

Sustainable Construction and Demolition Practices: Sustainable construction is a process that considers environmental protection, recycling, nature conservation, and health from the demolition phase onward. It involves ensuring energy efficiency during construction, using renewable energy on-site, managing construction waste, applying modular and prefabricated construction techniques by pre-producing building components off-site, establishing transportation efficiency through a well-planned sustainable supply chain, using construction equipment efficiently, and preserving resources by reusing salvaged materials. Through this approach, sustainable construction and demolition practices significantly reduce or eliminate the negative environmental, economic, and social impacts of construction and demolition. These processes provide effective solutions in the fight against one of the world's most critical problems, global warming, while supporting the conservation of limited resources through circular economy principles.



1.2. Overview of Conventional and Sustainable Practices

Conventional construction and demolition practices rapidly deplete water and other virgin resources while also having negative impacts on social life and health in construction areas.

Fundamental sustainable construction practices essential for human and habitat health include:

- Ensuring energy efficiency in construction and temporary facilities,
- Increasing the use of renewable energy on construction sites,
- Managing construction waste, enabling off-site pre-production of building components, and applying modular and prefabricated construction techniques,
- Waste separation and recycling, as well as recovering construction and demolition waste,
- Reusing salvaged materials,
- Enhancing the efficiency of transportation fleets,
- Establishing a sustainable supply chain,
- Efficient use of construction materials and equipment,
- Protecting soil, water, ecology, and human health.



Image: Pexel [2]

1.3. Resource Efficiency



Image: Passengers traveling by train in Vienna can see the first photovoltaic system installed on the roof of the temporary construction site office of the Northern Railway Station construction project when looking out the window between Praterstern and Traisenstraße stations. This is an example of a construction project that meets its own energy consumption through PV panels [3].

Sustainable construction practices minimize environmental impacts by optimizing the use of water, energy, and materials.

Sustainable construction techniques help conserve water resources, reduce the consumption of virgin raw materials in building material production, and lower energy use.

Key resource efficiency strategies include:

- Recycling during construction,
- Using building materials with recycled content,
- Enhancing water efficiency,
- Preferring low-impact building materials,
- Improving energy efficiency in construction,
- Utilizing renewable energy sources.

1.4. Green Construction Method

- The energy consumption resulting from the construction of buildings, the production of building materials, and their use throughout their life-cycle accounts for a significant share of global greenhouse gas emissions. The built environment is responsible for 39% of global carbon emissions, with 28% stemming from the operational processes of buildings and 11% from construction activities and materials [4].
- Utilizing renewable energy in the following four key areas of energy consumption can significantly reduce the emissions generated throughout a building's life-cycle:
 1. Building demolition
 2. Production of building materials
 3. Construction of the building
 4. Operation of the building



Image: In Vienna, Northern Railway Station site manager Daniel and technician Niko power their equipment and vehicles with green electricity generated from the rooftop of their site office. This approach not only saves energy but also reduces construction-related emissions [5].

1.5. Low-Impact Construction Techniques

- Modular construction methods involve producing building elements in a controlled factory environment and assembling them on-site. Compared to conventional construction processes, this method significantly reduces construction waste, energy consumption, air pollution (dust), and noise levels on-site, thereby minimizing environmental impacts.
- By reducing water and energy consumption during production, transportation, and assembly processes, modular construction enables the development of buildings with lower energy, carbon, and water footprints. This approach minimizes environmental impacts throughout the whole life-cycle of a building and contributes to the creation of sustainable structures with lower embodied carbon.
- Prefabricated building elements, produced through optimized manufacturing processes in factory settings, have a lower embodied carbon content compared to conventional methods. Reduced energy consumption and minimized material waste lower the carbon emissions associated with production. Additionally, modular and standardized building components enhance transportation efficiency, reducing transport-related carbon emissions and supporting the conservation of natural resources.
- Embodied energy and carbon refer to the total energy consumed and carbon emissions generated throughout a material's life-cycle, from raw material extraction to production, transportation, construction, and demolition. Construction and demolition processes have high embodied carbon emissions due to the use and processing of carbon-intensive materials, directly impacting environmental sustainability.



Image: The LEED Gold-certified Kuzu Effect Mixed-Use green building in Ankara has recycled 92% of its construction waste through its recycling practices [6].

1.6. Impact of Construction on Urban Life

- The negative impacts of construction can adversely affect the local economy and tourism in the surrounding area. Construction management should implement measures (such as scheduling and barriers) to mitigate these effects.
- During construction, special attention should be given to preserving historical and cultural assets in the area, ensuring they are not damaged.
- Newly constructed buildings in areas with historical heritage or natural landscapes should maintain the local visual identity, facade characteristics, and overall architectural integrity



Image: In Delhi, dust from construction activities has lowered air quality across the city to below health standards. The Delhi administration and the Ministry of Environment have deployed 586 dust control teams to mitigate construction-related dust pollution [8].



Image: The impact of the La Casa por el Tejado construction project on the historical Eixample district in Barcelona [7].

1.7. Sustainable Construction Impact Mitigation Management Plan

- A sustainable construction project must be well-planned. The project should implement a Sustainable Construction Impact Mitigation Management Plan to address the environmental and social impacts of construction.
- The content of a Sustainable Construction Impact Mitigation Management Plan should comprehensively assess all environmental impacts of the construction process, including:
 - *Preservation of historical, cultural, and economic values,*
 - *Protection of natural vegetation, water resources, and soil,*
 - *Prevention of noise, particulate matter, and emission pollution,*
 - *Implementation of recycling and waste management practices,*
 - *Efficient transportation planning,*
 - *Occupational health and safety measures,*
 - *Use of sustainable energy and procurement practices,*
 - *Preservation of existing infrastructure.*
- A Sustainable Construction Impact Mitigation Management Plan should include a feedback mechanism and performance monitoring criteria. The general sustainability management team and other key personnel should be designated, and a training plan must be incorporated into the plan.

The Sustainable Construction Impact Mitigation Management Plan is structured under the following headings and order:

- 1. Current Situation Analysis:** A detailed examination of the environmental, social, and economic characteristics of the project site.
- 2. Impact Identification:** Identification and assessment of the potential negative impacts of construction activities.
- 3. Development of Mitigation Strategies:** Planning of appropriate measures and practices to minimize identified impacts.
- 4. Implementation and Monitoring:** Execution of mitigation strategies and regular monitoring of their effectiveness.
- 5. Reporting and Feedback:** Documentation of implementation results and revision of the plan when necessary.



Image: Normalm, Stockholm, Sweden. Various aspects, from pedestrian access to the local economy, are affected under the urban renewal project. Prior to construction, planning was conducted, and several measures, including temporary pedestrian bridges, were implemented [9].

1.8. Community Engagement During Construction

- For sustainable construction, the social and economic life of the affected community is crucial. A plan should be developed outlining how community engagement will occur during the construction period. This plan should include:
 - *Social impact analysis*
 - *Stakeholder analysis and identification of stakeholders*
 - *Participation process, including meetings, surveys, websites, etc.*
 - *Participation evaluation and feedback*
 - *Complaint resolution mechanism*
 - *Relevant administrative personnel and other related topics*
- Stakeholders should encompass all affected parties, both individuals and legal entities. The plan should specify the timing and methods for establishing the engagement connection with stakeholders, as well as how feedback and solutions will be addressed.
- Evaluations should be conducted after periodically planned participation activities, solutions should be implemented, and feedback should be communicated.

Stakeholder analysis can be conducted in five stages:

1. Identification of project stakeholders
2. Determination of stakeholders' areas of interest, level of impact, and relative priority
3. Assessment of stakeholders in terms of importance and impact
4. Outlining assumptions and risks
5. Defining stakeholder engagement



Visual: An example of a stakeholder meeting. The company identifies the locations of its planned data centers by consulting with affected stakeholders [10].



Section 2

SUSTAINABLE DEMOLITION PRACTICES



2.1. Introduction to Sustainable Demolition

- Conventional demolition methods are practices that either do not take necessary precautions or inadequately implement measures regarding occupational health, dust and other airborne particles, water resources, vegetation, and living organisms during demolition. Additionally, conventional demolition methods do not facilitate the recycling of demolition waste, leading to negative environmental impacts.
- Many components of a demolished structure can be recovered for recycling. Recycled demolition waste is measured by its weight and expressed as a percentage of the total building weight. This percentage is referred to as the demolition recycling rate. Today, up to 95% of post-demolition waste can be recycled.
- Sustainable demolition practices mitigate all the adverse effects of conventional demolition methods through a planned and systematic approach while ensuring that a significant portion of demolition waste is recycled.



Image: Unplanned, unstructured, and unregulated conventional demolition practices result in negative environmental impacts, including risks to public safety. The recycling rate of demolition waste in such cases remains very low [11].

2.2. Construction Demolition Plan

- Sustainable demolition methods begin with a construction demolition plan and project.
- This plan outlines all the procedures to be followed during demolition within a defined timeline.
- It also includes measures to mitigate impacts on various factors such as wildlife, the socio-economic structure, infrastructure, transportation, accident risks, hazardous waste, and groundwater resources.
- A pre-demolition assessment is conducted as part of the plan to identify building materials that can be reused (as salvaged building materials) or recycled.
- Discussions and agreements are made with public, corporate, and private entities, such as local governments, that have the potential to process waste materials. The plan also details the transportation conditions, destinations, and recycling processes for these materials.
- With a well-structured construction demolition plan, achieving a high recycling rate becomes feasible.



Image: The construction site buildings, parking lot shading elements, and all permanent construction site structures of the Izmir Adnan Menderes Airport Domestic Terminal were built entirely using salvaged building materials from the old airport structure [13].



Image: The construction site buildings, parking lot shading elements, and all permanent construction site structures of the Izmir Adnan Menderes Airport Domestic Terminal were built entirely using salvaged building materials from the old airport structure [13].

