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From The Editor

Euras Journal of Engineering and Applied Sciences (EJEAS), is a peer-reviewed academic journal, establishing a solid platform for all academicians, consultants, researchers, and those who have a strong interest in global current issues and trends in engineering and applied sciences. Euras Journal of Engineering and Applied Sciences is based on engineering and applied sciences; artificial intelligence, cybersecurity, environmental sciences, food and food safety, biotechnology, material science and composites, nanotechnology, energy technologies, electronics, robotics, thermal sciences, earthquakes – structures – foundation and earth sciences studies. Subject areas could be as narrow as a specific phenomenon or device or as broad as a system.

EJEAS was established with the intention of promoting scholarly communication all over the world in a more effective manner. Our aim is to establish a publication that will be abstracted and indexed in the Engineering Index (EI) and Science Citation Index (SCI) in the near future. The journal has a short processing period to encourage young scientists.

Prof. Dr. Hasan HEPERKAN
Editor

Research Article

REAL-TIME ONLINE EDUCATION STUDENT LECTURE EMOTION DETECTION

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ABSTRACT

During the Covid-19 pandemic, everything has been shifted to using the internet to get whatever the job is done. In particular, the educational system used the internet for online classes and meetings. This virtual connection faced some issues such as no facial expression between the students and the teachers. This is a big issue when it comes to learning. Neither the teacher nor the student has got to understand everything in the online classroom. This study comes to a solution. So, in order to make those virtual classrooms as normal as the face-to-face classroom, it creates a system of capturing the Emotion expressions into understandable language. This language is data that transforms into words. So, the teacher could get a statement about the student's emotions. Emotion recognition (ER) is the process of identifying human emotion, and it's the most complex field of pattern recognition. It has become an even more important topic since it has become the main component in many Artificial Intelligence applications. The goal of emotion recognition is to identify human feelings. Feelings can be captured either from the face or from verbal communication. Emotion recognition is a valuable tool for a variety of industries and applications. It can improve security measures, aid in healthcare, and assist in the care of children with autism. Additionally, it is utilized in the development of video games and human-computer interactions. One example of its use is in a study that uses students' computers to capture facial expressions through a camera, helping to identify common emotions.

Keywords: *Emotion recognition (ER).*

1. INTRODUCTION

This study connects the instructor with the student's emotional responses, so it could help them understand the best teaching methods based on what's affecting their classes at that time. Emotions are a normal part of human lives, they help us to engage socially with the world. Emotions are involuntary responses to our thoughts, so it all affects our thoughts and actions. People express emotions through facial expressions and by using their body language to communicate with others. One way to understand the emotions of others is to detect emotional expressions in facial images or body language. Emotional recognition is an active research area in computer vision, and many networks

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have been trained to identify different emotions from facial images. Computer vision techniques are used to analyze real-time lecture videos in order to extract the emotions of students, as emotions are crucial for effective learning. A pre-trained Convolutional Neural Network (CNN) is utilized to identify seven basic emotions: anger, disgust, fear, happiness, sadness, surprise, and contempt. These emotions are then used to determine levels of engagement among students in a virtual classroom, including highly engaged, and disengaged students. To achieve this goal, it is intended to investigate the possible use of two different classifiers; the classifiers used in this study include Convolutional Neural Network (CNN) and a genetically Optimized CNN model, The Convolutional neural networks (CNN) are trained to recognize emotions from facial images by taking advantage of deep learning techniques. A CNN contains several layers of neural networks that process and classify an image based on its features, and the second classifier is the Genetic Algorithm (GA) is a technique for solving optimization problems, both those with constraints and those without, using principles inspired by natural selection, the mechanism that drives biological evolution.

2. LITERATURE REVIEW

In this paper, Preeti develops a computer algorithm for the Classification of leukemia as an aspect of research in hematological image processing [1]. ADNAN and others present an automated dermatological diagnostic system that uses color image processing techniques to identify diseased skin [2]. Taiping and colleagues employ image processing to adjust face images to consistent lighting conditions [3]. Additionally, Zhangcan and associates describe an image processing based method for identifying crack patterns in cement [4].

Convolutional Neural Networks (CNNs) are powerful tools for image recognition and processing. These networks are a type of Artificial Neural Network (ANN) that are specifically designed to handle image data. CNNs consist of multiple layers, including convolutional layers, pooling layers, and fully connected layers, that work together to identify objects within an image. CNNs have made significant advancements in the field of computer vision and have been proven to be highly effective at object recognition tasks. The convolutional layer is responsible for creating feature maps by applying a set of filters to the input image, the pooling layer is responsible for reducing the spatial dimensions of the feature maps and the fully connected layers are responsible for making the final decision on the object in the image by combining the features extracted by the convolutional and pooling layers. The combination of these layers enables CNNs to effectively recognize patterns and features within images, making them an important tool for a wide range of computer vision applications.

I studied the paper by Yakup et al to explore the utilization of CNN in recognition tasks, the paper presents a modified CNN architecture that includes the addition of two normalization operations to two layers [6].

The convolutional neural network is highly effective in recognizing human facial expressions. Steve and his team presented a rapid, automated system for face recognition, which combines a local image sample representation, a Self-Organizing Map (SOM) network, and a convolutional network for face recognition [7]. Furthermore, Earnest and his team proposed two methods for facial recognition under varying lighting conditions, utilizing deep convolutional neural networks, which allows the system to distinguish between individuals by analyzing the unique patterns in their facial information [8].

Facial expression recognition has become a core concept in Artificial Intelligence (AI) research. It has a crucial role in many applications of computer vision, and human-computer interaction, it is also essential for communication and emotional processing.

In this paper, Khadija and others provide a comparative study on facial emotion recognition problems and offer a more up-to-date introduction to the area [9]. Ananthu and his colleagues proposed a real-time facial emotion recognition system that aims to create an advanced system that can accurately identify a user's facial expression in real-time, and generate the corresponding emotion. The system could have wide range of applications from user engagement in virtual reality to psychological research and mental health monitoring [10].

The process of extracting features from data is crucial for many machine learning and computer vision tasks, including face recognition. One notable example of a feature extraction algorithm is the Feature Extraction based Face Recognition, Gender, and Age Classification (FEBFRGAC) algorithm proposed by Ramesha and his team. This algorithm involves three main steps: pre-processing, feature extraction, and classification.

Another approach to feature extraction that has been proposed for face recognition is the margin-based between-class scatter and regularization process developed by Youn Jung and his colleagues. This method aims to improve the accuracy and reliability of face recognition systems by addressing the issue of accurate feature extraction. This approach uses a margin-based criterion to separate features and regularization process to improve the robustness of the model. This method can be used to improve the performance of face recognition systems by providing more accurate and reliable feature sets.

Face recognition utilizes ML and AI algorithms to recognize human faces. AI is a research field that utilizes technology to simulate human intelligence processes. To evaluate information patterns using AI algorithms and correlate the information to produce results, AI needs a set of unstructured data. By learning from and discovering through data, AI may automate frequent, high-volume operations. Second, it gives products in the area of automation, conversational platforms, intelligent machines, and bots more intelligence. Thirdly, it can learn by itself via algorithms by identifying patterns and regularities.

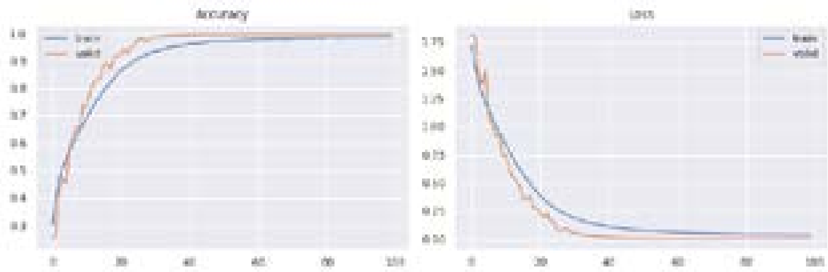
Machine Learning (ML) is a branch of Artificial Intelligence (AI) that primarily focuses on using data and algorithms to simulate human learning. It employs statistical techniques to train algorithms to classify, predict, and uncover insights from data mining projects. In the field of computer vision, ML is utilized to extract valuable information from images, videos, and other visual inputs. It can be used to identify patterns, objects and even emotions in the visual data, which can have wide-ranging applications in various industries such as healthcare, security, and entertainment.

Computer vision is a branch of Artificial Intelligence (AI) that is focused on giving computers the ability to understand and interpret the visual information in images or videos. One of the key ways that this is accomplished is through the use of deep learning techniques, which are known for their ability to achieve superior results in challenging computer vision tasks such as image classification, object detection, and facial recognition. These methods are able to learn complex patterns and features from the data, allowing for more accurate and robust results.

3. PROPOSED METHOD

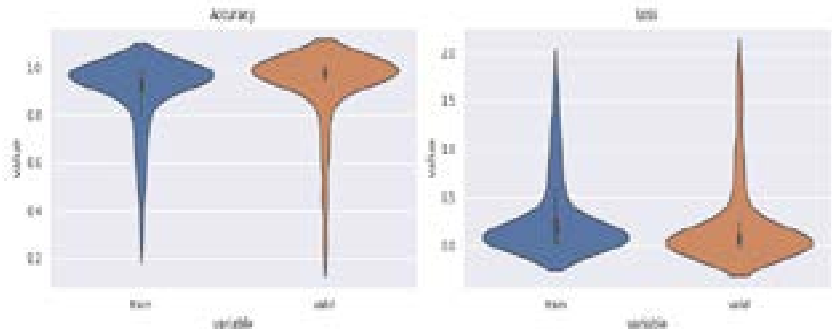
This section explains the proposed system, which includes data gathering and preprocessing. Following preprocessing, the data will be fed into both ML and DL models. In ML, the preprocessed data will be fed into ML classifiers and the outputs of all ML classifiers will be shown. It will also choose the best ML model with the maximum accuracy. The goal of this model is to effectively recognize facial expressions by utilizing a limited dataset through training. This approach is inspired by the research of Caroppo et al. and Heidari and Fouladi-Ghaleh [13]. In order to achieve this, I employed the transfer learning technique by building a convolutional neural network (CNN) using a pre-trained model known as VGG16. This model is provided by the Keras library in Python. As discussed in the literature review, VGG16 is a powerful model that comprises of five convolutional blocks and three fully connected layers. I utilized this framework as a foundation for my CNN model, while also making several modifications and additions. Specifically, the input layer was adjusted to accept images of size 48 * 48 *1. In this approach, we are leveraging the already learned feature from the pre-trained model and fine-tuning it to our dataset, this will reduce the amount of data needed for training, and also will increase the performance of the model. For each convolutional block, there are convolutional layers, one 2D max-pooling layer, and one Batch Normalization layer for each convolutional layer. The five convolutional blocks contain 265, 500, 800, and 1024 convolutional kernels of size 3 * 3. Following the convolutional blocks are three fully connected layers of 512 neurons. A “Rectified Linear Unit (RELU)” activation function is applied after each layer to improve the model’s performance. Additionally, dropout layers with a rate of 25% are included. To counteract the potential issue of overfitting due to limited data, I incorporated dropout layers into the model. These layers act as a form of regularization by randomly deactivating certain neurons during the training process. This helps to prevent the model from becoming too specialized to the training data and increases the generalization of the model. As a result, it will be able to perform better on unseen data. This way we can improve the robustness and the accuracy of the model.

4. RESULTS



(a) (b)

Figure 1. The plot line between the accuracy and the number of epochs.



(a) (b)

Figure 2. Expresses the accuracy, and it represents the loss.

