POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

INVESTIGATION OF WASTEPAPER SLUDGE AS A PARTIAL REPLACEMENT FOR SAND IN CONCRETE

JABATAN KEJURUTERAAN AWAM

MEGAT ALLIY TAYYIB BIN SHAHRUL AFFENDI

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SESI 1:2023/2024

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This report was submitted to the Civil Engineering Department as part of the requirements for the award of the Civil Engineering

Jabatan Kejuruteraan Awam Diploma Kejuruteraan Awam

JABATAN KEJURUTERAAN AWAM

SESI 1:2023/2024

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APPRECIATION

Bismillahirrahmanirrahim,

Alhamdulillah, Grateful to God who is all-loving and all-powerful loving, with His permission gave us the opportunity to complete the Project This Final Year. This project is only possible because of the help and support of many people people. I would like to take this opportunity to thank everyone for their help.

Puan Farihah Binti Mansor, our dedicated supervisor overseeing our studies and research, holds a pivotal role in our academic journey, and we express our deepest gratitude for the invaluable guidance and unwavering support extended to us. His commitment, time, and effort invested in assisting us through the intricacies of this project, particularly during the demanding phases of research and report composition, have been instrumental in our progress and success. We are truly thankful for his enduring patience and encouragement, which have been a source of motivation throughout this endeavor.

Furthermore, we extend our appreciation to the final year project coordinator and all the lecturers involved, whose collective efforts in imparting knowledge, providing clarifications, and delivering insightful lectures on the project have enriched our learning experience and contributed significantly to our project's development. Their dedication and expertise have been instrumental in shaping our understanding and refining our work.

ABSTRAK

Industri pembinaan merupakan salah satu punca kemerosotan alam sekitar. Masalah ini timbul kerana penggunaan sumber semula jadi yang meluas seperti pasir yang merupakan komponen utama dalam penghasilan konkrit. Konkrit adalah bahan binaan yang paling banyak digunakan, dan permintaan pasir untuk menghasilkan konkrit, telah menyebabkan kebimbangan tentang kehabisan sumber asli serta menjejaskan alam sekitar. Di samping itu, penjanaan sisa seperti sisa enap cemar kertas menimbulkan satu lagi cabaran alam sekitar. Penyelidikan ini bertujuan untuk menyiasat kebolehlaksanaan dan faedah menggantikan sebahagian pasir dalam konkrit dengan sisa enap cemar kertas. Objektif kajian ini adalah untuk membandingkan kekuatan mampatan dan kadar penyerapan air bagi konkrit tradisional dan konkrit yang mengandungi sisa enap cemar kertas. Menggunakan nisbah campuran 1:2:4 (simen:pasir:agregat kasar) untuk konkrit gred M15, sisa enap cemar kertas diagihkan dalam jumlah 3%, 6% dan 9% mengikut berat untuk menggantikan pasir dalam konkrit dengan kekuatan sasaran sebanyak 15 N/mm² pada 28 hari. Dalam kajian ini, beberapa ujian telah dilakukan seperti ujian kekuatan mampatan dan ujian serapan air. Keputusan menunjukkan kekuatan mampatan tertinggi bagi konkrit 28 hari ialah 0% dengan 26.7 N/mm² diikuti oleh 6% dengan 18.7 N/mm², 3% dengan 17.4 N/mm² dan 9% dengan 15.1 N/mm². Selain itu, bagi ujian serapan air, kesemua spesimen konkrit menunjukkan kadar serapan air yang rendah iaitu tidak melebihi 3%. Keputusan ini menunjukkan kebolehtelapan air yang minimum untuk semua spesimen konkrit. Kesimpulannya, kajian ini menunjukkan kebolehlaksanaan dan keberkesanan enap cemar kertas buangan dalam menghasilkan konkrit, pada masa yang sama dapat memelihara sumber semula jadi dengan mengurangkan kebergantungan terhadap pasir dalam sektor pembinaan.

Kata kunci: sisa enap cemar kertas, pasir, konkrit

ABSTRACT

The construction industry is one of the causes of environmental degradation. This problem arises due to the extensive use of natural resources, such as sand, which is the main component in the production of concrete. Concrete is the most widely used building material, and the demand for sand to produce concrete has led to concerns about the depletion of natural resources as well as affecting the environment. In addition, waste generation, including wastepaper sludge, poses another environmental challenge. This research aims to investigate the feasibility and benefits of replacing partially sand in concrete with wastepaper sludge. The objective of this study is to compare the compressive strength and water absorption rate of traditional concrete with concrete containing wastepaper sludge. Using a mixture ratio of 1:2:4 (cement: sand: coarse aggregate) for M15 grade concrete, wastepaper sludge was distributed in amounts of 3%, 6% and 9% by weight to replace sand in concrete with a target strength of 15 N/mm² at 28 days. In this study, several tests were performed such as compressive strength test and water absorption test. The results show the highest compressive strength of 28-day concrete is 0% with 26.7 N/mm² followed by 6% with 18.7 N/mm², 3% with 17.4 N/mm² and 9% with 15.1 N/mm². Besides that, for the water absorption test, all the concrete specimens showed low water absorption rate, which did not exceed 3%. These results indicate minimal water permeability for all concrete specimens. In conclusion, this study shows the feasibility and effectiveness of wastepaper sludge in producing concrete, while at the same time being able to preserve natural resources by reducing the dependence on sand in the construction sector.

Keywords: wastepaper sludge, sand , concrete

TABLE OF CONTENT

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The construction industry plays a significant role in the global production of waste and environmental degradation. One aspect of this problem is the extensive use of natural resources, such as sand, which is a primary component of concrete. Concrete is the most widely used construction material, and the demand for sand, a key ingredient in concrete production, has led to concerns about its depletion and environmental consequences. Additionally, the generation of waste, including wastepaper sludge, poses another environmental challenge. Proper disposal of this waste is not only costly but also environmentally unsustainable. To address these issues, researchers and engineers have been exploring alternative materials to replace or supplement traditional ingredients in concrete. This research aims to investigate the feasibility and benefits of replacing sand in concrete with wastepaper sludge. By doing so, it seeks to address both environmental and waste management challenges simultaneously, contributing to sustainable construction practices and resource conservation. The investigation of wastepaper sludge as a substitute for sand in concrete is a promising avenue for sustainable construction practices. By understanding its potential benefits and limitations, we can promote an eco-friendly approach to the building while mitigating the environmental and waste management issues associated with wastepaper sludge. This research can provide valuable insights for the construction industry to work towards a more sustainable and responsible future.

1.2 PROJECT BACKGROUND

In the construction world, we use a lot of sand to make concrete. This is a problem because sand is running out and digging it up harms the environment. At the same time, the paper industry produces a lot of waste called wastepaper sludge, which is difficult and expensive to get rid of. To solve these problems, some smart people are looking into using wastepaper sludge instead of sand in concrete. This project is all about figuring out if this is a good idea and how it can help. The main goals of this project are to save resources, manage waste, and green construction. To make this happen, we'll test how it affects the strength and permeability of concrete. By doing this research, we hope to provide information that can help decision-makers, builders, and others make good choices. We want to make construction more sustainable and find a better way to handle wastepaper sludge.

1.3 PROBLEM STATEMENT

1.3.1 Environmental Concern

Wastepaper sludge is a growing problem worldwide and subsequently, sludge production will continue to increase, and environmental quality standards will become more stringent. Global production in the pulp and paper industries is expected to increase by 77% by the year 2020 with over 66% of paper will be recycled at the same time (Rosazlin Abdullah et. al,2016**).** River-sand mining has risen dramatically in the last few decades to fulfill the need for concrete in the building sector. The sand in a river's bed preserves its environmental equilibrium. Excessive river-sand mining for use as fine aggregate in concrete is responsible for riverbed degradation, which causes a wide range of problems, including the loss of water-holding soil strata and the slippage of riverbanks (Hong Lich Dinh et. al,2022).