2.3. Dismantling and Salvaging

- The most critical component of sustainable demolition is the planning of dismantling and identifying building materials that can be recovered for recycling.
- During the dismantling process, materials such as doors, windows, bricks, roof tiles, and wall partitions, which can be reused for the same function, are classified as salvaged building materials and repurposed in different buildings. Materials like concrete and steel, on the other hand, are sent for recycling.
- **The key benefits of salvage operations in sustainable demolition include:**
 - Preservation of virgin natural resources
 - Reduction of greenhouse gas emissions from the building construction and materials sector
 - Minimization of the environmental impacts throughout the life-cycle of building materials
 - National-scale energy and water conservation
 - Enhancement of price competitiveness in the construction sector



Image: Markets selling salvaged building materials are becoming increasingly widespread. When construction materials recovered from sustainable demolition are used in new buildings, they help conserve natural resources and significantly reduce environmental impacts [14].

2.4. Waste Segregation and Recycling

- During sustainable demolition, recyclable materials identified in the planning phase are sorted and stored in designated areas. The most common of these building materials are described below:
 - **Concrete:** Transported to recycling facilities to be processed into recycled aggregate or fill material. Mobile recycling technologies also allow it to be repurposed as on-site fill.
 - **Metals:** Iron, steel, aluminum, copper, and other metals are separated on-site and stored. These materials are sent to recycling firms at scheduled intervals.
 - **Wood:** Stored separately as dimensional and non-dimensional wood. It is periodically sent to recycling facilities according to a pre-planned schedule.
 - **Plastic and PVC:** All types of plastic and PVC waste are sorted and sent to recycling firms.



Image: A facility producing recycled aggregate is shown. Concrete waste from construction sites is crushed at these facilities, transforming it from solid blocks into recycled aggregate. This material is then reused in concrete production or as a base material in construction [15].



Image: Metals recovered from construction sites are processed and reused as construction materials [16].

2.5. On-Site Waste Reduction Techniques

- Conducting on-site recycling at demolition sites stands out as the most environmentally friendly recycling method, as it reduces emissions from transportation.
- On-site recycling can be achieved using mobile recycling systems. Crushed and resized concrete can be repurposed as fill material, foundation material, or aggregate in new concrete construction.



Image: On-site recycling technologies are rapidly advancing. The image shows a mobile crusher performing on-site concrete recycling [17].

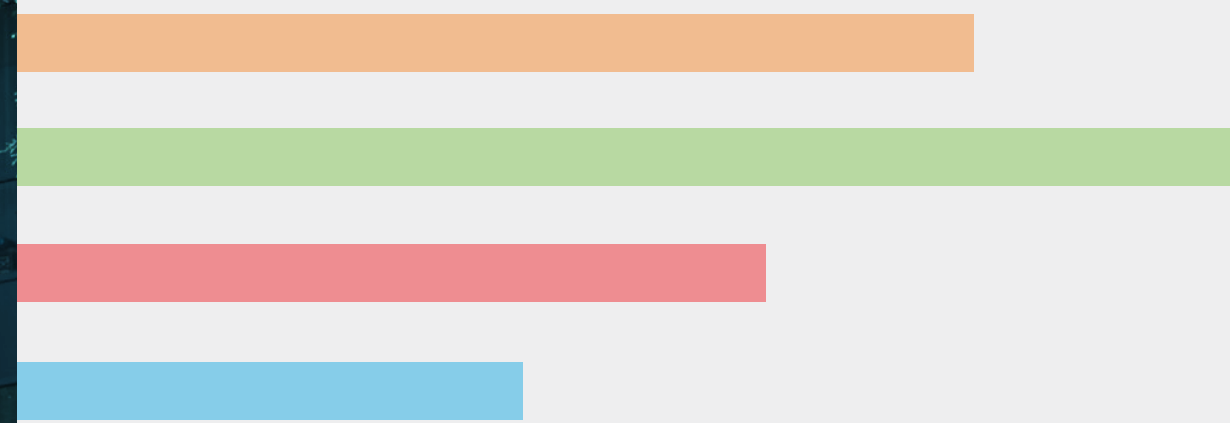


Image: Concrete fragments obtained from demolition are processed on-site using a mobile crusher and reused [18].



Section 3

FUNDAMENTAL PRINCIPLES OF SUSTAINABLE CONSTRUCTION



3.1. Sustainable Site Management

- The proximity of a construction site to transportation routes, urban infrastructure, and municipal services can increase emissions throughout the building's life-cycle.
- An improper site selection may harm local ecology, leading to the degradation of underground and surface water sources, endemic species, and agricultural land.
- If the designated construction area or its surroundings contain sensitive ecological assets, appropriate buffer zones should be established, and necessary measures should be planned to prevent pollution caused by construction activities.
- If any natural areas are utilized during construction, they should be restored to their original state upon project completion.



Image: Existing trees in the construction area should be protected from heavy machinery impact using protective barriers and equipment [19].

3.2. Construction Light Pollution Plan and Implementation

- Light pollution refers to the disruption of natural darkness due to the misdirection, overuse, or unnecessary illumination of areas with artificial light. This phenomenon can negatively impact ecosystems, alter the behavior of nocturnal species, waste energy, and disrupt human sleep patterns, leading to health issues.
- To prevent light pollution at construction sites, the following lighting strategies should be incorporated into a plan and implemented:
 - Use of Directional Lighting
 - Timers and Sensors
 - Fixtures with Low (Adequate) Light Power
 - Materials that Reduce Light Spread
 - Limitation of Nighttime Lighting



Image: Improper lighting during construction can lead to unnecessary energy consumption, increased emissions, and, most importantly, harm to the local community and ecology in the area [20].

Image: Controlled lighting during construction prevents light pollution [21].

3.3. Protection of Water Resources in Construction

- Construction or demolition sites may be located near surface water bodies such as lakes, rivers, wetlands, or underground water sources.
- During demolition or construction, dust pollution or water runoff from stored materials can contaminate nearby water resources.
- To prevent this, the following measures should be implemented:
 - Enclosing the construction site
 - Storing construction waste in areas that do not affect water resources
 - Storing building materials (lime, cement, sand, etc.) in a manner that prevents runoff into water sources
 - Preventing rainwater runoff
 - Ensuring that no discharges from construction activities reach water sources



Image: The negative impact of construction on nearby water resources [22].



Image: The prevention of pollution from construction through water barriers [23].

3.4. Reducing Water Consumption in Construction

- Construction and demolition activities typically involve high water consumption [ANNEX-1]. To reduce water consumption, the following measures should be taken:
 - Use minimal water for dust control during demolition, focusing on deconstruction and material recovery.
 - Use recycled water in concrete and prefer prefabricated building components with low water footprints during construction.
 - Implement rainwater harvesting and use it on the construction site.
 - Recycle greywater from showers, hand-washing sinks, washing machines, etc., in temporary accommodations and construction buildings. This water can then be used for toilet flushing, washing vehicle tires, and irrigating suitable areas.
 - Filter drainage water and use it for landscaping.



Image: Rainwater collected from the roofs of temporary structures on construction sites is used to wash vehicle tires [24].

3.5. Soil Protection in Construction

- Soil is one of the most valuable natural resources, forming the foundation of life by supporting plant growth, ensuring the continuity of ecosystems, regulating the water cycle, and playing a critical role in combating climate change by storing carbon. During construction, the following measures should be taken to protect the soil:
 - The plant soil present at the construction site should be stored and reused in landscaping after the construction is completed. If there is excess soil, it can be used in urban farming areas.
 - A consistent soil balance calculation should be made for excavation and backfilling at the construction site to reduce transportation emissions.
 - The land topography on the existing site should be considered during shaping.
 - If non-vegetative soil from excavation needs to be transported, a soil analysis should be conducted, and it should be planned to be transported to the nearest areas with a compatible soil structure.



Image: The plant soil excavated from the construction site should be protected by covering it or temporary planting. Surface runoff should be prevented, and it should be reused in landscaping after construction is completed. [25]

3.6. Erosion Control in Construction

During construction, erosion measures should be implemented to prevent soil loss due to surface runoff, vehicle tires, or wind.

- The construction site should be surrounded by silt curtains.
- The entrance and exit of the construction site should be controlled.
- The construction entrance should be organized with a gravel road for vehicle tire cleaning and soil protection.
- A vehicle tire washing unit should be installed and used at the construction exit.
- If drainage water is present, it should be settled in a temporary settling pond before being discharged.
- Stormwater grates should be protected with filters or sandbags.
- Temporary settling ponds suitable for rainfall and slope should be constructed on the construction site.
- Soil compaction should be prevented, and compacted soil should be de-compacted.