The following graph (Figure 1) expresses the plot line between the accuracy and the number of epochs, In the graph, the blue line indicates the accuracy of the training set, while the red line represents the accuracy of the validation set. It can be observed that the accuracy improves as the number of epochs increases. The validation set reaches its peak at around 83 epochs, while the training set reaches its optimal performance at 90 epochs, and for the other plot (Los function) it expresses the percentage change of the real value with the value of predict through the model, and this value we want to try to approach zero starts The loss was at a value of 1.75 about the training and validation, and the loss kept improving, and when it reached the number of epochs 40, the loss in terms of validation had reached the maximum value, and the training set was at the number of epochs 80. Graph (Figure 2. a) expresses the accuracy, and graph (Figure 2. b) represents the loss. The white dot on the violin plots represents the median, the black bar in the center of the violin is the interquartile range and the black lines stretched from the bar represent the lower/upper adjacent values. It's concluded that when the number of epochs is 80, the accuracy increases to reach 1.0, and the loss decreases until it becomes almost zero and we reach the best accuracy result.

5. CONCLUSION

In conclusion, this research aimed to enhance communication and engagement between teachers and students during online lectures through the use of facial expression recognition technology. The program developed in this study provides teachers with valuable insights into students' emotional states in real time, which can be used to adjust teaching methods and materials to better meet the needs of the students. One of the unique contributions of this study is the analysis of less frequently examined facial expressions, which expands the scope of previous research in the field of facial expression recognition. The program developed in this study is based on the combination of two technologies: facial recognition and image processing. The program uses the OpenCV library for feature extraction, which is then fed into a Support Vector Machine (SVM) classifier that is trained with labeled data sets. The program is designed to recognize and distinguish between five primary facial expressions: happy, sad, surprised, angry, and disgusted. The implementation of this program can result in a more effective and engaging learning experience for students and can help teachers to adjust their teaching style to better meet the needs of their students. Additionally, this program can be used in other fields such as customer service, security, and marketing where understanding people's emotions is crucial.

NOTE: This article is taken from master's thesis (REAL-TIME ONLINE EDUCATION STUDENT LECTURE EMOTION DETECTION) under the supervision of Prof. Dr. Ali Okatan, at Istanbul Aydin University.

REFERENCES

[1] 2017 International Conference on Trends in Electronics and Informatics (ICEI) https://ieeexplore.ieee.org/abstract/document/8300983

[2] Proceedings of the 2012 International Conference on Machine Learning and Cybernetics, Xian, 15-17 July, 2012 DERMATOLOGICAL DISEASE DIAGNOSIS USING COLOR-SKIN IMAGES M. SHAMSUL ARIFINI , M. GOLAM KIBRIA2, ADNAN FIROZE" M. ASHRAFUL AMINI , HONG YAN3 https://ieeexplore.ieee.org/document/6359626

[3] IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 18, NO. 11, NOVEMBER 2009 Face Recognition Under Varying Illumination Using Gradientfaces Taiping Zhang, Student Member, IEEE https://ieeexplore.ieee.org/document/5173527

[4] Detection crack in image using Otsu method and multiple filtering in image processing techniques " 2015 Published by Elsevier GmbH , Zhangcan Huang https://www.sciencedirect.com/science/article/abs/pii/S0030402615012164

[5] IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE, VOL. 27, NO. 5, MAY 2005 "Active and Dynamic Information Fusion for Facial Expression Understanding from Image Sequences" , Yongmian Zhang https://ieeexplore.ieee.org/document/1407874

[6] Musab Coúkun "Face Recognition Based on Convolutional Neural Network" https://ieeexplore.ieee.org/document/8248937

[7] IEEE TRANSACTIONS ON NEURAL NETWORKS, VOL. 8, NO. 1, JANUARY 1997 "Face Recognition: A Convolutional Neural-Network Approach" , Steve Lawrence https://ieeexplore.ieee.org/document/554195

[8] 'Illumination Invariant Face Recognition Using Convolutional Neural Networks' N. Pattabhi Ramaiah , https://ieeexplore.ieee.org/abstract/document/7091490

[9] Proceedings of the Third International Conference on Smart Systems and Inventive Technology (ICSSIT 2020) IEEE Xplore Part Number: CFP20P17-ART 'Real-Time Facial Emotion Recognition System with Improved Preprocessing and Feature Extraction' https://ieeexplore.ieee.org/document/9214207

[10] (IJCSE) International Journal on Computer Science and Engineering , "Feature Extraction based Face Recognition, Gender and Age Classification"https://www.researchgate.net/publication/41392206_Feature_Extraction_based_Face_Recognition_Gender_and_Age_Classification

[11] Sang-Ki Kim, Youn Jung Park, Kar-Ann Toh, Sangyoun Lee Biometrics Engineering Research Center, School of Electrical & Electronic Engineering, Yonsei University, 134 Shinchon-dong, Seodaemun-gu, Seoul 120-749, Republic of Korea " SVM-based feature extraction for face recognition" https://www.sciencedirect.com/science/article/abs/pii/S0031320310001287

[12] Proceedings of the Third International Conference on Smart Systems and Inventive Technology "Real-Time Facial Emotion Recognition System With Improved Preprocessing and Feature Extraction" https://ieeexplore.ieee.org/document/9214207

[13] M. Heidari and K. Fouladi-Ghaleh, "Using Siamese networks with transfer learning for face recognition on small-samples datasets,https://ieeexplore.ieee.org/abstract/document/9116915

UNIVERSITY CAMPUS BUILDING ENERGY MODELING: A CASE STUDY

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ABSTRACT

Several universities in Turkey are implementing efforts to make their campuses more sustainable. Typically, their sustainability initiatives focus on improving the energy efficiency of new and existing buildings. There are several ways to improve building's energy efficiency and building energy models may be used to evaluate these strategies. While energy models are frequently utilized during the design of new buildings, they are rarely utilized to analyze the actual performance of those buildings. This paper presents a case study in which a prominent energy modeling software (Energy Plus) was used to assess the performance of a 12000-square-meter university building. The building was built in 1995 and has undergone significant alterations over the years. The aim of the research is to utilize energy modeling software to estimate the building's energy use and compare it to actual utility data. This paper discusses the data collection method, the modeling process, and the analysis of modeling outputs.

***Keywords**: Building Energy Modeling, Energy Use, Existing Buildings.*

1. INTRODUCTION

Several universities in Turkey are implementing efforts to make their campuses more sustainable [1]. Universities have a special responsibility for their societies and for educating the individuals who will develop the social, economic, and technical solutions necessary to reverse global warming and contribute to the development of a healthy and sustainable society [2]. The buildings and buildings construction sectors combined are responsible for over one-third of global final energy consumption and nearly 40% of total direct and indirect CO_2 emissions [3]. Thus, every efficient climate change mitigation strategy should include measures to dramatically reduce building energy use.

Increasing the energy performance of the buildings is one of the most effective strategies to significantly reduce GHG emissions. At present, about 35% of the European Union's buildings are over 50 years old and almost 75% of the building stock is energy ineffi-

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cient. At the same time, only about 1% of the building stock is renovated each year. Renovation of existing buildings can lead to significant energy savings, as it could reduce the EU's total energy consumption by 5-6% and lower CO_2 emissions by about 5% [4]. Therefore, there is an increasing demand for energy modeling tools to assist in the study of an existing building's energy use.

Building Energy Modeling (BEM) is the practice of using computer-based simulation software to perform a detailed analysis of a building's energy use and energy-using systems. The simulation software works by enacting a mathematical model that provides an approximate representation of the building. BEM offers an alternative approach that encourages customized, integrated design solutions, which offer deeper savings. Using BEM to compare energy-efficiency options directs design decisions prior to construction. It also guides existing building projects to optimize operation or explore retrofit opportunities [5].

By accounting for actual construction materials and HVAC systems, BEMs can estimate a building's energy use. BEMs also take into consideration the impact of occupants on energy use by setting occupant schedules. Occupants have a major impact on thermal load and ventilation needs, which in turn affects the demand on HVAC systems and fans [6].

While energy models are frequently utilized during the design of new buildings, they are rarely utilized to analyze the actual performance of those buildings. For existing buildings, every effort to find optimal energy efficiency methods should begin with an understanding of how the building presently consumes energy through the use of an energy model that accurately simulates real building performance. Actual system performance fluctuates throughout the course of a building's life cycle since buildings' systems deteriorate and their efficiency decrease with time, especially if they are not properly maintained. Failures in mechanical systems and lighting equipment alone can account for between 2% and 11% of a commercial building's overall energy use [7].

This paper presents a case study in which a prominent energy modeling software (Energy Plus) was used to assess the performance of a 12000 square meter university building. The building was built in 1995 and has undergone significant alterations over the years. The aim of the research is to utilize energy modeling software to estimate the building's energy use and compare it to actual utility data. This paper discusses the data collection method, the modeling process, and the analysis of modeling outputs.

2. DATA COLLECTION

With the advancement of building energy modeling technologies, the quantity of user input and data necessary to develop the models increased. While some of the needed data is readily available, some require greater effort to collect with sufficient accuracy. Accurately obtaining the needed data is particularly difficult in older buildings, as the information contained in designs may be out of date because of renovations undertaken. The following data are required for creating an energy model for a building.

Architectural Data: The architectural design of a building has a significant impact on its energy use. When architects and designers have a solid understanding of the complicated interactions between building design and energy use, they can make educated and cost-effective decisions regarding energy-saving measures in their buildings

[8]. The architectural data required for modeling are mostly the following:

- The building's orientation, the city in which it is located (for weather details), and the building's relative location in relation to any tall building that throws a shadow on it.
- The number of floors, the total square meter of conditioned, unconditioned, and ventilated spaces (m2) on each floor.
- The materials used to create all external walls, roof and floor slabs, windows and doors, the thickness and type of insulation used in walls, the flooring material used in walls, and the kind of wall-slab construction connection.
- The total number, size, and location of external doors and windows, as well as any overhangs, fins, blinds, or curtains on windows.
- U-value (conductance) and shading coefficient (SC) of external window and door materials.

Mechanical Data: HVAC systems are among the most energy-intensive systems in many buildings [9]. As a result, precise information on their size and zoning is critical.

- The division of conditioned floor area into separate areas (zones) based on the AHUs that serve them.
- Each HVAC zone is designated to a certain activity (e.g., classroom, library, office, etc.) and is assigned a m2/person and a minimum m3/person.
- Each AHU is established with a Minimum Design Flow (m3/m2) and a minimum design flow for the core and perimeter zones.
- System and equipment description, the cooling and heating sources, the hot water supply, and the return air channel.
- Each zone has a set maximum and lowest set-point temperature for both occupied and unoccupied states.

Electrical Data: Another significant user of power in buildings is electrical equipment.

- Lighting types present in buildings (including interior and exterior end uses), interior lighting, office equipment, and exterior lighting loads and profiles (W/m2).

Internal Loads Data:

- Calculate maximum occupancy (m2/person)
- Wattage per square meter (W/ m2) of all lighting fixtures installed in the building

- W/m2 of all electrical equipment installed in the building.

Operations Data: Because operation schedules have a significant impact on energy use, it is critical to have precise information about them.

- The number of seasons in the year, their beginning and ending dates, building opening, and closing times, and occupancy, lighting, and miscellaneous (office) equipment schedules.

- Set-point temperatures for both occupied and unoccupied circumstances.

- Data on the size (kilowatts) and quantity of all sorts of fans (exhaust, ventilation, return) in the building.

3. ENERGY MODELING

Design Builder is used to create full three-dimensional architectural models that are exported to EnergyPlus (v9.4) as an input file which is used for analysis of existing building energy performance.

Energy Plus implements detailed building physics for air and heat transfer including treating radiative and convective heat-transfer separately to support modeling of radiant systems and calculation of thermal comfort metrics; calculates lighting, shading, and visual comfort metrics; supports flexible component-level configuration of HVAC, plant, and refrigeration systems; includes a large set of HVAC and plant component models; simulates sub-hourly time steps to handle fast system dynamics and control strategies; and has a programmable external interface for modeling control sequences and interfacing with other analyses [10].