1.4 OBJECTIVES

i. To produce traditional concrete and wastepaper sludge concrete
ii. To test the compressive strength and water absorption rate of traditional concrete and wastepaper sludge concrete.
iii. To compare the compressive strength and water absorption rate between traditional concrete and wastepaper sludge concrete.

1.5 SCOPE STUDY

Partial fine aggregate will be replaced by wastepaper sludge using the ratio of 1:2:4 using grade M15 concrete which is suitable for making curb. Next, wastepaper sludge will be collected at UPP Pulp & Paper (M) Sdn Bhd. The concrete will be prepared with wastepaper sludge as a partial replacement for fine aggregate, with ratios of 3%, 6%, and 9%. Three samples will be prepared for each ratio, and the results will be evaluated after 7 days and 28 days of curing. Concrete will be cast using cube size which is 150mm x 150mm x 150mm. Lastly, The tests will include the assessment of compressive strength and water absorption. The objective is to evaluate the ability of wastepaper sludge to maintain the strength, durability, quality, and behavior of concrete under weathering conditions.

1.6 DEFINITION

1.6.1 Definition Of Concrete

Concrete is a combination of cement and aggregates such as sand, water, fine and coarse aggregates. The mixing rate of concrete is very important in the production of quality concrete. Quality concrete can have a positive impact on a construction project. Concrete is a substance with a diverse composition. The aggregate determines the maximum characteristics and workability of concrete. The mechanical properties of concrete are influenced by aggregate properties such as aggregate shape, size, source, crushing type, normal or light or heavy weight aggregate, angularity index, modulus of elasticity, surface texture, specific gravity, bulk density, adsorption and moisture content, cleanliness, soundness of aggregate, bulking of aggregate, thermal properties, and aggregate grading, among others (Varsha Rathore and Aruna Rawat,2019). Concrete is one of the world's oldest and most widely used construction materials, owing to its low cost, wide availability, long durability, and ability to withstand adverse weather conditions. Concrete is a brittle substance with strong compressive but poor tensile strength (Hasan M.Y. Tantawi,2015). The new generational mix design method should be developed based on the performance criteria. The concrete strength obtained from the design concrete mix and optimum cement content should not be considered the only parameter for the stability of the concrete mix. (Shoib Bashir Wani, 2021).

1.6.2 Definition Of Wastepaper Sludge

Wastepaper sludge refers to the residual material generated during the process of recycling paper and cardboard products. It primarily consists of pulp and paper industry residues, which may include various components such as fibers, inks, chemicals, and contaminants. These residues are typically removed during the recycling process as they are not suitable for making new paper products.

The composition of wastepaper sludge can vary depending on the specific recycling process and the source of the recycled paper. In general, it comprises materials that cannot be effectively reused in the production of new paper, and as a result, it is considered a waste product. Wastepaper sludge may require disposal or further treatment to manage its environmental impact.

The recycling process for paper and cardboard involves several steps, including collection, sorting, pulping, and deinking. During these stages, various impurities and unwanted materials are removed from the recycled fibers. The resulting wastepaper sludge is a byproduct of this process and can account for a significant portion of the total waste generated by the paper recycling industry.

Wastepaper sludge can pose environmental challenges due to its composition and potential for contamination. If not properly managed, it can lead to soil and water pollution, as well as air pollution from the decomposition of organic matter. To mitigate these risks, wastepaper sludge may require disposal in landfills or further treatment, such as composting or incineration with energy recovery.

1.7 CONCLUSION

At the conclusion of this comprehensive research study, the concrete undergoes rigorous testing through a compression test, a standard procedure employed to ascertain the structural integrity and strength of the concrete material. This critical evaluation not only serves to validate the quality and durability of the concrete but also provides valuable insights into its performance under varying conditions.

Furthermore, this research endeavor delves into the innovative realm of sustainable practices by exploring novel methods to repurpose the escalating volume of wastepaper sludge. As the accumulation of wastepaper sludge continues to rise in contemporary times, this study aims to uncover sustainable solutions that not only mitigate environmental impact but also contribute to the circular economy by transforming waste into a valuable resource. Through meticulous analysis and experimentation, this research seeks to unlock the potential of wastepaper sludge as a viable alternative in various applications, thereby promoting eco-friendly practices and resource conservation.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The construction sector is about to embark on a revolutionary journey towards resource efficiency and sustainability. The search has intensified for novel building materials that not only meet structural requirements but also lessen the ecological impact, since environmental concerns are now at the forefront of modern building practices. This makes the study on using wastepaper sludge instead of sand in concrete an interesting investigation into environmentally friendly building techniques.

One essential component of concrete, which is a basic building material, is natural sand. However, because of its detrimental effects on the environment, such as habitat destruction and resource depletion, the extraction of sand from rivers and quarries has come under scrutiny. In order to tackle this problem, scientists and engineers have been looking for substitutes that preserve or improve concrete's functionality while lessening its environmental impact. The paper recycling industry's wastepaper sludge is a potential source for this project.

Once thought to be an issue for disposal, wastepaper sludge has developed into a resource that could completely change the way concrete is made. In order to replace conventional sand in concrete mixes and take advantage of wastepaper sludge's structural and sustainable benefits, this study intends to investigate whether doing so is feasible. With every batch of concrete representing a more environmentally conscious decision, it is clear that sustainable construction is more than just a vision for the future as we explore the opportunities and difficulties of this project.

This study sets out on an exploratory expedition to assess the effects of wastepaper sludge on the mechanical and environmental characteristics of concrete. In addition to recognising the necessity of strict quality control to guarantee structural integrity, it attempts to evaluate the possible advantages, such as less waste, cost savings, and an ecological impact. As we begin our investigation, wastepaper sludge's transition from a problem for the environment to a resource for sustainable building serves as a reminder of how quickly the world of building materials is changing. We provide a peek into a more sustainable future for the construction sector in the pages that follow by examining the possible benefits and drawbacks of using wastepaper sludge instead of sand in concrete.

2.1.1 Previous Studies of Concrete with Additional Material

2.1.2 Real Type Projects

I. Use of paper waste industry [Hypo Sludge] in design mix concrete. (Ahmad S. , 2017)

II. Study of concrete involving the use of wastepaper sludge ash as a partial replacement of cement (Sajad, 2013)

III. Study on the use of soya bean as a substitute for sand in concrete (Shahkur, 2013)

IV. Study of the Incorporation of Waste from the Paper Industry in Ceramic Tiles (Azevedo,2019)

V. Study Of Concrete Involving Use Of Waste Glass As Partial Replacement Of Fine Aggregates (Iqbal Malik,2019)

2.2 CONCRETE

Sand and gravel aggregate are usually bound together with cement and water to form concrete, an essential building element. Clay and then lime were employed as binders by prehistoric societies. Since 1824, Portland cement, a blend of clay and limestone, has ruled the market. Both fine and coarse aggregates come in different sizes. Aggregate quality is dependent on cleanliness. Water-to-cement ratio determines concrete strength; more water content results in greater strength. Reinforced and prestressed concrete improvements improve structural capabilities, whereas environmental conditions and curing impact strength. Concrete has been a vital building material worldwide due to its adaptability, fire resistance, and extensive use. (encylcopedia, 2023)

2.3 WASTEPAPER SLUDGE AS AN ADDITIONAL MATERIAL IN CONCRETE

Wastepaper sludge, or WPS, is an industrial byproduct that can contaminate the environment and is created when paper is recycled. Its application requires a comprehensive review due to its impacts on pollutants. The effects of using WPS as a cementitious material are still being assessed, despite the efforts of several researchers worldwide to address the usage of WPS as a sustainable material. Consequently, this study offers a comprehensive summary of WPS's effects as a cementitious material. A general assessment of WPS's physical characteristics, chemical makeup, reactive capabilities, and industrial uses was conducted. According to the assessment of WPS characteristics, the WPS has a high potential as a material in the construction sector, particularly in the manufacture of concrete, brick, mortar, soil stabilizing additives, rigid pavement, and co-wastepaper sludge (WPS) as a substitute for sand in concrete is according to [Katsina Christopher BALA1 et.al, 2013.]

