



# DESIGN OF CERTIFIED GREEN BUILDINGS USING BUILDING INFORMATION MODELING

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Design of green buildings involves specific processes compared to conventional construction projects that require participation of several disciplines. Having particular activities, functions, and physical aspects, green buildings impose their own difficulties during design. Building Information Modelling systems (BIM) use different software for virtual simulation of characteristics of projects, which promotes early detection of potential problems even before production of the intended design details. Implementing BIM technology in design stage, not only helps to minimize design problems, but also to shorten the stage itself. With this effect of BIM combined with sustainable practices and energy efficient technologies, design stage alone can be considered as a sustainable application of construction activities. Therefore, principles and requirements of green building certification systems can easily be performed for projects with capabilities of BIM technologies and tools. In this study, redesign of Yildiz Technical University, Faculty of Civil Engineering Building based on LEED certification system using BIM tools is presented. The project is prepared as part of a capstone project by senior civil engineering students. Design stages are planned to promote sustainability and qualify the requirements of LEED v3 BD+C (Schools). The main objective is to introduce the students to two major trends in construction industry (green buildings and BIM applications) and to create awareness of sustainable construction, green building certification systems and emerging technologies.

*Keywords:* BIM, Sustainable construction, Green building certification systems, LEED, Civil engineering education.

## 1 INTRODUCTION

Sustainability is becoming an important factor due to depletion of natural resources and environmental pollution. With the introduction of sustainability into construction industry, design of environmentally-friendly “Green Buildings” is frequently practiced. Standards and certification systems have been developed in mostly developed countries are also used in other countries.

Construction sector constitutes an important role in the use of natural resources and energy consumption all over the world. It is reported that construction sector alone is responsible for 50% of the energy consumption and 42% of water consumption globally (Dikmen 2011). Management of construction and other activities in the whole life cycle buildings can be improved by the help of advances in information technology. Building Information Modeling (BIM) has become a significant technological tool that provides foresight about future problems and addresses solutions for multi-disciplinary working groups in projects (Akkaya and Basaraner 2012).

Although BIM is recognized as a tool to contribute positively to the management of projects, the current curriculum of civil engineering programs in Turkey merely provides theoretical and practical background of BIM. In this study, the effort to introduce BIM to senior students along with sustainable construction and LEED system by integrating all these concepts in a Capstone Project is presented. In the following parts, briefly sustainability, BIM and LEED are explained, followed by the implementation of them together on an existing building, namely Yildiz Technical University, Faculty of Civil Engineering Building.

## **2 SUSTAINABILITY, GREEN BUILDINGS AND LEED**

Sustainability principles ideally should be applied throughout the life cycle of a building, including design and construction phases, while supporting decisions made in course (Kibert 2013). It should be noted that the life cycle starts from inception to the termination phases of a building. Principles of sustainable construction can be listed as follows:

With the increasing use of sustainable practices in construction industry, the efforts to establish standards started emerging, particularly in developed countries; followed or adapted by developing countries. Currently, there are several certification systems initiated, i.e., BREEAM (Building Research Establishment Environmental Assessment Method), LEED (Leadership in Energy and Environmental Design), DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen e.V.), IISBE (International Initiative for Sustainable Built Environment), Greenstar (Environmental Rating System for Buildings), Casbee (Comprehensive Assessment System for Built Environment Efficiency).

Green buildings can be constructed with different features referring sustainable construction methods and practices. The design can provide low carbon emissions, efficient energy use, effective water management, automated and smart lighting systems, green material use, and other environmental-friendly technologies and methods (GYODER 2014).

## **3 BUILDING INFORMATION MODELING (BIM)**

Building Information Modeling (BIM) can simply be described as a three-dimensional platform that aims for information sharing among architectural, structural, electrical, mechanical, construction design, and facility management teams. In this process, different software is used for the management of the projects. Project parties and members such as owners, contractors, engineers, and architects can be able to contribute, follow, and revise project information, and reach details whenever needed. BIM can be used for the entire construction process as well as for only a particular part in this process.