The case building, located in the main campus of Marmara University, Istanbul, Turkey, consists of two connected buildings which are rectorate building and library building. The building has a reinforced concrete building with filled in brick walls and with heat insulation. The fenestration of the building consists of aluminum frames without thermal break and double-pane clear glass with U-value of 3.2 W/m2K. Heating demand is met by an old non-condensing boiler with 500 kW heating capacity using natural gas as the primary energy source. Cooling demand is met by an old air-cooled chiller with 650 kW cooling capacity for library building and 20 air conditioning split units for administrative building spaces. Air Handling Unit (AHU) provides outdoor air for library building spaces. The AHU total supply air flow rate is 19500 m3/h, heating and cooling coils are supplied by boiler and chiller. There are no individual indoor thermostats for different parts of the building. Main thermostat setpoint temperatures were designed as 23 ºC for heating season and 24 ºC for cooling season. The library building lighting system has recently been renovated with LED lamps, while most of the administrative building office areas have fluorescent lamps. The performance of a 12000-square-meter university facility was evaluated using Energyplus. The building was built in 1995 and has undergone significant alterations over the years. The building includes offices, meeting rooms, corridors and has a library with reading areas. The administrative building is used between 8am and 6pm on weekdays, while some part of the library building is used 7/24. For energy simulation weather data, Typical Meteorological Year (TMY) of Istanbul Goztepe region weather file is used.

General building information and building envelope elements U-values are provided in Table 1 and Table 2, respectively.

Table 1. Building information

Building Information	
Building Area (m^2)	12000
Conditioned Building Area (m^2)	8610
Façade Surface Area (m^2)	4690
Roof Area (m^2)	2300
Glazing Area (m^2)	820
Glazing Ratio (%)	17.5

Table 2. Building Envelope Elements and U-values

Building Elements	**U-Value (W/m^2K)**
External Walls	0.60
Roof	0.42
Slab On Grade Floor	0.56

Authorized personnel from the Department of Construction and Maintenance provided the necessary data, which included CAD drawings of all levels, floor plans, HVAC designs and final energy audit report dated December 2020. Provided energy audit report includes general building information, building occupancy patterns, HVAC, and lighting system/equipment description. Building energy model generated through observations from site visit and measurements taken from 2020 energy audit. The building depicted in Figure 1 is one utilized in the case study.

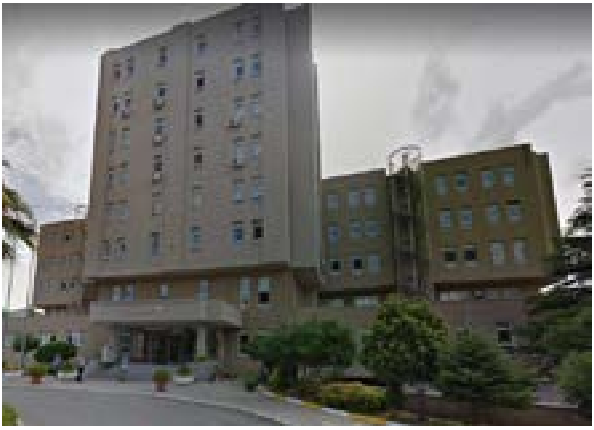

Figure 1. The building used in the case study

Additionally, the building had been visited twice with the assistance of university authorized personnel, who discussed the configuration of the building's HVAC systems and any modifications made since their initial installation. Moreover, university authorized personnel provided utility bills for 2018, 2019, and 2020, broken down by natural gas and electricity use.

As seen in Figure 2 and Figure 3, Energy Plus model was generated with the following input:

- Computer-aided design (CAD) drawings of all floors,
- The orientation of the building and its geographical location – the floor-to-floor heights
- Construction of the external and interior envelopes of buildings (roofs, walls, slabs) – materials and insulation,
- Fenestration details, HVAC zoning of all floors, assigning these zones to various activities,
- Building operating schedule, building occupancy details, lighting and office equipment load details, details of all HVAC systems, settings for ventilation and airflow in all areas

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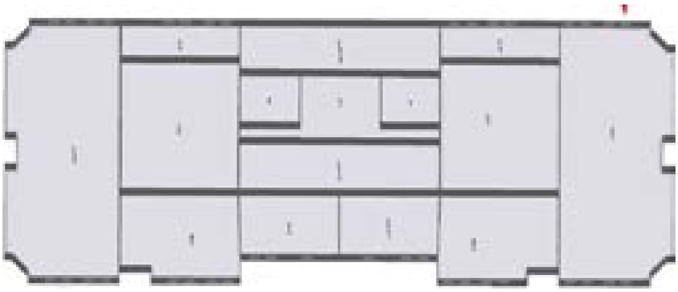
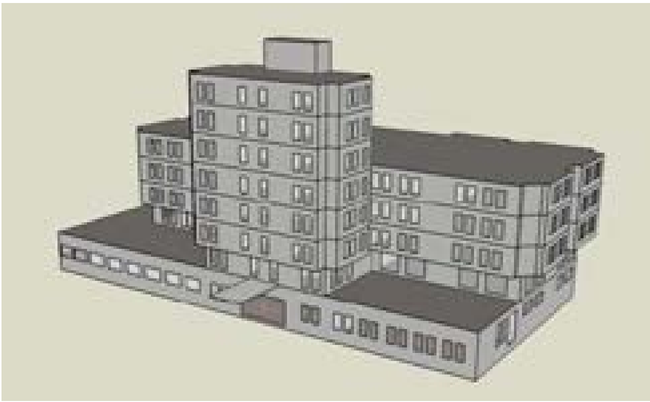




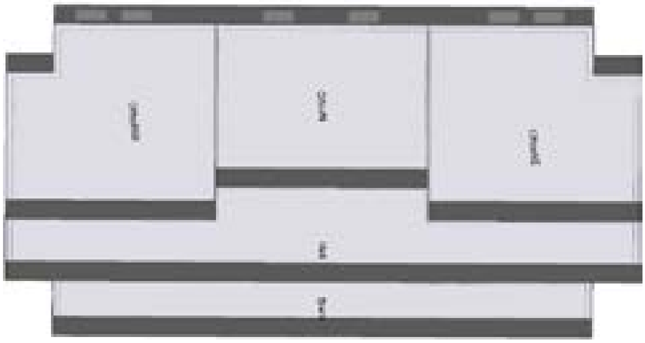


Figure 2. Design Builder rendering of the building and floor plans

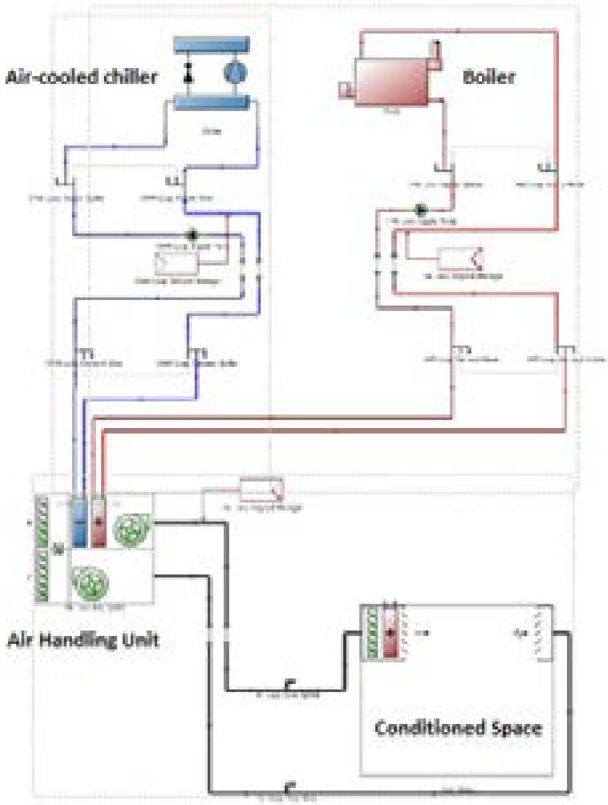
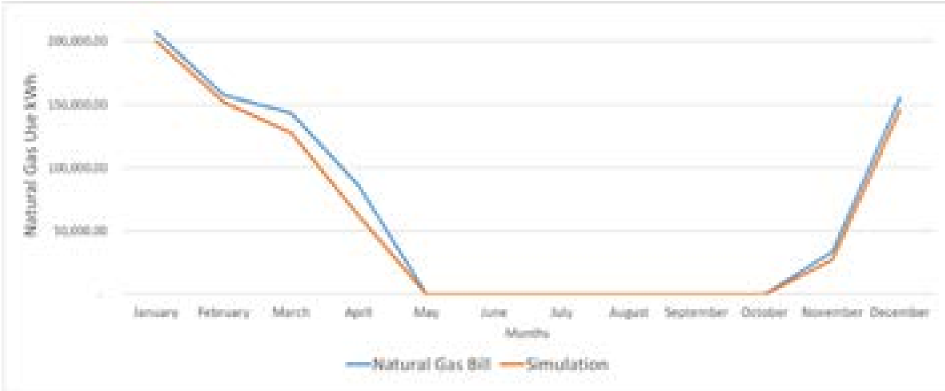


Figure 3. HVAC system schematic view for library building

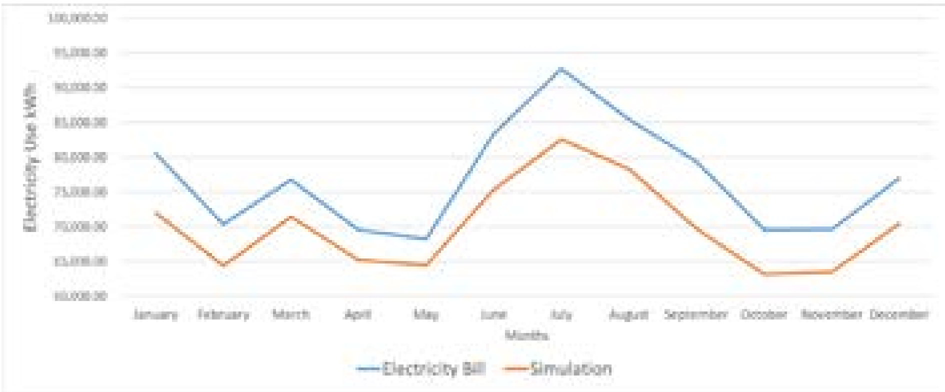
4. RESULTS AND DISCUSSION

The results of the simulation are depicted in Figure 4 and Figure 5. The numbers depict both actual and modeled energy use for natural gas and electricity, respectively. As seen in the images, while the modeled total yearly utility consumption is similar to the actual energy use, there are significant energy use differences in terms of month-to-month utility use. These differences are due to a variety of variables, which are discussed in further detail in the next section.



Actual Annual Natural Gas Use (kWh)	Modeled Annual Natural Gas Use (kWh)
783,097.28	716,022.47

Figure 4. Graph comparing actual natural gas use with that simulated by the model



Actual Annual Electricity Use (kWh)	Modeled Annual Electricity Use (kWh)
922,770.81	840,878.42

Figure 5. Graph comparing actual electricity use with that simulated by the model

The parameters affecting the overall energy use of a building can be categorized as follows:

- The climate (e.g., outdoor air temperature, solar radiation, wind velocity, etc.),
- Characteristics of buildings (e.g., type, area, orientation, construction materials, etc.)
- Building services systems and operation (space cooling/heating, hot water supply, etc.)
- The behavior and activities of building occupants (e.g., time they come and leave the building, whether they turn light off when they leave, etc.)

Among these categories, predicting the behavior and activities of building occupants with sufficient accuracy is the most difficult and challenging of getting accurate data on building occupant behavior. Other studies have also found it difficult to fully characterize the influences of occupants' behavior and activities through simulation, owing to the diversity and complexity of users' behavior in real life [11].

5. CONCLUSION

It is critical that any sustainability initiative aimed at reducing greenhouse emissions includes major efforts to enhance building energy efficiency. There are several ways for improving a building's energy efficiency, and energy models should be used to compare these strategies. For existing buildings, every attempt to find optimal energy efficiency measures should begin with an energy model that depicts how the building currently consumes energy. The article discussed a case study in which an energy model of an existing university building was developed. Energy plus was utilized to assess the building's performance. Although the modeled annual energy use is comparable to the actual energy use, there are greater variances in monthly energy use between the actual and modeled results due to the current difficulties in obtaining data accurately describing building occupants' behavior/activities and building's thermal properties, temperature set points, and internal loads. A new tool that can aid in better predicting occupant behavior and activity through people counters to track the occupancy of each room and area.