Motivated by its unique qualities and the chemical combinations it possesses, which together take into account material, financial, and environmental factors. Conventional concrete ingredients like natural sand are linked to environmental problems, such as habitat loss from heavy mining. However, as WPS is a result of recycling paper, it is an environmentally beneficial substitute, reusing what would otherwise be garbage. (M F Azrizal1*, 2019)

Important chemical components found in WPS include alumina and silica. It has the ability to react with calcium hydroxide generated during cement hydration thanks to these compounds. As a result of this chemical reaction, more binding compounds are created inside the concrete, improving its strength, resilience, and capacity to withstand different types of degradation. WPS is a potential material for building because of these qualities.

Furthermore, situations where enhancing thermal insulation and lowering concrete density are critical benefit from WPS's lightweight aggregates. The use of WPS in concrete is a wise decision because of its advantages for the environment, improved performance, and affordability. WPS supports sustainable construction methods that are in line with the values of environmental responsibility and the circular economy by addressing the negative effects of sand mining on the environment, protecting natural resources, and providing a workable and environmentally friendly building solution.

Table 1 Constituents of Hypo Sludge according to (Ahmad S., 2017)

SR. #	CONSTITUENT	PERCENTAGE (%)
1	ACID INSOLUBLE	11.1
2	SILICA (Sio2)	9.0
3	MAGNESIUM	3.3
4	CALCIUM SULPHATE	46.2
5	MOISTURE	56.8

Table 2: structural performance of concrete with paper sludge as a partial replacement of fine aggregate in concrete according to (Adajar, 2006)

MATERIAL	FINE AGGREGATE (%)
SILICA	18.91
CALCIUM	1.66
MAGNESIUM	2.055
IRON	0.93
SODIUM	3.68
ALUMINIUM	6.33

2.4 PREVIOUS STUDY

In previous studies, researchers have discovered that wastepaper sludge, a byproduct of the paper manufacturing industry, contains a chemical compound that reacts with cement to produce a process known as "Pozzolanic Activity." This chemical reaction can potentially benefit the structure of concrete and other cement-based materials.

One of the key chemical elements found in wastepaper sludge that works well with cement is its silica (SiO2) concentration. Silica is a common component in sand, which is traditionally used as an aggregate in concrete mixes. By replacing a portion of the sand with wastepaper sludge, it is possible to take advantage of the silica content in the sludge and potentially improve the properties of the cement-based material.

In a previous experiment conducted by the researchers, it was found that the wastepaper sludge used in the study contained approximately 9.0% silica. This silica content is significant, as it suggests that wastepaper sludge could be a viable alternative to sand in certain concrete applications.

The Pozzolanic Activity of wastepaper sludge is a result of the chemical reaction between the silica present in the sludge and the calcium hydroxide (Ca(OH)2) produced during the hydration of cement. This reaction leads to the formation of calcium silicate hydrate (C-S-H), which is the primary binding agent in concrete. By incorporating wastepaper sludge into the cement mix, the Pozzolanic Activity can potentially enhance the strength, durability, and overall performance of the resulting concrete structure.

Furthermore, the use of wastepaper sludge as a partial replacement for sand in concrete mixes can have environmental benefits. Diverting this industrial waste from landfills and incorporating it into construction materials can contribute to the sustainability of the built environment and reduce the demand for natural resources such as sand.

2.4.1 Use of Paper Waste Industry [Hypo Sludge] In Design Mix Concrete

The study by Ahmad S. (2017) delves into the utilization of anaerobic sludge in construction applications, specifically focusing on its economic viability for government-funded emergency shelters post natural disasters. The research findings reveal a correlation between the proportion of hypo sludge used and the compressive strength of the material, indicating a decrease in strength as the hypo sludge content rises, with an optimal level identified at 7.5%. This optimal ratio suggests a balance between cost-effectiveness and structural integrity, making anaerobic sludge a suitable choice for projects prioritizing affordability over sheer strength.

Moreover, the study underscores the environmental advantages of incorporating hypo sludge into concrete mixes, as it not only reduces environmental impact but also minimizes disposal costs. By addressing the challenges associated with anaerobic sludge disposal, the research advocates for innovative engineering solutions to enhance the material's performance, such as the potential integration of silica to bolster strength, particularly in the context of rural road construction. These strategic engineering interventions not only improve the material's properties but also promote sustainable and environmentally conscious construction practices, fostering a blend of creativity and ecological responsibility in the construction industry.

2.4.2 Study Of Concrete Involving The Use Of Wastepaper Sludge Ash As Partial Replacement Of Cement

The study delves into the potential of incorporating wastepaper sludge ash as a partial substitute for cement in concrete, presenting promising findings that highlight the benefits of this innovative approach.

The research reveals a notable enhancement in compressive strength, showcasing a 10% increase after 7 days and a further 15% improvement after 28 days with a mere 5% replacement of cement. This demonstrates the positive influence of wastepaper sludge ash on the structural integrity of the concrete.

Moreover, the strengthened materials exhibit a significant 15% increase in strength at up to 5% replacement, underscoring the efficacy of this substitution. Additionally, as the proportion of ash from waste paper sludge rises, the concrete becomes lighter, attributed to a reduction in water absorption. This dual benefit of increased strength and reduced weight can have advantageous implications for various construction applications.

While there is a decline in splitting tensile strength with higher ash content, it remains above that of reference concrete at the 5% replacement level. However, it is important to note that workability diminishes as the ash content increases, indicating a trade-off between strength and ease of handling during construction.

The utilization of wastepaper sludge ash in concrete offers multifaceted advantages from economic, environmental, and sustainable perspectives. By addressing disposal issues associated with wastepaper sludge and reducing harmful emissions from the cement industry, this approach aligns with the principles of sustainability and resource efficiency.

2.4.3 Study On The Use Of Soya Beans As A Substitute For Sand In Concrete

The study aimed to explore the feasibility of substituting sand in concrete with soybean dregs, a sustainable alternative. However, the cube compression test revealed disappointing results, attributing the low compressive strength to notable water absorption characteristics of soybean dregs. Despite the cost-effectiveness of utilizing soybean dregs due to their abundance as waste material, the research fell short in effectively highlighting the environmental benefits of this substitution. Ultimately, the findings suggest that replacing sand with soybean dregs is not advisable as the resulting concrete fails to meet the required compressive strength standards set by JKR (Shahkur, 2013). This underscores the importance of thorough testing and consideration of all factors when introducing new materials into concrete mixes to ensure structural integrity and compliance with industry standards.

2.4.4 Study of The Incorporation Of Waste From The Paper Industry In Ceramic Tiles

Azevedo's groundbreaking 2019 study delved into the innovative utilization of waste from paper sludge as a sustainable alternative in the production of red wall tiles. The research revealed a significant finding that up to 5 weight percent of conventional limestone material in red wall tile formulations could be effectively replaced by waste paper sludge. This substitution not only showcases a sustainable approach but also contributes to reducing environmental impact.

The manufacturing process involved in this study employed a fast-firing cycle at 1170 °C, showcasing the feasibility of incorporating waste paper sludge into the production of red wall tiles through uniaxial dry pressing. The resulting red wall tiles exhibited promising characteristics, with fragments displaying a flexural strength ranging from 15.77 to 16.17 MPa, water absorption levels between 17.15 to 18.31%, linear shrinkage of 2.88 to 3.22%, and an apparent density of 1.76 to 1.81 g/cm3.

