INTERNATIONAL 4th AL-JAZEERA ENGINEERING AND APPLIED SCIENCES CONGRESS

June 20-22, 2025
London/ENGLAND

PROCEEDINGS BOOK

EDITOR
Assoc. Prof. Seçil KARATAY

ISBN: 978-625-6997-71-4

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ISBN: 978-625-6997-71-4

by

ACADEMIC SHARING PLATFORM PUBLISHING HOUSE®

Issued: 30.07.2025

CONGRESS ID

CONGRESS TITLE

INTERNATIONAL 4th AL-JAZEERA ENGINEERING AND APPLIED SCIENCES CONGRESS

DATE and PLACE

June 20-22, 2025 London/ENGLAND

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UBS-Institute of International Scientific Research and Strategy Development Association, Akademik Paylaşım Platformu Eğitim Ltd.Şti.,Ankara,Türkiye

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IJHAS,International Journal of Health and Applied Science,Türkiye

PARTICIPANT COUNTRIES (6):

Pakistan, India, Malaysia, Philippines, Nigeria, Türkiye

NUMBER OF PARTICIPANTS (31):

(Türkiye-14, Other Countries-17)

NUMBER OF ACCEPTED PAPERS (22):

(Türkiye-7, Other Countries-15)

PRESENTATION

Oral presentation

EVALUATION PROCESS

All applications have undergone a double-blind peer review process

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İLGİLİ KURUMA

İçişleri Bakanlığı tarafından tahsis edilen 06-139-180 tescil kodu ile Tüzel kişiliğe sahip olan Uluslararası Bilimsel Araştırma ve Strateji Geliştirme Derneği, 5253 sayılı kanuna uygun olarak "Bilimsel Araştırmalar ve Akademik Çalışmalar" alanında ulusal ve uluslararası düzeyde faaliyetlerini yürütmektedir.

Kurumumuzun Yönetim Kurulu tarafından, 05.10.2024 tarihinde saat 14:00'da "Bilimsel Çalışmalarda Strateji Geliştirme" görüşmeleri ile "Bilimsel Kongreler Düzenlenmesi" gündemleri ile toplanmış ve alınan 9 nolu karara istinaden aşağıda detayları yazılı olan bilimsel etkinliğin düzenlenmesine ve etkinliğe ilişkin akademisyenlerin resmi olarak görevlendirilmesine oy birliği ile karar verilmiştir.

Bilgi ve gereğini arz ederim.

Dr. Nadire KANTARCIOĞLU

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Etkinlik Adı : 4. ULUSLARARASI EL-CEZERİ MÜHENDİSLİK VE UYGULAMALI BİLİMLER KONGRESİ

Etkinlik Tarihi: 20-22 HAZİRAN 2025, LONDRA, İNGİLTERE

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Uluslararası Bilimsel Araştırma ve Strateji Geliştirme Derneği

INTERNATIONAL 4th AL-JAZEERA ENGINEERING AND APPLIED SCIENCES CONGRESS
June 20-22, 2025 London/ENGLAND

Sayı:2025/015

İlgili Makama:

Uluslararası Bilimsel Araştırma ve Strateji Geliştirme Derneği (UBSDER) tarafından organize edilen "**INTERNATIONAL 4th AL-JAZEERA ENGINEERING AND APPLIED SCIENCES CONGRESS**" Haziran 20-22, 2025 tarihinde 6 farklı ülkeden (Türkiye'den 7, yurt dışından 15 bildiri sunuldu) olmak üzere toplam 22 adet sunum yapılarak, çevrimiçi olarak düzenlenmiştir.

Kongremiz, 16 Ocak 2020'de Akademik Teşvik Ödeneği Yönetmeliğine getirilen "Tebliğlerin sunulduğu yurt içinde veya yurt dışındaki etkinliğin uluslararası olarak nitelendirilebilmesi için Türkiye dışından en az beş farklı ülkeden sözlü tebliğ sunan konuşmacının katılım sağlaması ve tebliğlerin yarıdan fazlasının Türkiye dışından katılımcılar tarafından sunulması esastır." Değişikliğine uygun olarak düzenlenmiştir.

Bilgilerinize Arz Ederim

22.07.2025

Dr. Nadire KANTARCIOĞLU

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PARTICIPANT COUNTRIES (6):
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- ✓ Kongremizde Yazım Kurallarına uygun gönderilmiş ve bilim kurulundan geçen bildiriler için online (video konferans sistemi üzerinden) sunum imkanı sağlanmıştır.
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- ✓ The participant must be connected to the session 15 minutes before the presentation time.
- ✓ All congress participants can connect live and listen to all sessions.
- ✓ Moderator is responsible for the presentation and scientific discussion (question-answer) section of the session.

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- ✓ Make sure your computer has a microphone and is working.
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Meeting ID: 880 0871 3068
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Opening Ceremony

Online

Date: 21/06/2025

Time: 17:30

Meeting Link:
https://us06web.zoom.us/j/4603636838?pwd=Gx9rIRf5cUTPsZZ4pilDYkYWaaEAc6.1&omn=84532370470

Meeting ID: 460 363 6838
Password: 121314

Opening Speech:
Assoc. Prof. Seçil KARATAY
Kastamonu University

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- *The application works on tablets, phones and PCs.*
- *Speakers must be connected to the session 10 minutes before the presentation time.*
- *Online presentations; Presentation time is 10 minutes. There is 5 minutes of question and answer time.*
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- *During the session, your camera should be turned on at least %70 of session period*
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- *You should be able to use screen sharing feature in Zoom.*
- *Attendance certificates will be sent to you as pdf at the end of the congress.*
- *Moderator is responsible for the presentation and scientific discussion (question-answer) section of the session.*

INTERNATIONAL 4th AL-JAZEERA ENGINEERING AND APPLIED SCIENCES CONGRESS
June 20-22, 2025 London/ENGLAND

ONLINE

21.06.2025	SESSION-1 / HALL-5
London/ENGLAND	18:00-20:00

HEAD OF SESSION: ***Metin Uymaz SALAMCİ***
VICE CHAIR OF SESSION: ***Lecturer Muhammed Şerif YOLUK***

Author(s)	Affiliation	Title
Lecturer Muhammed Şerif YOLUK Assoc. Prof. Zeynep ALGIN Prof. Dr. H. Murat ALGIN	Harran Üniversitesi, Şanlıurfa Teknik Bilimler Meslek Yüksekokulu & Harran Üniversitesi, Mühendislik Fakültesi	VARIATION IN THE FLEXURAL STRENGTH OF LIGHTWEIGHT MORTARS PRODUCED WITH EXPANDED VERMICULITE AGGREGATE UNDER THE EFFECT OF ELEVATED TEMPERATURES
Adem TUNÇ Nafel DOGDU Metin Uymaz SALAMCİ	Graduate School of Natural and Applied Sciences, Gazi University, Ankara, Türkiye & Vocational School of Technical Sciences, Akdeniz University, Antalya, Türkiye. & Department of Mechanical Engineering, Gazi University, Ankara, Türkiye. Additive Manufacturing Technologies Application and Research Center (EKTAM), Gazi University, Ankara, Türkiye.	POWDER PRODUCTION OF ALUMINUM ALLOYS FOR ADDITIVE MANUFACTURING VIA ULTRASONIC ATOMIZATION METHOD AND CHEMICAL COMPOSITION VARIATION ANALYSIS
Dr. Sezer MORKAVUK	Karamanoğlu Mehmetbey University, Mechanical Engineering Department, Karaman, Türkiye	IMPACT OF AMPLITUDE IN SINUSOIDAL EDGE TRIMMING OF GLASS FIBER REINFORCED POLYMER COMPOSITES ON CUTTING FORCES AND SURFACE ROUGHNESS
Merve HATİPOĞLU İbrahim BACANAK Serdar AYDOĞDU	Demircioğlu Group, R&D Center	COMPARISON OF GAS METAL ARC WELDING AND LASER WELDING METHODS IN TERMS OF MECHANICAL PERFORMANCE FOR AIR SUSPENSION SYSTEM COMPONENTS USED IN HEAVY COMMERCIAL VEHICLES

All participants must join the conference 10 minutes before the session time.
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June 20-22, 2025 London/ENGLAND
ONLINE

21.06.2025	SESSION-1 / HALL-6
London/ENGLAND	18:00-20:00

HEAD OF SESSION: ***Ayşe KANIK***
VICE CHAIR OF SESSION: ***Moses Adeolu AGOI***

Author(s)	Affiliation	Title
Oluwadamilola Peace AGOI Moses Adeolu AGOI Oluwanifemi Opeyemi AGOI	Federal University of Agriculture Abeokuta, Ogun Nigeria. & Lagos State University of Education, Lagos Nigeria. & Obafemi Awolowo University, Osun Nigeria.	THE IMPACT OF AI INTELLIGENT CONTROL SYSTEMS ON SUSTAINABLE AGRICULTURAL PRACTICES: EVOLVING FROM SMART TECHNOLOGY TO SMART ECOSYSTEM
Ayşe KANIK Prof. Dr. Gülay TEZEL	Konya Teknik Üniversitesi, Mühendislik Ve Doğa Bilimleri Fakültesi	USED CAR PRICE PREDICTION USING LINEAR REGRESSION AND RANDOM FOREST ALGORITHMS
Ayyüce Sena GÜLPINAR Asst. Prof. Zeynep Huri ÖZKUL BİRGÖREN	Ankara Yıldırım Beyazıt Üniversitesi, Fen Bilimleri Enstitüsü & Ankara Yıldırım Beyazıt Üniversitesi, Mühendislik ve Doğa Bilimleri Fakültesi, İnşaat Mühendisliği, Geoteknik	EVOLUTION OF RELIABILITY AND RISK APPROACHES IN GEOTECHNICAL ENGINEERING: A LITERATURE-BASED ASSESSMENT
Ayşe KANIK	Konya Teknik Üniversitesi, Mühendislik Ve Doğa Bilimleri Fakültesi	PERFORMANCE ANALYSIS OF THE A*ALGORITHM FOR OBSTACLE AVOİDANCE IN AUTONOMOUS SYSTEMS AND COMPARATIVE EVALUATION WITH THE DIJKSTRA ALGORITHM

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21.06.2025	SESSION-2 / HALL-3
London/ENGLAND	04:00-06:00

HEAD OF SESSION: ***Prof. Rajiv SHARMA***
VICE CHAIR OF SESSION: ***Dr. Kittisak LERTCHAI***

Author(s)	Affiliation	Title
Dr. Ayesha KHAN	University of the Punjab, Pakistan	SUSTAINABLE WATER MANAGEMENT IN ARID REGIONS
Prof. Rajiv SHARMA	Delhi University, India	MACHINE LEARNING APPROACHES IN CANCER DETECTION
Dr. Nurul Aini ZAHID	University of Malaya, Malaysia	HALAL FOOD SUPPLY CHAIN AND CONSUMER TRUST
Miguel SANTOS	University of the Philippines Manila, Philippines	PUBLIC HEALTH CHALLENGES IN POST-PANDEMIC URBAN AREAS
Dr. Kittisak LERTCHAI	Chulalongkorn University, Tayland	SMART AGRICULTURE USING IOT IN SOUTHEAST ASIA
Dr. Sara RIZVI	Lahore College for Women University, Pakistan	GENDER-BASED ANALYSIS OF EDUCATION POLICIES
Priya DESAI	IIT Bombay, India	GREEN HYDROGEN PRODUCTION USING NANOCATALYSTS

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INTERNATIONAL 4th AL-JAZEERA ENGINEERING AND APPLIED SCIENCES CONGRESS
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ONLINE

21.06.2025	SESSION-2 / HALL-4
London/ENGLAND	04:00-06:00

HEAD OF SESSION: ***Dr. Ahmad FAISAL***
VICE CHAIR OF SESSION: ***Dr. Anil KUMAR***

Author(s)	Affiliation	Title
Dr. Ahmad FAISAL	Universiti Kebangsaan Malaysia, Malaysia	AI-DRIVEN FORECASTING MODELS IN RENEWABLE ENERGY SYSTEMS
Carla MENDOZA	Ateneo de Manila University, Philippines	DIGITAL LITERACY AND SOCIOECONOMIC MOBILITY IN RURAL COMMUNITIES
Dr. Napat CHAIYASIT	Mahidol University, Tayland	NEUROSCIENCE TRENDS IN STROKE REHABILITATION
Farooq JAMEEL	Quaid-i-Azam University, Pakistan	BLOCKCHAIN TECHNOLOGY IN PUBLIC ADMINISTRATION
Anil KUMAR	Banaras Hindu University, India	SOIL EROSION MODELING IN THE GANGES RIVER BASIN
Dr. Siti Mariam HASSAN	International Islamic University Malaysia, Malaysia	ROLE OF ISLAMIC FINANCE IN STARTUP ECOSYSTEMS
Dr. Jasmine TORRES	University of Santo Tomas, Philippines	EDUCATION STRATEGIES FOR ENHANCING STEM LEARNING IN HIGH SCHOOLS

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CONTENT

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GENLEŞTİRİLMİŞ VERMİKÜLİT AGREGASI İLE ÜRETİLEN HAFİF HARÇLARIN YÜKSEK SICAKLIK ETKİSİ ALTINDA EĞİLME DAYANIMLARINDAKİ DEĞİŞİM

VARIATION IN THE FLEXURAL STRENGTH OF LIGHTWEIGHT MORTARS PRODUCED WITH EXPANDED VERMICULITE AGGREGATE UNDER THE EFFECT OF ELEVATED TEMPERATURES

Lecturer Muhammed Şerif YOLUK
Harran Üniversitesi, Şanlıurfa Teknik Bilimler Meslek Yüksekokulu
ORCID ID: https://orcid.org/0000-0002-0036-1661

Assoc. Prof. Zeynep ALGIN
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Prof. Dr. H. Murat ALGIN
Harran Üniversitesi, Mühendislik Fakültesi

Özet

Enerji verimliliği, günümüzde yapı sektöründe hem ekonomik sürdürülebilirlik hem de çevresel etkilerin azaltılması bakımından kritik bir araştırma alanı olarak öne çıkmaktadır. Binaların toplam enerji tüketimindeki yüksek oranı, enerji performansı yüksek yapı malzemelerinin geliştirilmesini zorunlu kılmaktadır. Bu çerçevede, düşük yoğunluk, yeterli mekanik dayanım, ısı ve ses yalıtımı ile yangına karşı direnç gibi çok yönlü özellikler sunan hafif yapı malzemeleri ön plana çıkmaktadır. Genleştirilmiş perlit, pomza, genleştirilmiş kil ve vermikülit gibi doğal kökenli hafif agregalar, bu gereksinimleri karşılayabilen potansiyel malzemeler arasında yer almaktadır. Bu agregalar, düşük özgül ağırlıkları sayesinde taşıyıcı sistem üzerindeki yükleri azaltarak deprem performansını artırmakta ve enerji kayıplarını minimize ederek sera gazı emisyonlarının azaltılmasına katkı sağlamaktadır. Genleştirilmiş vermikülit ısı ve ses yalıtımı, soğuk hava deposu izolasyonu, dekoratif uygulamalar, dökümhane kaplamaları ve ateşe dayanıklı sıva gibi alanlarda yaygın şekilde kullanılmaktadır. Ancak bu agregayla üretilen harçların mekanik dayanımlarının yetersiz kalması, yapısal uygulamalardaki kullanımını sınırlamaktadır.

Bu çalışmada, genleştirilmiş vermikülit agregasının yüzey özelliklerini iyileştirmek ve mekanik performansını artırmak amacıyla, soğuk bağlama yöntemiyle çimento ve silis dumanı esaslı çok katmanlı kaplama işlemi uygulanmıştır. Farklı kalınlıklarda kaplanmış agregalar hazırlanmış ve bu agregalar dere kumu yerine %33, %66 ve %100 oranlarında kullanılarak toplamda 12 farklı hafif harç karışımı tasarlanmıştır. Her biri 40 × 40 × 160 mm boyutlarında olmak üzere toplam 108 adet harç numunesi üretilmiş ve tüm numuneler deney gününe kadar su küründe bekletilmiştir.

Her karışımdan üçer numune, referans eğilme dayanımı tayini için oda koşullarında, üçer numune 300 °C ve üçer numune ise 600 °C sıcaklıkta 6 saat boyunca ısıya maruz bırakıldıktan

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sonra oda sıcaklığına getirilerek eğilme dayanımı testine tabi tutulmuştur. Elde edilen sonuçlara göre, yer değiştirme oranı arttıkça tüm gruplarda eğilme dayanımı düşmüş; ancak bu düşüşün miktarı, agregaların kaplama kalınlığına bağlı olarak değişiklik göstermiştir. Oda sıcaklığında test edilen numuneler arasında, en düşük eğilme dayanımı değerleri kaplanmamış agregalarla üretilen karışımlarda gözlemlenmiştir. Özellikle %100 kaplanmamış vermikülit agregası içeren karışıma kıyasla, aynı oranda kaplanmış agregayla hazırlanan harçta yaklaşık %200'e varan bir dayanım artışı sağlanmıştır. 300 °C'ye maruz bırakılan numunelerde ise, kaplanmamış agregalı karışımlar tüm yer değiştirme oranlarında yaklaşık %10'luk sınırlı bir dayanım kaybı gösterirken, kaplanmış agregalı karışımlarda bu kayıplar %35 ile %65 arasında değişmiş ve yer değiştirme oranı arttıkça kayıp oranı belirgin biçimde artmıştır. Öte yandan, 600 °C'de test edilen numuneler, yüksek sıcaklık etkisi altında genleştirilmiş vermikülit agregalarının daha kararlı bir mekanik performans sergilediğini göstermiştir. Kaplanmamış agregalı numunelerde yer değiştirme oranı arttıkça eğilme dayanımı kaybı azalmakta; %33 oranında yaklaşık %50 olan kayıp, %100 oranında yalnızca %21'e kadar düşmektedir. Bu durum, kaplanmamış agregalı karışımlarda ısıl hasarın yer değiştirme oranı ile sınırlandığını göstermektedir. Buna karşın, kaplanmış agregalı numunelerde eğilme dayanımı kaybı %58 ila %69 arasında değişmiş ve tüm yer değiştirme oranlarında kaplanmamış agregaya kıyasla daha yüksek seviyelerde seyretmiştir. Sonuç olarak, soğuk bağlama yöntemiyle kaplanmış genleştirilmiş vermikülit agregalarının, ortam koşullarında eğilme dayanımını önemli ölçüde artırdığı; ancak yüksek sıcaklık altında kaplanmamış agregalara kıyasla daha fazla dayanım kaybına neden olduğu belirlenmiştir.