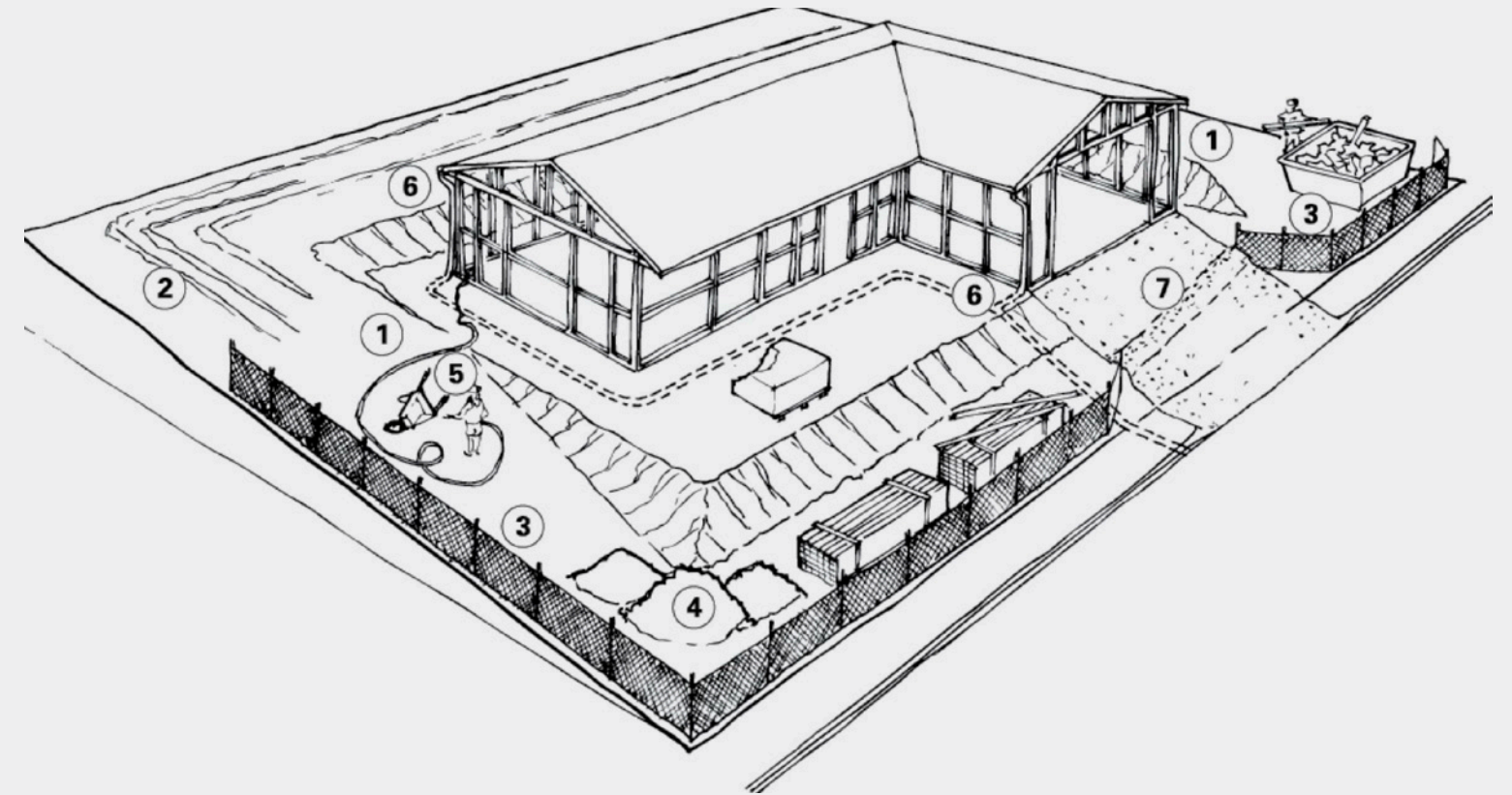


Image: Application of the construction erosion control plan [26].

1. Limiting the construction area
2. Flow speed reducers
3. Silt curtains or settling barriers
4. Safe soil storage
5. Other scopes
6. Early stormwater connection
7. Controlled, gravel construction entrance and vehicle tire washing.

3.7. Protection of Natural Life in Construction

Even in urban areas, construction sites must take measures to protect the local flora and fauna. The following measures should be implemented:

- Existing animals and plants on the construction site should be identified.
- Barriers should be placed around living areas, nesting sites, etc., to prevent approach.
- Trees and vegetation should be protected by restricting access.
- Additional planting should be carried out to support the existing ecology.
- Entry into unused virgin lands surrounding the construction site should be prohibited, storage should not be conducted, and the spread of construction should be prevented.



Image: Temporary fauna fence application. It prevents animal entry into the construction site and reduces live animal loss [27].

3.8. Increasing the Climate Resilience of Construction

During construction, measures should be taken to increase the site's resilience against climate-induced impacts such as urban flooding, winds, and heatwaves. The following measures should be implemented:

- Construction of ditches, channels, and sedimentation ponds to protect against urban flooding.
- Storing construction materials above the pallet level to prevent water contact.
- Use of temporary barriers for flood or storm surge protection.
- Installation of wind barriers and secure mounting of construction panels and materials that may pose a hazard during extreme wind events. Site dust cleaning should be performed.
- Use of light-colored coatings on the roofs and floors of temporary structures to reduce the urban heat island effect, and shading of vehicle parking areas.



Image: Temporary barriers to prevent flooding from urban flooding impact at the construction site. These barriers help prevent loss of life, property damage, and pollution [28].

3.9. Planning Community Mobility and Access

During construction, the mobility of communities living in the area should not be restricted. The following measures should be implemented:

- Improvement of access and wayfinding. Planning of passageways and construction of temporary gates, bridges, etc.
- Security-oriented lighting of passageways.
- Installation of directional signs and informational boards.
- If necessary, provision of temporary parking and roads for vehicles.



Image: Application of safe passageways and security signs around the construction site [29].



Section 4

PRINCIPLES OF CIRCULAR ECONOMY IN CONSTRUCTION



4.1. Circular Economy and Construction

A **circular economy** is a model that aims to extend the life-cycle of materials and resources in the building sector. In the construction industry, circular economy promotes environmental protection, economic viability, and sustainability by reducing waste generation and increasing resource efficiency through practices such as reuse, recycling, design flexibility, and reducing embodied carbon.

Key Concepts of Circular Economy:

- **Reuse:** Evaluating usable building components for use in other projects after deconstruction.
- **Recycling:** Reprocessing waste materials to produce new building materials.
- **Resource Efficiency:** Ensuring minimum resource consumption during production and usage processes of materials.
- **Design Flexibility:** Designing structures in a way that they can be easily dismantled, renovated, or reused in the future.
- **Reduction of Embodied Carbon:** Reducing the carbon footprint by minimizing energy use in material production and transportation processes.
- **Circular Design:** Design strategies focused on preserving materials throughout the whole building life-cycle.



Image: A value-focused visualization based on the carbon footprint generated throughout the whole life-cycle of the Ströms building in Gothenburg. Building information system tools are used to identify the circularity aspects of the building, such as reuse, recycling, and revaluation potential [30].

4.2. Materials Life-Cycle Approach

Building materials go through a life cycle that ranges from raw material extraction and production to use in building construction and recycling after demolition at the end of the building's life span. Using recycled building materials in construction provides significant benefits in reducing the multi-dimensional environmental impact of building materials.

When construction techniques and materials are determined through a Building Life-Cycle Assessment (LCA), the environmental impact of the building can be reduced across various impact categories. Building Life-Cycle Assessment is typically performed using software that complies with the ISO 15978 standard. It assesses the environmental impact created by the building throughout its life-cycle.

The most important strategies that can be applied are listed below:

- Use of building materials containing recycled content.
- Use of salvaged building materials.
- Use of low environmental impact building materials that have been assessed for environmental impact (with EPD certification).
- Restoration and reuse of an existing building or infrastructure.

EPD (Environmental Product Declaration) is a Type III certification in the ISO 14025 standard. The environmental impact of the building materials used in the building is measured using LCA software during the value chain, followed by certification assessment through on-site inspections. EPD-certified building materials are products with known and controlled environmental impacts. The use of building materials with low environmental impact, compared to the industry average, reduces the adverse environmental effects throughout the building's life-cycle.

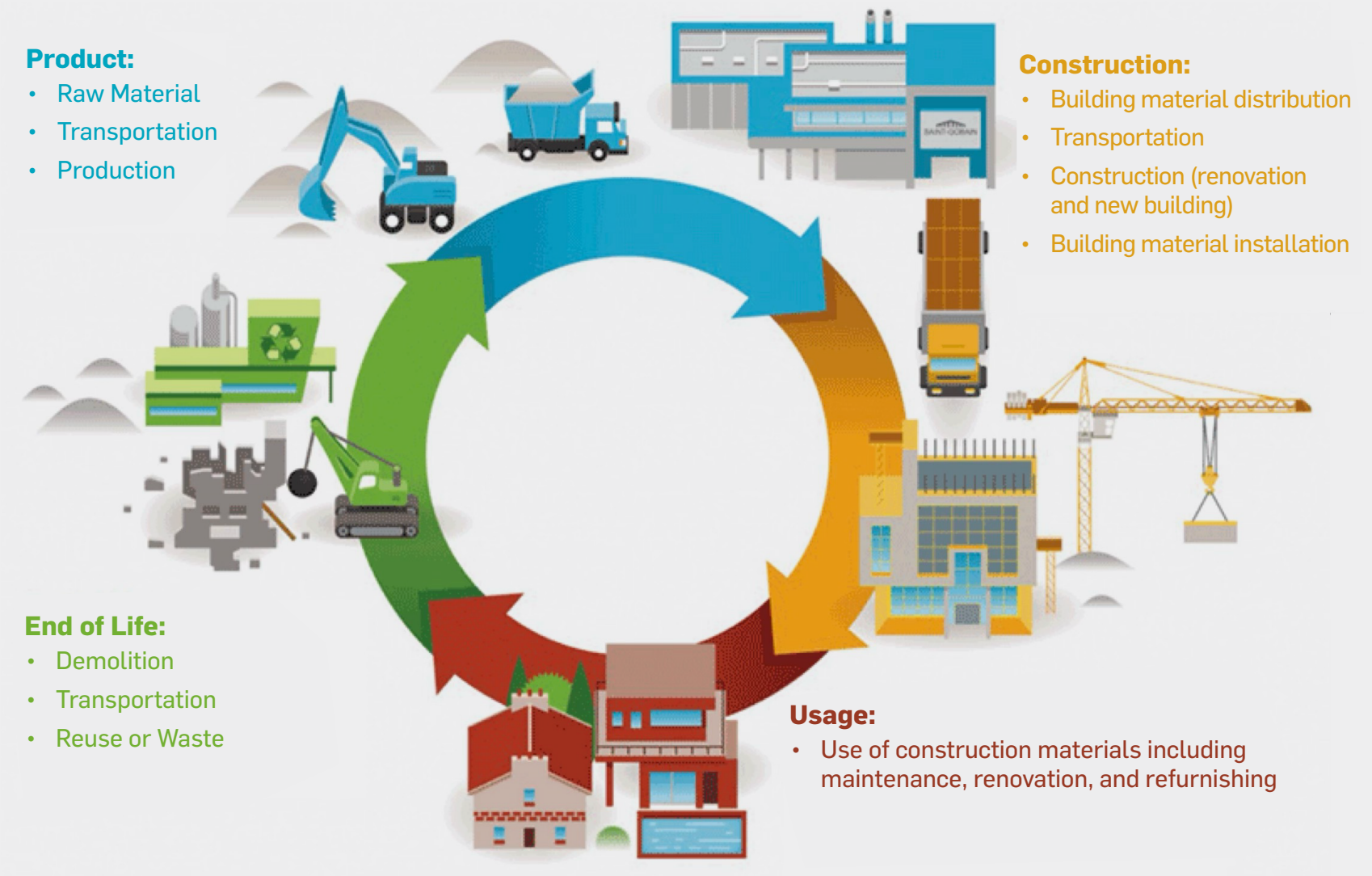


Image: Building life-cycle approach [31].