REFERENCES

[1] Erten D., Kampüs Sürdürülebilirliğine Bütünleşik Bir Yaklaşım: Piri Reis Üniversitesi, ITU Vakfı Dergisi Eylül 2014, Volume 65 pp.103-104.

[2] American College & University Presidents' Climate Commitment, 2014. http://www.presidentsclimatecommitment.org/about/mission-history, Access date:13.08.2021.

[3] Global Status Report for Buildings and Construction, 2019. https://www.iea.org/reports/tracking-buildings-2020, Access date:18.08.2021.

[4] Europen Commission Energy Performance of Buildings Directive. https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en, Access date:16.08.2021.

[5] EnergyPlus Documentation, EnergyPlus Documentation Engineering Reference, https://energyplus.net/sites/all/modules/custom/nrel_custom/pdfs/pdfs_v9.3.0/EngineeringReference.pdf, Access date:10.08.2021.

[6] Ryan, E. M., & Sanquist, T. F. Validation of building energy modeling tools under idealized and realistic.Energy and Buildings, 2011.

[7] Heo, Y., Choudhary, R., & Augenbroe, G. Calibration of building energy models for retrofit analysis underuncertainty. Energy and Buildings, 2011.

[8] http://www.glumac.com/greenResources/GR_EnergyModeling.html. Access date:23.08.2021.

[9] T Fong, K., Hanby, V., & Chow, T. HVAC system optimization for energy management. Buildings andEnergy, 2005.

[10] Crawley, D.B., L.K. Lawrie, F.C. Winkelmann, W.F. Buhl, Y. Joe Huang, C.O. Pedersen, R.K. Strand, R.J.Liesen, D.E. Fisher, M.J. Witte, and J. Glazer. EnergyPlus: Creating a new-generation building energy simulation program. Energy and Buildings 2001;33(4):319-331.

[11] Yu, Z., Fung, B. C., Haghighat, F., Yoshino, H., & Morofsky, E. A systematic procedure to study theinfluence of occupant behavior on building. Energy and Buildings, 2011.

Research Article

RETRO DESIGN OF IMPELLER BLADE OF THE INDUCED DRAFT FAN (FN-280) USING A COORDINATE MEASURING MACHINE (CMM)

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ABSTRACT

Centrifugal fans are widely encountered in engineering practices, they are essential in the cement production process. The three dimensional, complex and turbulent flow in a centrifugal fan makes the prediction of the performance of the centrifugal fan and the examination of the flow field very difficult. Computational techniques have made a great progress, because of time and cost that may be involved in experimental analysis of the flow, computational fluid dynamics (CFD) is intensively used in many industrial purposes. Nevertheless, the agreement between the numerical results and real data is a subject of many researches, because the numerical result is very sensitive to the numerical method being used, the boundary conditions applied, mesh generation and turbulence model selection. To consider the interaction between the main three parts of the fan namely the inlet, impeller, and scroll, it is necessary to carry out a three-dimensional Numerical simulation of the flow field for the whole centrifugal fan. The impeller is the important part of the centrifugal fan and the aerodynamic design of the impeller blades affects the flow passage, thus improving the aerodynamic design of the blades results in improvements of fan performance and reduction of flow separation. The selection of turbulence model depends on the flow separation that can occur, particularly in the blade passage, thus in order to get a good numerical investigation of the performance of the fan and predict the internal flow field in the impeller, a Coordinate measuring machine (CMM) machine is used as a reverse engineering tool to extract the original impeller blade design of the induced Draft fan (FN-280) by using Geomatics software for point cloud processing.

Keywords*: *Induced Draft Fan, Impeller Blade Design, Three-Dimensional Measurement, Point Cloud Processing.

1. INTRODUCTION

Over the last few years, centrifugal fan market has become hyper-competitive, with the expansion of its use in many industrial domains and the increasing priority being given to operation cost. High-powered draft fans used in the cement manufacturing process must be developed to deliver high aerodynamic efficiency today over a much wider operating

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range than before. Since the blades are the most important parts of the fan, their geometric properties and configuration determine the performance of the fan. While experimental analysis continues to play an important role in fluid mechanics, numerical simulation is extensively used to predict the flow behavior and provide performance evaluation of a specific design. Experimental method is money and time consuming for this reason, The technique of numerical simulation of fluid flow CFD (Computational Fluid Dynamics), based on the resolution of the Navier-Stokes equations has more benefit, it is used to improve the overall performance of fans in the design phase and develop new products more quickly and with less uncertainty. A large number of researches in this field mainly related to numerical simulation of flow in turbomachinery (centrifugal fan) are as follows: A. Amjadimanesh, H. Ajam and A. Hossein Nezhad [1], simulated numerically a 3D forward curved centrifugal fan. various turbulent models were compared and they examined the influence of blade shapes including (flat blade, circular blade and NACA4412 airfoil blade) on the fan performance.to determine the most efficient one. They introduced the k-epsilon and circular arc blade as the suitable model and most efficient blade shape respectively. Chhagan Lal Kharol, Shankar Lal Suthar [2], investigated the effect of the shape of two different airfoil blade namely (NACA2412 and NACA2424) in the performance of centrifugal fan. They found that the blade profile plays a predominant role to reduce flow separation and recirculation that occurs at trailing edge of the fan. Thus, providing better performance and energy consumption.

Kyung Jung Lee et al [3], proposed an optimized plenum fan by designing a four-layer three-dimensional blade. It was concluded that the optimized model stabilized the flow and reduced the flow separation at the leading edge resulted in an improvement of both the static pressure and static efficiency.

Lin Wu1 et al [4] carried out and optimization of the blade design by employing the controlling velocity distribution method. Good enhancement of the fan performance, static pressure and stability.

Rui Rong, Ke Cui, Zijun Li, Zhengren Wu [5], analyzed numerically the aerodynamic properties of the blade (G4- 73No.8D) of a centrifugal fan with slots cut along the blade pressure side to suction side. The study shows that creating slot in blades can improve the blade surface flow behavior by decreasing the blade surface resistance and boundary layer separation, which in turn decrease energy consumption.

With the development of computer resources and computational techniques, great efforts have been made in the context of numerical simulation of complex flow in a centrifugal fan in order to improve the performance design of these machines. According to the findings of the above researches, the aerodynamic characteristics of the blade of a centrifugal fan has a great influence on the overall performance of the fan including static pressure efficiency, pressure loss, flow separation and energy consumption.

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In this paper, an impeller blade of the draft fan FN-280 is considered for reverse design. With the intent purpose of numerically simulating the flow field in the centrifugal fan. The CAD model of the blade was not available. Considering the fact that geometrical characteristics of the blade is crucial in order to validate the numerical results, therefore, reverse design using a Coordinate measuring machine (CMM) is adopted to develop the CAD model of the blade on one hand, on the other hand, remaining parts of regular contours are designed by
SolidWorks.

2. REVERSE DESIGN METHODOLOGY

Reverse Design is the technology of converting digital data called 3D scan data collected by a 3D scanner of the geometrical information of a real object into a CAD model to be used in the manufacturing process.

Reverse design steps can be outlined as follow:

- **Scanning Phase:** This phase is involved with the scanning strategy–selecting the correct scanning technique, preparing the part to be scanned, and performing the actual scanning to capture information that describes all geometric features of the part such as steps, slots, pockets, and holes.

- **Point Processing Phase:** This phase involves importing the point cloud data, reducing the noise in the data collected, and reducing the number of points. A wide range of commercial software is available for point processing. The output of the point processing phase is a clean, merged, point cloud data set in the most convenient format.

- **Application Geometric Model Development Phase:** The generation of CAD models from point data is probably the most complex activity within RE because potent surface fitting algorithms are required to generate surfaces that accurately represent the three-dimensional information described within the point cloud data sets.[6]

In this work, coordinate measuring machine (CMM) is used for the collection of point cloud data which is shown in Figure [1]

2.1.Scanning the blade with CMM

Before starting the scanning, the workspace preparation must be taken into consideration. Blade alignment is the process of associating both the coordinate system of the CMM and the blade Figure [2]. Scan data is collected by mechanical method using touch-trigger probe. The CMM probe collects data by touching the surface along the complete profile of the part to provide continuous flux of data. Therefore, probe selection, position control, path followed by the probe and angle at which the probe approaches the surface is very important during the scanning phase.

2.2.Exporting 3D scan data to Geomatics design

All information collected during the scanning is converted into digital data (point cloud data) through (**PC-DMIS**) software then exported to any CAD modeling software (**Geomatics design X** in this case) to obtain a final CAD model.

Figure 1. Coordinate measuring machine **Figure 2.** Impeller Blade alignment

2.3. Impeller Blade Reverse Design workflow

3D scan data consists of point cloud and a mesh. Point cloud is a set of three-dimensional vertices. Each vertex corresponds to one position on the surface of the blade, whereas mesh is defined by vertices, edges and faces. The process of converting point cloud into mesh is performed by the scanning software (PC-DEMIS) of the coordinate measuring machine (CMM).

Scan data is raw information, mesh optimization is needed before proceeding to use 3D scan data provided by scanning machine. Features available in Geomatics design x for processing scan data were used in order to optimize mesh globally. Figure [3] shows scan data and figure [4] shows mesh regions created in order to use the surface fitting technology.

The reverse design strategy depends on the scan data type, the shape complexity of the model and the design intent. Because the section of the blade of the fan FN-280 is not uniform and the surface of the leading and trailing edge is deformed causing the scan data include deformities also, the method adopted in the reverse modeling process is Hybrid modeling which mixes with parametric modeling and surface fitting methods.

The surface fitting technology provides a powerful way to create freeform surface from a specific freeform region on a mesh [7]. The Mesh fit tool is used to generate the surface of both the suction and pressure side of the blade.

Figure [6] shows the surfaces created by setting the allowable deviation to (0.0008mm), number of control points to (70) for better control of iso-lines and minimizing the smoothness in order to envelope the entire mesh region. figure [6] illustrates the deviation from the mesh which shows that is within a good range.

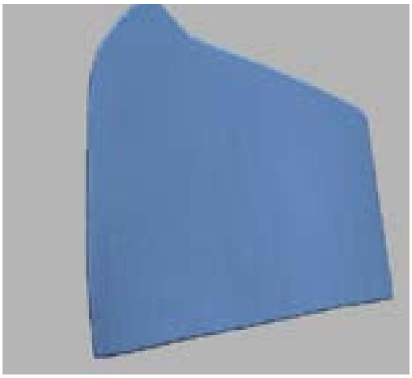

Figure 3. Cloud data from CMM

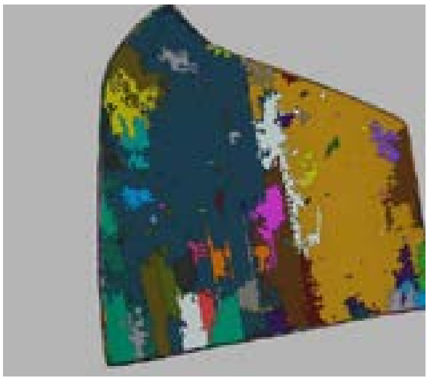

Figure 4. Mesh regions

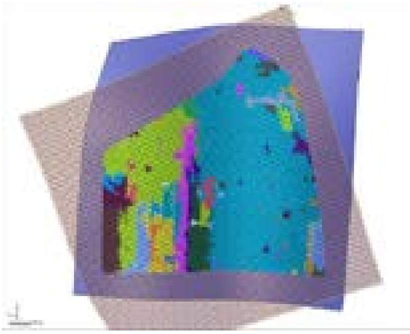

Figure 5. iso-lines created in the surface

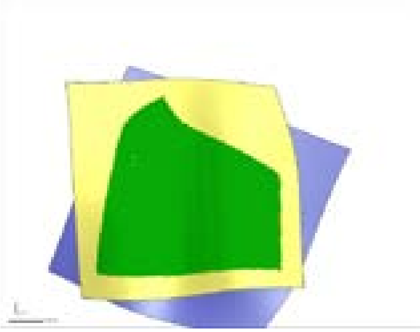

Figure 6. surface fitting of pressure and suction side

Three-dimensional mesh sketch curve with nodes connected to only concave mesh regions was created. Offset curve of (0.03mm) width is created to generate the Surface portion of the shroud and the leading-edge surface.