Anahtar Kelimeler: Hafif Harç, Genleştirilmiş Vermikülit, Çok Katmanlı Kaplama, Yüksek Sıcaklık.

Abstract

Energy efficiency has become a pivotal research topic in the construction industry, with significant implications for economic sustainability and environmental impact reduction. The significant contribution of the building sector to total energy consumption necessitates the development of building materials with high energy performance. In this context, lightweight construction materials that offer multifunctional properties such as low density, adequate mechanical strength, thermal and sound insulation, and fire resistance are becoming increasingly prominent. It is evident that natural lightweight aggregates, including but not limited to expanded perlite, pumice, expanded clay, and vermiculite, have the potential to satisfy the aforementioned requirements. The utilisation of these aggregates in construction leads to a reduction in loadings on the structural system due to their low specific gravity. This, in turn, enhances seismic performance and minimises energy losses, thereby contributing to a reduction in greenhouse gas emissions. Expanded vermiculite is a material that has a variety of applications. These include thermal and sound insulation, cold storage insulation, decorative applications, foundry coatings and fire-resistant mortars. Nevertheless, the inadequate

mechanical strength of mortars produced with this aggregate restricts their utilisation in structural applications.

In this study, a multi-layer coating process based on cement and silica fume was applied using the cold bonding method to improve the surface properties and increase the mechanical performance of expanded vermiculite aggregate. Aggregates with varying thicknesses were prepared and utilised in place of river sand at ratios of 33%, 66%, and 100%, yielding a total of 12 distinctive lightweight mortar mixtures. A total of 108 mortar samples, each measuring 40 × 40 × 160 mm, were produced, and the tests were applied to the 28-day cured specimens.

Subsequently, three samples from each mixture were subjected to flexural strength testing under ambient conditions to determine the reference flexural strength. Furthermore, three samples were exposed to 300°C for six hours, and three samples were exposed to 600°C for six hours, followed by cooling to room temperature. Subsequent to this, the samples were tested for flexural strength. The findings of the study indicate that as the aggregate replacement ratio increases, there is a reciprocal decline in flexural strength across all test groups. However, the extent of this decline is contingent on the coating thickness of the aggregates. Among the samples that were tested at room temperature, the lowest flexural strength values were observed in mixtures produced with uncoated aggregates. In comparison with the mixture containing 100% uncoated vermiculite aggregates, the mortar prepared with the same proportion of coated aggregates exhibited an increase in strength of approximately 200%. In samples exposed to 300°C, uncoated aggregate mixtures demonstrated a restricted strength reduction of approximately 10% across all replacement ratios. Conversely, coated aggregate mixtures exhibited a loss ranging from 35% to 65%, with the rate of loss demonstrating a substantial increase as the replacement ratio increased. Conversely, samples tested at 600°C demonstrated that expanded vermiculite aggregates exhibit more stable mechanical performance under high-temperature conditions. In uncoated aggregate samples, the reduction in flexural strength is observed to decrease as the replacement ratio increases; the loss, which is approximately 50% at a 33% replacement ratio, is reduced to only 21% at a 100% replacement ratio. This finding suggests that the occurrence of thermal damage in uncoated aggregate mixtures is constrained by the replacement ratio. Conversely, the reduction in flexural strength of coated aggregate samples exhibited a range from 58% to 69%, persistently maintaining higher levels in comparison to uncoated aggregates across all replacement ratios. In conclusion, it has been determined that multi-layer coated expanded vermiculite aggregates significantly increase flexural strength under ambient conditions; however, they cause greater strength loss compared to uncoated aggregates at elevated temperatures.

Keywords: Lightweight mortar, expanded vermiculite, multi-layer coating, elevated temperature.

ISBN: 978-625-6997-71-4

POWDER PRODUCTION OF ALUMINUM ALLOYS FOR ADDITIVE MANUFACTURING VIA ULTRASONIC ATOMIZATION METHOD AND CHEMICAL COMPOSITION VARIATION ANALYSIS

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ABSTRACT

7000 series aluminum alloys are widely used in the aerospace industry due to their high strength, toughness, and corrosion resistance. For example, 7050 aluminum alloy is commonly employed; however, conventional manufacturing processes generate a considerable amount of scrap**.** This study aims to produce metal powders suitable for additive manufacturing using these scrap materials, thereby contributing to the circular economy and reducing material costs. Spherical and homogeneous metal powders were produced from scrap materials using an induction melting–ultrasonic atomization device. Both the produced powders and the raw samples from the same batch were analyzed in terms of chemical composition using the XRF method. When comparing the chemical composition of the raw scrap material and the produced powder, a decrease in weight percentage was observed in Mg (0.29%), Si (0.483%), Cu (0.153%), Zn (0.588%), and Zr (0.012%), indicating slight evaporation of some elements during induction melting. The chemical composition of the produced powder matches the standard chemical composition of the Al 7050 alloy. Although there are slight changes in the chemical composition of the material, the produced powder still meets the standards of the 7050 series alloy. This indicates that the produced powders are suitable for use in additive manufacturing applications.

Keywords: Powder Metallurgy, 7050 Alloy, XRF, İnduction, Ultrasonic Powder Production

ÖZET

7000 Serisi alüminyum alaşımları yüksek mukavemeti, tokluğu ve korozyona karşı direnci nedeniyle havacılık sektöründe yaygın olarak kullanılmaktadır. Örneğin, 7050 alüminyum alaşımı yaygın olarak kullanılmakla birlikte geleneksel üretim yöntemleri ile parça üretimi sonucu önemli miktarda atık ortaya çıkmaktadır. Bu çalışmada söz konusu atık malzemelerin geri dönüşümüyle, hem döngüsel ekonomiye katkı sağlanması hem maliyetlerinin azaltılması hem de atık malzemelerin eklemeli imalatta kullanılmasına yönelik metal toz üretimi hedeflenmiştir. İndüksiyon ergitmeli- ultrasonik atomizasyon cihazı kullanılarak atık malzemelerden küresel ve homojen metal tozları üretilmiştir. Üretilen tozlar ile aynı partiden alınan ham numuneler, XRF yöntemiyle kimyasal bileşim açısından analiz edilmiştir. Atık ham malzemenin kimyasal analiz sonuçları ile üretilen toz

numunesi kimyasal analiz sonuçları arasında, ağırlık olarak Mg'da % 0,29, Si'da % 0,483, Cu'da 0,153, Zn'da % 0,588 ve Zr'da 0,012 oranında azalma olduğu belirlenmiştir. Bu durum indüksiyonla ergime esnasında 7050 alaşımının içerisindeki bazı elementlerden bir miktar buharlaşma olduğunu göstermektedir. Üretilen tozun kimyasal kompozisyonu ile Al 7050 alaşımın standartlardaki kimyasal kompozisyonu örtüşmektedir. Malzemenin kimyasal kompozisyonunda bir miktar değişme olsa da üretilen tozun hala 7050 serisi alaşım standartlarını sağladığı görülmüştür. Bu durum üretilen tozların eklemeli imalat uygulamalarında kullanılabileceğini göstermektedir.

Anahtar Kelimeler: Toz metalürjisi, 7050 Alaşımı, XRF, İndüksiyon, Ultrasonik Toz Üretimi

1.Giriş

Havacılık ve uzay sanayii, her geçen gün daha hafif ancak aynı zamanda daha dayanıklı malzemelere duyulan ihtiyacı artırmaktadır. Bu sektörde kullanılan malzemelerin yalnızca yüksek mukavemetli olması yeterli olmayıp, aynı zamanda korozyon ve yorulmaya karşı dirençli, uzun ömürlü olmaları da beklenmektedir. Bu özellikleri bir arada sunabilen az sayıdaki malzeme grubundan biri de 7000 serisi alüminyum alaşımlarıdır. Bu serinin öne çıkan üyelerinden 7050 alüminyum alaşımı, sahip olduğu yüksek dayanım ve iyi korozyon direnci sayesinde uçak gövdeleri ve iniş takımları gibi kritik parçalarda uzun yıllardır güvenle kullanılmaktadır [1].

Ancak bu değerli alaşımın geleneksel üretim yöntemleri ile işlenmesi sırasında önemli miktarda atık oluşmaktadır. Bu atıklar çoğu zaman düşük kaliteli alanlarda değerlendirilmekte ya da tamamen kaybedilmektedir. Hâlbuki bu atıkların yeniden değerlendirilmesi hem ekonomik kazanç sağlayabilir hem de çevresel sürdürülebilirliğe katkıda bulunabilir [2].

Bu noktada gelişen eklemeli imalat teknolojileri öne çıkmaktadır. Eklemeli imalat, parçaları katman katman üretilir. Malzeme israfını azaltan ve karmaşık geometriye sahip yapıları kolayca imal etmeyi sağlayan modern bir üretim tekniğidir. Ancak bu yöntemin etkin olarak kullanılabilmesi için, kullanılacak metal tozların özellikle küresel geometrili, homojen yapılı ve uygun tane boyut dağılımına sahip olması gerekir [2].

Metal toz üretiminde geleneksel olarak gaz atomizasyonu yaygın biçimde kullanılmakla birlikte, bu yöntem yüksek enerji tüketimi ve ekipman maliyetleri nedeniyle dezavantajlara sahiptir. Son yıllarda alternatif olarak gelişen ultrasonik atomizasyon yöntemi, daha düşük enerji tüketimi ve daha küresel, homojen partikül yapısı sayesinde dikkat çekmektedir [3]. Bu yöntemde, ergimiş metal yüksek frekanslı ultrasonik titreşimler yoluyla küçük damlacıklara ayrılarak katılaşır ve toz haline gelir.

Priyadarshi ve arkadaşları tarafından yapılan çalışmada, ultrasonik atomizasyon mekanizması ayrıntılı biçimde incelenmiş; bu yöntemin metal tozu üretiminde sağladığı avantajlar deneysel olarak ortaya konmuştur [4]. Özellikle alüminyum alaşımlarının bu yöntemle küresel ve homojen partiküller halinde üretilebildiği gösterilmiştir. Benzer

ISBN: 978-625-6997-71-4

şekilde Kustron ve arkadaşları yüksek güçlü ultrasonik sistemlerin verimli ve kararlı toz üretimi sağladığını vurgulamıştır[5].

Bu çalışmada, 7050 alüminyum alaşımlarının malzeme atıklarının geri dönüşümüyle hem döngüsel ekonomiye katkı sağlanması hem maliyetlerinin azaltılması hem de atık malzemelerin eklemeli imalatta kullanılmasına yönelik metal toz üretimi amaçlanmıştır. Bu kapsamda, önce 7050 alüminyum alaşımının ilk hali X-ışını Floresans (XRF) yöntemiyle analiz edilerek referans bileşimi elde edilmiştir. Daha sonra bu malzeme eritilerek ultrasonik atomizasyon yöntemiyle toz haline getirilmiş ve üretilen toz örneği tekrar XRF analizine tabi tutulmuştur. Bu sayede, üretim süreci sırasında gerçekleşen olası elemental kayıplar ya da değişimler değerlendirilmiş ve elde edilen sonuçlar yorumlanmıştır.

2. MALZEME VE METOD

TUSAŞ üretim uygulamalarından 7050 alüminyum alaşımına ait atık numuneler temin edilmiştir. 7050 serisi alüminyum alaşımı; yüksek mukavemeti, gerilim korozyon çatlağına karşı direnci ve tokluğu ile havacılık sınıfı bir alaşımdır. Bu nedenle 7050 alüminyum, gövde çerçeveleri, bölmeler ve kanat kaplamaları gibi kritik uçak bileşenlerinde yaygın olarak kullanılmaktadır. Al 7050 alaşımının ağırlık yüzdesine göre kimyasal bileşimi Tablo 1'de verilmiştir.

Element	Al	Zr	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Diğer
Min	87.3	0.08	–	–	2.0	–	1.9	–	5.7	–	–
Max	90.3	0.15	0.12	0.15	2.6	0.1	2.6	0.04	6.7	0.06	0.2

Tablo 1. Al 7050 alaşımının kimyasal bileşimi (Ağırlıkça %) [6]

Alaşımın bazı fiziksel ve mekanik özellikleri ise Tablo 2 ve Tablo 3'te sunulmuştur.

Özellik	Değer
Yoğunluk	2,83 g/cm³
Erime Noktası	488 °C
Genleşme Katsayısı	22,1 µm/m·°C
lastisite Modülü	71 GPa

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Özellik	Değer
Elektriksel Direnç	35 % IACS
Isı İletkenliği	140 W/m·K

Tablo 2. Al 7050 alaşımının fiziksel özellikleri [7]

Tablo 3. Al 7050 alaşımının mekanik özellikleri

Özellik	Değer
Maksimum Çekme Dayanımı	440 MPa
Akma Dayanımı	530 MPa
Kesme Dayanımı	310 MPa
Uzama (A50 mm)	%8
Sertlik	150 HB

Tablo 3. Al 7050 alaşımının mekanik özellikleri [7]

Toz üretimi, Gazi Üniversitesi Eklemeli İmalat Teknolojileri Uygulama ve Araştırma Merkezi (EKTAM) bünyesinde bulunan indüksiyon ergitmeli-ultrasonik toz üretim atomizeri /**ATO Lab+)** cazı ile gerçekleştirilmiştir. ATOLab+ cihazı, hazne içerisindeki potada metal malzemeyi indüksiyon yöntemiyle ergitmekte ve ardından platform üzerine akan ergiyik, 35 kHz frekansındaki ultrasonik titreşimlerle pulverize edilmektedir. Üretim ortamına argon gazı verilerek oksidasyon önlenmektedir.

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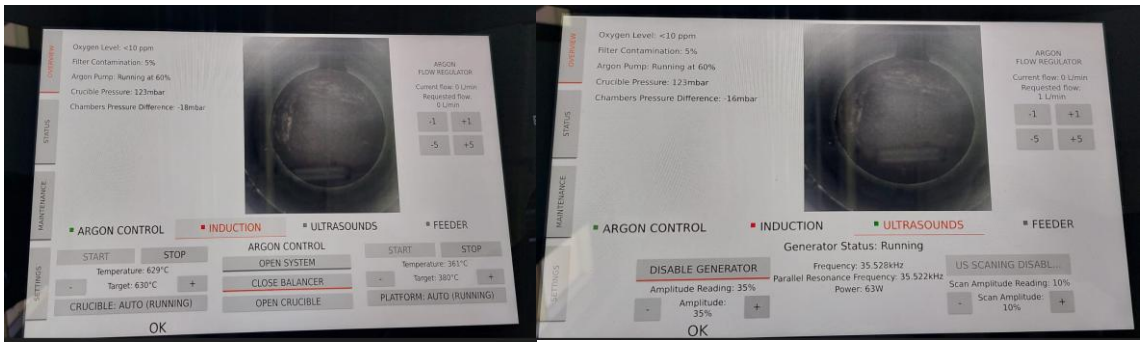
Şekil 1. ATO Lab+, Toz Üretim Cihazı



Şekil 2. ATO Lab+ cihazı ile toz üretim parametreleri

ISBN: 978-625-6997-71-4

Şekil 3. ATO Lab+ Cihazı İle Üretilen Toz

X-ışını Floresans (XRF) yöntemi, malzemenin elemental bileşimini belirlemek amacıyla kullanılmıştır. Bu analiz, katı, sıvı ve toz örneklerde tahribatsız şekilde çalışabilen etkili bir tekniktir. Bu çalışmada hem hammadde numunesi hem de elde edilen toz numunesi XRF analizi ile karakterize edilmiştir.

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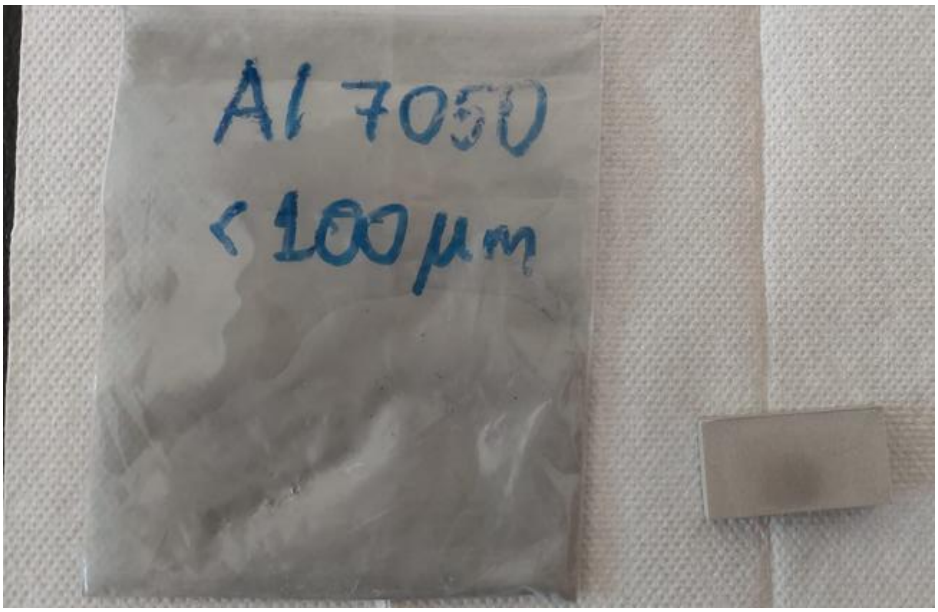
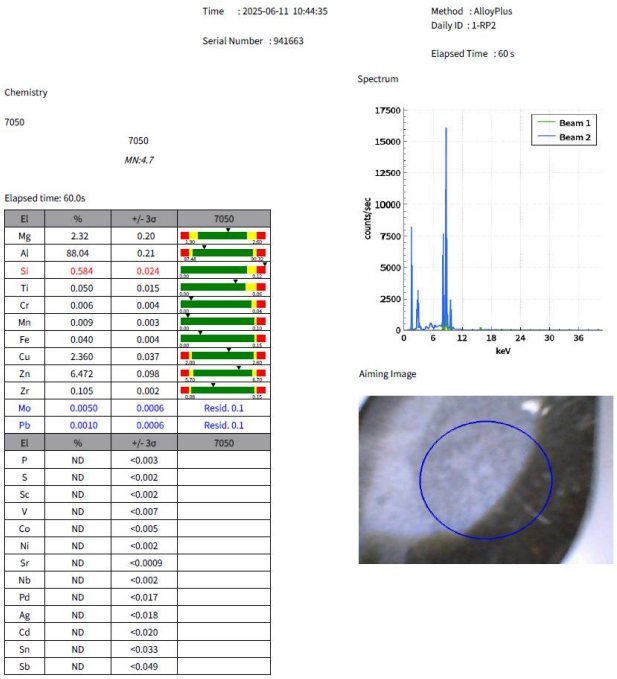


Şekil 4. XRF analizi için gönderilmiş ham ve toz numuneler görülmektedir.