4.3. Reuse of Existing Infrastructure

- The reuse of existing infrastructure surrounding a building eliminates the need for new construction materials, thereby significantly reducing environmental impact, similar to the reuse of buildings.
- Adaptive Reuse of Infrastructure can serve as building materials not only for buildings but also for other structures such as parks. With the application of Adaptive Reuse of Infrastructure, outdated or deteriorating unused infrastructures like highways, railways, or industrial facilities can be converted into new public projects, such as parks.
- Given the vast number of aging infrastructures worldwide, this type of reuse becomes a creative and appealing option.

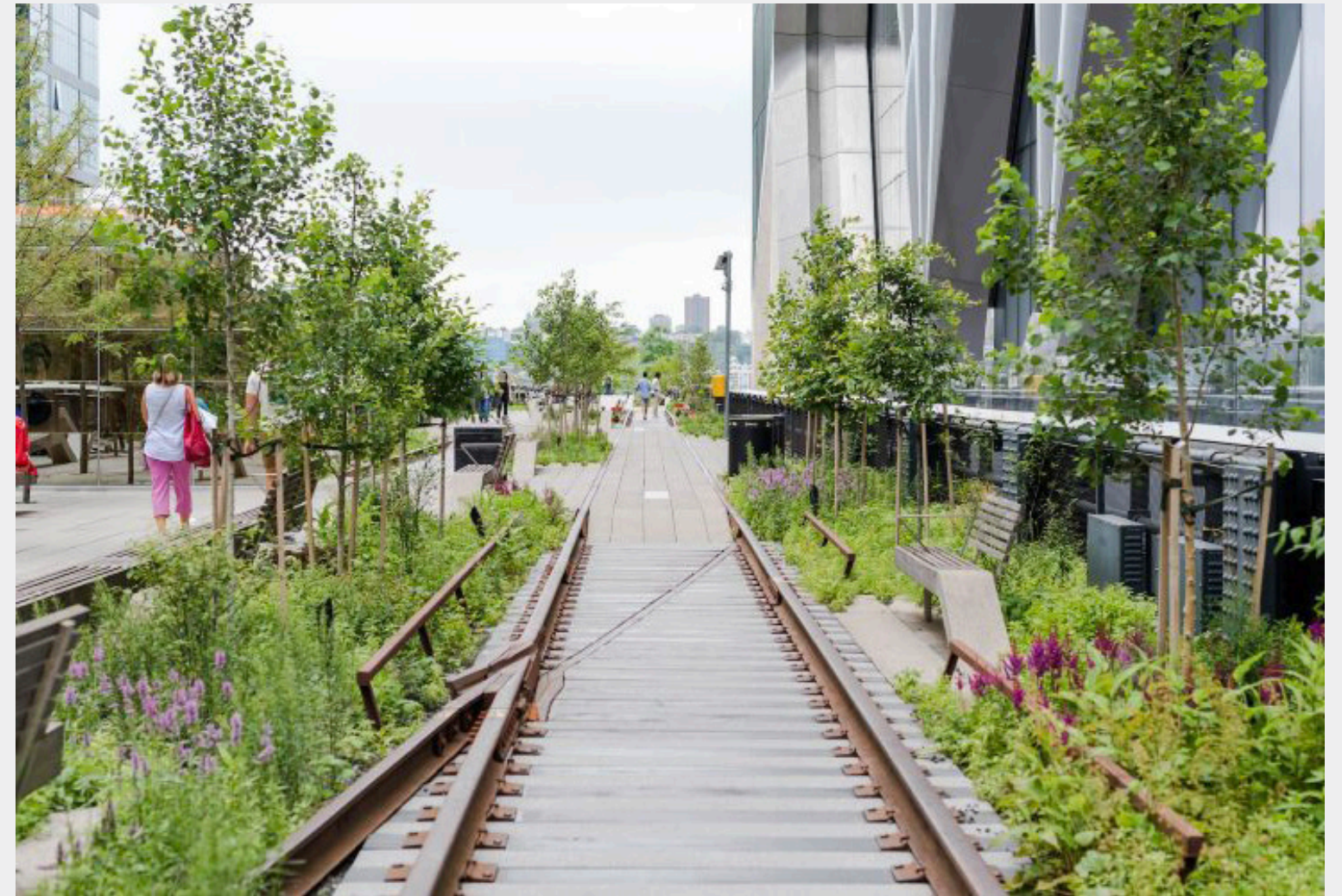


Image: The High Line in New York City is one of the most famous examples of reusing existing infrastructure. In the early 2000s, city planners transformed this area into a park featuring walkways, viewing platforms, and an open-air market, thus repurposing the structure to serve the community once again. NY High Line, Photo courtesy of Elizabeth Villalta via Unsplash [32].

4.4. Use of Recycled Building Materials

The use of building components containing recycled materials in the structural elements of a building contributes to reducing environmental impacts.

The most commonly used recycled materials in building construction are as follows:

- **Concrete:** Contains recycled water, aggregates, and fly ash.
- **Structural Steel:** Contains recycled steel.
- **Glass:** Contains recycled glass.
- **Aluminum:** Contains recycled aluminum.
- **Composite Wood:** Contains recycled wood.
- **Gypsum Board:** Contains recycled gypsum board, water, and paper.
- **Plastic and PVC:** PVC window frames containing recycled plastic.



Image: Wall panels and concrete elements made from prefabricated concrete with recycled content in a residential building completed in 4 months [33].

4.5. Reuse in Construction

The application of salvaged building materials in accordance with the building design significantly reduces the environmental impact throughout the building's life-cycle.

Examples of salvaged building materials include:

- Bricks and paving stones
- Structural steel, steel railings, and staircases
- Wall partitions and gypsum boards
- Doors
- Timber
- Window frames
- Lighting equipment
- Utility poles
- Pipes and ceramics



Image: A residential project built entirely from salvaged bricks and building materials. Elfort Road House / Amos Goldreich Architecture, London [34].

4.6. Waste Management Plan

A Waste Management Plan is a construction-specific plan prepared before the commencement of construction. It includes the necessary practices for minimizing, reusing, and, if unusable, sorting and recycling waste. Waste Management Plans can be developed in accordance with LEED, BREEAM, or EU Waste Framework Directive (2008/98/EC), ISO 14001, and ISO 21930 criteria. The plan incorporates the following strategies:

- **Reduction:** Implementing strategies such as using custom-sized products to prevent offcut waste.
- **Reuse:** Reusing construction debris, such as concrete remnants, within the construction site.
- **Sorting and Recycling:** Separating recyclable materials such as plastic, glass, metal, and wood for recycling.
- **Byproduct Synergy:** Utilizing construction waste as an input in another part of the construction process. For example, using vehicle tire wash water or concrete mixer cleaning wastewater in concrete production.
- **Training and Record-Keeping:** Educating personnel on waste management, maintaining records of all waste by weight (kg), and reporting them as percentages (%).



Image: The waste management area of the LEED Gold-certified SANKO Holding Gaziantep office building. During the construction process, 79.68% of the materials in nine different waste categories were recovered through recycling [35].



4.7. Waste Reduction Strategies

During construction, waste reduction strategies aim to use resources more efficiently and minimize environmental impacts.

The key strategies are as follows:

- **Use of Custom-Sized Materials:** Ordering materials in dimensions tailored to project requirements to prevent waste generation.
- **Use of Prefabricated Building Components:** Prefabricated materials, produced in factories and assembled on-site, should be preferred as they generate less waste during production.
- **Modular Design:** Selecting reusable and easily assembled/disassembled building elements to reduce future waste.
- **Use of Recyclable Materials:** Choosing recyclable or reusable materials to facilitate waste management.
- **Material Inventory Management:** Ordering materials in the correct quantity and at the right time to avoid surplus.
- **On-Site Recycling:** Recycling materials such as concrete, wood, and metals on-site for reuse.
- **Selection of Multi-Purpose Materials:** Using a single material for multiple functions to reduce waste.
- **Proper Storage and Handling:** Implementing appropriate storage and transportation methods to prevent material damage and waste.
- **Zero Waste Management Plan:** Preparing a detailed waste management plan before construction begins and monitoring its implementation.
- **Use of Local Materials:** Preferring locally sourced materials over those transported from long distances to reduce transport-related waste and carbon emissions.
- **Education and Awareness:** Providing construction personnel with training on waste reduction practices.