One of the most significant outcomes of this study is the compliance of these red wall tiles with ISO 13006 group-BIII specifications, highlighting their quality and suitability for various applications. By incorporating up to 5 weight percent of waste paper sludge in the manufacturing process, these tiles not only meet industry standards but also contribute to sustainable practices in the construction sector.

The integration of paper sludge waste in the production of red wall tiles represents a commendable step towards minimizing the environmental impact associated with the paper industry. This research not only demonstrates the potential for sustainable material utilization but also underscores the importance of innovation in creating eco-friendly solutions within the construction industry.

2.4.5 Study of Concrete Involving Use Of Waste Glass As Partial Replacement Of Fine Aggregate

In 2013, Mohamaad Iqbal Malik conducted a groundbreaking study that unveiled the remarkable potential of waste glass powder in revolutionizing concrete production. The research findings highlighted that integrating waste glass as a partial substitute for fine aggregates can yield a myriad of benefits, transforming the properties of concrete in significant ways.

The study revealed that waste glass powder can effectively replace up to 30% of fine aggregates by weight in concrete mixes, particularly for particle sizes ranging from 0-1.18mm. This substitution not only offers a sustainable solution for waste management but also enhances the performance of concrete structures.

As the proportion of waste glass in the concrete mix increased, there was a notable decrease in water absorption, reaching its minimum point in mixtures containing 40% waste glass. This reduction in water absorption can contribute to the durability and longevity of concrete structures. Moreover, the introduction of waste glass particles improved the workability of the concrete mix, attributed to the lower water absorption capacity of glass compared to traditional sand.

An intriguing outcome of incorporating waste glass in concrete was the development of a lightweight composition. Concrete specimens containing 40% waste glass exhibited a 5% reduction in dry weight compared to standard mixes, showcasing the potential for creating lighter and more sustainable structures. Furthermore, the study demonstrated a significant enhancement in compressive strength with a 20% replacement of fine aggregates by waste glass. Notably, a remarkable 15% increase in compressive strength was observed at 7 days, escalating to a substantial 25% improvement at 28 days, underscoring the efficacy of waste glass in bolstering the structural integrity of concrete.

In conclusion, the study by Mohamaad Iqbal Malik underscores the viability of substituting fine aggregates with waste glass in concrete mixes, up to a maximum of 30% by weight. This substitution not only contributes to sustainable construction practices but also yields a noteworthy 9.8% enhancement in compressive strength at 28 days, emphasizing the transformative potential of waste glass in advancing the performance and sustainability of concrete structures.

2.5 CHAPTER SUMMARY

The literature review pertaining to the exploration of utilizing wastepaper sludge (WPS) as a substitute for sand in concrete reveals a wealth of significant findings. Researchers have conducted thorough investigations into the benefits associated with incorporating WPS, particularly highlighting its pozzolanic properties that contribute to the enhancement of concrete's strength and durability. This sustainable approach not only reduces the environmental impact of sand mining but also aligns with eco-friendly construction practices, promoting a more sustainable ecosystem. The utilization of recycled materials like WPS, which are generated annually due to the increasing paper consumption, underscores the potential for sustainable construction practices.

The primary objective of this study is to address the existing research gap by analyzing the specific effects of WPS in concrete mixtures, thereby advancing sustainable construction methodologies. This section of the literature review serves to summarize key insights and discoveries while also shedding light on the challenges and inconsistencies present in current research. It identifies areas for further exploration, such as the standardization of testing protocols, conducting long-term performance assessments, and optimizing mixture designs to maximize the benefits of WPS in concrete applications.

By highlighting these research gaps and opportunities for future investigation, this chapter lays the groundwork for forthcoming studies, emphasizing the importance of addressing these gaps to advance knowledge in the field of sustainable construction and promote the widespread adoption of environmentally conscious building practices.

CHAPTER 3

METHODOLOGY

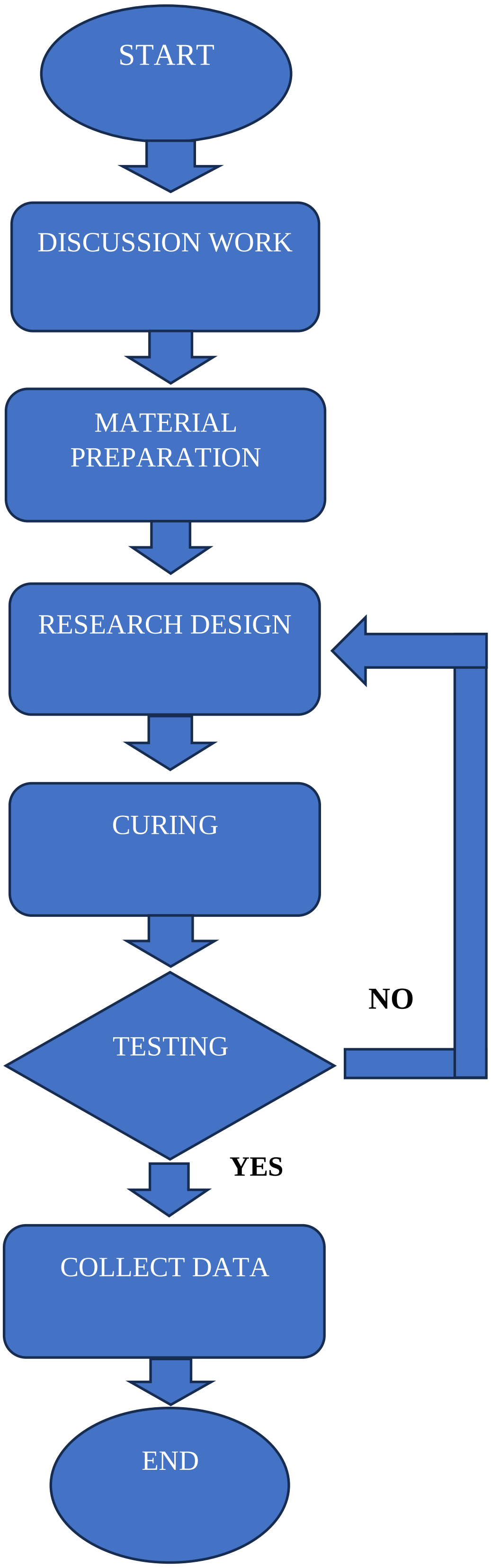
3.1 INTRODUCTION

This chapter will provide a more in-depth look at several key aspects of the research approach and plan used to complete the study. Employing a well-defined research methodology makes the overall research process more intentional and systematic, ensuring the research conducted is methodical in order to effectively meet the study's objectives. The specific strategies and research methodology have been carefully developed to obtain relevant data and information using particular techniques and procedures.

To investigate the compressive strength and water absorption properties of wastepaper sludge concrete, a variety of mix designs will be utilized in this study. These mix designs will incorporate different proportions of the key concrete components - water, coarse aggregate, cement, fine aggregate, and wastepaper sludge. The wastepaper sludge will be used to partially replace the fine aggregate in the concrete mixture at varying replacement levels.

The compressive strength and water absorption tests will be performed on the concrete samples at two key curing ages - 7 days and 28 days after casting. This will provide insight into the early-age and later-age performance of the wastepaper sludge concrete. The results from these tests will be carefully recorded and analyzed to determine the effects of incorporating wastepaper sludge as a partial fine aggregate replacement.

3.2 METHODOLOGY FLOW CHART



3.3 MATERIAL

3.3.1 Waste Paper Sludge

Wastepaper sludge, commonly known as pulp and paper mill sludge, is a residual byproduct resulting from the process of paper production. This waste material is generated in large quantities by paper mills worldwide, posing a significant challenge for disposal and management. Wastepaper sludge typically comprises organic matter, such as cellulose fibers, along with various mineral fillers and additives used in the papermaking process, including talc, kaolin, calcium carbonate, and other mineral loading agents (Friedel, Moises et al., 2011).