Analizler, **Troy-Met Kalite Kontrol Sistemleri Ltd. Şti.** laboratuvarında gerçekleştirilmiştir. Kullanılan cihaz **Olympus Vanta Max** olup 50 kV geniş alan SDD dedektöre sahiptir. Numuneler 60 saniye boyunca üç tekrar alınarak analiz edilmiş ve ortalama değerler raporlanmıştır.

Analiz Raporları



Time : 2025-06-11 10:44:35
Serial Number : 941663
Method : AlloyPlus
Daily ID : 1-RP2
Elapsed Time : 60 s

Chemistry

7050

7050
MN:4.7

Elapsed time: 60.0s

El	%	+/- 3σ	7050
Mg	2.32	0.20	
Al	88.04	0.21	
Si	0.584	0.024	
Ti	0.050	0.015	
Cr	0.006	0.004	
Mn	0.009	0.003	
Fe	0.040	0.004	
Cu	2.360	0.037	
Zn	6.472	0.098	
Zr	0.105	0.002	
Mo	0.0050	0.0006	Resid. 0.1
Pb	0.0010	0.0006	Resid. 0.1

El	%	+/- 3σ	7050
P	ND	<0.003	
S	ND	<0.002	
Sc	ND	<0.002	
V	ND	<0.007	
Co	ND	<0.005	
Ni	ND	<0.002	
Sr	ND	<0.0009	
Nb	ND	<0.002	
Pd	ND	<0.017	
Ag	ND	<0.018	
Cd	ND	<0.020	
Sn	ND	<0.033	
Sb	ND	<0.049	

Spectrum

Aiming Image

Şekil 5. XRF analiz proses fotoğrafı ve raporlama

ISBN: 978-625-6997-71-4

Time : 2025-06-11 10:46:42

Method : AlloyPlus
Daily ID : 2A

Serial Number : 941663

Elapsed Time : 0 s

Chemistry

Elapsed time: 0.0s

El	%	+/- 3σ
Mg	2.39	0.20
Al	88.03	0.21
Si	0.583	0.024
Ti	0.046	0.015
Cr	0.007	0.004
Mn	0.007	0.003
Fe	0.038	0.004
Ni	0.001	0.002
Cu	2.353	0.037
Zn	6.440	0.097
Zr	0.104	0.002
Mo	0.0043	0.0006
Pb	0.0009	0.0005

Şekil 6. Ham numuneye ait XRF tekniği ile üç tekrarlı analiz sonucu ortalama değerler

ISBN: 978-625-6997-71-4

Time : 2025-06-02 07:16:20
Serial Number : 941663
Method : AlloyPlus
Daily ID : 6A
Elapsed Time : 0 s

Chemistry

Elapsed time: 0.0s

El	%	+/- 3σ
Mg	2.05	0.23
Al	89.36	0.23
Si	0.100	0.017
Ti	0.259	0.024
V	0.017	0.010
Cr	0.015	0.005
Mn	0.011	0.004
Fe	0.043	0.004
Ni	0.001	0.002
Cu	2.200	0.035
Zn	5.852	0.089
Zr	0.092	0.002
Mo	0.0038	0.0006
Pb	0.0009	0.0005

Şekil 7. Toz numuneye ait XRF tekniği ile üç tekrarlı analiz sonucu ortalama değerler

3. SONUÇLAR

Toz üretimi öncesinde ve sonrasında elde edilen numuneler X-ışını Floresans (XRF) analizi ile kimyasal bileşim açısından karşılaştırılmıştır. Analiz sonuçları, üretim süreci sırasında alaşımın bazı bileşenlerinde, özellikle buharlaşan elementlerde, sınırlı düzeyde kütle kaybı meydana geldiğini ortaya koymuştur. Üretilen toz numunelerinde, ilk hammaddeye kıyasla; magnezyum (Mg)'da %0,29, silisyum (Si)'da %0,483, bakır (Cu)'da %0,153, çinko (Zn)'da %0,588 ve zirkonyum (Zr)'da %0,012 oranında azalma tespit edilmiştir. Bu durum, yüksek sıcaklıkta gerçekleşen indüksiyon ergitme işlemi sırasında söz konusu elementlerin buharlaşarak sistemden uzaklaştığını göstermektedir. Literatürde de benzer şekilde, özellikle Mg ve Zn gibi düşük kaynama noktasına sahip elementlerin yüksek sıcaklıklı işlem koşullarında buharlaşma eğilimi gösterdiği ifade edilmektedir.

Buna karşın, elde edilen tozların genel kimyasal bileşimi, ASTM standardında belirtilen Al 7050 alaşımı sınır değerleri ile büyük oranda uyumludur. Elemental azalmalar, alaşımın sınıf dışına çıkmasına neden olmamış, üretilen tozun hala 7050 serisi olarak sınıflandırılabilir nitelikte olduğu belirlenmiştir. Bu bulgu, malzemenin yeniden kullanım potansiyelini doğrulamakta ve söz konusu tozların eklemeli imalat süreçlerinde doğrudan kullanılabileceğine işaret etmektedir. Nitekim, tozların uygun kimyasal bileşime sahip olması, ergitme davranışları, mikro yapı kararlılığı ve nihai mekanik özellikler üzerinde doğrudan etkilidir.

Sonuç olarak, bu çalışma; yüksek performanslı alüminyum alaşımlarının, ileri düzey toz üretim teknolojileri ile yeniden değerlendirilerek katmanlı imalat teknolojilerine kazandırılabileceğini göstermiştir. Bu yaklaşım, hem ekonomik açıdan malzeme geri

ISBN: 978-625-6997-71-4

kazanımı sağlayarak maliyetlerin düşürülmesine katkıda bulunmakta, hem de döngüsel ekonomi ve sürdürülebilir üretim ilkeleriyle uyumlu bir yöntem olarak dikkat çekmektedir.

KAYNAKLAR

[1] V. K. Varma, M. M. Butt, H. Laieghi, Z. Uddin, E. Salamci, D. B. Kim, and H. Kizil, "Recent progress in additive manufacturing of 7XXX aluminum alloys," *Int. J. Adv. Manuf. Technol.*, vol. 137, pp. 4353–4399, Mar. 2025.

[2] M. J. Yadegari, A. Martucci, S. Biamino, D. Ugues, L. Montanaro, P. Fino, and M. Lombardi, "Aluminum laser additive manufacturing: A review on challenges and opportunities through the lens of sustainability," *Applied Sciences*, vol. 15, no. 4, p. 2221, 2025.

[3] W. Presz, R. Szostak-Staropiętka, A. Dziubińska, and K. Kołacz, "Ultrasonic atomization as a method for testing material properties of liquid metals," *Materials*, vol. 17, no. 24, p. 6109, Dec. 2024.

[4] . Priyadarshi, S. B. Shahrani, T. Choma, Ł. Żrodowski, L. Qin, C. L. A. Leung, S. J. Clark, K. Fezzaa, J. Mi, P. D. Lee, D. Eskin, and I. Tzanakis, "New insights into the mechanism of ultrasonic atomization for the production of metal powders in additive manufacturing," *Additive Manufacturing*, vol. 83, p. 104033, Mar. 2024.

[5] P. Kustron, M. Korzeniowski, A. Sajbura, T. Piwowarczyk, P. Kaczynski, and P. Sokolowski, "Development of high-power ultrasonic system dedicated to metal powder atomization," *Applied Sciences*, vol. 13, no. 15, p. 8984, 2023.

[6] "Aluminium 7050 Technical Data," Aircraft Materials. [Online]. Available: https://aircraftmaterials.com/data/aluminium/7050.html. [Accessed: 16-Jun-2025].

[7] "7050 T74 AlZn6CuMgZr Alaşımı – Referans Metal," [Online]. Available: https://www.referansmetal.com/alasimli-aluminyum/product/397/uzay-havacilik-savunma/cubuk-lama/ams-4107-alzn6cumgzr-7050-t74. [Accessed: 16-Jun-2025].

ISBN: 978-625-6997-71-4

IMPACT OF AMPLITUDE IN SINUSOIDAL EDGE TRIMMING OF GLASS FIBER REINFORCED POLYMER COMPOSITES ON CUTTING FORCES AND SURFACE ROUGHNESS

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ABSTRACT

Glass fiber reinforced plastics (GFRP) are the most preferred composites in industrial applications due to their excellent properties as well as economical cost. Following the removal of the composites from the mold, they are subjected to edge trimming in order to remove any excess part from the production process and obtain final shape. Due to the anisotropic structure of composites, some damages, especially delamination, may occur during machining. Consequently, it is imperative to process the composites in a manner that generates minimal cutting forces and preserves the integrity of the surface quality. The present study investigates the edge trimming of GFRP with linear and sinusoidal tool paths of different amplitudes, examining the cutting forces in detail. Furthermore, the impact of varying tool paths on surface roughness was thoroughly examined. The results show that sinusoidal milling generates a lower resultant force in comparison to linear milling. However, an increase in amplitude is accompanied by an increase in resultant force, whilst surface roughness is reduced.

Keywords: Edge trimming, Glass fiber, milling, sinusoidal milling, tool paths

INTRODUCTION

Composite materials are defined as new materials formed by the combination of at least two different materials at the macro level. In composite materials, which are constituted by two components (i.e. the matrix and the reinforcement element), the latter provides the composite with load-bearing properties, as the name suggests. The primary function of the matrix is to hold the reinforcement elements together and to distribute the load homogeneously. The matrix material can be ceramic, metal or polymer, while glass, carbon, basalt, aramid and natural fibres are used as reinforcement elements [1, 2]. Despite the existence of different reinforcement elements and matrix material alternatives, glass fiber reinforced plastics (GFRP) and carbon fiber reinforced plastics (CFRP) are widely used in the industry, and it is stated that GFRP constituted the highest volume in the market [3, 4]. The reasons behind GFRP's widespread preference in the industry include its cost-effectiveness and properties such as high specific strength, lightness, high fracture toughness, and excellent corrosion resistance [5, 6].

Despite being produced close to net shape, composite parts require trimming after demolding to achieve the desired final shape and tolerances [7]. However, during the processing of fiber-reinforced plastics, undesirable damages such as delamination, fiber pull out, and matrix crack may occur, which can deteriorate the surface quality and adversely impact the performance of the composite [5, 8]. For this reason, many researchers have focused on improving the machinability of GFRP. Davim et al. [9] investigated milling GFRP produced with hand-lay-up method and evaluated machinability considering cutting forces, delamination, surface roughness, and dimensional precision. Ghalme et al. [8] optimized cutting parameters in milling GFRP and reported cutting speed was more effective on surface roughness. Slamani et al. [2] investigated and compared edge trimming of flax and glass fiber reinforced plastics. They reported that the cutting tool type had a significant effect on delamination and the two-flute polycrystalline Diamond end mill was more suitable for GFRP. Abburi Lakshman and Prakash et al. [10] researched the influence of fiber orientation on the milling of GFRP considering cutting forces, surface quality, and machinability index. It was stressed that fiber orientation significantly affects machinability. Schrab et al. [3] investigated edge trimming of uni-directional GFRP composites at different fiber angles using diamond coated burr tool. They reported that orientation angle of the fiber significantly influenced cutting forces, surface finish and uncut fiber formation.

Studies to improve the machinability of difficult-to-cut materials are ongoing, and especially recently significant improvements have been achieved by sinusoidal tool milling instead of linear milling. This machining strategy was applied for Ti-6Al-4V alloy [11] and CFRP [12] and significant improvements in cutting forces, surface quality were achieved. However, the effect of this machining strategy on the machinability of GFRP has not yet been investigated. Additionally, the effect of the amplitude value of the sinusoidal curve has not been investigated in existing studies. In this study, the effects of sinusoidal tool paths with different amplitudes on the cutting forces and surface quality in the side milling operation of GFRP were experimentally investigated.

MATERIALS AND METHOD

In the present study, 0/90° bidirectional GFRP plates produced with the vacuum-assisted resin transfer molding method were utilized as the workpiece. The thickness of the GFRP plate was approximately 5.5 mm. Three samples with dimensions of 50 mm x 30 mm cut from the GFRP plate for edge trimming experiments as shown in Fig. 1.

ISBN: 978-625-6997-71-4

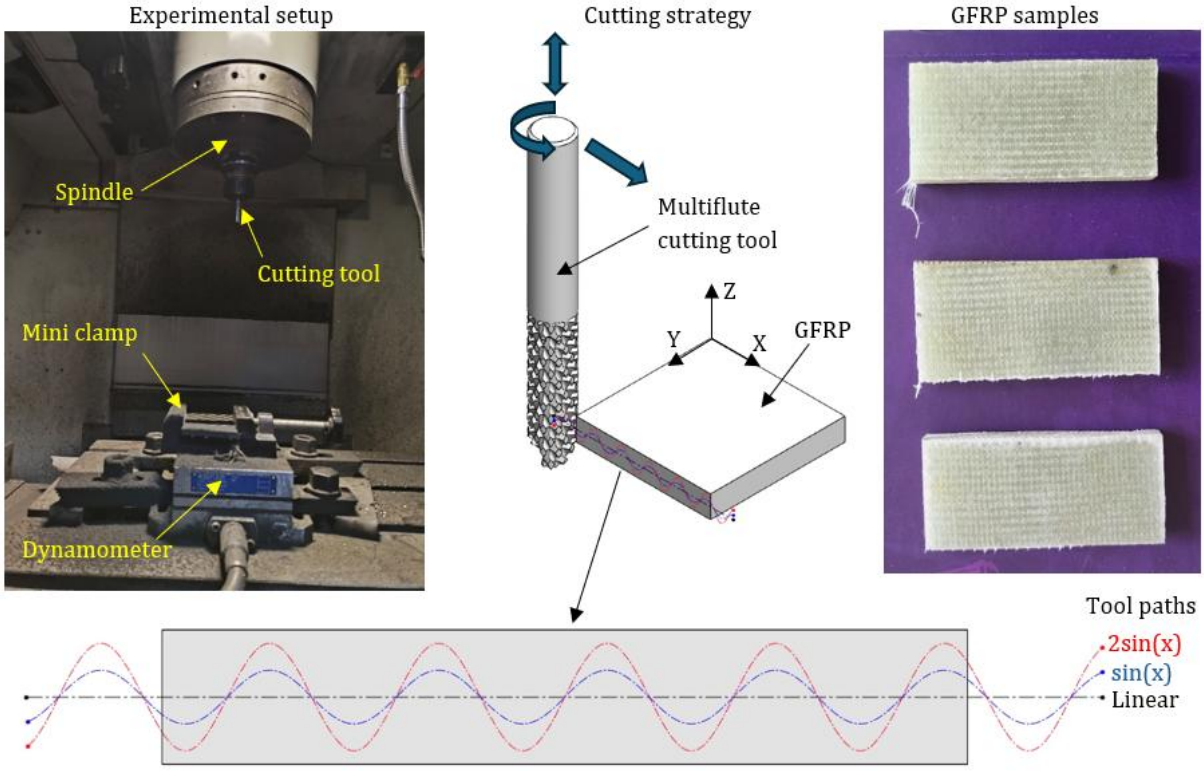

Fig. 1 Experimental setup and cutting strategy

Milling tests were performed on a three-axis vertical machining center. A mini clamp placed on a dynamometer was used to rigidly fix the samples to the dynamometer and the forces recorded during tests. The cutting tests were performed using 3 different tool paths with constant cutting parameters (3000 rpm spindle speed, 500 mm/min feed rate, and 4 mm radial depth of cut). A multi flute solid carbide end mill with 8 mm diameter was used as a cutting tool. The edge trimming operation was carried out with three different tool paths illustrated in Fig. 1. The first of these was straight edge milling with linear tool path, while the other two were machining with a sinusoidal curve. In sinusoidal milling, the machining was carried out with two different tool paths with amplitudes (A) of 1 mm (sin(x)) and 2 mm (2sin(x)). During the experiments, the cutting forces in the X, Y and Z directions were measured with a Kistler 9257b dynamometer and analyzed with Dynoware software. After the cutting operations, the machined surfaces were examined with a Zygo Zegage 3D optical profiler and the surface quality was analyzed.

FINDINGS AND DISSCUSSIONS

The changes in cutting forces in X, Y and Z directions over time depending on different tool path strategies are given in Fig. 2. The initial column of the figure presents the cutting forces that are generated along the sample, while the subsequent column offers an enlarged image from a designated area, facilitating a more detailed examination of the alterations in forces.