Figure [7].and [8] shows the deviation for mesh using the accuracy analyzer and Figure [9] and [10] shows the surfaces generated respectively.

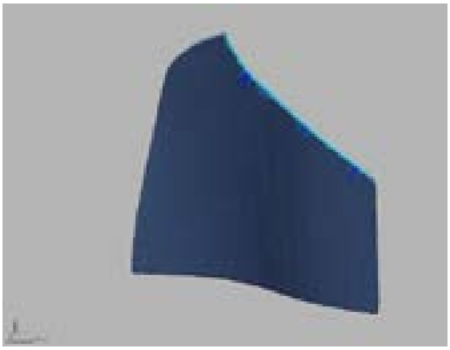

Figure 7. shroud side curve deviation from mesh

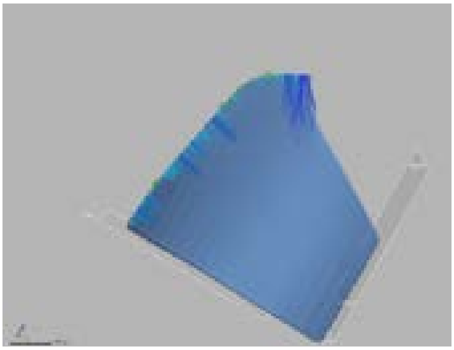

Figure 8. leading edge curve deviation from mesh

Figure 9. surface-cut of shroud part

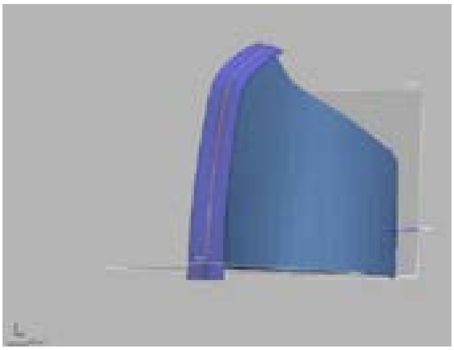

Figure 10. surface-cut of leading edge

- The process of creating the trailing edge surface is as follows:
- Extract a tangent plane (plane 1) to the surface of the pressure side of the blade near the trailing edge mesh region
- Create a plane (plane 4) that is orthogonal to both (plane 1) and the front plane.

(Plane 4) must contain the first point of the 3D mesh sketch on the trailing edge mesh region contour.

Figure [11] and [12] Shows the surface cut plane (plane 4)

Figure 11. 3D sketch on surface cut plane

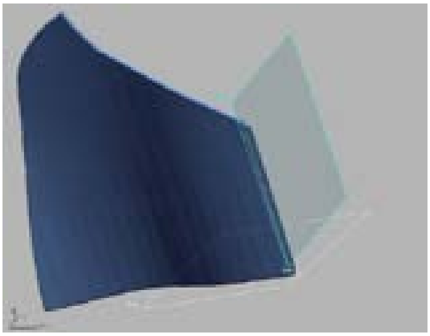

Figure 12. surface cut plane (plane 4)

The impeller CAD model is finally obtained by trimming all surfaces and planes created. Accuracy analyzer is used to control the deviation of the CAD model from the model.

Figure [13] shows all the surfaces and planes used in the CAD model design process and Figure [14] shows the final CAD model of the impeller Blade.

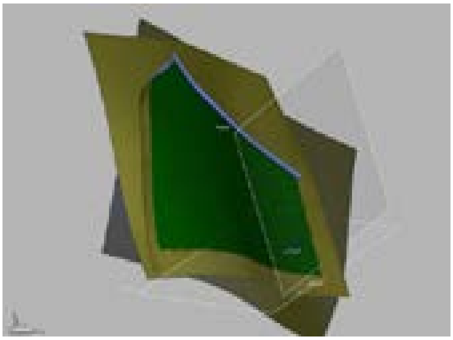

Figure13. planes and surfaces

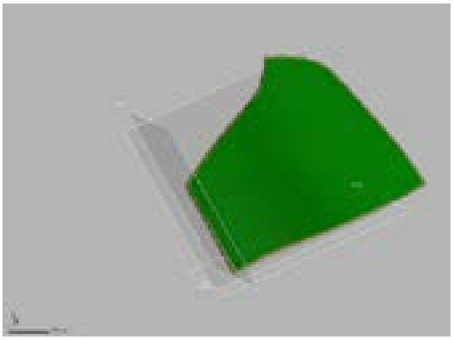

Figure 14. Final CAD model

3. CONCLUSION

All main parts of the centrifugal fan FN-280 including the inlet duct and the casing were designed by soldiworks. the impeller blade is selected for reveres design because the CAD model is not available and the complexity of its geometrical characteristics.

Scanning of the impeller blade is done using Coordinate Measuring Machine (CMM), 3D scan data obtained is exported from the software bundle machine (PC-DMIS) to Geomagic design X to obtain CAD model of the impeller blade.

This study shows that revere design using coordinate measuring machine (CMM) helps to get all details about complex geometrical information of any object with high level of accuracy resulting in minimizing the design process time, provided the scanning technique and the modeling strategy are selected properly.

REFERENCES

[1] A. Amjadimanesh, H. Ajam and A. Hossein Nezhad. Effect of blade type on a 3D FC centrifugal fan. Journal of the Serbian Society for Computational Mechanics / Vol. 8 / No. 1, 2014 / pp. 23-35

[2] Chhagan Lal Kharol, Shankar Lal Suthar. Performance Analysis of Centrifugal Fan with Airfoil Blade usingCFD. international journal of research culture society Volume - 3, Issue - 5;2019.

[3] Kyung Jung Lee, Wung Park , Ki Suk Bang , Yeong Min Kim and Young Chu Ahn. Optimal Design of a Plenum Fan with Three-Dimensional Blades. Appl. Sci. 2020, 10, 3460.doi:10.3390/app10103460.

[4] Lin Wu1, Hua-Shu Dou, Yikun Wei, Yongning Chen, Wenbin Cao, Cunlie Ying. International Journal of Fluid Machinery and Systems Vol. 9, No. 1, January-March 2016.http://dx.doi.org /10.5293/IJFMS.2016.9.1.095

[5] Rui Rong, Ke Cui, Zijun Li, Zhengren. Numerical study of centrifugal fan with slots in blade surface. Procedia Engineering 126 (2015) 588 – 591.doi:10.1016/j.proeng.2015.11.309.

[6] Gayatri D. Barai1, Sunil S. Shete2, Laukik P. Raut. design and development of a component by reverse engineering. International Journal of Research in Engineering and Technology Volume: 04 Issue:05;May- 2015.

[7] Geomagic fesign X user guide

[8] PC-DMIS- training manual n-I (2012 MEI-M'sila).

[9] PC-DMIS- training manual n-II (2016 MEI-M'sila).

BUILDING ENERGY OPTIMIZATION OF A RESIDENTIAL BUILDING IN ISFAHAN CITY OF IRAN

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ABSTRACT

Buildings are one of the most energy consuming parts in the world. It is essential to design optimized new buildings and also to try to modify and retrofit the exciting ones. In this research, an existing residential one-story house located in the city of Isfahan in the center part of Iran has been simulated and studied to find the best options for retrofitting. Some photovoltaic panels are proposed to be used in the roof of the building. The studied methods to modify the building and optimize the energy consumption include replacement of simple old windows with double glazed smart windows, and adding thermal insulators embedded in the walls and the ceiling. Results indicate that considering all of the methods except installing solar panels, about 40% of energy savings will be available. Also, it is indicated that solar power can support more than 35% of energy in Isfahan. Finally, the total energy saving of about 61% can be obtained after retrofitting and solar panel installation.

Keywords: *Building Energy Optimization, Solar Energy, Design Builder.*

1. INTRODUCTION

The biggest global challenges to sustainable development are the diminution of energy and water resources and increased environmental pollutions. Global statistics report the construction sector accounting for 40% of energy consumption and 30% of the world's greenhouse gas emissions [1]. The best strategy to reduce global energy consumption and emission of harmful gases to the environment is to improve energy efficiency in buildings.

According to studies, the 30-year period between 1983 and 2012 is likely to have been the warmest in the past 1,400 years [2]. Given the longevity of buildings and the initial construction cost, the impacts of construction on climate change and the importance of reducing energy consumption and pollution production should be considered [3].

The major contribution of the building energy consumption is related to the buildings constructed prior to the need for compliance with the sustainability criteria that need to be

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improved in order to reduce energy consumption in the construction sector [4]. Research also shows that renovating existing buildings has a significant impact on reducing the total global energy demand [5].

The construction of new buildings and the creation of different applications make up a large portion of the total final energy consumption in the world [6]. Statistics also suggest that in the construction sector, most of the energy consumption occurs in the existing buildings, with the energy consumption of new constructions rating about 1 to 3 percent of the existing buildings per year [7, 8]. Therefore, improving the energy efficiency of existing buildings is more important than constructing new ones to reduce global energy consumption and promote environmental sustainability [4].

Generally, two solutions are offered when designing urban renewal projects; one is to maintain and improve existing buildings with minor modifications and interventions, and another is to replace existing buildings with new ones. Making improvements to existing buildings may be acceptable if the current status of the building is good enough to meet current needs, but in general improving the current buildings is closer to the principles of sustainability [9].

Improving existing buildings for energy efficiency has also been recognized as an effective step towards reducing global energy consumption and greenhouse gas emissions [10].

Among studies conducted to investigate the significance, advantages and disadvantages of improvement, is a study by Letham in 2000, in which he discussed the importance of reusing existing buildings and even changing their use given their current status. Letham considers using existing buildings to be far more creative than constructing new ones. His paper provided the starting point for his book, in which he examines a case study and factors affecting the state of reusing old structures [11]

In 2006, Shipley et al. focused on commercializing and reconstructing existing buildings, especially historic ones in Ontario, Canada. In some cases, they examined, improving a building to be reused was more costly than constructing a new one; but in general, the existing building had more positive economic impacts along with other factors compared to new constructions [12].

In the same year, in his book, Douglas introduced how to adapt existing buildings by improving and renovating them. This book discusses the reasons for renovating buildings, feasibility conditions, advantages and disadvantages, maintenance, energy efficiency, compliance with sustainability principles, and how to apply changes to improve existing buildings [13].

In 2007, Itard et al. discussed the environmental impact of renovating existing buildings compared to constructing new ones. In this study, renovation, maintenance and redevelopment of Dutch urban textures were investigated and compared. The parameters investigated in this study were materials, energy, water consumption and environmental impacts calculated based on the building life cycle. Based on the results of this study, reconstruction of existing buildings imposes less environmental impact, and directs new construction such that the longevity of the buildings suffices for future reconstruction and improvement practices [9].

In 2011, Bolen et al. conducted interviews with owners and users of various buildings to inform them on the benefits and strategies to preserve buildings and reuse them. According to the analysis of these interviews, three factors influenced owners' decision to preserve buildings, including the amount of national capital, assets status and regulations. Eco-social sustainability principles were also considered important, but less prioritized by owners and users [14].

Given the extending construction process in recent years in Iran and consequently the growing need for reconstruction, as well as ecological and climatic problems in Iran, in a study conducted in 2016, Afzalian et al. presented the principles of passive architecture design based on green principles and sustainability by examining case studies objectively [15]

In 2015, Oliviera et al. introduced a new system aimed at adhering to the principles of sustainability by reviewing existing systems to reconstruct and improve historic buildings. The study was conducted on a historic building in Portugal and a questionnaire was filled by beneficiaries in order to investigate aspects of sustainability, as well as some economic information and parameters [16].