## **4 GREEN BUILDING MODELING BASED ON LEED CRITERIA USING BIM**

The redesign of the Yildiz Technical University Faculty of Civil Engineering Building according to LEED certification system using BIM tools is presented. The design is performed with technologies using BIM provided by analysis steps and several implementation and practices supporting sustainable construction. Autodesk Revit is utilized as one of the BIM based programs. In the first step, architectural and structural drawings of the building were acquired in 2D, which were prepared in AutoCAD, and then these drawings were used in Revit to establish the 3D model. Figure 1 shows Autodesk Revit drawing and front entrance of the actual building.



Figure 1. Yildiz Technical University, Faculty of Civil Engineering Building.

#### 4.1 Assessment of the Existing Building According to LEED

LEED certification system can be applicable on different type of buildings. In this study, the existing design of Yildiz Technical Faculty of Civil Engineering Building is evaluated according to LEED BD+C Schools v3 rating system. The objective is to identify the criteria and their corresponding points applicable to this building. Based on this evaluation, it is found that for the building in its existing form, 16 points could be achieved based on LEED BD+C Schools v3 rating system (Table 1).

Table 1. LEED points achieved with existing design (USGBC 2009).

LEED Criteria	Achieved point	Intent
Site selection	1	To avoid the development of environmentally sensitive lands and reduce the environmental impact from the location of a building on a site.
Joint use of facilities	1	To integrate the school with the community by sharing the building and its playing fields for non-school events and functions
Development density and community connectivity	4	To channel development to urban areas with existing infrastructure, protect greenfields, and preserve habitat and natural resources
Brownfield redevelopment	1	To rehabilitate damaged sites where development is complicated by environmental contamination and to reduce pressure on undeveloped land.
Alternative transportation- public transportation access	4	To reduce pollution and land development impacts from automobile use
Alternative transportation- bicycle storage and changing room	1	To reduce pollution and land development impacts from automobile use
Alternative transportation- parking capacity	2	To reduce pollution and land development impacts from automobile use
Site development- protect or restore habitat	1	To conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity
Process water use reduction	1	To increase water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems

## 4.2 Redesigning the Building According to LEED System

Although with its existing condition, the building is insufficient to qualify for a level of certification through LEED system, it is possible to add some features that might help to achieve points adequate for certification, as well as acquiring additional sustainable practices in the building. New design options are searched to collect points based on LEED BD+C Schools v3. For this purpose, BIM libraries are reviewed for potential materials, which can be integrated to the new design. Once the convenient options are found, the building is redesigned Table 2 shows the additional 16 points that can be achieved after this stage.

Table 2. LEED points achieved after redesigning according to LEED BD+C Schools v3 (USGBC 2009).

LEED Criteria	Achieved point	Intent
Alternative transportation-low-emitting and fuel-efficient vehicles	2	To reduce pollution and land development impacts from automobile use
Site development-maximize open space	1	To promote biodiversity by providing a high ratio of open space to development footprint
Heat island effect- roof	1	To reduce heat islands1 to minimize impacts on microclimates and human and wildlife habitats
Heat island effect - nonroof	1	To reduce heat islands1 to minimize impacts on microclimates and human and wildlife habitats
Light pollution reduction	1	To minimize light trespass from the building and site, reduce sky-glow to increase night sky access, improve nighttime visibility through glare reduction and reduce development impact from lighting on nocturnal environment
Site master plan	1	To ensure that the environmental site issues included in the initial development of the site and project are continued throughout future development caused by changes in programs or demography.
Water use reduction	4	To increase water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems
Enhanced refrigerant management	1	To reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to climate change
Rapidly renewable materials	1	To reduce the use and depletion of finite raw materials and long-cycle renewable materials by replacing them with rapidly renewable materials
Certified wood	1	To encourage environmentally responsible forest management
Daylight and views - daylight	1	To provide building occupants with a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building
Daylight and views - views	1	To provide building occupants a connection to the outdoors through the introduction of daylight and views into the regularly occupied areas of the building

## 4.3 Additional LEED Criteria Achieved Assumed for the Existing Building

In this section, the criteria that are assumed to have been qualified during the construction stage of the existing building are presented (Table 3) and sample drawings of the building can be seen in Figure 2. It is noted that 9 points can be achieved.

Table 3. LEED points achieved assumed during design stage.