4.8. Design for Deconstruction in Buildings

Design for deconstruction (DfD) ensures that buildings, materials, and components can be easily disassembled, reused, or recycled at the end of their lifespan.

How to Implement Design for Deconstruction?

- 1. Modular Design:** Building elements are designed in standard sizes and can be independently assembled and disassembled.
- 2. Connection Systems:** Mechanical fasteners such as bolts and screws are used instead of adhesives.
- 3. Material Selection:** Recyclable and reusable materials are prioritized.
- 4. Material Labeling and Documentation:** Materials used in construction are documented and labeled for easier future disassembly and recycling.
- 5. Layered Building Systems:** Different building layers, such as walls, floors, and ceilings, are designed for easy separation.
- 6. Accessible Connections:** Fasteners are placed in easily accessible locations for straightforward disassembly.
- 7. Deconstruction Training and Guidelines:** A detailed deconstruction plan and manual are prepared.
- 8. Compliance with Local Regulations:** The design follows building codes and regulations.

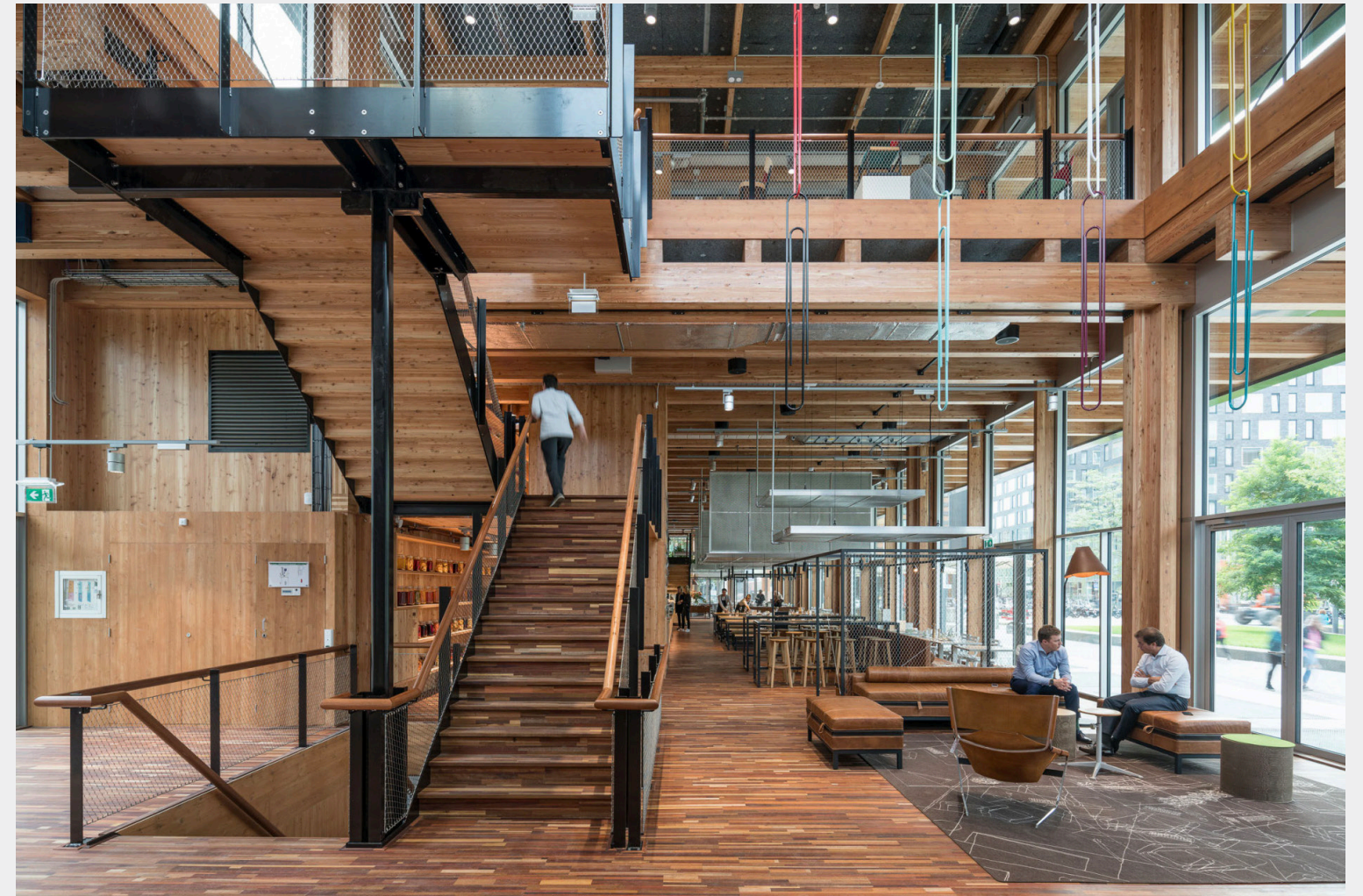
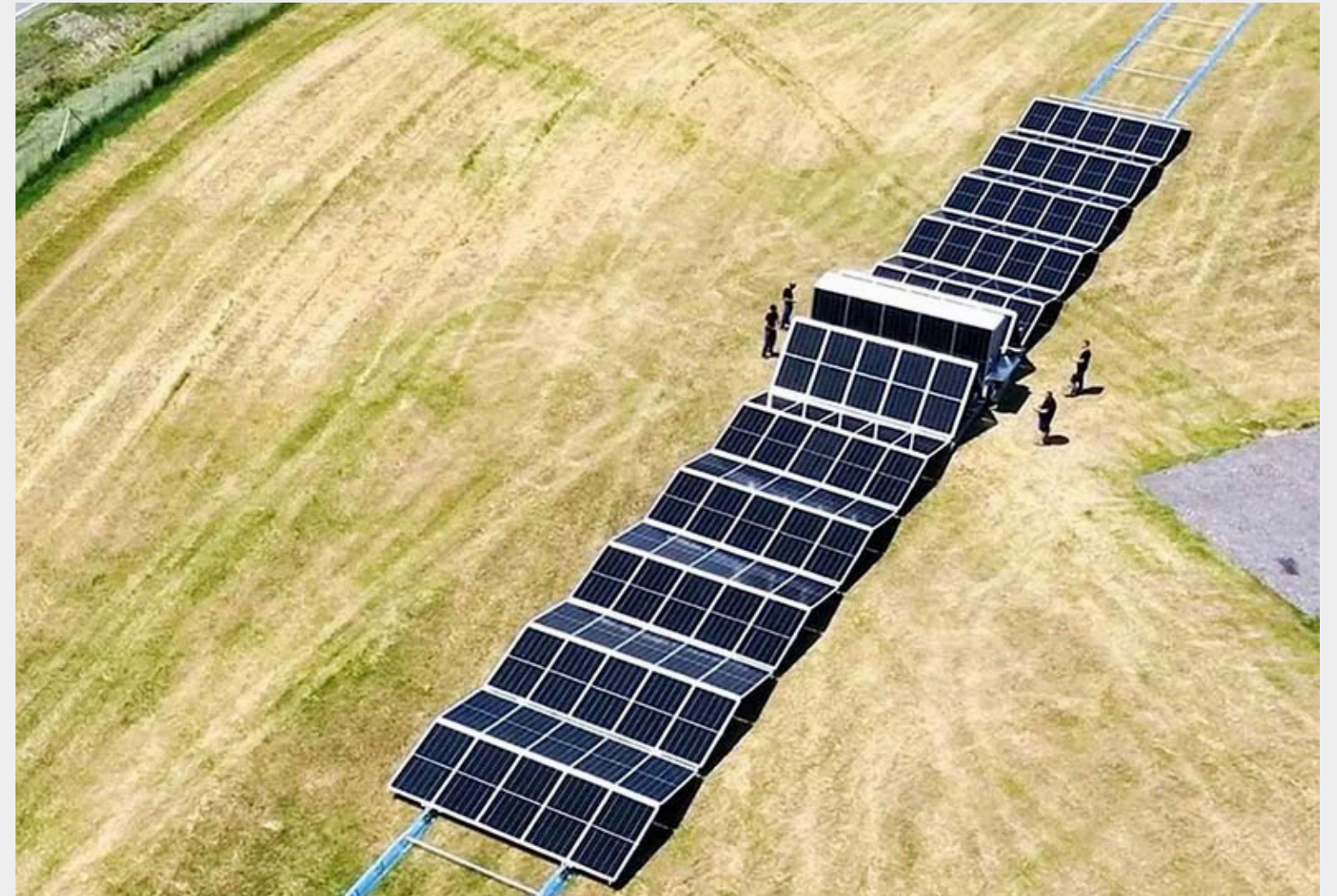


Image: Ossip van Duivenbode. The Circl Pavilion, located at ABN Amro's headquarters in Zuidas, Amsterdam, is a semi-public meeting and exhibition space. Although completed in 2017, the building will be deconstructed due to the relocation of the bank's headquarters. This project serves as an interesting case study demonstrating how Design for Deconstruction (DfD) can be applied at the end of a building's life-cycle [36].

4.9. Construction Energy Production and Consumption Planning

The main categories that contribute to energy consumption during the construction process are as follows:

- **Material Production and Transportation:** Production and transportation of concrete or mortar during construction.
- **Site Operations:** Equipment used at the construction site (cranes, concrete mixers, generators, etc.) consume significant amounts of energy. Lighting, heating, cooling, and other electrical devices also use energy.
- **Machinery and Vehicle Usage:** Construction machinery such as excavation machines, excavators, and transport vehicles typically run on fossil fuels.
- **Temporary Structures and Offices:** The heating, cooling, and lighting of temporary shelters, offices, and storage areas set up at the construction site contribute to energy consumption.
- **Waste Management and Disposal:** Storing and transporting waste consumes energy. Energy is used for sorting, recycling, and disposal of construction waste.
- **Water Management:** Processing, pumping, and purifying water used in construction requires energy.
- **Building Ventilation, Testing, and Quality Control Processes:** Devices used during testing and the operation of the building consume energy.