In 2016, Alam et al. reviewed and evaluated guidelines and research conducted in this area to develop guidelines for the reconstruction of existing buildings for energy efficiency purposes. In this study, guidelines developed in the United States, England, Singapore, Australia, and India were investigated and compared. According to the results of these studies, the common disadvantage of these guidelines were assessing their constraints and managing them. They also examined factors affecting the choice of building reconstruction such as economy, community, energy, and awareness[10]. In 2017, Littlewood et al. investigated the current status of buildings in Wales and the impact of their reconstruction on economy, carbon emissions, energy performance, thermal comfort and user health. Unlike other studies conducted in the UK, all of the above-mentioned parameters were investigated simultaneously while affecting one another [17].

Di Agostino et al. also examined the different levels of improvement including surface and deep level and approaching near-zero energy, and introduced the best policies and administrative strategies to improve existing non-residential buildings. The study also emphatically compared existing residential and non-residential buildings and returns on capital as an important parameter in Europe [18].

In some of the studies conducted on improvement of the current status, a specific construction sector was considered; for example, in 2016, Karimian examined the energy improvement process of buildings in warm and dry climate of Iran in his Master's thesis with an ecological attitude while considering climate change. The sample investigated in this study was a common office building in Isfahan in which energy audit was conducted with the aim of profound improvement. Open Studio and Energy Plus were employed in this study, and appropriate details were suggested after calibration and evaluation of optimization scenarios and adhering to minimum shell requirements. In this study, using fixed awnings, internal insulation, low emission film, and secondary windows and doors reduced energy consumption by 19% and solar cells were used for deep improvement [19].

In 2013, Arias investigated the process of improving building facades to increase energy efficiency in a master's thesis focusing on existing buildings from the mid-20th century, most of which were equipped with mechanical systems. In most samples, facade retrofitting was introduced as the first approach to reconstruction for rapid action. However, in this study, several solutions have been investigated using simulation process. The building in question was located in a temperate and climate, on which passive solutions were evaluated [20].

One of the functional studies on improvement of existing buildings is the study by Chadiac et al. conducted in 2011 who explored various methods and approaches to improve office buildings in Canada with the aim of achieving the most economically viable status, and finally obtained a methodology. To find this methodology, several other factors such as climate, user conditions, heating and cooling systems, shells and building shape were also considered [5].

In 2012, Ma et al. provided a planned system to select and identify the best process and strategy for reconstruction of existing buildings. They examined the most important and key issues in the reconstruction of existing buildings, and identified building energy audits, economic analysis, potential risks and constraints, and certification of energy storage as the most important measures in assessing the current status of existing buildings. They have also addressed the technologies and strategies of building reconstruction to raise awareness on the importance and impact of reconstruction on sustainability and energy consumption [4].

One of the case studies on improvement was conducted in 2015 by Shan et al. to reconstruct a floor of a house in Beijing with an energy storage approach using passive systems. A layer of polystyrene insulation was used in the reconstruction of this house as the heat insulation in the walls and ceiling. Results of this study indicated that energy consumption was reduced by 57% and the period of return on capital required for reconstruction was estimated as 5 to 6 years [21].

Since developing energy efficiency policies has been an important tool in resolving the energy, water and climate change crises, in recent years many governments have taken steps to reduce energy consumption of buildings, convert them into zero-energy buildings and, consequently, reduce carbon emissions. In 2018, in a research project sponsored by the Australian Department of Environment and Energy, with an emphasis on standardizing and developing economic and administrative plans for zero-energy buildings, Harrison obtained different definitions of zero-energy buildings and administrative policies in their construction [22].

In addition, in terms of zero-energy buildings, near to zero energy and other related definitions, Torcellini et al. critically examined different definitions of zero and pure zero-energy buildings and provided various definitions for each one with regard to influential parameters such as construction site [23].

In addition, in 2009, Marsal et al. studied different definitions of zero-energy buildings during a technical report at the University of Aalborg. Based on the results of their study on existing definitions of zero-energy building, they have found the exact definition to be very complex which demanded a wide range of terms. In general, given the differences and similarities of available definitions, zero-energy structures can be defined from different perspectives [24].

In 2014, in a study sponsored by Asia-Pacific Economic Cooperation [25], Wei at al. studied and evaluated policies, indicators and definitions of zero energy buildings, related codes and standards, required infrastructures, related organizations and some examples of such buildings have been addressed in leading countries such as Canada, Japan, USA, Korea and China to find out the latest advances in zero-energy building types and improve their performance in Asia [25].

In 2018, in a case study in Tabriz metropolis, Namdar Akbari et al. investigated the feasibility of creating and developing zero-energy buildings in Iranian metropolises. By evaluating statistics of peak electricity consumption in some months and the potential for using renewable energies such as solar radiation and wind in Iran, they studied design strategies for zero-energy buildings to find the most effective solutions [19].

In 2016, Cao et al. examined the state of energy consumption in existing buildings and the trend of change in the next century and its impacts on climate change, as well as zero-energy buildings as a strategy to reduce energy consumption in buildings. They also revised a design approach to zero-energy buildings as a combination of traditional green architecture and new energy production technologies [1].

In a study conducted in 2019, Liu et al. conducted a comprehensive analysis on the definitions, development and design rules for near-zero-energy buildings, with an emphasis on Chinese buildings. In their paper, they described the international definitions of zero-energy buildings, analyzed the latest definitions and determined the design boundaries of zero- and near-zero-energy buildings in China, and also provided suggestions to design building and develop its administrative policies [26].

In this study, an over 35-year-old real residential building in Isfahan was studied to optimize energy consumption. According to rich solar radiation in many parts of Iran, it is a good idea to use this renewable energy resource to support building energy needs. Here, several solutions were applied, such as photovoltaic panels, natural ventilation, installation of various insulators, built-in smart awnings and multiple glazing windows. The system was initially calibrated with existing water and utility bills. Assuming the same building in Bandar Abbas climate, the influence of climate on energy consumption was also investigated.

2. MATERIALS AND METHODS

The solar panels were used for energy optimization in this study in parallel with some other scenarios. Thermal insulations were also proposed for the ceiling and walls. Moreover, the benefits of replacing simple single windows with advanced double glazed windows integrating thermal sensors were investigated. The Design Builder software [27] was used to simulate the building and calculate thermal loads and energy consumption under different scenarios. The data from the electricity and gas bills were used to validate the software outputs. The effect of different climatic conditions on the energy consumption of the building was analyzed assuming that it is located in the hot and climate of Bandar Abbas, Iran.

This study investigates a residential villa building aged over 35 years old, located in the hot and dry climate of Isfahan city in Iran and also the similar one assumed to be located in hot and humid climate in Bandar Abbas to consider the effects of different climates. Figure 1 shows this single-story building with a basement used for storage purposes.

Figure 1. Real building in Isfahan city.

The thermophysical properties of the materials are presented in the different tables. First, without applying the optimization approaches, the heating and cooling energy consumptions were calculated in a one-year period and considered as the base state for both considered cities. The base state results were then compared to the simulated building after applying some modifications to the building, such as using photovoltaic solar panels, and using thermal insulation in the walls and ceiling, natural ventilation, smart shadings, and automatic double-glazed windows including thermal sensors.

Gas was used as the fuel for the heater packages and wall-mountable water heaters, and the evaporative coolers were used for cooling. Moreover, all spaces were exposed to sunlight through openings and glass doors.

Figures 2 and 3 show the simulated building from two different angles in the Design Builder.

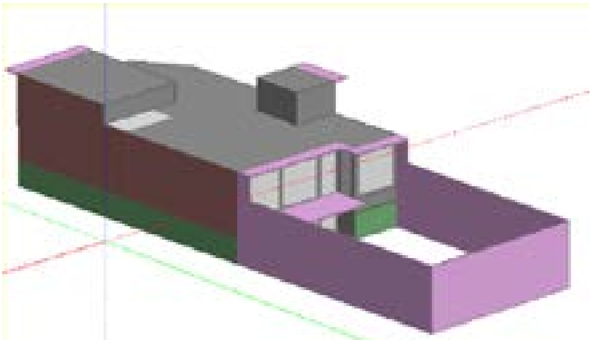

Figure 2. Schematic of the simulated building from angle 1.

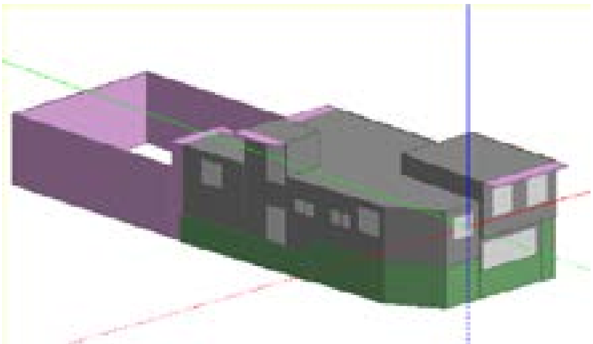

Figure 3. Schematic of the simulated building from angle 2.

Figures 4 and 5 show the overall geographical position of the sun in different months and different hours of the day for Isfahan and Bandar Abbas, respectively.

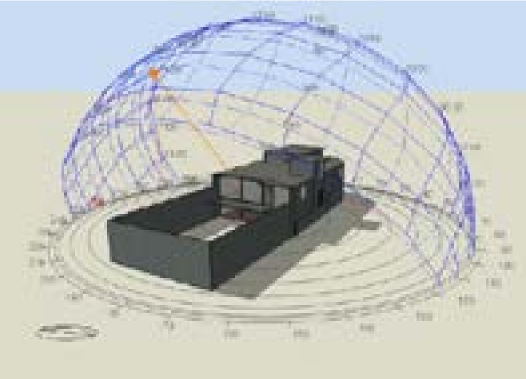

Figure 4. The overall geographical position of the sun in different months and different hours of the day for Isfahan.

Figure 5. The overall geographical position of the sun in different months and different hours of the day for Bandar Abbas.

Table 1 presents the climatic data of Isfahan and Bandar Abbas.

Table1. Climate data for Isfahan and Bandar Abbas [27].

Reference	**IRN_Esfahan408000_ ITMYEPW**	**IRN_Bandar Abbas.408750_ ITMY**
Site:	Esfahan – IRN	Bandar Abbas - IRN
Location Time zone	{GMT + 3.0	{GMT + 3.0 Hours}
Elevation	Hours} 1550	10
above sealevel Standard	84038pa	101207pa
Pressure at ElevationData	ITMY	ITMY
Source WMO	408000	408750
Station Weather	Climate Design	Climate Design Data
File Design	Data 2013	2013 ASHRAE
Conditions	ASHRAE	Handbook
Maximum	Handbook 40.2	43.6
Dry BubbleTemp Maximum	04-Aug	30-May
Dry BubbleOccurs on Minimum	-7.5	5.7
Dry BubbleTemp Minimum	26-Jan	29-Dec
Dry Bubble Occurs onMaxi-mum	12.5	30.6

Dew PointTemp Maximum	18-Mar	20-Jul
Dew Point Occurs onMini-mum	-26.6	-17.1
Dew Point Temp		

Minimum Dew Point Occurs on	28-Aug	28-Nov
ASHRAE	Warm-Dry	Very Hot - Dry
Description		
ASHRAE	3B	1B
Climate		
Zone		

The properties of the materials used in the ceiling and walls are presented in Tables 2 and 3, respectively.

Table 2. The properties of the materials used in the ceiling [27].

Material	**Thickness**	**Density**	**Conductiv-ity**	**Specific**
	(m)	**(kg/m^3)**	**(W/mK)**	**heat**
				(J/kgK)
Asphalt- roofing, mastic	0.1	2330	1.15	840
2010 NCM membrane	0.03	1100	1	1000

Concrete, high density	0.07	2400	2	1000
Concrete, reinforced (with 1% steel)	0.03	2300	2.3	1000
Gypsum Plastering	0.02	1000	0.4	1000

Table 3. The properties of the materials used in the walls [27].