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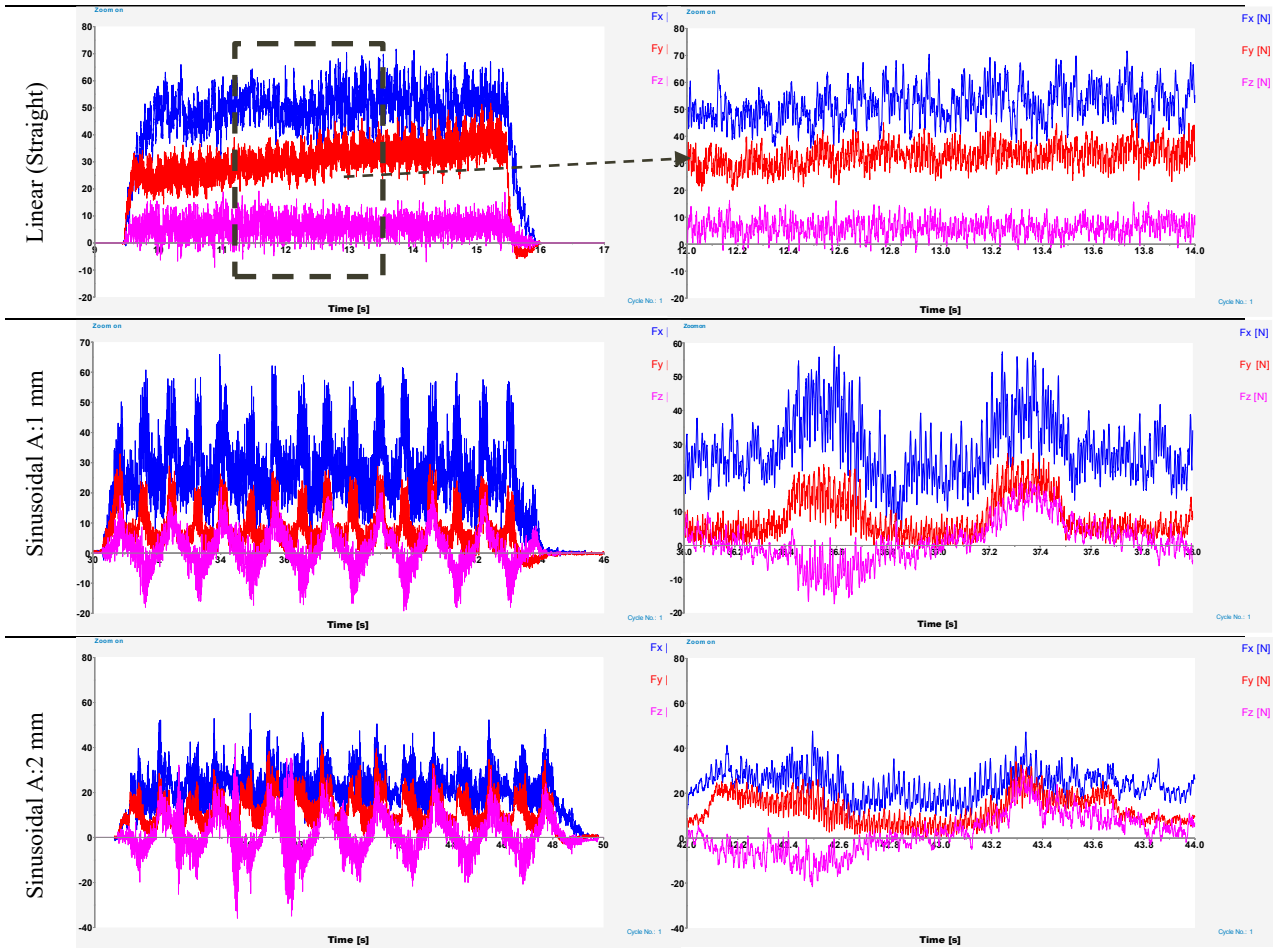

Fig. 2 Cutting forces vs time graph depending on tool path strategy

The cutting force versus time results (Fig. 2) demonstrated a significant difference between straight (linear) milling and sinusoidal milling. While the forces remained stable during straight milling, as anticipated, the force signals exhibited a formation analogous to a sinusoidal curve in sinusoidal milling. On the other hand, the maximum recorded force is observed to be in the feed direction (i.e. in the X direction) in both milling strategies. Upon examination of the amplitude value, it becomes evident that as the amplitude increases, the forces demonstrate a more stable behaviour.

After the time-dependent analysis of the force data, filtering was performed and then the maximum forces recorded during side milling are given in Fig. 3 depending on different tool path strategies. An examination of the maximum forces in the feed direction (Fx) reveals that the highest force occurs in straight milling followed by Sinusoidal milling with 1 mm and 2 mm amplitude respectively (Fig. 3). When the cutting forces (Fy) are examined, the maximum force is again the highest in straight milling followed by Sinusoidal milling with 2 mm and 1 mm amplitude respectively. When the cutting force in the Z direction (Thrust force) is examined, it is seen that the highest force occurred in Sinusoidal milling with 2 mm amplitude and the lowest force occurred in straight milling. The increase in forces can be

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related to the chip load per unit time, i.e. the amount of chip that is removed. It can thus be concluded that the magnitude of the feed force (Fx) is highest during linear milling, whilst the thrust force exhibits its maximum value during sinusoidal milling with 2 mm amplitude.

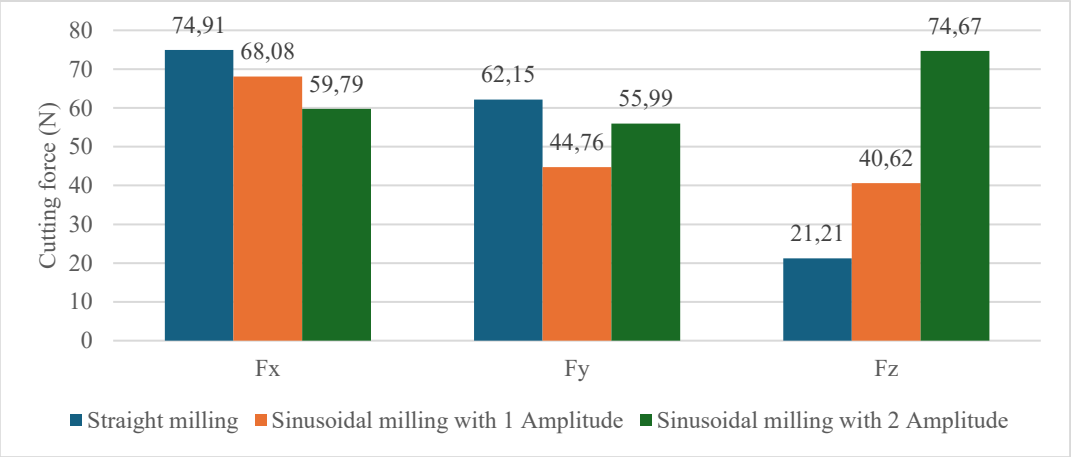

Fig. 3. Maximum cutting forces recorded depending on tool path strategy

The different behaviors of the force components depending on the change in the tool path made the comparison difficult. For this reason, in order to evaluate and compare the maximum forces more easily, the resultant of the cutting forces is calculated with the help of Equation 1 and the results are given in Table 1.

$$F_r = \sqrt{F_x^2 + F_y^2 + F_z^2} \quad (1)$$

Table 1. Resultant cutting forces

Tool path	Fx	Fy	Fz	Fr
Linear (Straight) edge milling	74.91	62.15	21.21	99.619
Sinusoidal edge milling (A:1 mm)	68.08	44.76	40.62	91.040
Sinusoidal edge milling (A:2 mm)	59.79	55.99	74.67	110.839

When evaluated according to the resultant cutting forces (Table 1), it is seen that the lowest force occurred in sinusoidal milling with 1 mm amplitude, and the highest force occurred in sinusoidal milling with 2 mm amplitude. The resultant force is a significant factor in the evaluation of milling machinability. It is thus concluded that sinusoidal milling with 1 mm amplitude is improved machinability.

The variation in surface roughness values according to the tool path is illustrated in Fig. 4. The surfaces were examined in three different regions of the same sample, and the average results are shown in the graph. Selected surface roughness plots are also provided in the figure.

ISBN: 978-625-6997-71-4

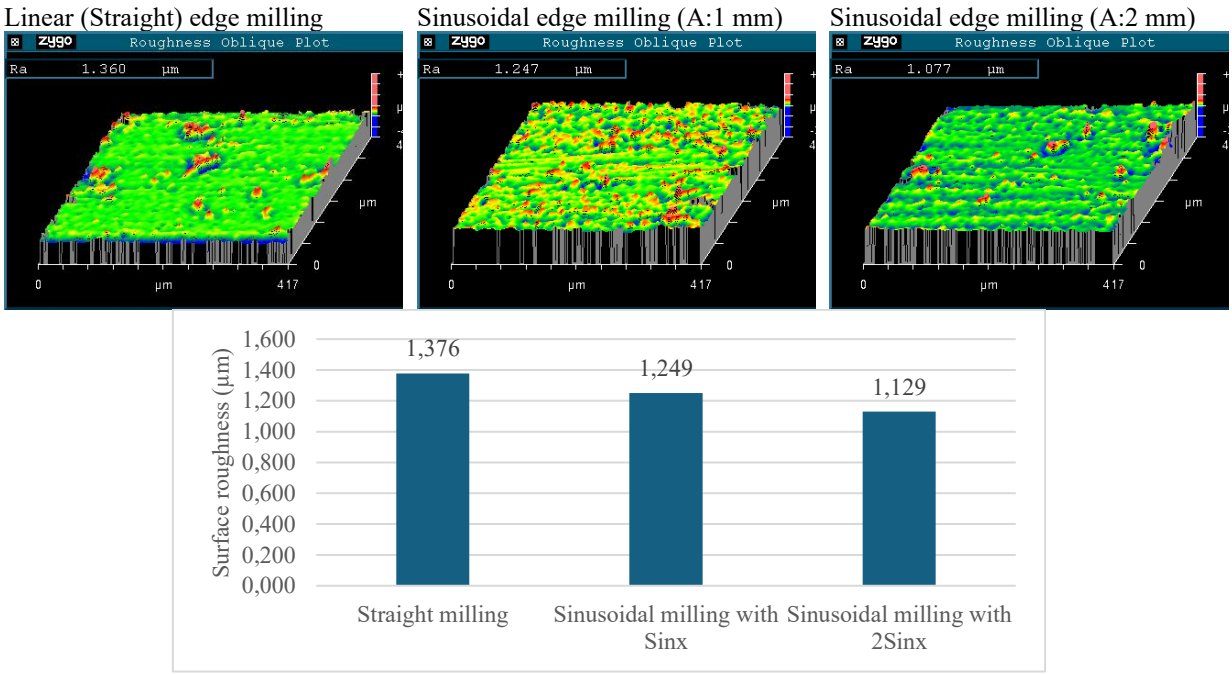

Fig. 4. Surface plots and average roughness (Ra) depending on tool path strategy

An evaluation of the machining strategies in relation to surface quality reveals that sinusoidal milling with an amplitude of 2 mm achieves the best surface quality, while the lowest surface quality is attained through straight edge milling. Particularly, compared to linear milling, the surface roughness decreased by about 9% with 1 mm amplitude sinusoidal machining, while it decreased by about 18% with 2 mm amplitude sinusoidal machining.

CONCLUSION

The edge milling machinability of GFRP with linear and two different amplitude sinusoidal tool path strategies is investigated experimentally and the prominent results are given below:

- Sinusoidal milling improves the machinability of GFRP.
- The resultant cutting force was reduced by approximately 8% by sinusoidal milling.
- As the amplitude of the sinusoidal cutting tool path increases, the resultant force increases even though a better surface is obtained.
- Sinusoidal milling with 1 mm amplitude is recommended for the edge milling of GFRP composite since it gives the best results at the same cutting parameters in terms of both surface roughness and cutting forces.

REFERENCES

[1] M. Altin Karataş & H. Gökkaya. (2018). A review on machinability of carbon fiber reinforced polymer (CFRP) and glass fiber reinforced polymer (GFRP) composite materials. Defence Technology, 14, 4, 318-326.

ISBN: 978-625-6997-71-4

[2] M. Slamani, N. Karabibene, J.-F. Chatelain, & Y. Beauchamp. (2021). Edge trimming of flax fibers and glass fibers reinforced polymers composite – An experimental comparative evaluation. International Journal of Material Forming, 14, 6, 1497-1510.

[3] B. Schrab, A. Collaine, J.-M. Freyburger, & M. Tourlonias. (2025). Machinability analysis of UD-GFRP composites in edge trimming with diamond-coated burr tools at various fiber orientations. CIRP Journal of Manufacturing Science and Technology, 59, 194-206.

[4] A. C. Sayin, S. Danisman, E. Ersoy, C. Yilmaz, & S. Kesriklioglu. (2024). Experimental and statistical damage analysis in milling of S2-glass fiber/epoxy and basalt fiber/epoxy composites. Polymer Composites, 45, 16, 15140-15158.

[5] M. P. Jenarthanan, V. S. S. Gujjalapudi, & V. V. (2017). Multi-objective optimization in end-milling of glass fiber reinforced polymer composites using desirability functional analysis and grey relational analysis. Multidiscipline Modeling in Materials and Structures, 13, 3, 391-408.

[6] Ö. Erkan, B. Işık, A. Çiçek, & F. Kara. (2013). Prediction of Damage Factor in end Milling of Glass Fibre Reinforced Plastic Composites Using Artificial Neural Network. Applied Composite Materials, 20, 4, 517-536.

[7] J. Sheikh-Ahmad, F. Almaskari, & F. Hafeez. (2019). Heat partition in edge trimming of glass fiber reinforced polymer (GFRP) composites. Procedia CIRP, 85, 20-25.

[8] S. Ghalme, A. Mankar, & Y. J. Bhalerao. (2016). Parameter optimization in milling of glass fiber reinforced plastic (GFRP) using DOE-Taguchi method. SpringerPlus, 5, 1, p. 1376.

[9] J. P. Davim, P. Reis, & C. C. António. (2004). A study on milling of glass fiber reinforced plastics manufactured by hand-lay up using statistical analysis (ANOVA). Composite Structures, 64, 3, 493-500.

[10] A. L. Kumar & M. Prakash. (2021). The effect of fiber orientation on mechanical properties and machinability of GFRP composites by end milling using cutting force analysis. Polymers and Polymer Composites, 29, 9_suppl, S178-S187.

[11] R. H. Inácio, R. H. L. da Silva, I. C. Pereira, & A. Hassui. (2023). Suppressing notch wear by changing the tool path in the side milling of a Ti-6Al-4 V alloy. The International Journal of Advanced Manufacturing Technology, 125, 1, 453-463.

[12] S. Morkavuk, U. Köklü, & F. Aktaş, The influence of sinusoidal milling on surface quality of CFRP, in 3rd International Conference on Materials Science and Manufacturing (ICMSM 2024) Karaman, Türkiye, 15-16 November 2024.

ISBN: 978-625-6997-71-4

AĞIR TICARI ARAÇLARIN HAVA SÜSPANSIYON SISTEMLERINDE KULLANILAN GAZALTI VE LAZER KAYNAK YÖNTEMLERININ MEKANIK PERFORMANS AÇISINDAN KARŞILAŞTIRILMASI

COMPARISON OF GAS METAL ARC WELDING AND LASER WELDING METHODS IN TERMS OF MECHANICAL PERFORMANCE FOR AIR SUSPENSION SYSTEM COMPONENTS USED IN HEAVY COMMERCIAL VEHICLES

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ÖZET

Metal birleştirme teknolojileri, başta otomotiv ve makine sanayi olmak üzere pek çok endüstriyel alanda kritik rol oynamaktadır. Kaynak işlemleri, iki metal malzemenin kalıcı şekilde birleştirilmesini sağlarken; seçilen kaynak yöntemine bağlı olarak birleştirmenin mekanik dayanımı, yüzey kalitesi ve üretim süreci üzerinde önemli etkiler yaratmaktadır. Gazaltı (MIG/MAG) ve lazer kaynak yöntemleri, bu alanda yaygın olarak kullanılan iki modern tekniktir. Gazaltı kaynak yöntemi, yüksek nüfuziyet kapasitesi ve saha uygulamalarındaki esnekliğiyle öne çıkarken; lazer kaynak, dar ısı girdisi, düşük deformasyon ve yüksek hassasiyet avantajları sunarak otomasyon sistemlerine daha uygun bir alternatif oluşturmaktadır.Bu çalışma, ağır ticari araçların hava süspansiyon sistemlerinde geleneksel olarak gazaltı kaynağı ile birleştirilen sac metal elemanların, lazer kaynak yöntemiyle alternatif olarak birleştirilebilirliğini araştırmayı amaçlamaktadır. Farklı kalınlıklardaki (2,5 mm – 4 mm) DD13 kalite çelik numuneler üzerinde hem lazer hem de gazaltı kaynak işlemleri uygulanmış; numuneler çekme testine tabi tutularak akma mukavemeti, çekme dayanımı ve kopma uzaması gibi temel mekanik parametreler karşılaştırılmıştır.

Çalışmada elde edilen veriler, literatürde yer alan kaynak yöntemlerine ilişkin mekanik performans analizleri ile birlikte değerlendirilmiş ve karşılaştırmalı olarak analiz edilmiştir. Farklı kaynak yöntemleriyle elde edilen birleşimlerin çekme testi sonuçları detaylı şekilde incelenmiş; akma mukavemeti, çekme dayanımı ve kopma uzaması gibi parametreler üzerinden yöntemler arası performans farkları ortaya konmuştur. Bu kapsamda yürütülen değerlendirmeler, lazer ve gazaltı kaynak yöntemlerinin ağır ticari araçlarda kullanılan hava süspansiyon sistem elemanları açısından üretim verimliliği ve mekanik uygunluk kriterleri doğrultusunda analiz edilmesine olanak sağlamıştır. Çalışma, alternatif kaynak teknolojilerinin uygulanabilirliğini değerlendirmek üzere yöntemsel bir zemin sunmakta; süreç optimizasyonu ve kaynak tekniği seçimi konularında karar vericilere teknik bir referans oluşturmaktadır.

Anahtar Kelimeler: Lazer kaynak, Gazaltı kaynak (MIG/MAG), Çekme testi, Mekanik dayanım

ABSTRACT

Metal joining technologies play a critical role in many industrial sectors, particularly in the automotive and machinery industries. Welding processes ensure the permanent joining of two metal materials and significantly affect the mechanical strength, surface quality, and overall production process, depending on the chosen welding method. Among the widely used modern techniques in this field are Gas Metal Arc Welding (GMAW/MIG/MAG) and laser welding. While gas metal arc welding stands out for its high penetration capability and flexibility in field applications, laser welding offers advantages such as narrow heat-affected zones, low deformation, and high precision, making it a more suitable alternative for automation systems.

This study aims to investigate the feasibility of using laser welding as an alternative to the conventional gas metal arc welding method for joining sheet metal components used in the air suspension systems of heavy commercial vehicles. Welding processes were applied to DD13-grade steel specimens of various thicknesses (2.5 mm to 4 mm), and the specimens were subjected to tensile testing to compare fundamental mechanical parameters such as yield strength, tensile strength, and elongation at break.