4.9. Construction Energy Production and Consumption Planning

The construction process significantly contributes to energy consumption. Therefore, the energy used during construction must be planned. The main emission reduction strategies related to energy consumption are as follows:

- **Renewable energy should be installed or purchased.**
 - Renewable energy should be used for heating, cooling, and lighting in construction site offices, temporary shelter units, and storage areas.
 - Renewable energy should be used for site lighting.
 - Renewable energy should be used for material production at the construction site.
- Cranes, concrete mixers, and other equipment used at the site should be selected from models that operate with renewable energy.
- **A sustainable transportation plan should be implemented as follows:**
 - Transport vehicles, excavation machines, and excavators should be selected to run on alternative fuels.
 - Personnel transport should be carried out using electric or alternative fuel vehicles.



Image: Large, medium, and small-scale portable PV energy systems [37].

4.11. Sustainable Transportation Planning

Sustainable transportation planning is a strategy aimed at optimizing the transportation of materials and labor in building construction to reduce energy consumption, carbon emissions, air pollution, and noise, while also improving economic efficiency. This plan seeks to minimize the environmental impact of the supply chain from material sourcing to the construction site.

Steps:

- 1. Supply Chain Analysis:** Preference for local and low-carbon products in material selection.
- 2. Transportation Mode Selection:** Identification of energy-efficient and low-emission transportation vehicles.
- 3. Route Optimization:** Determining the shortest routes with the least traffic congestion.
- 4. Timing and Scheduling:** Adjusting transportation schedules to reduce traffic density and minimize noise pollution.
- 5. Load Consolidation:** Combining loads to reduce the number of trips in material transportation.
- 6. Monitoring and Reporting:** Regular monitoring and evaluation of emissions, fuel consumption, and environmental impacts.
- 7. Collaboration:** Coordination with suppliers, transporters, and local authorities.



Image: Electric construction machinery reduces emissions and noise, without contributing to air pollution [39].

4.12. Importance of Commissioning

Commissioning of a building is the process that starts from the design phase and ensures that all systems (heating, ventilation, and air conditioning; lighting; water; energy management, etc.) work according to planned performance standards during construction and operation.

Proper commissioning increases energy efficiency, extends the durability and lifespan of materials, prevents emissions and resource consumption caused by construction errors during the rework process, and also reduces operational costs [Appendix-2].

Key points [Appendix-3]:

- Commissioning reduces energy and water consumption in buildings by 15-20%.
- The lifespan of commissioned buildings increases by 10-15%.
- Maintenance costs and life cycle operational costs for non-commissioned buildings increase by 20-40% compared to commissioned buildings.

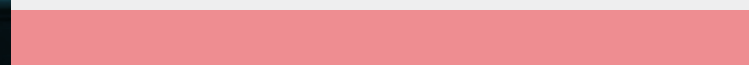


Image: Commissioning process [40].



Section 5

CONSTRUCTION AND HEALTH



5.1. Occupational Health and Safety in Construction

The occupational health and safety (OHS) plan is a systematic approach to hazard assessment, risk management, and preventive measures aimed at protecting the health and safety of workers, surrounding individuals, and the broader community during building construction. This plan is developed in accordance with national regulations and international standards to prevent workplace accidents and occupational diseases. It consists of five key stages:

- 1. Hazard Identification and Risk Assessment:** Identifying potential hazards in the construction area.
- 2. Planning of Preventive Measures:** Implementing safety measures such as engineering controls, administrative controls, personal protective equipment, and warning signs.
- 3. Training and Awareness Programs:** Providing regular training to workers on hazards and protective measures.
- 4. Emergency Preparedness:** Developing procedures for potential emergencies, including fire, falls, and chemical spills.
- 5. Continuous Monitoring and Updating:** Assessing the effectiveness of safety measures, conducting inspections, and revising the plan as needed.

Image: Occupational health and safety training program, Germany [41].



5.2. Noise and Vibration Mitigation During Demolition and Construction

Controlling noise and vibration during demolition and construction protects workers' hearing health while also preventing reduced quality of life, stress, and sleep disturbances in surrounding communities. Additionally, these control measures support environmental sustainability by minimizing soil vibrations that could negatively impact ecosystems and wildlife. Below are five key measures:

- 1. Use of Noise-Reducing Equipment:** Utilizing technologies such as machines with silent operation modes and sound barriers.
- 2. Vibration-Damping Systems:** Implementing ground modifications that absorb vibrations and using low-vibration machinery.
- 3. Time Management:** Scheduling noise- and vibration-generating activities during hours that minimize disruption to the community.
- 4. Monitoring and Evaluation:** Regularly measuring noise and vibration levels to ensure compliance with legal limits.
- 5. Community Communication:** Informing local communities about working hours and potential impacts, and establishing a complaint mechanism.



Image: Construction noise barrier in use, London [42].



Image: Sound- and dust-preventing cutting station used during construction [43].

5.3. Prevention of Dust and Pollution During Demolition and Construction

The control of dust and pollution during demolition and construction prevents health issues such as respiratory diseases for workers and nearby communities, while also reducing the risk of erosion and the negative impacts on ecological balance. These control measures contribute to maintaining air quality in the surrounding area, improving community quality of life, and protecting natural ecosystems from harm. The five key measures are as follows:

- 1. Dust Suppression Systems:** The use of water spraying systems and humidifiers on the site to reduce dust formation.
- 2. Temporary Ground Coverings:** The use of geotextiles or stabilizing coatings on construction sites to prevent erosion.
- 3. Closed Material Storage:** Storing and transporting bulk materials in enclosed areas to prevent dust spread.
- 4. Vehicle and Equipment Cleaning:** Cleaning the tires of vehicles entering and exiting the construction site to prevent dust from spreading on the roads.
- 5. Air Quality Monitoring:** Regular measurement of dust particle levels and the implementation of additional protective measures when necessary.



Visual: Dust suppression system with water spraying [44].



Visual: Cleaning of vehicle tires at the construction site exit [45].

5.4. Prevention of Dust and Pollution During Demolition and Construction

The Construction Indoor Air Quality Management Plan aims to minimize dust, volatile organic compounds (VOCs), and other air pollutants that arise during construction, thereby preventing long-term health impacts to building occupants. Once the building is in use, this plan helps improve indoor air quality, ensuring protection against respiratory diseases, allergies, and other health issues for the occupants [46]. Below are five key measures:

- 1. Use of Low-VOC Materials:** Utilization of products with low VOC levels in paints, adhesives, and coatings.
- 2. Dust and Particle Control:** Use of air filtration systems on the construction site, and implementation of humidity control to prevent dust.
- 3. Airflow Management:** Keeping HVAC systems closed and implementing appropriate sealing measures to prevent pollutants from entering the system.
- 4. Material Protection:** Storing construction materials in enclosed or sheltered areas to protect them from mold and moisture.
- 5. Post-Construction Cleaning:** Thorough cleaning of all interior surfaces before the building is occupied and air quality testing.



Visual: Construction cleaning [47].

5.5. Tobacco Smoke Control During Construction

Tobacco smoke control during construction is a management plan aimed at preventing cigarette smoke from penetrating building components, such as HVAC systems and surfaces, causing permanent pollution and leading to long-term respiratory problems, allergies, and other health issues for building occupants. This control measure seeks to maintain indoor air quality, thereby ensuring the health of building occupants and the long-term efficiency of mechanical systems. The five key measures to be taken are as follows:

1. Designation and Enforcement of No-Smoking Areas
2. Restriction of Access to Tobacco Products
3. Protection and Isolation of HVAC Systems
4. Creation of Controlled Outdoor Smoking Areas
5. Post-Construction Deep Cleaning and Air Quality Testing



5.6. Post-Construction Indoor Air Quality Assessment

Post-construction indoor air quality assessment is a process aimed at preventing building occupants from being exposed to long-term health issues by removing pollutants from the air through a “flash-out” procedure and testing the air quality to ensure compliance with standards before the building is occupied. This practice minimizes the negative effects of volatile organic compounds (VOCs), dust, and other pollutants on the respiratory system, providing a healthy indoor environment for the occupancy phase.

- 1. How is Flash-Out Performed?** Flash-out involves running the HVAC systems to replace the air volume inside the building with high levels of fresh air, thus removing indoor pollutants.
- 2. How is Indoor Air Quality Testing Performed?** Indoor air quality testing involves measuring the levels of particulate matter (PM2.5, PM10), VOCs, carbon dioxide (CO2), formaldehyde, and other pollutants within the building using precise instruments [48]. If air quality is insufficient, the flash-out procedure is applied.



Visual: Construction air quality testing [49].



5.7. Hazardous Material Management

During construction, hazardous waste, particularly materials such as asbestos and lead, can cause serious health issues, including cancer, respiratory diseases, and neurological problems, if not disposed of in accordance with regulations. Additionally, they can cause permanent pollution and ecosystem damage to the environment. Proper management of these waste materials aims to comply with legal requirements and protect the health of both workers and the surrounding community.

Applicable Regulations/Standards:

1. Regulation on the Control of Hazardous Wastes [50]
2. Regulation on Health and Safety Measures in Asbestos Work [51]

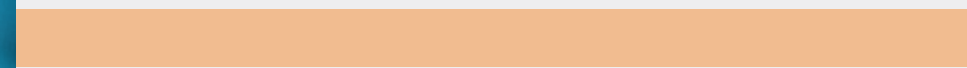


Visual: Management of hazardous waste during construction [52].