Material	Thickness	Density	Conductivity	Specific heat
Brick sofall	0.2	1500	0.45	840
Plaster (lightweight)	0.005	600	0.16	1000
Brickwork outer	0.1	1700	0.84	800
XPS Extruded ply-styrene-CO2 blowing	0.0795	35	0.034	1400
Concrete block (medium)	0.1	1400	0.52	1000
Gypsum Plastering	0.013	1000	0.4	1000

Table 4 shows the soil temperature in different months of a year and at different depths in these two cities.

Table 4. The soil temperature in different months of a year and at different depths in Isfahan and Bandar Abbas [27].

Month	Surface monthly temperatures		Shallow monthly temperature (2m depth		C	
	Isfahan	Bandar Abbas	Isfah-an	Bandar Abbas	Isfa-han	Bandar Abbas
January	17.92	18.13	9.2	21.3	12.5	23.2
Febru-ary	17.65	17.87	7.3	21.6	10.5	23
March	17.67	17.87	7.7	23.1	10.1	23.7
April	19.26	19.45	9.3	24.9	10.7	24.6
May	19.61	19.78	14.5	28.6	13.6	27.1
June	19.72	19.85	19.2	31	16.8	29
July	21.32	21.42	23	32.1	19.8	30.1
August	21.62	21.70	25.1	31.9	21.8	30.4
Septem-ber	21.61	21.72	24.6	30.2	22.3	29.7
October	21.55	21.71	22	27.6	21.1	28.2
Novem-ber	19.92	20.10	17.6	24.7	18.6	26.2
Decem-ber	19.57	19.77	13.1	22.4	15.5	24.5

For the ceiling Polystyrene insulation with thickness of 5cm and heat transfer coefficient of 0.6 W/m2K was used and for the walls Polystyrene insulation with thickness of 5cm.

Since natural ventilation should be done automatically, it is necessary to apply thermal control conditions in the windows section when natural ventilation is activated in the Design Builder.

To this end, thermal sensors are placed on the windows to measure the indoor to outdoor temperature and prevent excess heat or cold from getting into the room. In this work, the windows-opening schedule was set 'off' in the winter and 'on' in the summer 24 hours a day. In the hot seasons, the sensors will send the required ventilation signal for automatic windows opening using the operators only if the outdoor temperature is lower than the indoor temperature. Regarding of hot and humid climate of Bandar Abbas, the natural ventilation was considered just for Isfahan cooling mode.

The solar panels with an area of 40 m2 were used for partial supply of the required energy. Figure 6 shows the images of the building and solar panels. The implemented panels are installed at geographical latitude in each city that means 35 in Isfahan and 57 in Bandar Abbas. They are also installed facing south direction.

Cooling loads(kWh)

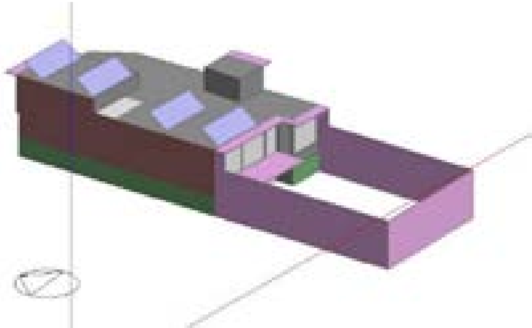

Figure 6. Schematic of the simulated building including photovoltaic panels.

By modeling natural ventilation in the software, the opening and closing schedule for the smart windows were obtained. Finally, the smart shading system installation was simulated for both cases to find its effects on energy consumption, especially in the cooling mode.

3. RESULTS AND DISCUSSION

In this part, the results of the study are presented and discussed. Figures 7 and 8 show the monthly cooling and heating loads for both studied cities in the base state where no retrofit scenario has been implemented.

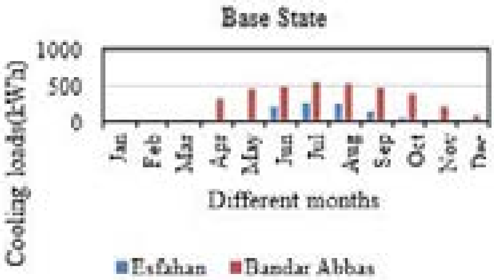

Figure 7. Monthly cooling loads for both studied cities in the base state.

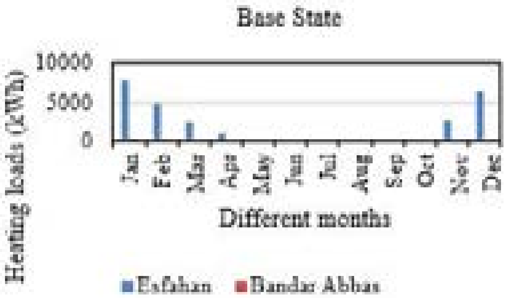

Figure 8. Monthly heating loads for both studied cities in the base state.

In coming graphs, the effect of each retrofit scenario is compared with the base state results of the city for both studied climates. Figures 17 and 18 report the cooling and heating loads of Isfahan when wall insulation is implemented, in compare with those of the base state.

As it is calculated, there is 4.6% decrease in the cooling loads in Bandar Abbas when installing smart shadings. The shading should not be used through cold seasons there.

It is obvious that natural ventilation in the method implemented here just helps the cooling loads of Isfahan by opening the windows in a smart manner. In hot and humid climate of Bandar Abbas there is no justification for natural ventilation with some window openings.

4. CONCLUSION

A climate-based study was conducted on a single-story residential villa building. The solar energy was used for partial supply of energy needs of the building. The effects of different factors on energy consumption were studied including: thermal insulators embedded in the ceiling and walls, and installation of double-wall windows equipped with temperature sensors and smart interior shades. According to the results, in hot and dry climate of Isfahan, implementing solar panels, wall and ceiling insulation, double glazed smart windows, internal smart shading and natural ventilation lead to optimal energy consumption with 38.43 and 50.94% reduction in the cooling and heating loads, respectively. In hot and humid climate of Bandar Abbas, all of mentioned scenarios except natural ventilations were used and showed 46% thermal loads reduction. Using natural ventilation had no justification in hot and humid climates. The solar photovoltaic panels could supply 67.3% of required electricity in Isfahan and 42.3% of it in Bandar Abbas. In the future works studying the effect of solar absorption coefficient of external walls on the energy saving may be considered.

REFERENCES

[1] Cao, X., X. Dai, and J. Liu, Building energy-consumption status worldwide and the state-of-the-art technologies for zero-energy buildings during the past decade. Energy and buildings, 2016. 128: p. 198-213.

[2] Isaac, M. and D.P. Van Vuuren, Modeling global residential sector energy demand for heating and air conditioning in the context of climate change. Energy policy, 2009. 37(2): p. 507-521.

[3] Stocker, T., et al., IPCC, 2013: summary for policymakers in climate change 2013: the physical science basis, contribution of working group I to the fifth assessment report of the intergovernmental panel on climate change. Camb. Univ. Press Camb. UKNY NY USA, 2013.

[4] Ma, Z., et al., Existing building retrofits: Methodology and state-of-the-art. Energy and buildings, 2012. 55: p. 889-902.

[5] Chidiac, S., et al., A screening methodology for implementing cost effective energy retrofit measures in Canadian office buildings. Energy and Buildings, 2011. 43(2-3): p. 614-620.

[6] Sanders, K.T. and M.E. Webber, Evaluating the energy consumed for water use in the United States.

Environmental Research Letters, 2012. 7(3): p. 034034.

[7] Roberts, S., Altering existing buildings in the UK. Energy policy, 2008. 36(12): p. 4482-4486.

[8] Council, A.C. and J.L. LaSalle, Building refurbishment guide. Adelaide City Council, 2007.

[9] Itard, L. and G. Klunder, Comparing environmental impacts of renovated housing stock with new construction. Building Research & Information, 2007. 35(3): p. 252-267.

[10] Bertone, E. and J. Wilson, Guidelines for Building Energy Efficiency Retrofitting.

[11] Latham, D., Creative Re-Use of Buildings. Volume 2: Building Types Selected Examples. 2000, Bath, UK: Donhead Publishing.

[12] Shipley, R., S. Utz, and M. Parsons, Does adaptive reuse pay? A study of the business of building renovation in Ontario, Canada. International Journal of Heritage Studies, 2006. 12(6): p. 505-520.

[13] Douglas, J., Building Adaptation. 2006: Butterworth-Heinemann.

[14] Bullen, P. and P. Love, A new future for the past: a model for adaptive reuse decision□making. Built Environment Project and Asset Management, 2011.

[15] Affzalian, K. and S. Hasanzadehrad, Reconstruction and Reuse with a Sustainable and Green Approach in Contemporary Iranian Residential Architecture, in Forth Conference on New Technologies in the Building Industry. 1395: Sustainable Development and Construction Technologies.

[16] Oliveira, R.A., et al., A system for the management of old building retrofit projects in historical centres: the case of Portugal. International Journal of Strategic Property Management, 2017. 21(2): p. 199-211.

[17] Littlewood, J.R., et al., Introduction to a Wales project for evaluating residential retrofit measures and impacts on energy performance, occupant fuel poverty, health and thermal comfort. Energy Procedia, 2017. 134: p. 835-844.

[18] D'agostino, D., P. Zangheri, and L. Castellazzi, Towards nearly zero energy buildings in Europe: A focus on retrofit in non-residential buildings. Energies, 2017. 10(1): p. 117.

[19] Namdarakbary, S. and A. Asghary. Placement of Creation and Development of Zero Energy Buildings in Iranian Metropolises (Case Study: Tabriz Metropolis). in Islamic World Conference on Civil, Architecture and Urban Development. 1397. Tabriz: Tabriz University.

[20] Arias, A.S.M., Facade retrofit: enhancing energy performance in existing buildings. 2013, University of Southern California.

[21] Shan, M., et al., Energy and environment in Chinese rural buildings: Situations, challenges, and intervention strategies. Building and Environment, 2015. 91: p. 271-282.

[22] Harrison, S., Zero Energy Building Definitions and Policy Activity. 2018, IPEEC Building Energy Efficiency Taskgroup.

[23] Torcellini, P., S. Pless, and M. Deru, Zero Energy Buildings: A Critical Look at the Definition, National Renewable Energy Laboratory and Department of Energy. 2006.

[24] Marszal, A.J. and P. Heiselberg, A literature review of zero energy buildings (ZEB) definitions. 2009, DCE Technical Report.

[25] Xu Wei, Z.S., Nearly (Net) Zero Energy Building. 2014, China Academiy of Building Research: Asia Pacific Economic Cooperation (APEC).

[26] Liu, Z., et al., A comprehensive analysis on definitions, development, and policies of nearly zero energy buildings in China. Renewable and Sustainable Energy Reviews, 2019. 114: p. 109314.

[27] DesignBuilderCompany. DesignBuilder. 2019 27/01/2020; Available from: https://designbuilder.co.uk/download.

EXPERIMENTAL AND NUMERICAL INVESTIGATION OF THE EFFECTS OF HOLE DIAMETER ON THE TENSILE STRENGTH OF STEEL PLATE

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ABSTRACT

Plate materials are used in many industrial areas by drilling holes on it for different reasons (mounting, fastener like bolt or pin etc.). This situation affects the strength of the material. In this study, the effect of hole diameter on the stainless steel plate material on the tensile strength was investigated experimentally and numerically. The work pieces were prepared with a gauge length of 32 mm, a width of 18 mm and a thickness of 1.5 mm. Then they were divided into groups of three, and holes were not drilled in the first group, but holes were drilled in the centers of the others with a diameter of 4,6 and 8mm. Then, these work pieces were subjected to the tensile test at room temperature at a speed of 16mm/min (strain rate is 0.008 sec-1). The test results were determined by taking the average of each group and the results were compared within themselves. As expected, the applied tensile force and elongation decreased as the diameter increased, whereas the tensile strength was nearly the same for all cases. In this study, a correlation was obtained between the decrease in tensile force and elongation and the increase in hole diameter. In addition, tensile test simulation was performed with numerical analysis for all cases and similar results to the experiment were obtained. In the numerical analysis results, it was found that the stress concentration increased when approaching the hole from the edge, confirming the theoretical information.