Given the increasing emphasis on sustainability and the circular economy, researchers have been exploring innovative ways to repurpose and recycle wastepaper sludge. One promising application is the incorporation of this material into eco-friendly matrices employed in the production of concrete. By utilizing wastepaper sludge as a partial replacement for traditional concrete ingredients, such as cement or aggregates, the environmental impact of concrete production can be reduced while potentially enhancing certain properties of the resulting concrete mixture.

To investigate the feasibility and potential benefits of incorporating wastepaper sludge into concrete, a specimen of this material has been acquired for the purpose of this inquiry from UPP Pulp & Paper (M) Sdn.Bhd., a leading paper manufacturer in Malaysia. The study aims to assess the impact of wastepaper sludge on the water absorption and compression strength characteristics of concrete.

To facilitate the execution of these examinations, wastepaper sludge will be incorporated into concrete at varying proportions, specifically 3%, 6%, and 9% by weight of the total concrete mixture. By testing concrete samples with different percentages of wastepaper sludge replacement, the researchers can determine the optimal dosage that balances improved performance with cost-effectiveness and environmental benefits.

Figure 3.3.1: Collecting wastepaper sludge at UPP Pulp & Paper (M) Sdn.Bhd

Figure 3.3.1: waste paper sludg

e

3.3.2 Coarse Aggregate

Coarse aggregate plays a critical and indispensable role in the construction of concrete structures, serving as a fundamental component that significantly influences the strength, durability, and overall performance of the final product. Comprising geological materials such as gravel, sand, and crushed rock, coarse aggregate forms a substantial portion of the concrete mix, contributing to its mechanical properties and structural integrity.

The meticulous selection of high-quality coarse aggregate is paramount in ensuring that the resulting concrete meets the stringent standards of strength and durability required for various construction applications. An optimal construction aggregate should exhibit specific characteristics such as a rough surface texture, cleanliness, inherent strength, and freedom from any undesirable coatings or extraneous particulate matter, all of which are essential for achieving a robust and long-lasting concrete structure.

In the context of this investigation, a coarse aggregate size of 20mm has been chosen in alignment with the prescribed dimensions for concrete production, reflecting a deliberate and informed decision based on established industry practices and standards. Coarse aggregates, by definition, are particles that are retained by a sieve with a 4.75mm aperture, underscoring the importance of size uniformity and consistency in the aggregate mix.

Through the meticulous process of sieve analysis, the coarse aggregate will be systematically evaluated and characterized to ascertain its specific properties and suitability for integration into the concrete mixture. This analytical approach enables engineers and construction professionals to make informed decisions regarding the optimal combination of coarse aggregate with other components of the concrete mix, thereby ensuring the desired performance, durability, and structural integrity of the final construction product.

Figure 3.3.2 : coarse aggregate

3.3.3 Fine Aggregate

Fine aggregates, as defined by Pitroda et al. (2013), are the natural sand particles extracted through mining processes. These particles typically fall within the size range of 4.75mm to 150 microns, making them crucial components in construction materials. On the other hand, aggregates encompass a broader category that includes naturally occurring stones, whether crushed or uncrushed, along with gravel, sand, or a blend of these materials. To meet quality standards, these components must exhibit specific attributes such as hardness, strength, density, and durability, while being devoid of undesirable features like veins, coatings, disintegration, alkali content, organic matter, or other harmful substances. It is generally recommended to minimize the presence of flaky and elongated particles for optimal performance.

In the context of our study, a novel approach involves substituting a portion of the fine aggregate with wastepaper sludge. This innovative strategy not only aims to explore sustainable alternatives but also seeks to evaluate the impact of incorporating such unconventional materials on the properties and performance of the final product. By introducing wastepaper sludge into the mix, we anticipate potential benefits such as resource conservation, waste reduction, and possibly enhanced characteristics in the resulting construction material. This experimental shift underscores the ongoing efforts within the industry to embrace eco-friendly practices and explore new avenues for sustainable development.

Figure 3.3.3 : fine aggregate

3.3.4 ORDINARY PORTLAND CEMENT (OPC)

Cement, a versatile material renowned for its solid and adhesive properties, plays a crucial role in construction by enabling the seamless integration of various building materials and ensuring the formation of durable connections. Within the construction industry, Ordinary Portland Cement stands out as one of the most commonly used types of Portland Cement due to its widespread applicability and reliability.

In the context of this particular study, the anticipated usage of cement is specified as one bag, highlighting the precision and attention to detail in the project's planning and execution. Pitroda's in-depth analysis further underscores the importance of adhering to industry standards, with the physical characteristics of the cement meeting the stringent requirements outlined in IS:8112-1989.

Examining the setting times of the cement, Pitroda's findings reveal a minimum initial setting time of 30 units, indicating the time taken for the cement to begin solidifying after mixing, and an ultimate setting time reaching a maximum value of 600 units, signifying the duration for the cement to achieve its full strength and hardness. These parameters not only demonstrate the quality and performance of the cement but also ensure the structural integrity and longevity of the construction project.

In conclusion, the meticulous evaluation of cement properties and adherence to established standards are essential for achieving optimal results in construction projects, emphasizing the significance of selecting the right type of cement and monitoring its setting characteristics to guarantee the success and durability of the built structure.

Figure 3.3.4: Ordinary Portland Cement (OPC)

3.3.5 Water

Water is an indispensable substance for all known life forms on Earth, although its presence and significance may vary on other celestial bodies. The Earth's surface is substantially covered by water, accounting for approximately 71% of its total area. This vast expanse of water, including oceans, seas, lakes, and rivers, plays a crucial role in regulating the planet's climate, supporting diverse ecosystems, and sustaining life.

Water, a seemingly simple compound composed of hydrogen and oxygen atoms, is anything but ordinary. It lacks both color and taste, yet it possesses unique properties that make it essential for life. One of the most remarkable characteristics of water is its ability to act as a solvent, capable of dissolving a multitude of chemical compounds, such as salt, sugar, acid, various gases, and diverse organic molecules. This property allows water to transport essential nutrients and minerals throughout living organisms, facilitating the exchange of substances necessary for survival.

In the field of construction, water assumes a crucial function in the amalgamation of concrete, facilitating the reaction between cement and active components. This process enables the binding of cement and sand in accordance with the desired form, resulting in a sturdy and durable material used in various building projects. Without water, the concrete would remain a dry and unusable mixture, incapable of achieving its intended strength and structure.

As the global population continues to grow and the demand for water increases, it is crucial to prioritize water conservation efforts. Individuals, communities, and governments must work together to implement sustainable water management practices, such as promoting water-efficient technologies, encouraging water recycling and reuse, and raising awareness about the importance of water conservation. By taking proactive steps to conserve water, we can ensure that this precious resource remains available for present and future generations.

3.4 RESEARCH DESIGN

The primary objective of the current research endeavor is to meticulously craft a novel concrete formulation by infusing wastepaper sludge, meticulously adhering to the standardized specifications of grade M15 concrete, which is characterized by dimensions measuring 150mm x 150mm x 150mm. The comprehensive experimental investigation will entail the meticulous execution of compression and water absorption assessments on cubical concrete specimens.

The core focus of this study will revolve around the development of three distinct concrete specimens, each strategically incorporating wastepaper sludge as a partial replacement for fine aggregate, with varying concentrations of 3%, 6%, and 9% respectively. These concrete cubes will be meticulously positioned within a precisely engineered mold featuring dimensions of 150 mm x 150 mm x 150 mm to ensure uniformity and consistency in testing conditions.

Furthermore, a water-cement ratio of 0.55 will be meticulously employed to maintain the desired consistency and strength of the concrete mix. The mixture ratio for grade M15 concrete will be meticulously upheld at 1:2:4 to ensure optimal performance and structural integrity of the concrete specimens under scrutiny. This meticulous approach aims to not only enhance the sustainability of concrete production but also explore the potential benefits of incorporating wastepaper sludge in concrete formulations, paving the way for eco-friendly and innovative construction practices.