The data obtained in the study were evaluated in conjunction with mechanical performance analyses from the literature and analyzed comparatively. The tensile test results of joints produced with different welding methods were examined in detail, and performance differences between methods were revealed based on parameters such as yield strength, tensile strength, and elongation. These evaluations made it possible to analyze the applicability of laser and gas metal arc welding methods in terms of production efficiency and mechanical suitability, specifically for components used in the air suspension systems of heavy-duty vehicles. The study provides a methodological basis for assessing the applicability of alternative welding technologies and serves as a technical reference for decision-makers regarding process optimization and welding technique selection.

Keywords: Laser welding, Gas welding (MIG/MAG), Tensile test, Mechanical strength

ISBN: 978-625-6997-71-4

CUTTING-EDGE TECHNOLOGY: AN APPRAISAL OF THE EFFICACY OF INTERNET SERVICES IN ACADEMIA AND ITS RELEVANCE IN EDUCATIONAL MANAGEMENT

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Abstract
The transformative impact of cutting-edge technology on education is immeasurable. The education sector was among the pioneers that embrace the use of internet services and has continued to explore the opportunities within its sphere. Today, the survival of academia without internet services is hardly imaginable as the various fields of education have found useful applications in online services, library catalogues, digital administrative systems and electronic learning systems. Thus, the internet has been a vital tool that is driving institutions of learning to greater heights in the journey of knowledge-based economy. This paper is a quantitative survey on the application of internet services in the education sector. The paper discussion provides an assessment of the relevance of internet utilization in learning fields. Some of the challenges associated with the use of internet in education were highlighted. In order to collect relevant data for the paper work, online Google form questionnaire instrument was used to gather vital information from respondents and subjected to reliability analysis. In conclusion, the paper affirmed that the internet is a major tool in the era of information and communication technology and it enhances the capability of students' studies and professional career. Finally, recommendations were made.

Keywords: Technology, Internet Services, Academics, Educational Management.

INTRODUCTION

The incorporation of modern day technology into the various sector of human society is increasingly having

ISBN: 978-625-6997-71-4

transformative impact on all aspects of human endeavor including the education industry. Notably, among the pioneers to embrace the use of the internet is the education sector which has since continued to explore the services offered by the internet within its institutions of learning. The internet has essentially served as useful tool in various educational activities ranging from teaching to research. It has also been used in different cognitive applications including online services, library catalogues, digital administrative systems and electronic learning systems. Higher institutions of learning are now investing on internet services because it is found to be helpful as medium of information sharing. Internet services encompass all of the facilities of the internet that assist in communication and collaboration; they include e-mail, Bulletin board, File Transfer Protocol (FTP), Discussion group, Usenet and Google Classrooms. Today, academia can hardly survive without internet services. Internet services are capable of providing researchers and scholars with enabling environment to overcome the barriers of communication and provide institutions of learning with the opportunity of presenting their research findings to others across the world. Internet services enable: lecturers to download free e-journals and e-books, prepare up-to-date lecture notes and send them to their students, use e-mail for collaboration with their colleagues and update their knowledge. Students can also use the internet services for other contemporary applications such as entertainment, eMarking and eDating.

LITERATURE REVIEW

The internet is a worldwide network system that interconnects autonomous set of commercial, business, public, academic and government networks in order to enable global communication and access to information resources. Techopedia, (2020), sees the internet as a worldwide communication system that composes of both hardware (i.e., computer, mobile phone, etc.) and infrastructure (i.e., protocol, mode of connectivity, etc.). Yebowaah (2018), identified the internet as the major information and communication technology that has caused a global change in information quality. There are several services offered by the internet including World Wide Web. According to Ameyaw & Asante (2016), the availability of internet services is critical for the survival of all aspect of the society including education. Yebowaah (2018) explains that the internet helps to gather various types of data that college students and senior high school students use. Accessibility to internet resources and services is therefore crucial for learners (Akande & Bamise, 2017). Munangatire (2021) reveals that that the benefits of using online teaching and learning include flexibility, individualized learning and increased interaction between teachers and students. Blackwell, et al. (2014) outlines the devices that can be utilized as internet-based learning to include mobile phone, tablet, iPod, laptop and other computing gadgets. Among the platforms that can be used for "internet-based" learning include social media (Wolfson, et al., 2014), the web (Khatri, et al., 2016), blog (Noel, L.,2015) & blog videos (Shih, R., 2010)

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Applications of Internet Services in Education

The internet offers various opportunities. Such as:-

1. Information retrieval:
   The key advantage of using the Internet is in the area of increased accessibility to reference materials and data for all categories of its users. The internet allows users with any software and hardware to retrieve the needed information from the network.
2. Individualized learning and teaching:
   The importance of using internet services is in its prevalence of the "person-to-person" communication on using the Net. Internet application in education facilitates the practice of learners interacting directly with experts in the same or different fields.
3. Group learning and teaching:
   Many learners are accessible to online presentations or lectures material that are partially or fully published on the Net using paradigms such as electronic mail discussion lists (Listservs) and electronic bulletin board (BBS) where students have access to "read-only" course notes.
4. Collaborative activities:
   The Net is an environment essentially designed for collaborative work of group of learners or researchers from various remote territories of educational spheres. The Internet technology has given rooms for joint use of educational resources.

Challenges Associated with the Use of Internet in Education

Internet-based learning is very helpful in achieving educational objectives but it is still experiencing many obstacles. These include:

1. Distraction:
   This is a major challenge where students' extreme desire to use the Internet causes renders them to unable to accomplish regular daily tasks. Studies have proven that students are susceptible with difficulties such as anxiety, impulsive control and mood disorders.
2. Spending Too Much Time Online:
   In this situation, students are prone to ignoring their academics but rather spend more time online. Many students devote less time to their studies and instead waste their precious time talking with pals or watch movies over the Internet.
3. Privacy Issues:
   The internet threatens students' data and privacy as hackers sometimes use the internet to break into students' mobile phones or computer in order to steal their personal information and also blackmail them.
4. Cyber bullying:
   This is a common negative consequence of the use of the internet. Some mean students use the internet to oppress or harm other fellow students.
5. Health Concerns:
   The excessive use of the internet sometimes creates a number of health issues including back pain, neck discomfort and eye pain. Also, the rays emitted from smart

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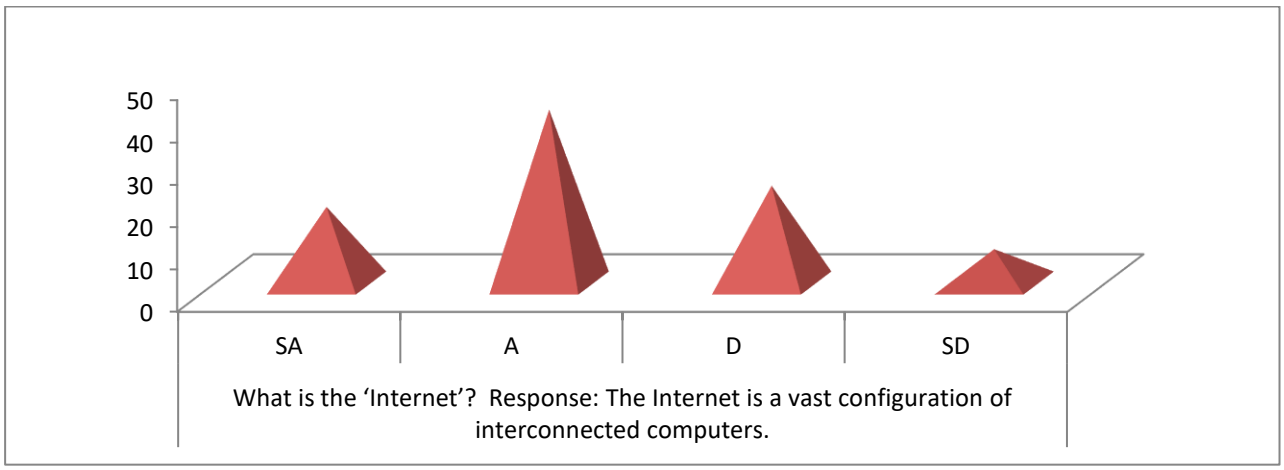
devices are known to cause various eye disorders resulting to eye health disorder such as difficulty focusing and impaired vision.

MATERIALS AND METHODS

This paper adopts a quantitative survey approach on the relevance of internet services in learning fields. The researcher interviewed 100 respondents including students, teaching and non teaching staff from 10 selected schools from 5 different education zone in Lagos State, Nigeria. In order to gather useful data for the paper write-up, carefully drafted copies of questionnaires were administered the respondents using online Google form questionnaire instrument. The responses were gathered and subjected to Cronbach's alpha reliability analysis. The result of 0.86 gave a good reliability index of the instrument. The entire exercise took place within the space of 28 days before completion.

RESULT AND DISCUSSION

Fig.1: Chat Analysis



The graph plotted in figure 1 indicates that most of the respondents are technology inclined. The respondents are fully aware that the internet is a vast configuration of interconnected computers. According to the respondents, the internet consists of computer peripheral components, satellites, telephone lines and numerous assorted device infrastructures. The respondents further noted that the components of the internet encompasses of smaller domestic, business, academic and government networks that convey various data and services including file transfer, online chat, electronic mail, interlinked web pages and other web resources.

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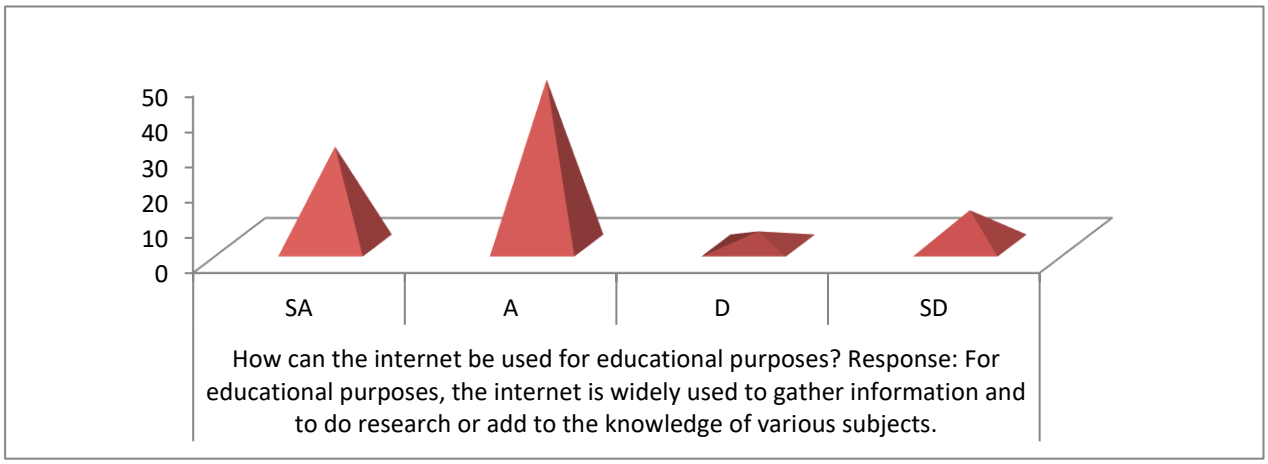
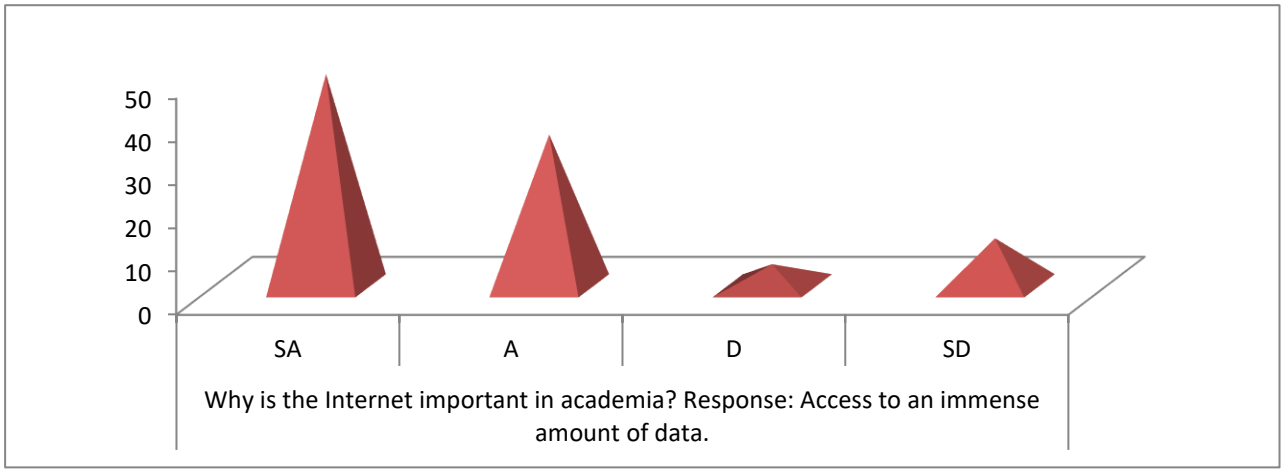
Fig.2: Chat Analysis



The graph plotted in figure 2 reveals that the internet applications cut across a variety of purposes including education. A higher number of the respondents inferred that the internet can essentially serve a number of educational purposes especially in gathering vital data or information and also for carryout research in various fields. Other uses of the internet include collaborative learning, individualized learning, language learning, virtual tours and evaluation purposes.

Fig.3: Chat Analysis



The graph plotted in figure 3 depicts that majority of the respondents actually supports that the internet is inferably important because gives not just tutor but learners the access to an immense amount of data. According to the respondents, there are times when educators or researchers need to acquire journals, books or other publications for academic purposes. The internet provides them with the opportunities to acquire these materials in digital format with

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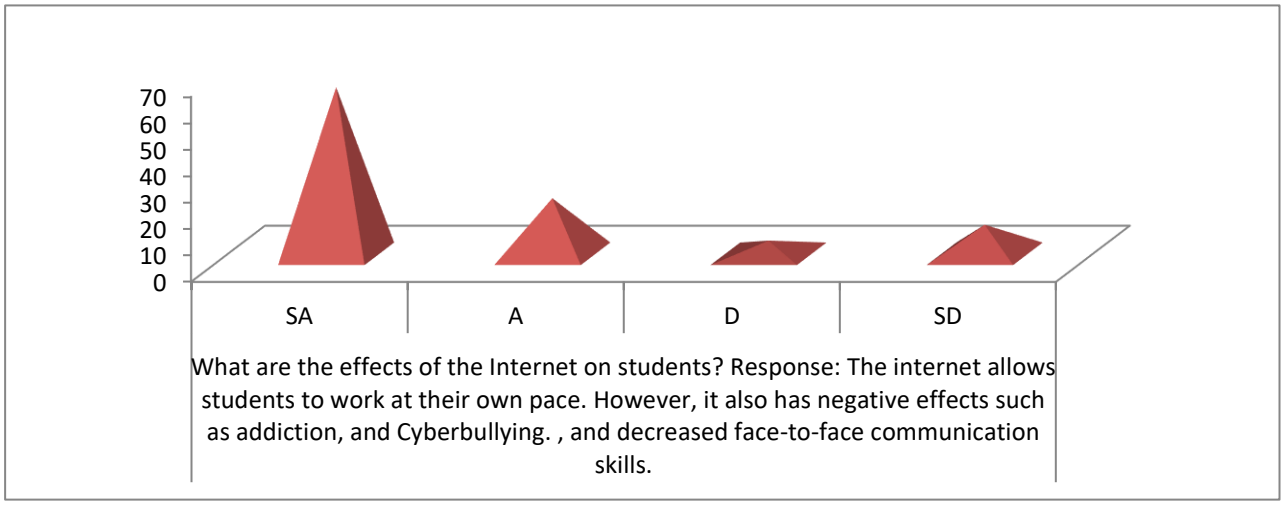
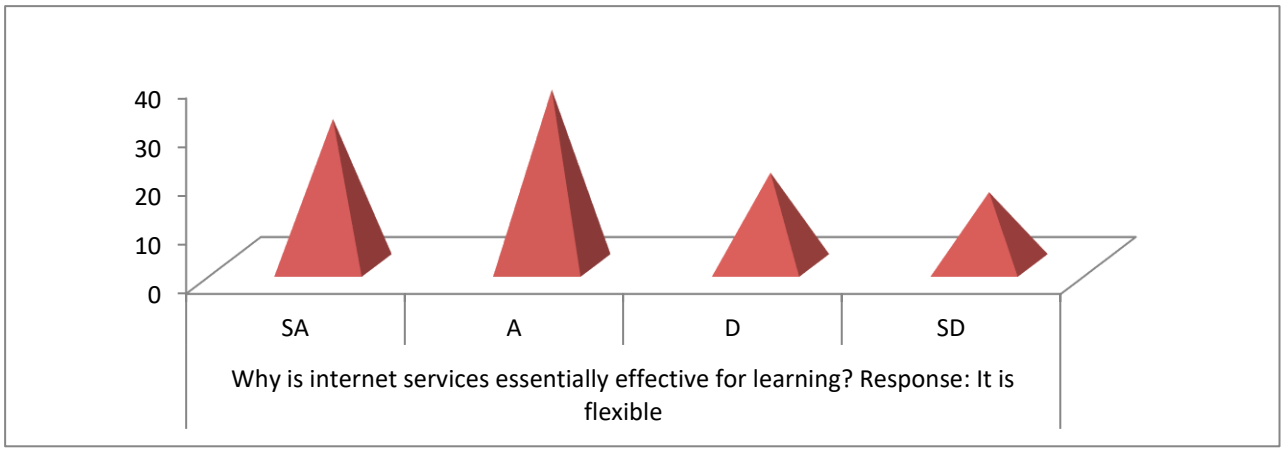
Fig.4: Chat Analysis

just one click



The graph plotted in figure 4 shows that a greater number of respondents agree with the statement that the internet allows students to work at their own pace. The respondents further added that the internet enables asynchronous communication which is most suitable for those who are anxious or may feel uncomfortable in conventional classrooms. In the cases of students who are having difficulty with their schoolwork, they will be able to find useful materials written by academicians and other professionals that may be of help. However, the respondents emphasized that the internet also has its negative effects on students such as online addiction and Cyberbullying.