Keywords: *Elongation, Stress Concentration, Tensile Strength.*

1.INTRODUCTION

In the developing industrial technologies, the use of sheet and plate materials has become widespread in many areas, and they are used where needed by being brought into different forms. During this shaping, assembly, joint, etc. Due to the reasons, holes of different diameters are drilled on the materials. These applications on the material cause stress concentration in that area of the material and affect the strength of the material. In order to prevent the negative consequences of this situation, different studies have been carried out for materials exposed to different situations. Some of these will be briefly summarized below.

Erim and Uyaner investigated the stress distributions and stress concentration coefficients in a simple beam with a circular hole under the effect of constant bending moment. In this study, a beam with a circular hole on its transverse axis was investigated by the Finite Element Method under the effect of simple bending. The hole is displaced along the aforementioned axis and both isotropic (steel) and orthotropic (Graphite-Epoxy) materials are used for the beam [1].

Çelik et al. on the other hand, the stress concentrations in the welding of different metals (iron and steel) were investigated in their study [2].

Bulut examined the thermal stresses around a hole in the composite (including steel and stainless steel) materials used in the reactor body. He supported his work with finite element analysis and analytical methods [3].

Çelik and Turan investigated the damage behavior of notched composite plates in their research. Eight layers of glass fiber braided and epoxy resin filled composite sheets were used as materials. They examined the effect of notches and holes drilled on the edges and middle of the plate on the tensile strength [4].

In this study, three different diameter holes were drilled on the stainless steel plates and tensile tests were performed for four different situations, one without holes, and the effects of hole diameter on stress, strain and displacement were investigated. In addition, the study was supported by finite element analysis (FEA).

2. MATERIAL AND METHODS

The work pieces were formed from steel plates with a length of 70 mm and a width of 18 mm, 1.5 mm thick. Four groups of three work pieces were formed, the first group was left unperforated, and the others were drilled with 4mm, 6mm, 8mm diameter holes. Some of these samples are shown in the figure below (Fig.1). Then, a tensile test was applied to all these work pieces with a gauge length of 32mm. In addition, the stresses in the material were determined by finite element analysis and the results were compared with the experimental. The results obtained are given both visually and graphically in the results section.

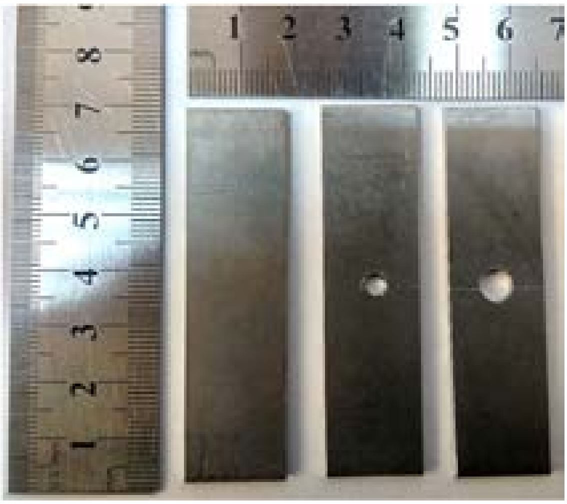

Figure1. Energy harvesting system

3. RESULTS AND DISCUSSION

Three tensile tests were repeated for each case, and the resulting Force-Displacement and Stress-Strain graphs are given below. As seen in Figure 2, the applied Force, and Displacement decreased as the hole diameter increased. Figure 3 shows the stress-strain graphs obtained from the tensile tests. As can be seen from this graph, there was a proportional decrease in the area and force with the increase in the hole diameter, and the tensile strength was not affected much by this situation. However, the strain value was negatively affected by this situation and showed a decrease similar to the Displacement.

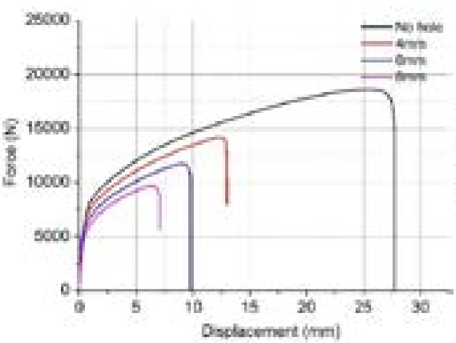

Figure 2. Force-Displacement tensile graphs

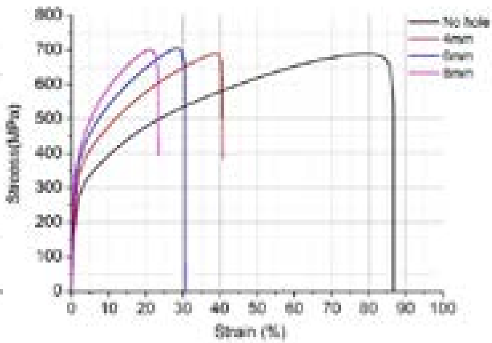

Figure 3. Stress- Strain tensile graphs

Table 1. Force-Displacement and Stress-Strain values

	Force (N)	Displace-ment (mm)	Stress (MPa)	Strain (%)
No hole	18627	27,75	688,7	86,7
4 mm	14188	12,93	689,4	40,4
6 mm	11764	9,79	705,1	30,6
8 mm	9680	7,04	700,7	23,4

In the figure below (Fig. 4), displacement, strain and force curves are given for the having hole work pieces and it is observed that they show an almost linear behavior. This showed that there is a linear relationship between the hole diameter and these values.

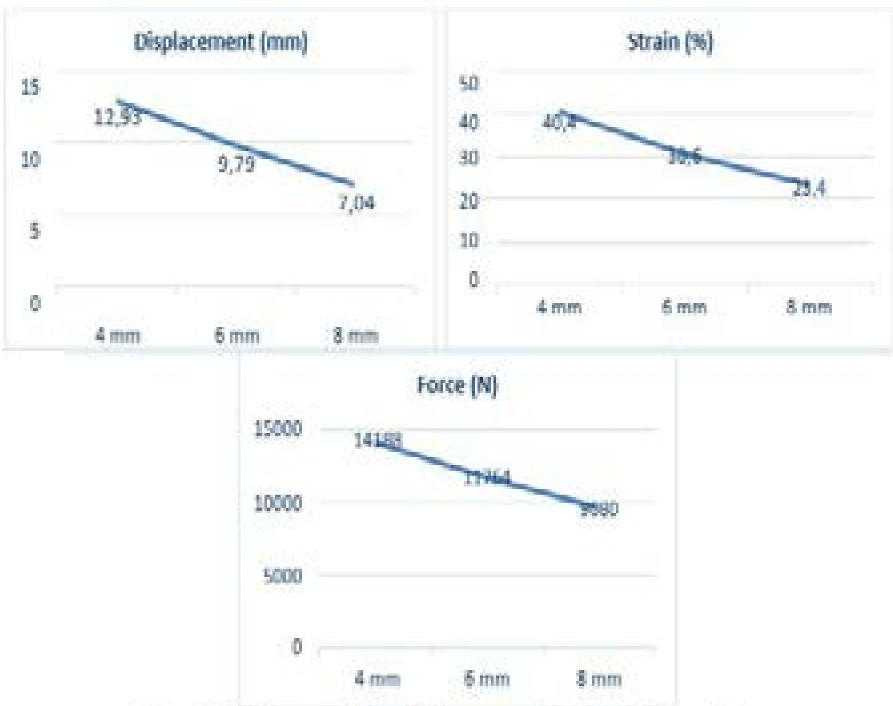

Figure 4. Displacement, Strain and Force curves for having hole work pieces

In Figure 5, there are examinations of the images of a perforated plate after it has been subjected to the tensile test. In Figure 5a, the elliptical structure of the hole on the work piece after drawing and the tears on its edges can be seen. In Figure 5b, the deformation at the edge of the hole is seen more closely, while in Figure 5d this situation is shown in 3D. In Figure 5c, the stress concentration formed around the hole after the finite element analysis (FEA) is seen and it is similar in shape to the experimental one. In addition, it has been shown both experimentally and numerically that the first tear is at the edges where the stress is most intense.

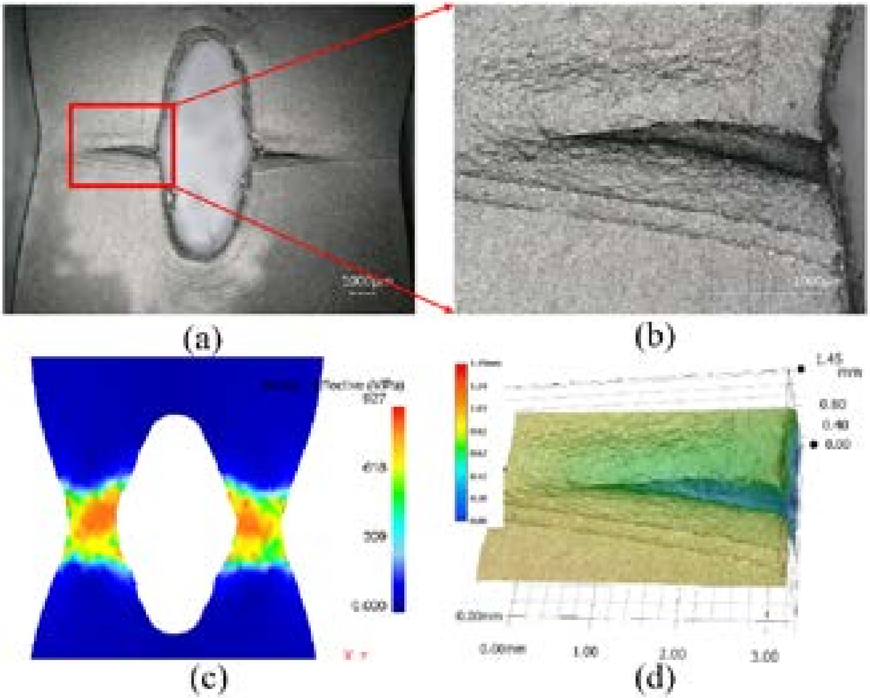

Figure 5. (a) Having hole plate with tensile test, **(b)** close-up view of deformation, **(c)** FEA results of stress concentration view, **(d)** 3D view of deformation

4. CONCLUSION

In this study, the effect of hole diameter on the steel plate on the tensile strength of the material was investigated by experimental and numerical methods. It has been observed that there is a proportional decrease in displacement, strain and force values with the increase of hole diameter and this situation is shown graphically. In addition, with the finite element analysis performed, the stress concentration due to the tensile force in the material was observed and it was observed that the deformation occurred in this region.

REFERENCES

[1] S. Erim and M. Uyaner, "Stress distributions and stress concentration factors in a simple beam with a circular hole subjected to constant bending moment," *Model. Meas. Control B*, vol. 67, no. 1, pp. 65–78, 1999.

[2] A. Çelik, A. Özel, and S. Karadeniz, "Farklı metallerin kaynağında gerilme yığılmalarının incelenmesi,"*Pamukkale* Üniversitesi *Mühendislik Bilim. Derg.*, vol. 2, no. 1, pp. 55–60, 1996.

[3] O. Bulut, "The thermal stress analysis around the cavities in composite plates used for the body of reactors,"*J. Fac. Eng. Archit. Gazi Univ.*, vol. 34, no. 2, pp. 1077–1086, 2019, doi: 10.17341/gazimmfd.460504.

[4] A. ÇELİK and K. TURAN, "Çentikli kompozit levhaların hasar davranışlarının incelenmesi," *Dicle* Üniversitesi *Mühendislik Fakültesi Mühendislik Derg.*, vol. 6, no. 2, pp. 73–82, Dec. 2015, Accessed: Oct. 05, 2021. [Online]. Available: https://dergipark.org.tr/en/pub/dumf/312812.