Figure 3.4: cube concrete mould

Table 3.3: specification of the mix value of concrete with the addition of waste paper sludge.

MATERIAL	0%	3%	6%	9%
CEMENT	6.87 kg	6.87 kg	6.87 kg	6.87 kg
WASTEPAPER SLUDGE	0 kg	0.33 kg	0.64 kg	0.97 kg
FINE AGGREGATE	15.65kg	15.18kg	14.71kg	14.24kg
COARSE AGGREGATE	26.53kg	26.53kg	26.53kg	26.53kg

Water cement ratio:0.55

3.5 CURING

The implementation of appropriate curing circumstances assumes a crucial function in the augmentation of the durability of concrete. It is essential to commence the curing procedure promptly subsequent to the attainment of satisfactory solidification of the sample at ambient temperature for a period of 24 hours. This initial curing stage is crucial as it allows the concrete to develop its early strength and resistance to external factors.

In this specific examination, the concrete specimens were subjected to curing within a reservoir of water for durations of 7 and 28 days, respectively, until the designated testing intervals were attained. The choice of water curing is a widely accepted method as it ensures that the concrete remains saturated throughout the curing process, preventing premature drying and promoting optimal hydration of the cement paste.

The duration of curing is another critical factor that influences the long-term performance of concrete. In this study, the specimens were cured for 7 days and 28 days, respectively. The 7-day curing period is often considered the minimum requirement for achieving adequate early strength, while the 28-day curing duration is commonly used as a benchmark for assessing the ultimate strength and durability of concrete.

The extended curing period of 28 days allows for a more complete hydration of the cement paste, resulting in a denser and less permeable concrete matrix. This, in turn, enhances the concrete's resistance to various forms of deterioration, such as chemical attack, freeze-thaw cycles, and abrasion. By subjecting the specimens to prolonged water curing, the researchers aimed to simulate real-world conditions where concrete structures are exposed to continuous moisture for extended periods.

It is important to note that the curing conditions and durations employed in this study are in line with established standards and best practices in the field of concrete technology. The results obtained from this examination will contribute to a better understanding of the relationship between curing and the long-term performance of concrete, ultimately leading to the development of more durable and resilient concrete structures.

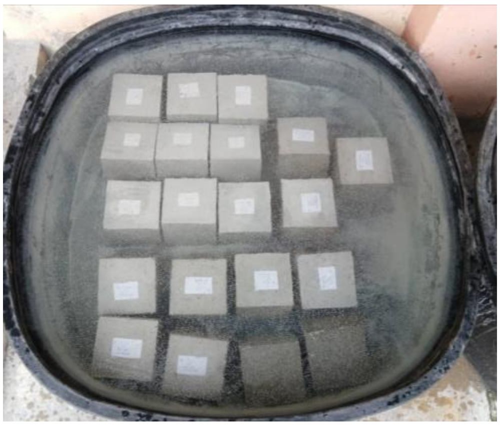


Figure 3.5: Concrete cubes immersed in a water tank

3.6 TESTING METHOD

3.6.1 Water Absorbtion Test

A comprehensive water absorption analysis is a crucial component of this investigation, aimed at evaluating the water absorption capacity of concrete specimens in compliance with the standards outlined in BS 1881-122. The detailed methodology for conducting the water absorption analysis is outlined below:

Sample Labeling: Each concrete sample is meticulously labeled with a unique sampling number and the corresponding proportion of wastepaper sludge to ensure accurate identification and tracking throughout the analysis process.

Initial Weighing: The dry concrete samples are carefully weighed using a precise electronic weighing device to establish a baseline weight measurement for each specimen.

Recording Weights: It is imperative to meticulously record the weight of each sample to maintain a comprehensive dataset for subsequent analysis and comparison.

Immersion in Water: Subsequently, a container filled with water to a specific level, typically 150 mm above the surface, is prepared. The concrete samples are then submerged in water, and the exact time of immersion is meticulously recorded to track the duration of exposure.

Post-Immersion Procedure: After a designated period, usually 24 hours, the concrete specimens are carefully removed from the water, cleaned using a cloth to eliminate any external contaminants, and allowed to air-dry for a brief period.

Final Weighing and Calculation: Following the drying phase, the concrete samples are weighed once again to determine the post-absorption weight. These measurements are crucial for calculating the average weight gain and employing Equation 3.1 to precisely determine the percentage of water absorption by the concrete specimens.

By adhering to this meticulous methodology, the water absorption analysis will yield valuable insights into the performance and durability of the concrete samples under investigation, facilitating informed decision-making and enhancing the overall quality of the research outcomes.

$$absorbtiate = \frac{100\ (mw - md)}{md}$$

Where,

mw: mass wet concrete, g

md: mass dry concrete,

3.6.2 Compressive Strength Test

The compressive strength test will be performed by the research team using the EN 12390-3:2012 compaction testing apparatus. This standard specifies the method for determining the compressive strength of hardened concrete specimens, such as cubes or cylinders. The test is conducted by applying a compressive load to the specimen at a constant rate until failure occurs.

Three cubic specimens, each measuring 150 x 150 x 150 mm, will be tested for each batch of concrete mixture. The specimens were prepared in accordance with EN 12390-2:2019, which outlines the procedures for making and curing concrete test specimens in the laboratory. Before testing, the specimens were dried in an oven at a temperature of 105°C (221°F) for twenty-four hours to remove any excess moisture.

The compressive strength test was conducted using the EN 12390-3:2012 compaction testing apparatus. The specimen was placed between the platens of the testing machine, ensuring that the load was applied to the opposite faces of the cube that were cast perpendicular to the direction of compaction. The test was then started at the specified loading rate, which is typically between 0.2 and 1.0 MPa/s (0.029 and 0.145 ksi/s) for cubes with a side length of 150 mm.

The loading was continued until the test specimen failed, and surface fractures appeared. The maximum force applied to the specimen during the test was recorded and used to calculate the compressive strength.

The average compressive strength of the three specimens was then determined for each batch of concrete mixture. This value represents the average compressive strength of the concrete produced using that particular combination of materials and mix proportions.

The results of the compressive strength test provide valuable information about the quality and performance of the concrete mixture. This data can be used to optimize the mix design, ensure compliance with project specifications, and make informed decisions about the suitability of the concrete for its intended application.

$$fc = \frac{P}{A}$$

Where

fc= compressive strength, MPa

P= maximum load sustained by the specimen, N

A=cross sectional area of the specimen to which load applied, mm2

Figure 3.6.2: Compressive strength testing machine

3.7 CONCLUSION

In this study, the compressive strength and water absorption of concrete containing varying percentages of wastepaper sludge will be investigated. The test will be conducted using concrete grade M15 with a mix ratio of 1:2:4 (cement:fine aggregate:coarse aggregate). The following percentages of wastepaper sludge will be added to the concrete mix: 0%, 3%, 6%, and 9%.

For Compressive Strength Test, is to assess the compressive strength of the concrete, a compressive strength test will be conducted on days 7 and 28 after casting the concrete specimens. This test will be performed in accordance with relevant standards and guidelines to ensure the reliability of the results.

For Water Absorption Test, on day 28, after the compressive strength test, a water absorption test will be carried out on the concrete specimens. This test will provide insights into the ability of the concrete to resist water penetration, which is an important factor in determining the durability of the concrete.

The study aims to investigate the effects of incorporating wastepaper sludge on the compressive strength and water absorption properties of concrete. It is hypothesized that the addition of wastepaper sludge will influence the compressive strength and water absorption of the concrete, with the extent of the influence depending on the percentage of sludge added.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

This chapter delves into the detailed analysis of data and findings obtained from compression and water absorption experiments carried out on concrete samples that had undergone curing for both 7 and 28 days. The primary focus lies on investigating the impact of incorporating wastepaper sludge into concrete mixes at a specific ratio of 1:2:4, where 3%, 6%, and 9% of fine aggregate are replaced accordingly. The research methodology employed in this study involves the utilization of a combination of a comprehensive table and a visually informative graph to present the results effectively.