LEED Criteria	Achieved point	Intent
Building Reuse-Maintain Existing Walls, Floors and Roof	2	To extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport
Construction Waste Management	2	To divert construction and demolition debris from disposal in landfills and incineration facilities. Redirect recyclable recovered resources back to the manufacturing process and reusable materials to appropriate sites
Building Reuse- Maintain Interior Nonstructural Elements	1	To extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport
Materials Reuse	2	To reuse building materials and products to reduce demand for virgin materials and reduce waste, thereby lessening impacts associated with the extraction and processing of virgin resources
Recycled Content	2	To increase demand for building products that incorporate recycled content materials, thereby reducing impacts resulting from extraction and processing of virgin materials

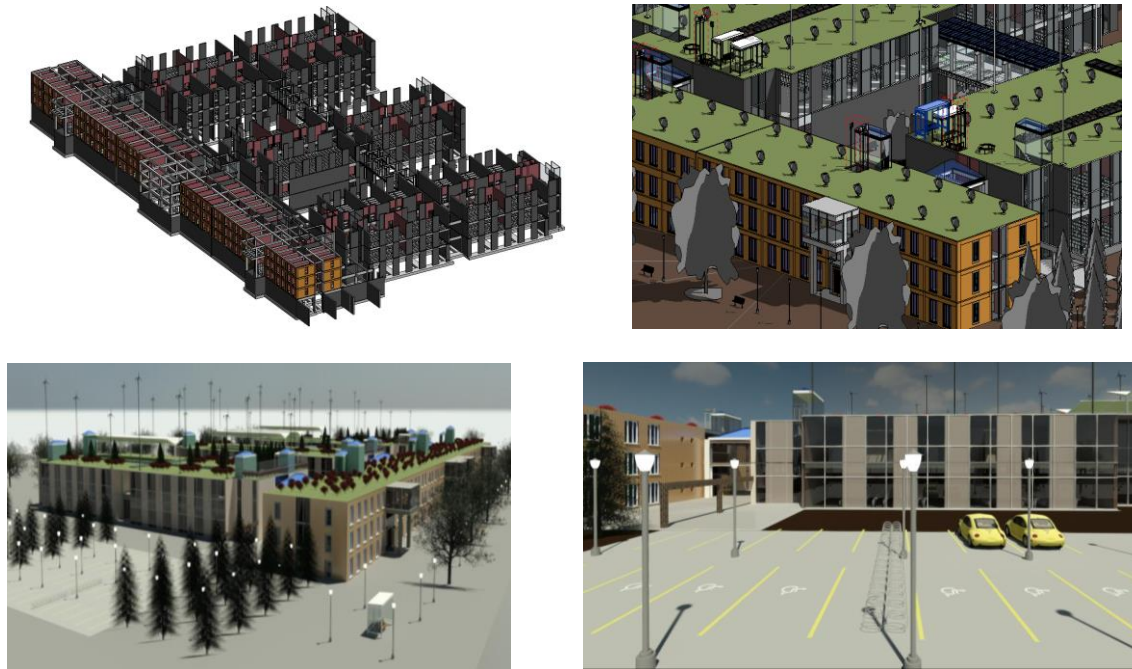


Figure 2. Sample drawings from the building.

## 5 CONCLUSIONS

In this study, Yildiz Technical University, Faculty of Civil Engineering Building was assessed and redesigned according to green building principles, using one of the BIM-based tools - Autodesk Revit.

Compliance with LEED certification system is analyzed through modeling by BIM applications. Analysis results showed that, existing design conditions exhibit 16 points. By redesigning the building, it is found that 16 more points can be achieved with additional sustainable construction practices. With the assumptions of points that are achieved during construction stage, the building score can reach to 41 points, which qualifies for LEED certification.

It is observed that BIM-based tools can be efficiently used during design stage of buildings, which aim to register for green building certification systems. Use of such tools can help to identify and prevent possible problems related to certification requirements that might occur in the future before construction stage.

BIM can be simply described as a system that provides a platform for all parties to participate in different phases of projects, which eventually influence the success of project management processes. Most of the undergraduate curriculum plans of civil engineering programs still lack related courses in Turkey. Therefore, students preparing a Capstone Project using means such as BIM could benefit from experiencing innovative approaches, which have become popular in construction industry before graduation. Inclusion of LEED green building certification system has also provided insights to students about sustainable construction and how they could utilize it as a means to achieve sustainability goals.

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