Fig.5: Chat Analysis



The graph plotted in figure 5 signifies that a bigger amount of respondents asserted that the internet can significantly be effective for learning. The respondents inferred that the internet services are flexible. According to the respondents, using an online platform for educational purposes allow for better academic work. Viz, the internet allows students to take control of their own learning. More so, the internet provides access to a wide range of information thereby enriching learning process.

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CONCLUSION

The discussion on this paper provides a quantitative assessment of the services provided by the internet to the education industry. The paper asserted that the significance of internet services to academia cannot be over emphasized. This is achieved through the regular exposure of internet users to up-dated information in the various fields of learning. This paper evaluated the application of internet services and highlighted some of the challenges confronted using the internet including distraction, spending too much time online, privacy issues, cyber bullying and health concerns. Amidst these challenges, reduction in the cost of using the internet could go a very long way to enable its users have more access to relevant and updated academic materials.

RECOMMENDATION

While this study, highlights the importance of the utilization of internet services in the education sector, the under listed recommendation are necessary for optimizing the use of the internet. Viz:-

1. Government should as a matter of necessity improve the state of power availability and stability in educational institutions.
2. The is need for extensive training at regular interval for students, teaching and non-teaching staff of learning institutions on how to leverage the use of internet services in academia.
3. Educational managers should acquire high speed internet connectivity with maximum bandwidth for academic use.
4. The charges for browsing should be minimized so that users access to the internet can increase.

REFERENCES

Ameyaw, S. & Asante, E. (2016). Internet usage by distance students in private university libraries in GHANA. International Journal of Computer Science and Network, 5(3), 513-522.

Blackwell, C. K., Lauricella, A. R. & Wartella, E. (2014). Factors Influencing Digital Technology Use in Early Childhood Education. Computer Education. Pp. 82-90.

Khatri, R., Henderson, C., Cole, R., Froyd, J. E., Friedrichsen, D. & Stanford, C. (2016). Designing for Sustained Adoption: A Model of Developing Educational Innovations for Successful Propagation. Phys. Rev. Phys. Educ. Res. Vol. 10112. Pp. 1-22.

Noel, L. (2015). Using Blogs to Create a Constructivist Learning Environment. Procedia – Social Behavioural Science. Vol. 174. Pp. 617-621.

Rabiu, H., Muhammed, A. I, Umaru, Y., & Ahmed, H. T. (2016). Impact of Mobile Phone Usage on Academic Performance among Secondary School Students in Taraba State, Nigeria. European Scientific Journal. Vol. 12 (1). Pp. 466.

ISBN: 978-625-6997-71-4

Shih, R. (2010). Blended Learning using Video-Based Blogs : Public Speaking for English as a Second Language students. Australas. J. Educational. Technology. Vol. 26 (6). Pp. 883–897.

Techopedia. (2020). Internet Use and Academic Success in University Students. Media Education Research Journal. Pp. 61-70.

Wolfson, N. E., Cavanagh, T. M. & Kraiger, K. (2014). Older Adults and Technology-Based Instruction : Optimizing Learning Outcomes and Transfer. Academic Management Learning Education. Vol. 13 (1). Pp. 26-44.

Yebowaah, F. A. (2018). Internet Use and Its Effect on Senior High School Students in Wa Municipality of Ghana.

ISBN: 978-625-6997-71-4

DOĞRUSAL REGRESYON VE RANDOM FOREST ALGORİTMALARI İLE İKİNCİ EL OTOMOTİV FİYAT TAHMİNİ

USED CAR PRICE PREDICTION USING LINEAR REGRESSION AND RANDOM FOREST ALGORITHMS

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Özet

Bu çalışmada, ikinci el otomobil piyasasında araç fiyatlarının tahmin edilmesi amacıyla makine öğrenmesi tabanlı iki farklı regresyon modeli geliştirilmiş ve bu modellerin üretim ortamında kullanılmasını sağlayan bir web uygulaması tasarlanmıştır. Araştırma kapsamında, Türkiye'nin önde gelen ikinci el araç satış platformlarından Python programlama dili ve web scraping yöntemi kullanılarak 2000 araç kaydı toplanmıştır. Veri seti; marka, model, üretim yılı, kilometre, motor hacmi, motor gücü, yakıt türü, vites tipi, çekiş sistemi ve kasa tipi gibi teknik özellikleri içermektedir.

Çalışma üç temel aşamada gerçekleştirilmiştir: Model Geliştirme aşamasında doğrusal regresyon ve Random Forest algoritmaları kullanılarak fiyat tahmin modelleri geliştirilmiş olup, performans değerlendirmelerinde Random Forest modeli %62,1 R^2 değeriyle doğrusal regresyonun (%21) önemli ölçüde üzerinde bir başarı göstermiş ve elde edilen RMSE (12.450 TL) ile MAE (9.200 TL) metrikleri modelin pratik kullanım için yeterli doğruluk seviyesinde olduğunu ortaya koymuştur. Sistem Entegrasyonu kısmında ise geliştirilen model Flask tabanlı bir REST API ile üretim ortamına taşınmış, pickle formatında kaydedilerek canlı tahminlere hazır hale getirilmiş ve sistemin sürekli çalışır durumda olması sağlanmıştır. Kullanıcı Arayüzü geliştirme aşamasında modern ve işlevsel bir web uygulaması tasarlanmış olup, bu uygulam kullanıcıların araç özelliklerini kolayca girerek anında fiyat tahmini alabilmelerini sağlayan kullanıcı dostu bir deneyim sunmakta; mobil ve masaüstü cihazlarla tam uyumlu responsive tasarım, marka-model seçiminde akıllı filtreleme mekanizması gibi özellikler ile kullanıcıların daha bilinçli kararlar alabilmelerine yardımcı olacak şekilde optimize edilmiştir.

Çalışmanın en önemli katkısı, akademik araştırma ile endüstriyel uygulamayı birleştiren bütüncül bir yaklaşım sunmasıdır. Geliştirilen sistem, alıcı ve satıcıların piyasa koşullarına uygun fiyat belirlemesine yardımcı olabilecek pratik bir araç niteliğindedir. Gelecek çalışmalarda veri setinin genişletilmesi, derin öğrenme modellerinin denenmesi ve coğrafi bilgilerin modele eklenmesi planlanmaktadır.

Anahtar Kelimeler: Makine öğrenmesi, doğrusal regresyon, random forest, ikinci el araç, fiyat tahmini

Abstract

This study developed two machine learning-based regression models for predicting used car prices and designed a web application to deploy these models in a production environment. The research collected 2,000 vehicle records from Turkey's leading used car sales platforms using Python programming language and web scraping techniques. The dataset includes technical specifications such as brand, model, production year, mileage, engine capacity, engine power, fuel type, transmission type, drivetrain, and body type.

The study was conducted in three main phases: In the Model Development phase, price prediction models were developed using Linear Regression and Random Forest algorithms. Performance evaluations showed that the Random Forest model significantly outperformed Linear Regression with an R^2 score of 62.1% compared to 21%. The RMSE (12,450 TL) and MAE (9,200 TL) metrics demonstrated sufficient accuracy for practical use. In the System Integration phase, the developed model was deployed to production via a Flask-based REST API, saved in pickle format for live predictions, and maintained in continuous operation. The User Interface phase created a modern, functional web application that provides a user-friendly experience for instant price predictions, featuring responsive design for mobile and desktop devices, smart filtering for brand-model selection, and optimization to help users make more informed decisions.

The study's most significant contribution is its holistic approach combining academic research with industrial application. The developed system serves as a practical tool to help buyers and sellers determine market-appropriate prices. Future work plans include expanding the dataset, testing deep learning models, and incorporating geographical information.

Keywords: Machine learning, linear regression, random forest, used cars, price prediction

GEOTEKNİK MÜHENDİSLİĞİNDE GÜVENİLİRLİK VE RİSK YAKLAŞIMININ GELİŞİMİ: LİTERATÜRE DAYALI BİR DEĞERLENDİRME

EVOLUTION OF RELIABILITY AND RISK APPROACHES IN GEOTECHNICAL ENGINEERING: A LITERATURE-BASED ASSESSMENT

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Özet

Geoteknik mühendisliği uygulamalarında tasarım kararları uzun yıllar boyunca geleneksel güvenlik katsayısı yöntemlerine dayandırılmıştır. Ancak sahadaki doğal değişkenlik, zemin parametrelerinin belirsizliği ve sınırlı veriyle yapılan mühendislik kararları bu yaklaşımın yetersizliklerini ortaya koymaktadır. Bu noktada güvenilirlik temelli tasarım, belirsizlikleri yalnızca tanımakla kalmayıp bunları sayısal olarak ifade ederek mühendislik hesaplarına ve karar süreçlerine entegre eden alternatif bir yöntem olarak öne çıkmaktadır.

Bu çalışma geoteknik mühendisliğinde güvenilirlik temelli yaklaşımın ortaya çıkışını, gelişimini ve günümüzdeki uygulama örneklerini inceleyen kapsamlı bir literatür taramasına dayanmaktadır. Michael Duncan'ın güvenlik katsayısına yönelik eleştirileri bu dönüşümün başlangıcını oluştururken, Phoon'un çalışmaları istatistiksel düşüncenin mühendislik kararlarına entegre edilmesine dikkat çekmektedir. Van Staveren ve Lacasse ise risk kavramının yalnızca sayısal analizlerde değil karar destek sistemlerinde ve proje yönetiminde de dikkate alınması gerektiğini vurgulamaktadır. Nadim'in denizaltı heyelanlarıyla ilgili çalışmaları doğal afetlerin mühendislik risk yaklaşımlarına entegrasyonunu gündeme getirmiştir.

Ayrıca offshore projelerde güvenilirlik stratejileri (Duell ve Fleming), küçük veri setleri için örnekleme duyarlılığı (Liu), geçmiş şev kaymalarına yönelik geriye dönük analizler (Tan ve arkadaşları) ve killerde şev stabilitesinin olasılıksal yöntemlerle modellenmesi (Zhu ve çalışma arkadaşları) incelenmiştir.

Sonuç olarak bu literatür taraması geoteknik mühendisliğinde güvenilirlik temelli yaklaşımın yalnızca alternatif bir hesaplama yöntemi değil aynı zamanda gerçek saha koşullarına daha yakın, belirsizlikleri yönetebilen bütüncül bir mühendislik anlayışı sunduğunu ortaya koymaktadır.

Anahtar Kelimeler: Geoteknik mühendisliği, güvenilirlik temelli tasarım, risk değerlendirmesi, belirsizlik, olasılıksal analiz

Abstract

In geotechnical engineering, design decisions have long been guided by traditional safety factor methods. However, the inherent variability of soil conditions, uncertainties in material properties and the frequent need to make judgments based on limited data have increasingly exposed the limitations of this approach. In response, reliability based design has emerged as an alternative framework that not only acknowledges uncertainty but also incorporates it quantitatively into both analysis and decision making processes.

This study presents a comprehensive literature based evaluation of how reliability thinking has developed within the geotechnical engineering field. Duncan's early critiques of safety factors initiated this shift, followed by Phoon's advocacy for integrating statistical reasoning into design. Van Staveren and Lacasse emphasized that risk should be addressed not only through calculations but also within broader decision making systems. Nadim's work on submarine slides highlighted how natural hazards can be assessed through structured geotechnical risk frameworks.

The review also considers practical contributions including Duell and Fleming's reliability strategies in offshore projects, Liu's jackknife based statistical assessment for small datasets, Tan and colleagues' back analyses of slope failures and Zhu's probabilistic modeling of slope stability in normally consolidated clays. Together these studies illustrate how probabilistic tools can be effectively applied to diverse challenges across geotechnical practice.

Ultimately this literature review shows that reliability based design is more than an advanced analysis method. It offers a realistic and adaptable engineering approach that aligns with the complexity and uncertainty that characterize real world geotechnical problems.

Keywords: Geotechnical engineering, reliability based design, risk assessment, uncertainty, probabilistic analysis

INTRODUCTION

In geotechnical engineering applications, the inherently uncertain nature of soil behavior poses significant challenges in assessing structural safety. Due to the spatial variability of soil parameters, limited site investigation data, and measurement uncertainties, engineering analyses are subject to varying levels of risk. This condition directly influences the reliability of computed results, particularly in determining strength and deformation characteristics.

For decades, the primary approach for evaluating structural safety was based on the Factor of Safety (FS). While this method has been widely adopted for its practicality and ease of application in engineering practice, it accounts for uncertainties only indirectly and does not provide a quantitative measure of failure probability. In recent years, however, the view that it is necessary to move beyond the deterministic limits offered by the factor of safety has gained

prominence. Instead, reliability-based design approaches, which explicitly evaluate the probability of structural failure, are increasingly advocated.

In this context, the growing adoption of reliability- and risk-based analyses in geotechnical engineering has driven a transformation not only in computational methodologies but also in design philosophy, decision-making processes, and quality management systems. The ability to quantify uncertainties, evaluate them systematically, and integrate them into the project enhances the robustness, transparency, and defensibility of engineering decisions.

The purpose of this study is to examine the evolution of reliability and risk approaches in geotechnical engineering, review key contributions from the literature, and explore how these concepts have been integrated into design processes. Both theoretical frameworks and practical case studies are analyzed to assess how statistical methods have been incorporated into engineering calculations. Furthermore, the study highlights the link between reliability-based analyses and their implications for quality management, field implementation, and overall system performance.

KEY CONCEPTS

The understanding of geotechnical reliability begins with two fundamental measures: Factor of Safety (FS) and Probability of Failure (Pf).

Factor of Safety (FS)

Traditionally, the safety of a geotechnical structure is expressed as a ratio between its resistance and the applied load :

$$FS = \frac{S}{R}$$

where R is the resistance (or capacity), and S is the load effect. A design is considered safe if $FS \geq FS_{target}$, where FS_{target} is prescribed by codes or engineering practice. A factor of safety of 1 or less indıcates failure. Figure 1 shows two factor of safety curves representing conditions with different variability in loads and resistances. The probability of failure is represented by the shaded area bounded by the FS distribution and the FS = 1 line. For the case with low uncertainty, the probability of failure is low whereas for the case with high uncertainty, eventhough the mean FS is much larger, the probability of failure is significantly higher. This example illustrates that while it is easy to apply a factor of safety method , it does not directly account for the variability of soil parameters or uncertainties in load estimation and does not neccessarily reflect the true probability of failure.

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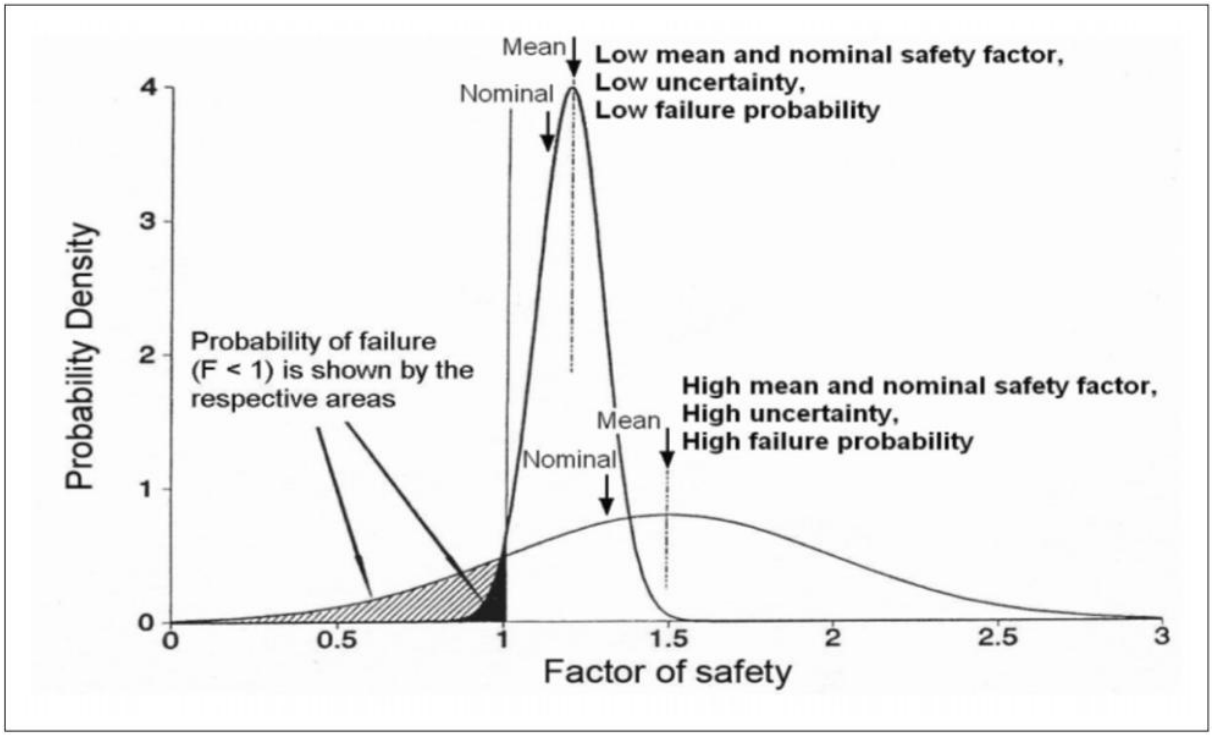
Probability of Failure (Pf)

Reliability-based design expresses safety as the probability that the performance function falls below zero:

$$Pf = P[g(X) \leq 0]$$

where $g(X) = R - S$ is the limit state function, with $g(X) > 0$ indicating safety and $g(X) \leq 0$ indicating failure. Pf provides a more rational measure of safety because it incorporates the statistical distribution of input variables, such as soil strength parameters, geometry, and loads.

The relationship between FS and Pf is nonlinear and influenced by the variability and correlation of geotechnical parameters. A structure with a FS=1.5 may still have a significant Pf, as shown in several reliability studies.