The overarching objectives of this study revolve around two key aspects: firstly, to assess the water absorption characteristics of the concrete specimens following a 28-day curing period, and secondly, to evaluate the compressive strength of the concrete when wastepaper sludge is introduced as a partial substitute for fine aggregate. Notably, a total of 36 concrete cubes, each measuring 150 mm x 150 mm x 150 mm, were meticulously fabricated within the state-of-the-art facilities of the Polytechnic Premier Sultan Salahuddin Abdul Aziz Shah Concrete Laboratory to facilitate the subsequent testing procedures.

4.2 COMPRESSIVE STRENGTH TEST RESULTS AFTER 7 DAYS

Table 4.2.1: Compression test for 7 days of curing

Wastepaper Sludge (%)	**Reading (N/mm2)**			**Average (N/mm2)**
	1	2	3	
0	22.2	22.1	23.0	22.4
3	14.7	14.3	14.9	14.6
6	13.4	13.0	14.9	13.8
9	10.2	10.7	10.9	10.6

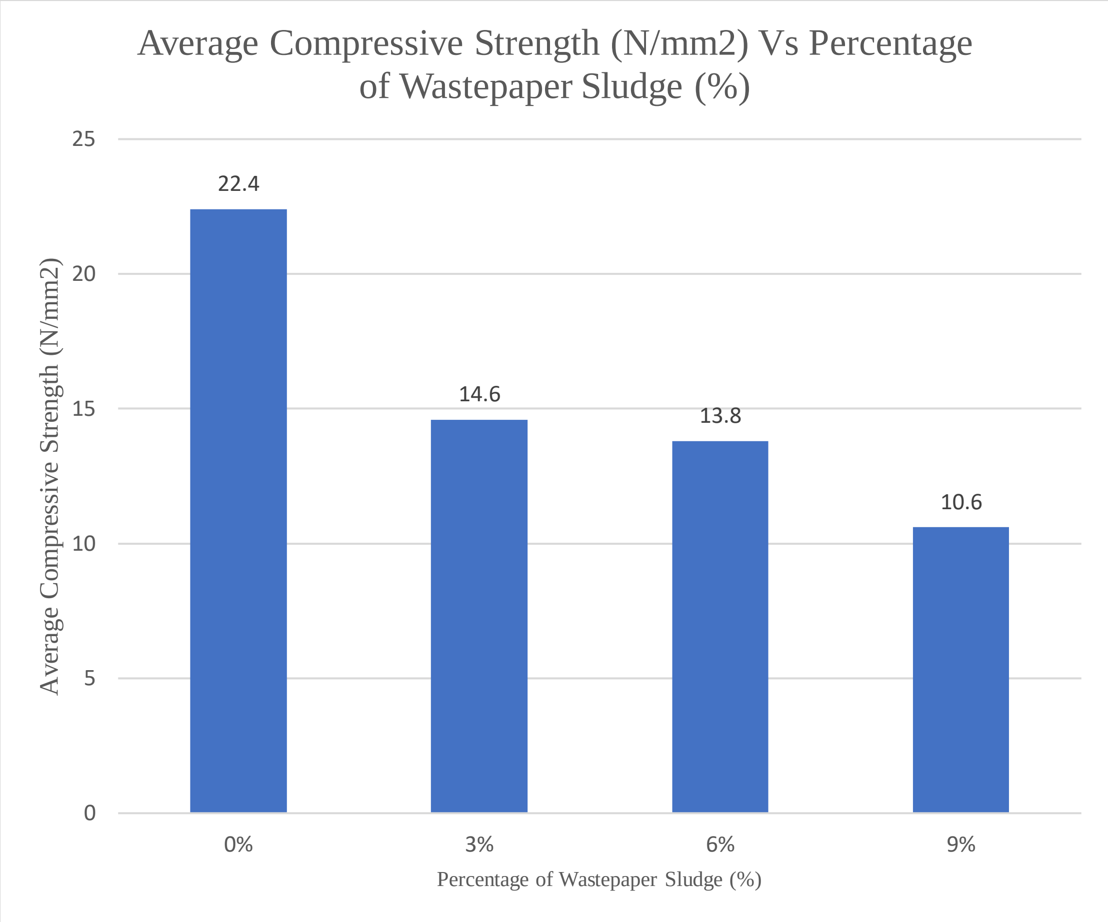


Chart 4.2.1: Compression test for 7 days of curing

The compression test is conducted to assess concrete strength under applied loads, typically using three cubes to determine the average strength. Table 4.2.1 presents data from a concrete compression test based on the percentage of wastepaper sludge replacing sand, challenging its preservation over 7 days. Notably, the average compressive strength at 0% wastepaper sludge is 22.4 N/mm², decreasing to 14.6 N/mm² at 3%, 13.8 N/mm² at 6%, and 10.6 N/mm² at 9%. This data illustrates a decline in concrete strength with increasing wastepaper sludge content. The table indicates that the maximum 7-day compressive strength is achieved with 0% wastepaper sludge replacement. Chart 4.2.1 visually depicts a clear trend of decreasing concrete strength with higher sludge content. Ultimately, all specimens met the minimum 7-day compressive strength requirement of 10 N/mm², showcasing the impact of wastepaper sludge on concrete strength.

4.3 COMPRESSIVE STRENGTH TEST RESULTS AFTER 28 DAYS

Table 4.3.1: Compression test for 28 days of curing

Wastepaper Sludge (%)	**Reading (N/mm2)**			**Average (N/mm2)**
	1	2	3	
0	26.8	25.4	27.9	26.7
3	17.7	15.7	18.7	17.4
6	18.4	17.8	19.8	18.7
9	16.3	14.0	15.1	15.1