Section 6

REGULATORY FRAMEWORKS AND POLICIES

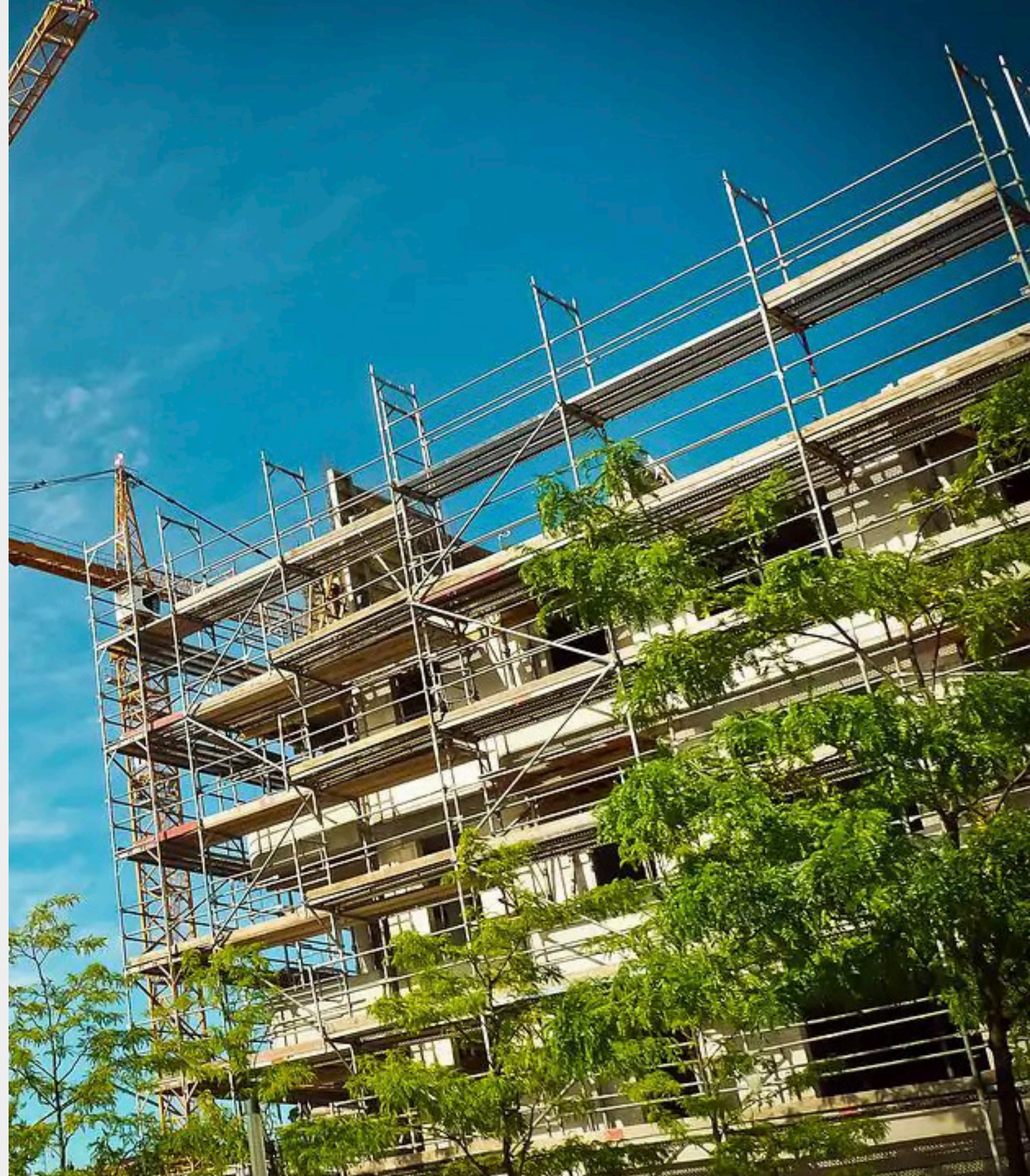


6.1. National and International Regulations

Standards and Regulations for Sustainable Construction Management and Implementation Principles:

- [EPA Construction General Permit \(CGP\) - USA](#)
- [LEED Leadership in Energy and Environmental Design - USA](#)
- [BREEAM Building Research Establishment Environmental Assessment Method - Europe, UK](#)
- [Green Certificate for Buildings and Settlements \(YeS-TR\) Green Certificate Building Assessment Guide - Türkiye](#)
- [ISO 14001 - Environmental Management System Standard, International](#)
- [ISO 15392 - Sustainability in Building Construction - General Principles, International](#)
- [DGNB \(Deutsche Gesellschaft für Nachhaltiges Bauen\) - Europe, Germany](#)
- [The Regulation on Environmental Impact Assessment \(EIA\) - Türkiye](#)
- [Energy Performance of Buildings Directive \(EPBD\), European Union](#)
- [Energy Efficiency Law and Relevant Regulations - Türkiye](#)
- [ASHRAE Green Guide \(American Society of Heating, Refrigerating, and Air-Conditioning Engineers\) - USA](#)

Image: Sustainable construction [53].



6.2. Local and Global Green Building Certifications

A “Green Building” is designed and constructed with an integrated design approach, in harmony with its surrounding environment and nature. Green buildings, by adhering to specific standards, cause less harm to the residents and the environment compared to standard buildings. They consume less energy and water and offer healthier environments for their users. Key considerations in green buildings include reducing energy and water consumption, indoor air quality, selection of environmentally friendly materials, and the impact of the building on the surrounding land. Green buildings, with these characteristics, create a more sustainable environment and city. As they consume less energy, water, and operational costs, green buildings are much more economical for building owners. Green buildings, with their high indoor environmental quality, provide healthy environments for users, enabling them to be healthier and more productive.

Green building certification systems are rating systems that look at the building’s sustainability goals from a holistic and synergistic approach. Therefore, they serve as an important guide for sustainable construction methods.

- **LEED - USA:** LEED is the most widely used green building certification system that evaluates building performance in terms of energy efficiency, water conservation, indoor environmental quality, health, material selection, and sustainability. LEED-certified buildings can reduce energy consumption by 25-30%, water consumption by 20-40%, and operational costs by 15-25%.
- **BREEAM - Europe (UK):** BREEAM is a system that evaluates the environmental, social, and economic sustainability performance of buildings and is widely used in Europe. BREEAM-certified buildings can reduce energy consumption by 20-30%, water consumption by 20%, and carbon emissions by 10-15%.
- **YeS-TR - Türkiye:** YeS-TR is a green building certification system unique to Türkiye that promotes sustainable building standards specific to Türkiye’s climate, culture, and construction sector [Annex-4].



Visual: Izmir Adnan Menderes Airport, LEED Silver [54].

6.3. Waste Management and Recycling Policies

National and international key waste management regulations and incentives are listed below:

European Union:

- [Waste Framework Directive \(2008/98/EC\)](#): Establishes the waste management hierarchy and encourages waste prevention and recycling in member countries.
- [Directive on Packaging and Packaging Waste \(94/62/EC\)](#): Aims to reduce packaging waste and increase recycling rates.
- [Waste Electrical and Electronic Equipment Directive \(2012/19/EU\)](#): Defines the rules for the collection and recycling of electrical and electronic waste.
- [Regulation on Shipments of Waste \(EC No 1013/2006\)](#): Regulates the inspection and control mechanisms for the transboundary movement of waste.
- [Circular Economy Action Plan](#): A strategic plan implemented across the EU to enhance resource efficiency and reduce waste generation.
- [Waste Hierarchy](#): A waste management approach that includes prevention, reuse, recycling, recovery through energy generation, and disposal in this order.
- [Recycling Targets](#): Binding targets have been set for member countries to increase recycling rates for specific types of waste.

Türkiye:

- [Zero Waste Regulation](#): Binding targets have been set for member countries to increase recycling rates for specific types of waste.
- [Recycling Contribution Fee \(GEKAP\)](#): A fee collected during the market introduction of specific products to finance waste management.
- [Environment Law](#): Defines waste management and recycling policies and includes regulations aimed at environmental protection.



6.4. Government Incentives for Sustainable Practices

Various incentives are implemented in the European Union, the United States, and Türkiye to promote the construction of sustainable, green, or low environmental impact buildings. Some of these incentives are listed below:

European Union:

- **Green Financing and Low-Interest Loans:** Within the scope of the European Green Deal, low-interest loans and financial support are provided for sustainable building projects.
- **Energy Performance Directive Incentives:** Financial support and tax reductions are offered for renovation projects aimed at improving the energy efficiency of buildings.
- **Circular Economy Action Plan:** A strategic plan implemented across the EU to enhance resource efficiency and reduce waste generation, which also promotes sustainable building projects.

United States

- **Federal Tax Credits:** Federal-level tax credits and discounts are offered for energy-efficient building projects.
- **State and Local Incentives:** Many states and municipalities provide zoning advantages, expedited permitting processes, and financial support for projects with green building certifications.
- **Energy Efficiency Loans:** Low-interest loan programs are available for energy-efficient construction and renovation projects.

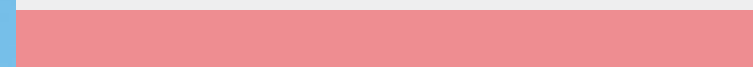
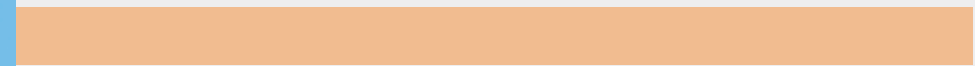
Türkiye

- **Alignment with the European Green Deal:** Türkiye is developing various action plans and incentive mechanisms to align with the European Green Deal. LEED certification is incentivized for industrial buildings under market entry certificates.
- **Zero Energy and Passive House Association (SEPEV) Incentives:** Training and certification programs are organized to support sustainable building projects.
- **Türkiye Sustainable Buildings Network Project:** Under this EU-supported project, various activities and support are offered to promote green building practices.