(Figure 1.Conceptual relationship between FS and Pf)

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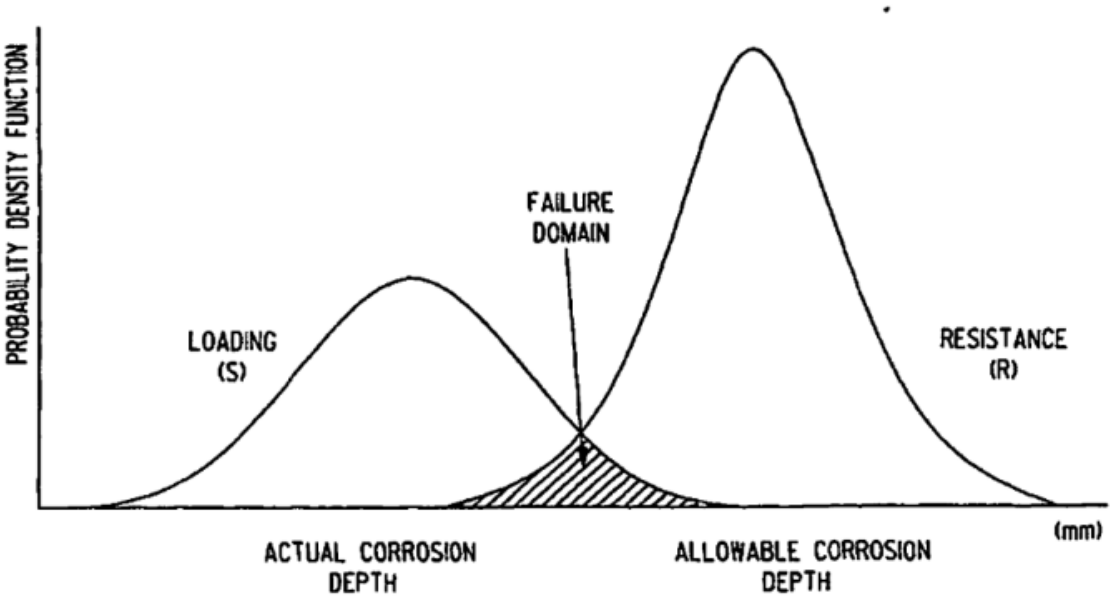

(Figure 2.Probabilistic Limit State Function)

The shaded area represents the failure domain, where the applied loading (S) exceeds the available resistance (R). Reliability-based design quantifies safety by calculating this probability, $P_f = P(R - S \leq 0)$, instead of relying solely on deterministic factors of safety.

RELIABILITY METHODS AND THEIR EVOLUTION

Geotechnical engineering design has traditionally relied on deterministic approaches, primarily using the Factor of Safety (FS) concept. Fundamental concepts for integrating reliability and statistical principles into geotechnical analysis were introduced by Baecher and Christian (2003), providing a foundation for probabilistic design frameworks.

FS is defined as the ratio of the structure's resistance to the applied load, and a design is considered safe if FS exceeds a predefined threshold. While convenient and widely adopted due to its simplicity, this approach neglects the inherent uncertainties in soil properties and loading conditions. Parameters such as cohesion, internal friction angle, and unit weight are often treated as single deterministic values, which can lead to a misleading perception of safety.

This limitation was prominently highlighted by Duncan (2000) in his classic study comparing FS and reliability-based design. In his example of a retaining wall, deterministic analysis yielded an FS of 1.50 generally considered safe in practice. However, when the same problem was analyzed probabilistically, considering statistical variability in soil parameters, the picture changed dramatically.

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Case Example – Retaining Wall Analysis (Duncan)

One of the most illustrative demonstrations of the limitations of deterministic design is presented by Duncan in his analysis of a retaining wall. The problem considers a cantilever retaining wall subjected to lateral earth pressure and evaluates its stability using both the traditional Factor of Safety (FS) and a reliability-based approach.

In the deterministic design, the wall's safety is expressed as:

$$FS = \frac{R}{S} = 1.50$$

Where R represents the resisting moment due to wall weight and base friction, and SSS denotes the driving moment generated by active earth pressure. According to conventional practice, $FS = 1.5$ typically regarded as sufficient.

However, this calculation assumes that soil strength parameters are fixed, whereas in reality, they exhibit variability. Duncan incorporated this uncertainty by treating key parameters as random variables with the following statistical properties:

Parameter	Mean Value	Standard Deviation
Cohesion, c	25 kPa	5 kPa
Friction angle, φ	30°	3°
Unit weight, γ	18 kN/m	1 kN/m³

The limit state function was formulated as:

$$g(x) = R - S$$

Using a Taylor series first-order approximation (First Order Reliability Method – FORM), the performance function was linearized around the mean. The reliability index was computed as

$\beta = \frac{\mu_g}{\sigma_g} \approx 1.64$, which corresponds to a failure probability:

$$Pf = \Phi(-\beta) = \Phi(-1.64) \approx 0.05$$

Thus, despite an FS of 1.50, the probability of failure was approximately 5%, illustrating the inadequacy of FS alone in representing actual safety. This example strongly motivated the adoption of probabilistic approaches in geotechnical design.

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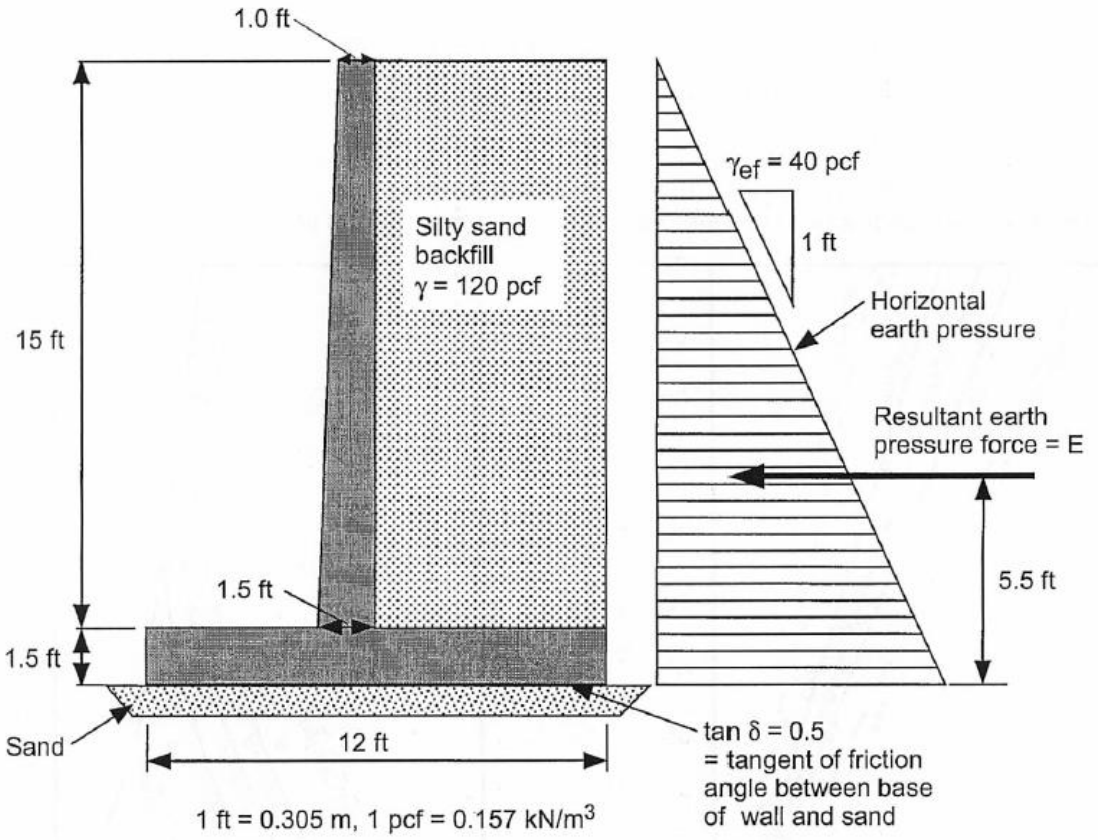

(Figure 3. Cantilever retaining wall with sand backfill, used ind Duncan's reliability example. The wall's stability is evaluated using FOSM – based Taylor series expansion)

First-Order Second-Moment (FOSM)

The FOSM approach estimates the mean and variance of the performance function using a first-order Taylor series expansion around the mean values of the basic variables:

$$\mu_g \approx g(\mu_X), \quad \sigma^2{}_g \approx \sum(\frac{\partial_g}{\partial x_i})^2 \sigma^2{}_{X_i}$$

This method provides an approximate reliability index:

$$\beta = \frac{\mu_g}{\sigma_g}$$

Extended FOSM accounts for correlated variables and higher-order effects, improving accuracy in complex problems.

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FORM (First-Order Reliability Method) and SORM (Second-Order Reliability Method)

FORM transforms correlated variables into an uncorrelated standard normal space and computes β as the shortest distance from the origin to the failure surface. SORM refines the failure surface approximation by including curvature, resulting in more accurate Pf estimates.

Monte Carlo Simulation (MCS)

MCS estimates Pf by random sampling of input variables:

$$Pf \approx \frac{Number\ of\ Failure}{Total\ Simulations}$$

While accurate, MCS requires significant computational effort, particularly for low failure probabilities.

Bayesian Updating in Geotechnical Design

Phoon (2019) emphasized that probabilistic analysis should not be limited to pre-construction estimates but should adapt as new data become available. Bayesian updating integrates prior knowledge with new observations:

$$Posterior \propto Likelihood \times Prior$$

This approach allows design adjustments based on site investigation and construction-stage monitoring, reducing epistemic uncertainties.

Applications in Offshore and Slope Stability Engineering

In offshore environments, Duell & Fleming (2001) implemented reliability-based strategies to minimize operational risks in subsea systems. Their approach incorporated failure mode analysis, critical component identification, and historical data integration for maintenance planning. This framework aimed not only at structural safety but also at performance continuity throughout the system's life cycle.

Similarly, Nadim (2005) addressed submarine landslides and associated tsunami hazards using probabilistic models, advocating for risk-informed design and regional hazard mapping.

Klar and Leung (2009) advanced the application of reliability principles to foundation engineering by proposing an energy-based approach for the nonlinear analysis of pile groups in clays.

In slope stability, Tan et al. (2015) demonstrated that probabilistic methods align more closely with observed landslide frequencies compared to deterministic FS. Zhu et al. (2013) further validated probabilistic modeling for normally consolidated clays, highlighting the limitations of conventional methods in capturing real-world variability.

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Handling Limited Data and Spatial Variability

Data scarcity often challenges reliability analysis. Liu et al. (2020) proposed using the jackknife resampling technique to enhance reliability predictions with small datasets. Fenton & Griffiths (2008) introduced Random Field Theory to account for spatial variability in soil **properties,** significantly improving failure probability estimates over traditional homogeneous assumptions.

Finally, Li & Zhang (2014) combined probabilistic optimization and decision trees to integrate economic and technical risk considerations, paving the way for holistic risk management frameworks.

Key Observations

The literature consistently demonstrates that deterministic methods are insufficient for capturing the complexity of geotechnical systems. Today, Reliability-Based Design (RBD) is not just an analytical option but a regulatory requirement in many standards, including Eurocode 7 and LRFD frameworks. Furthermore, risk-based thinking now extends beyond design, influencing construction monitoring, life-cycle maintenance, and decision-making under uncertainty.

CONCLUSION

The transition from traditional factor of safety–based design to reliability-oriented frameworks marks a significant paradigm shift in geotechnical engineering. The literature reviewed clearly demonstrates that deterministic methods, while simple and historically effective, fail to account for the inherent variability and uncertainty associated with soil properties and loading conditions. Duncan's analysis, revealing a 5% failure probability for a retaining wall with an FS of 1.5, exemplifies the fundamental limitations of conventional approaches.

The introduction of probabilistic methods such as FOSM, FORM, SORM, and Monte Carlo Simulation has enabled a more rigorous and quantifiable treatment of uncertainty. Each method offers a trade-off between computational effort and accuracy: FORM provides a practical solution for many design cases, while MCS, despite its computational cost, remains the benchmark for reliability estimation in complex systems. Bayesian updating, as emphasized by Phoon (2019), represents a pivotal advancement, allowing engineers to integrate new site-specific data during construction phases and thereby reduce epistemic uncertainty dynamically.

The practical applications of these approaches extend well beyond theoretical exercises. Offshore systems, as shown in Duell & Fleming (OTC 12998), rely on reliability-based strategies to ensure life-cycle performance under conditions where intervention costs are

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extremely high. Similarly, probabilistic slope stability analyses by Tan et al. (2015) and Zhu et al. (2013) demonstrate that observed landslide frequencies align more closely with reliability-based predictions than with deterministic FS assessments. These studies highlight the superiority of probabilistic approaches for risk assessment in natural hazard–prone environments.

However, challenges persist. A major limitation remains data availability, particularly for site-specific geotechnical parameters. Innovative solutions, such as Liu's (2020) jackknife resampling technique, offer promising avenues to improve reliability predictions under data scarcity. Furthermore, accounting for spatial variability through techniques such as Random Field Theory (Fenton & Griffiths, 2008) underscores the need for advanced modeling tools and robust statistical frameworks in modern practice.

Looking forward, future developments in reliability-based design are likely to be driven by big data analytics, artificial intelligence, and real-time monitoring systems. These technologies can facilitate continuous updating of reliability assessments and enhance decision-making under uncertainty. Moreover, integrating economic optimization with technical reliability, as explored by Li & Zhang (2014), will become increasingly important as geotechnical projects face tighter budgetary and sustainability constraints.

In conclusion, reliability-based and risk-informed frameworks are no longer optional enhancements to geotechnical design—they are essential components of a resilient and sustainable engineering practice. By systematically incorporating uncertainty into design, analysis, and operational decision-making, these methods ensure not only structural safety but also optimize life-cycle performance, cost-effectiveness, and risk mitigation strategies in increasingly complex and uncertain environments.

REFERENCES

- Baecher, G. B., & Christian, J. T. (2003.). *Reliability and Statistics in Geotechnical Engineering*. https://doi.org/10.5194/hess-21-2301-2017
- Duell, C., & Fleming, R. (2001). Implementing Deepwater Subsea Reliability Strategy. All *Days*, OTC-12998-MS. https://doi.org/10.4043/12998-MS
- Duncan, J. M. (2000). Factors of Safety and Reliability in Geotechnical Engineering. *Journal of Geotechnical and Geoenvironmental Engineering*, *126*(4), 307–316. https://doi.org/10.1061/(ASCE)1090-0241(2000)126:4(307)
- Klar, A., & Leung, Y.-F. (2009). Simple Energy-Based Method for Nonlinear Analysis of Incompressible Pile Groups in Clays. *Journal of Geotechnical and Geoenvironmental Engineering*, *135*(7), 960–965. https://doi.org/10.1061/(asce)gt.1943-5606.0000002
- Lacasse, S., & Nadim, F. (1998). *Risk and Reliability in Geotechnical Engineering*. *Proceedings of the 4th International Conference on Case Histories in Geotechnical*

ISBN: 978-625-6997-71-4

Engineering (Paper SOA-5), St. Louis, MO. https://doi.org/10.1080/17499518.2015.1070784

- Liu, X.-F., Tang, X.-S., Li, D.-Q., & Qi, X.-H. (2020). Jackknifing for modeling sampling properties of soil statistics for geotechnical reliability analysis. *Computers and Geotechnics*, *125*, 103685. https://doi.org/10.1016/j.compgeo.2020.103685
- Nadim, F. (2005). Challenges to geo-scientists in risk assessment for sub- marine slides. *Norwegian Journal of Geology, 85(3), 267–277. https://doi.org/10.1144/njg85-3-267*
- Phoon, K.-K. (2020). The story of statistics in geotechnical engineering. *Georisk: Assessment and Management of Risk for Engineered Systems and Geohazards*, *14*(1), 3–25. https://doi.org/10.1080/17499518.2019.1700423
- van Staveren, M. Th. (2009). Extending to geotechnical risk management. *Georisk: Assessment and Management of Risk for Engineered Systems and Geohazards*, *3*(3), 174–183. https://doi.org/10.1080/17499510902788835
- Tan, X., Li, D., & Zhang, L. (2015). Probabilistic back-analysis of slope stability considering spatial variability of soil properties. *Engineering Geology, 187*, 60–70. https://doi.org/10.1016/j.enggeo.2014.12.004
- Zhu, J., Nadim, F., & Phoon, K.-K. (2013). *Probabilistic modeling of slope stability in normally consolidated clays. Engineering Geology*, 153, 63–71. https://doi.org/10.1016/j.enggeo.2012.10.006
- Li, D., & Zhang, L. (2014). Probabilistic optimization framework for geotechnical risk management. *Computers and Geotechnics*, 61, 1–12. https://doi.org/10.1016/j.compgeo.2014.05.003
- Fenton, G. A., & Griffiths, D. V. (2008). Risk assessment of footings on slopes in spatially variable soils using random finite element modeling. *Journal of Geotechnical and Geoenvironmental Engineering*, 134(2), 250–259. https://doi.org/10.1061/(ASCE)1090-0241(2008)134:2(250)

ISBN: 978-625-6997-71-4

*OTONOM SİSTEMLERDE ENGELDEN KAÇINMA İÇİN A**ALGORİTMASININ PERFORMANS ANALİZİ VE DİJKSTRA ALGORİTMASI İLE KARŞILAŞTIRMALI DEĞERLENDİRME

PERFORMANCE ANALYSIS OF THE A*ALGORITHM FOR OBSTACLE AVOİDANCE IN AUTONOMOUS SYSTEMS AND COMPARATIVE EVALUATION WITH THE DIJKSTRA ALGORITHM

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Özet

Bu çalışma, otonom sistemlerde engelden kaçınma problemlerine yönelik olarak A* algoritmasının uygulanabilirliğini ve performansını sistematik biçimde incelemektedir. Sezgisel tabanlı bu yol planlama algoritmasının, başlangıç noktasından hedefe optimal rota bulmadaki etkinliği teorik ve pratik boyutlarıyla ele alınmıştır. Algoritmanın çalışma prensibi, kullanılan veri yapıları ve Python implementasyonu sunularak, sabit ve dinamik engeller içeren senaryolardaki davranışı değerlendirilmiştir.

Çalışmanın ikinci aşamasında, A* algoritmasının performansını daha iyi anlamak amacıyla klasik Dijkstra algoritması ile karşılaştırmalı analiz yapılmıştır. Rota optimizasyonu, hesaplama süresi ve enerji verimliliği gibi kriterlere dayalı sonuçlar, A* algoritmasının bilinen ortamlarda sağladığı üstünlüğü ortaya koymuştur. Bununla birlikte, dinamik engel senaryolarında kullanılan sezgisel fonksiyonun türünün performans üzerindeki etkisi vurgulanmıştır.

Savunma uygulamaları özelinde gerçekleştirilen kamikaze İHA simülasyonlarında, A* algoritmasının 50 milisaniye altında gerçek zamanlı karar verme yeteneği uygulamalı olarak test edilmiştir. Bulgular, A* algoritmasının özellikle otonom savunma sistemleri ve mobil robotlar için düşük hesaplama maliyetiyle yüksek performans sunduğunu göstermekte; bununla birlikte doğru sezgisel fonksiyon tasarımının sistem güvenilirliği açısından belirleyici rol oynadığı ortaya konulmaktadır.

Anahtar Kelimeler: A* algoritması, Dijkstra algoritması, yol planlama, sezgisel yöntemler, otonom navigasyon, engel kaçınma.

Abstract

This study systematically investigates the applicability and performance of the A* algorithm for obstacle avoidance problems in autonomous systems. The heuristic-based path planning algorithm's effectiveness in finding the optimal route from the start point to the target is examined from both theoretical and practical perspectives. The working principle of the algorithm, data structures used, and Python implementation details are presented, and its behavior in scenarios involving static and dynamic obstacles is evaluated.

In the second phase of the study, a comparative analysis was conducted with the classical Dijkstra algorithm to better understand the performance of the A* algorithm. Results based on route optimization, computation time, and energy efficiency demonstrate the superiority of the A* algorithm in known environments. Additionally, the impact of the type of heuristic function used in dynamic obstacle scenarios on performance is highlighted.

ISBN: 978-625-6997-71-4

In defense applications, kamikaze UAV simulations were conducted, where the A* algorithm's ability to make real-time decisions under 50 milliseconds was experimentally validated. The findings show that the A* algorithm offers high performance with low computational cost, especially for autonomous defense systems and mobile robots; however, the correct design of the heuristic function plays a crucial role in system reliability.

Keywords: A* algorithm, Dijkstra algorithm, path planning, heuristic methods, autonomous navigation, obstacle avoidance.

SUSTAINABLE WATER MANAGEMENT IN ARID REGIONS

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Abstract:
Water scarcity in arid and semi-arid regions poses a significant threat to agricultural productivity, ecosystem stability, and human livelihoods. This paper provides a detailed exploration of sustainable water management strategies suitable for such regions, with a particular focus on Pakistan's southern provinces where desertification and low annual rainfall are prevalent. Drawing upon both primary data collected through field surveys and secondary data from institutional reports, the study evaluates the effectiveness of integrated water resource management (IWRM) techniques, including rainwater harvesting systems, greywater recycling, and the modernization of irrigation infrastructure. Additionally, the research analyzes socio-political factors influencing water governance, such as local water user associations and policy implementation gaps. Technological innovations like GIS-based water mapping, solar-powered water pumps, and smart sensors for moisture detection are also assessed for their practical viability in rural settings. Through comparative case studies and stakeholder interviews, the paper argues that a hybrid model of traditional knowledge and contemporary technology offers the most promising path toward long-term water sustainability. The findings emphasize the need for multi-level governance, capacity building, and community engagement to ensure the equitable distribution and conservation of water resources.

Keywords: Water Scarcity, Arid Regions, Sustainable Development, Integrated Water Resource Management, Irrigation Technology, Community Participation, Pakistan

ISBN: 978-625-6997-71-4

MACHINE LEARNING APPROACHES IN CANCER DETECTION

Prof. Rajiv SHARMA
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Abstract:
Cancer remains one of the leading causes of mortality worldwide, demanding continual advancements in early detection and diagnosis. This paper provides an in-depth analysis of the application of machine learning (ML) techniques in cancer detection, focusing on both theoretical frameworks and real-world implementations. The research reviews key ML algorithms such as Decision Trees, Random Forests, Support Vector Machines, and Deep Learning methods like Convolutional Neural Networks (CNNs) used for analyzing medical imaging data including CT scans, MRIs, and histopathological slides. Emphasis is placed on the training of models with diverse datasets, feature extraction, and performance metrics including sensitivity, specificity, and Area Under Curve (AUC) scores. The study includes clinical case studies that illustrate the successful deployment of AI tools in oncology departments across India. Furthermore, it explores the integration of ML with electronic health records (EHRs) for predictive analytics and personalized treatment planning. Ethical considerations such as data privacy, algorithmic bias, and patient consent are thoroughly addressed. The paper concludes by outlining future directions in AI-driven cancer research, including federated learning and real-time diagnostic platforms.

Keywords: Cancer Detection, Machine Learning, Medical Imaging, Convolutional Neural Networks, Early Diagnosis, AI Ethics, India

ISBN: 978-625-6997-71-4

HALAL FOOD SUPPLY CHAIN AND CONSUMER TRUST

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Abstract:
The integrity and transparency of the halal food supply chain are crucial in maintaining consumer trust, particularly in multicultural and multi-religious societies. This research explores the structure and perception of the halal food supply chain in Malaysia, focusing on how traceability, certification standards, and regulatory oversight influence consumer behavior and confidence. The paper examines the roles of various stakeholders including certification bodies, food producers, logistics providers, and retailers in ensuring compliance with Islamic dietary laws. Case studies of supply chain disruptions and fraud incidents are analyzed to highlight vulnerabilities in the system. Technological interventions such as blockchain, IoT, and QR code-enabled traceability systems are evaluated for their capacity to enhance transparency and accountability. Survey data collected from Malaysian consumers provide insights into trust dynamics, preferences for certified products, and awareness of halal verification mechanisms. The findings underscore the need for integrated digital platforms and stronger regulatory frameworks to fortify the halal ecosystem against reputational and operational risks.

Keywords: Halal Certification, Food Supply Chain, Consumer Trust, Traceability, Malaysia, Blockchain, Regulation

PUBLIC HEALTH CHALLENGES IN POST-PANDEMIC URBAN AREAS

Miguel SANTOS
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Abstract:
The COVID-19 pandemic exposed and amplified existing vulnerabilities in urban public health infrastructures, particularly in developing nations. This paper critically examines the multifaceted public health challenges faced by metropolitan areas in the Philippines in the wake of the pandemic. The study draws on data from urban health departments, hospital networks, and community clinics to assess issues related to healthcare accessibility, mental health crises, under-resourced facilities, and the digital divide in telemedicine adoption. A special focus is given to marginalized communities who faced disproportionate health risks due to overcrowded living conditions and limited access to preventive care. The research also evaluates policy responses such as emergency health funding, vaccination campaigns, and mobile clinic deployment. Using spatial analysis tools, the paper maps health service distribution and identifies urban health deserts. Recommendations are provided for strengthening healthcare resilience through decentralized planning, cross-sector collaboration, and investment in urban health infrastructure and workforce training.

Keywords: Urban Health, COVID-19, Health Infrastructure, Inequality, Telemedicine, Philippines, Public Policy

SMART AGRICULTURE USING IOT IN SOUTHEAST ASIA

Dr. Kittisak LERTCHAI
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Abstract:
Agricultural productivity in Southeast Asia is increasingly challenged by climate variability, limited arable land, and resource inefficiencies. This paper explores the transformative potential of Internet of Things (IoT) technologies in optimizing farming operations across the region. Drawing from pilot programs and field studies in Thailand and neighboring countries, the research investigates the deployment of IoT-based solutions for soil health monitoring, pest control, irrigation automation, and crop yield forecasting. Detailed system architecture and sensor network configurations are provided, along with performance evaluations based on parameters such as water use efficiency, crop output, and labor reduction. The study also addresses challenges related to infrastructure limitations, farmer training, and cost barriers to technology adoption. It advocates for public-private partnerships and government subsidies to accelerate the diffusion of smart farming tools. By integrating traditional agricultural wisdom with modern technological frameworks, smart agriculture emerges as a key strategy for achieving food security and environmental sustainability in Southeast Asia.

Keywords: IoT, Smart Farming, Agriculture Technology, Precision Agriculture, Thailand, Food Security, Sustainable Development

GENDER-BASED ANALYSIS OF EDUCATION POLICIES

Dr. Sara RIZVI
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Abstract:
Despite substantial progress in educational reforms, gender inequality persists in access to quality education, particularly in developing countries. This paper conducts a gender-focused evaluation of educational policies implemented in Pakistan, analyzing their impact on female enrollment, retention, and academic performance. The research employs a mixed-method approach involving statistical analysis of national education data and qualitative interviews with educators, policymakers, and female students. Findings reveal systemic barriers such as socio-cultural norms, school infrastructure deficiencies, and gender-insensitive curricula that hinder female educational advancement. The paper also reviews successful interventions, including conditional cash transfers, community engagement programs, and gender-sensitive teacher training. Policy recommendations emphasize the integration of gender equity goals in national education strategies, increased female representation in decision-making bodies, and targeted resource allocation for girls' education. The study concludes that a multi-dimensional approach is essential to address gender disparities and promote inclusive educational environments.

Keywords: Gender Equity, Educational Policy, Pakistan, Girls' Education, Inclusive Education, Social Barriers, Policy Reform

GREEN HYDROGEN PRODUCTION USING NANOCATALYSTS

Priya DESAI
IIT Bombay, India

Abstract:
As the global energy landscape shifts toward decarbonization, green hydrogen emerges as a promising alternative fuel. This paper investigates the role of nanocatalysts in enhancing the efficiency of electrochemical water splitting for green hydrogen production. The study focuses on the synthesis, characterization, and performance evaluation of advanced nanomaterials including transition metal dichalcogenides, metal-organic frameworks (MOFs), and perovskite oxides. Through laboratory experiments conducted at IIT Bombay, key performance indicators such as overpotential reduction, electrochemical surface area, and catalyst durability are assessed. The research also explores the scalability of these nanocatalysts for industrial applications, examining economic feasibility and environmental impact. Life cycle assessments and techno-economic analyses are presented to compare green hydrogen with conventional fossil-fuel-based hydrogen production. The paper concludes by outlining the strategic importance of public funding, international collaboration, and policy incentives in mainstreaming green hydrogen technologies for sustainable energy futures.

Keywords: Green Hydrogen, Nanocatalysts, Electrolysis, Renewable Energy, Energy Transition, India, MOFs

AI-DRIVEN FORECASTING MODELS IN RENEWABLE ENERGY SYSTEMS

Dr. Ahmad FAISAL
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Abstract:
The increasing global demand for clean and sustainable energy sources has accelerated the development and integration of renewable energy systems. However, the intermittent and unpredictable nature of renewable energy generation, particularly from solar and wind resources, presents significant challenges for grid stability and energy management. This study presents advanced AI-driven forecasting models that leverage machine learning algorithms and deep neural networks to predict renewable energy outputs with high accuracy. By incorporating real-time meteorological data, historical generation patterns, and energy consumption trends, these models enhance the precision of short-term and medium-term energy forecasts. The paper also explores hybrid AI techniques combining physical models with data-driven approaches to overcome limitations in data scarcity and improve adaptability across different geographic regions. The findings demonstrate that AI-enhanced forecasting can significantly improve operational efficiency, reduce reliance on fossil-fuel backup systems, and facilitate smoother integration of renewables into the energy grid, contributing to a more sustainable energy future.

Keywords:
Renewable energy forecasting, artificial intelligence, machine learning, deep learning, grid integration, solar energy, wind energy, energy management, hybrid models.

ISBN: 978-625-6997-71-4

DIGITAL LITERACY AND SOCIOECONOMIC MOBILITY IN RURAL COMMUNITIES

Carla MENDOZA
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Abstract:
Digital literacy has emerged as a critical factor in bridging socioeconomic gaps and enabling upward mobility, particularly in rural and underserved communities. This research investigates the relationship between digital literacy levels and socioeconomic mobility among rural populations in the Philippines. Employing a mixed-methods approach, the study integrates quantitative surveys with qualitative interviews to explore how access to digital tools and skills influences education, employment opportunities, and entrepreneurial activities. The results reveal that higher digital literacy correlates strongly with increased access to information, enhanced job prospects, and the ability to engage in digital marketplaces. Barriers such as limited internet infrastructure, affordability issues, and lack of training are identified as persistent challenges. Policy implications are discussed, emphasizing the need for inclusive digital education programs, public-private partnerships to improve connectivity, and targeted interventions to empower marginalized rural communities. The study underscores the transformative potential of digital literacy in fostering economic development and social inclusion in rural settings.

Keywords:
Digital literacy, socioeconomic mobility, rural communities, digital divide, education, employment, Philippines, social inclusion.

ISBN: 978-625-6997-71-4

NEUROSCIENCE TRENDS IN STROKE REHABILITATION

Dr. Napat CHAIYASIT
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Abstract:
Stroke rehabilitation has seen substantial advancements through the integration of neuroscience insights and innovative therapeutic techniques. This comprehensive review highlights the latest trends in neuroscience that are reshaping stroke rehabilitation paradigms. Emphasis is placed on neuroplasticity, the brain's ability to reorganize and form new neural connections, which underpins recovery processes. The paper discusses emerging interventions such as brain-computer interfaces (BCIs), non-invasive brain stimulation (including transcranial magnetic stimulation and transcranial direct current stimulation), and virtual reality-based therapies. Additionally, it examines the role of biomarkers and neuroimaging in personalizing rehabilitation strategies and monitoring progress. The study evaluates clinical trials and experimental data demonstrating improved motor function, cognitive recovery, and patient engagement through these novel approaches. Challenges related to technology accessibility, patient adherence, and integration into standard care practices are also explored. Overall, this work contributes to understanding how neuroscience-driven methodologies can enhance functional outcomes and quality of life for stroke survivors.

Keywords:
Stroke rehabilitation, neuroscience, neuroplasticity, brain-computer interfaces, non-invasive brain stimulation, virtual reality therapy, biomarkers, neuroimaging.

ISBN: 978-625-6997-71-4

BLOCKCHAIN TECHNOLOGY IN PUBLIC ADMINISTRATION

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Abstract:
Blockchain technology, known primarily for its role in cryptocurrency, is increasingly recognized for its potential to transform public administration by enhancing transparency, security, and efficiency. This study examines the application of blockchain systems within various public sector domains, including identity management, voting, land registry, and supply chain management. The immutable and decentralized nature of blockchain offers solutions to reduce fraud, corruption, and bureaucratic delays that commonly plague governmental processes. Through case studies and pilot projects in multiple countries, the research identifies best practices, implementation challenges, and policy frameworks necessary for effective adoption. Key issues such as data privacy, scalability, interoperability with existing IT infrastructure, and regulatory compliance are discussed. The paper also explores how blockchain can facilitate citizen engagement by providing verifiable and accessible public records. By mapping the strategic integration of blockchain in public administration, the study provides a roadmap for governments seeking to leverage emerging technologies for improved governance and public trust.

Keywords:
Blockchain, public administration, transparency, governance, decentralized systems, digital identity, e-voting, anti-corruption, smart contracts.

ISBN: 978-625-6997-71-4

SOIL EROSION MODELING IN THE GANGES RIVER BASIN

Anil KUMAR
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Abstract:
Soil erosion poses a significant environmental and agricultural threat in the Ganges River Basin, impacting soil fertility, water quality, and ecosystem stability. This research focuses on developing and validating soil erosion models tailored to the complex topography, climatic conditions, and land use patterns of the region. Utilizing Geographic Information Systems (GIS), remote sensing data, and the Revised Universal Soil Loss Equation (RUSLE), the study maps erosion-prone zones and quantifies soil loss across various sub-basins. Model calibration incorporates rainfall intensity, slope gradient, vegetation cover, and conservation practices to enhance predictive accuracy. The findings reveal critical hotspots where intervention is urgently needed and assess the effectiveness of current soil conservation measures. Moreover, the paper discusses the implications of climate change and anthropogenic activities on erosion dynamics. Recommendations are provided for policymakers and land managers to implement sustainable soil management strategies that protect agricultural productivity and preserve watershed health in the Ganges Basin.

Keywords:
Soil erosion, Ganges River Basin, GIS, RUSLE, remote sensing, land use, soil conservation, watershed management.

ROLE OF ISLAMIC FINANCE IN STARTUP ECOSYSTEMS

Dr. Siti Mariam HASSAN
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Abstract:
The rapid growth of startup ecosystems globally has necessitated innovative financial solutions that align with diverse cultural and ethical values. This paper explores the role of Islamic finance principles in fostering the development and sustainability of startups, particularly in Muslim-majority countries. Islamic finance, characterized by prohibitions on interest (riba) and speculative activities (gharar), offers alternative funding mechanisms such as profit-and-loss sharing, sukuk (Islamic bonds), and venture capital based on Shariah-compliant contracts. The study analyzes case studies of startups that have successfully accessed Islamic financial products and examines regulatory frameworks that support these initiatives. Challenges such as limited awareness, standardization issues, and scalability constraints are identified. Furthermore, the paper highlights how Islamic finance can promote ethical entrepreneurship, risk-sharing, and community development. Policy recommendations are provided to enhance collaboration between Islamic financial institutions and startup incubators, ultimately contributing to inclusive economic growth and innovation.

Keywords:
Islamic finance, startups, Shariah compliance, venture capital, ethical entrepreneurship, economic development, Muslim economies.

ISBN: 978-625-6997-71-4

EDUCATION STRATEGIES FOR ENHANCING STEM LEARNING IN HIGH SCHOOLS

Dr. Jasmine TORRES
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Abstract:
Strengthening STEM (Science, Technology, Engineering, and Mathematics) education at the high school level is critical to preparing students for the demands of the 21st-century workforce and fostering national competitiveness. This paper presents an analysis of innovative education strategies designed to enhance STEM learning outcomes among high school students in the Philippines. Drawing on a review of pedagogical models, curriculum reforms, and technology integration, the study evaluates methods such as project-based learning, inquiry-based instruction, collaborative learning, and the use of digital tools including simulations and coding platforms. Teacher professional development and community partnerships are also discussed as key factors in successful implementation. Empirical data from pilot programs demonstrate improvements in student engagement, critical thinking, problem-solving skills, and academic performance. The research further addresses challenges such as resource limitations, teacher preparedness, and socio-economic disparities. Recommendations emphasize the need for holistic policy support and sustained investment to build resilient STEM education systems that can nurture future innovators and scientists.

Keywords:
STEM education, high school, pedagogy, project-based learning, digital learning tools, teacher training, educational policy, Philippines.

ISBN: 978-625-6997-71-4