Section 7

CASE STUDIES IN SUSTAINABLE CONSTRUCTION AND DEMOLITION



7.1. Kuzu Effect Ankara, Zero Waste Construction Project

The Kuzu Effect Mixed-Use Project was built on a previously developed site with existing buildings. All existing trees were preserved [55].

State-owned residential buildings on the site were demolished, with 95% of the materials being recycled:

- **Concrete:** Repurposed as road base material and aggregate.
- **Steel:** Recycled.
- **Window Frames:** Dismantled and reused.
- **Wood/Doors:** Dismantled and reused.
- **Carpets and Textiles:** Dismantled and reused.
- **Other Materials:** Recycled.
- **Construction Dust:** Sent to landfill.

A Construction Waste Management Plan was implemented, achieving 100% waste recycling.

- **Concrete Waste:** Used as fill material and aggregate.
- **Metals:** Recycled.
- **Gypsum Panels:** Recycled by the manufacturer.
- **Wood/Pallets:** Donated and reused.
- **Plastic:** Recycled.
- **Glass:** Recycled.
- **Paper/Cardboard:** Recycled.
- **Drainage Water:** Recycled.
- **Soil:** Used for fill and landscaping.

Image: Kuzu Effect Mixed-Use

In 2019, the project was awarded the LEED Gold v3 Green Building Certification. Designed as a mixed-use building with residential, office, and shopping mall spaces, the project is located in Oran Neighborhood, Ankara, with a total area of 190,000 m².

Sustainable Building Consultant
ECOBUILD
Architecture
EAA, Emre Arolat Architects
Mechanical Systems Design
YMT Engineering
Electrical Systems Design
Özay Engineering

Facade Design
AXIS Cephe
Landscape Architecture
ON Tasarım
Structural Design
Ahmet YAKUT, AGM
Investment & Construction
Kuzu İnşaat, 2019



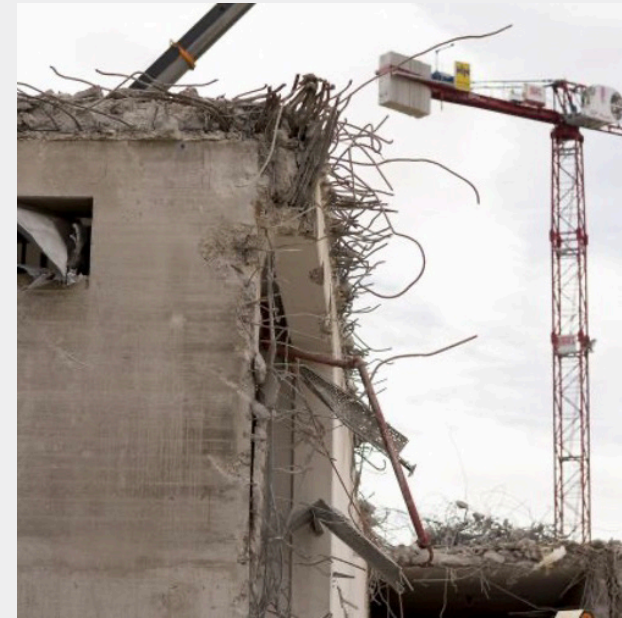
7.2. Munich Nockherberg Sustainable Demolition



The former Paulaner Brewery in Munich Nockherberg was demolished using sustainable deconstruction techniques [56].



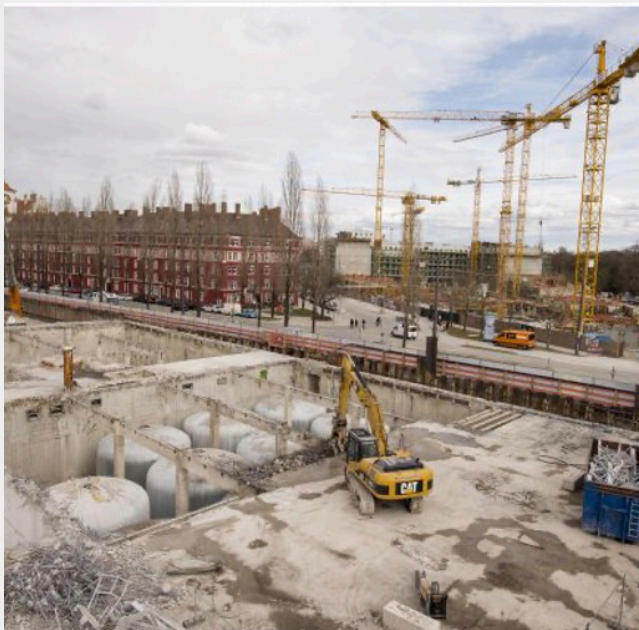
Dust control measures were implemented during demolition.



Material separation was conducted on-site.



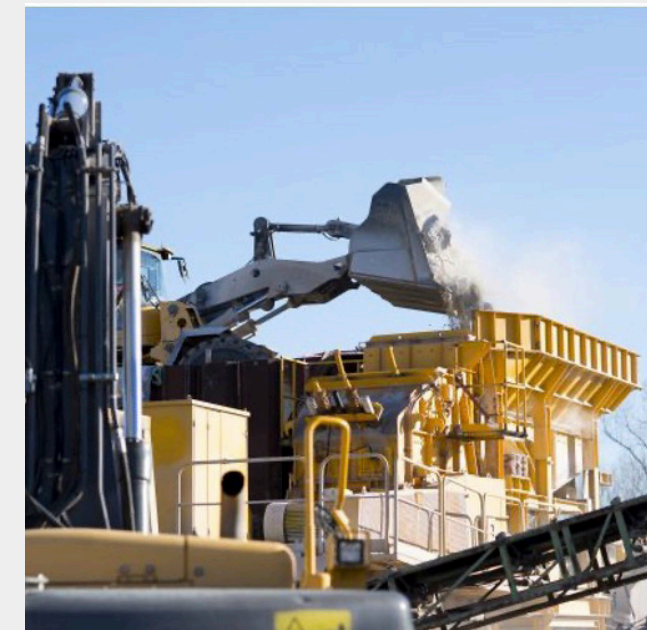
Steel components were recycled.



Old structural elements were dismantled and reused.



Concrete was cleaned and sorted on-site



Concrete was reused as aggregate on-site.



Concrete was used as road fill material.

7.3. Adnan Menderes Airport Sustainable Demolition



Image: The image depicts the demolished old İzmir Adnan Menderes Airport Domestic Terminal. With a planned approach, 95% of the demolished building was recycled [12].



Image: Including the parking lot shading elements, 100% of the permanent construction site buildings were built using salvaged materials from the old airport structure [13].



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Annexes



APPENDIX-1

Apart from the embodied water footprint of building materials, research conducted during the construction phase indicates that water consumption ranges from 1.63 to 2 kL/m² per 1 m² of construction. Factors affecting water consumption in the construction process in Tamil Nadu (IRJETS, Mohamed Rameez, 2022), Estimating the water footprint of a housing development (UAM, 2019), Studies on Virtual Water Content of Urban Buildings in India (Bardhan, 2015) <https://mcdberl.com/how-developers-can-help-save-environment-using-low-water-footprint-construction/#:~:text=Water%20footprint%20Definition%3A%20The%20fresh,the%20materials%20used%20in%20construction.>

APPENDIX-2

1. ASHRAE Guideline 0-2019 – USA: The most widely recognized guideline defining the standards for the building commissioning process.
2. LEED Commissioning Standards – USA: Includes basic and advanced commissioning criteria for LEED certification.
3. CIBSE Commissioning Code – Europe (UK): Regulates commissioning practices for mechanical and electrical systems.
4. EN 15603 – Europe: A European standard that assesses and optimizes the energy performance of buildings.
5. ISO 50001 – Energy Management System: Provides an international framework for improving energy performance.
6. Regulation on Energy Performance in Buildings– Türkiye: Covers commissioning processes to enhance energy efficiency in buildings in Türkiye.
7. Regulation on Mechanical Installation Applications in Buildings – Türkiye: Governs the proper design and commissioning of heating, cooling, and ventilation systems.

Annexes



APPENDIX-3

1. ASHRAE Guideline 0-2019: Commissioning Process: This guideline specifically highlights that commissioning practices can reduce energy consumption by 15-20%.
2. LEED v4 Reference Guide for Building Design and Construction: Energy and water savings rates are verified through data from example projects in LEED documentation.
3. National Institute of Building Sciences (NIBS) - Whole Building Design Guide: This guide states that commissioned buildings reduce operational costs by 15-20% and achieve significant energy savings.
4. U.S. Environmental Protection Agency (EPA) - Energy Star Program: The EPA reports that misconfigured systems in non-commissioned buildings can increase energy loss by 20-30%.
5. European Commission - Energy Performance of Buildings Directive (EPBD): Reports on EU energy performance standards indicate that commissioning procedures can reduce a building's life-cycle costs by up to 25%.
6. World Green Building Council (WGBC) - "The Business Case for Green Building" Report: Provides examples supporting a 15-30% reduction in operational costs.
7. Building Commissioning Association (BCA) - Best Practices Guide: The BCA emphasizes that commissioning processes have the potential to reduce energy loss in HVAC and water systems by 15-20%.

APPENDIX-4

1. LEED Reference Guide for Building Design and Construction
2. BREEAM International New Construction Technical Manual
3. World Green Building Council (WGBC) - "The Business Case for Green Building" Report
4. YeS-TR Regulation on Green Certificate for Buildings and Settlements
5. U.S. Green Building Council (USGBC) - Energy Performance Statistics
6. BRE Global - BREEAM Performance Metrics
7. European Commission - Energy Performance of Buildings Directive (EPBD)



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