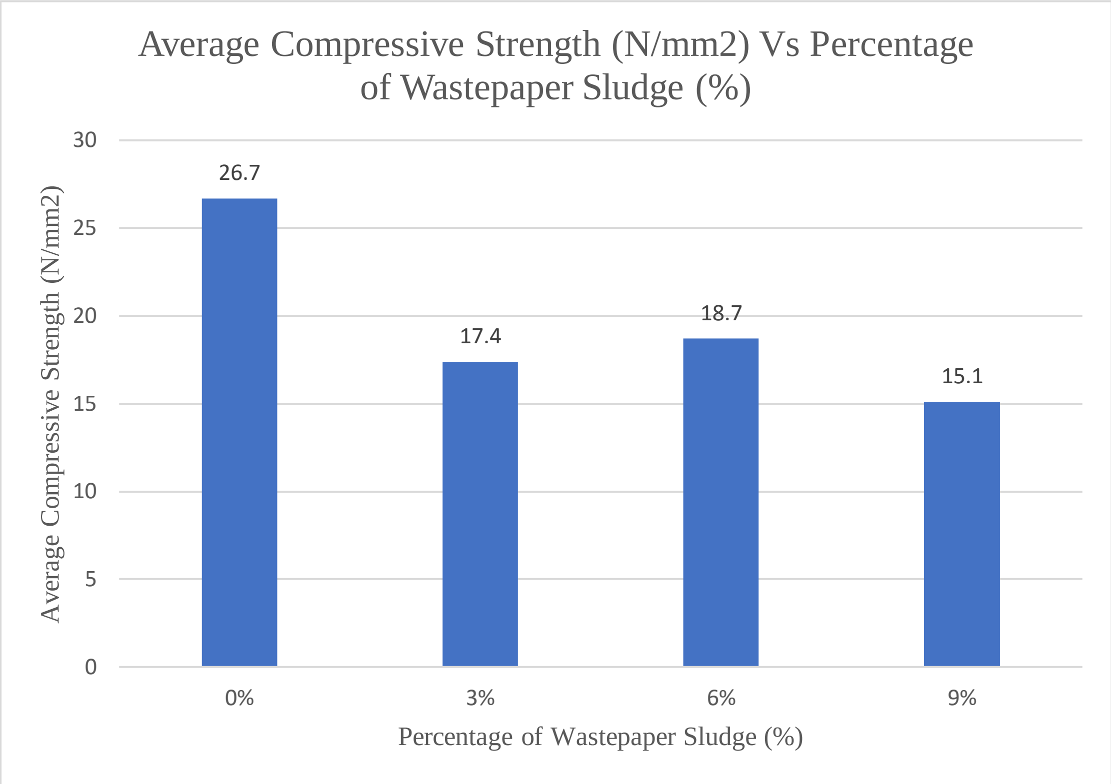


Chart 4.3.1: Compression test for 28 days of curing

The compression test is conducted to assess concrete strength under applied loads, typically using three cubes to determine the average strength. Table 4.3.1 presents data from a concrete compression test based on the percentage of wastepaper sludge replacing sand, examining its impact on concrete strength over 28 days. Notably, the average compressive strength is 26.7 N/mm² with 0% wastepaper sludge, decreasing to 17.4 N/mm² at 3% sludge, then increasing to 18.7 N/mm² at 6%, and finally decreasing to 10.6 N/mm² at 9% sludge. This data illustrates a fluctuating trend in concrete strength with increasing wastepaper sludge content. The table indicates that the maximum 28-day compressive strength is achieved with 0% wastepaper sludge. The graph in Chart 4.3.1 visually depicts the wavy trend of the average compressive strength test results. Ultimately, all specimens met the minimum 28-day compressive strength requirement of 10 N/mm², showcasing the impact of wastepaper sludge on concrete strength.

4.4 SUMMARY OF COMPRESSIVE STRENGTH TEST RESULTS

Table 4.4.1: Summary of compression test results

Wastepaper Sludge (%)	Average Compressive Strength (N/mm2)	
	7-days	28-days
0	22.4	26.7
3	14.6	17.4
6	13.8	18.7
9	10.6	15.1

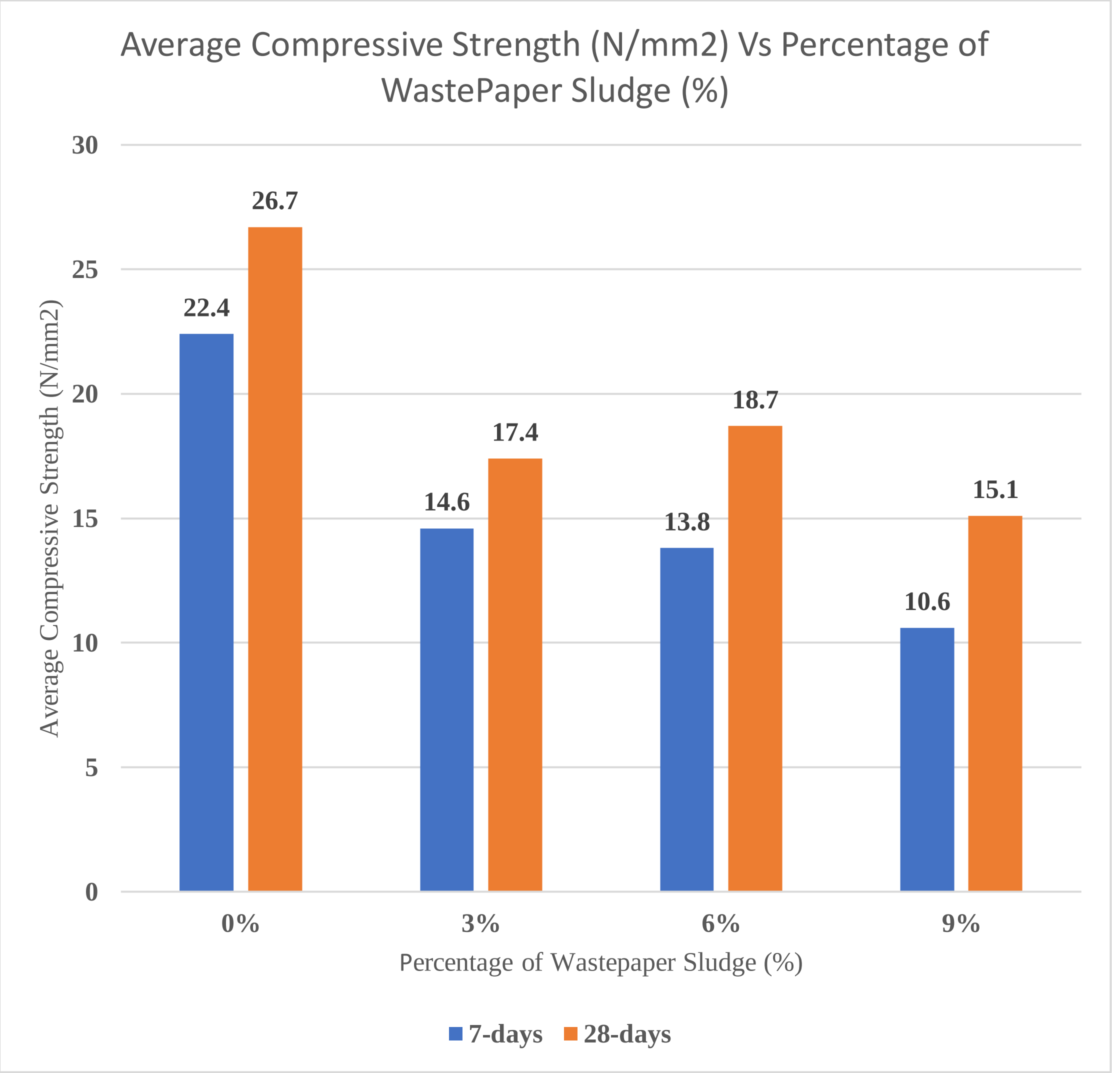


Chart 4.4.1: Summary Compression test results

Based on the data presented in Figure 4.3, the graph illustrates the compressive strength variations for different percentages of wastepaper sludge at both the 7th and 28th day intervals. Analyzing the trends, it is evident that the compressive strength of the specimens showed consistent improvement over time.

Starting with the 0% specimen, there was a notable increase in compressive strength from day 7 to day 28, with a significant rise of 4.3N/mm2. This indicates a positive trend towards enhanced strength characteristics.

Moving on to the 3% specimen, a similar pattern emerges with a commendable increase in compressive strength of 2.8N/mm2 between the 7th and 28th day. This demonstrates the positive impact of sludge residue on strengthening properties.

Furthermore, the 6% specimen exhibited a substantial enhancement in compressive strength, showing an impressive increase of 4.9N/mm2 from day 7 to day 28. This substantial improvement underscores the potential benefits of incorporating wastepaper sludge in the mixture.

Lastly, the 9% specimen also displayed a significant increase in compressive strength, with a rise of 4.5N/mm2 from day 7 to day 28. These results collectively indicate a consistent trend of strength improvement across different wastepaper sludge percentages.

It is worth noting that all specimens surpassed the minimum required strength threshold of 15N/mm2, highlighting the effectiveness of the wastepaper sludge in enhancing the compressive strength of the samples. This data underscores the potential for utilizing wastepaper sludge as a beneficial additive in construction materials to achieve superior strength characteristics beyond the specified minimum requirements.

4.5 WATER ABSORPTION TEST RESULTS AFTER 28 DAYS CURING

Table 4.5.1: Water absorption test for 28 days of curing

Wastepaper Sludge (%)	**Mass (kg)**		**Water Absorption Rate (%)**
	Wet	Dry	
0	6.97	6.87	1.46
3	7.04	6.92	1.73
6	6.73	6.63	1.51
9	6.74	6.62	1.81

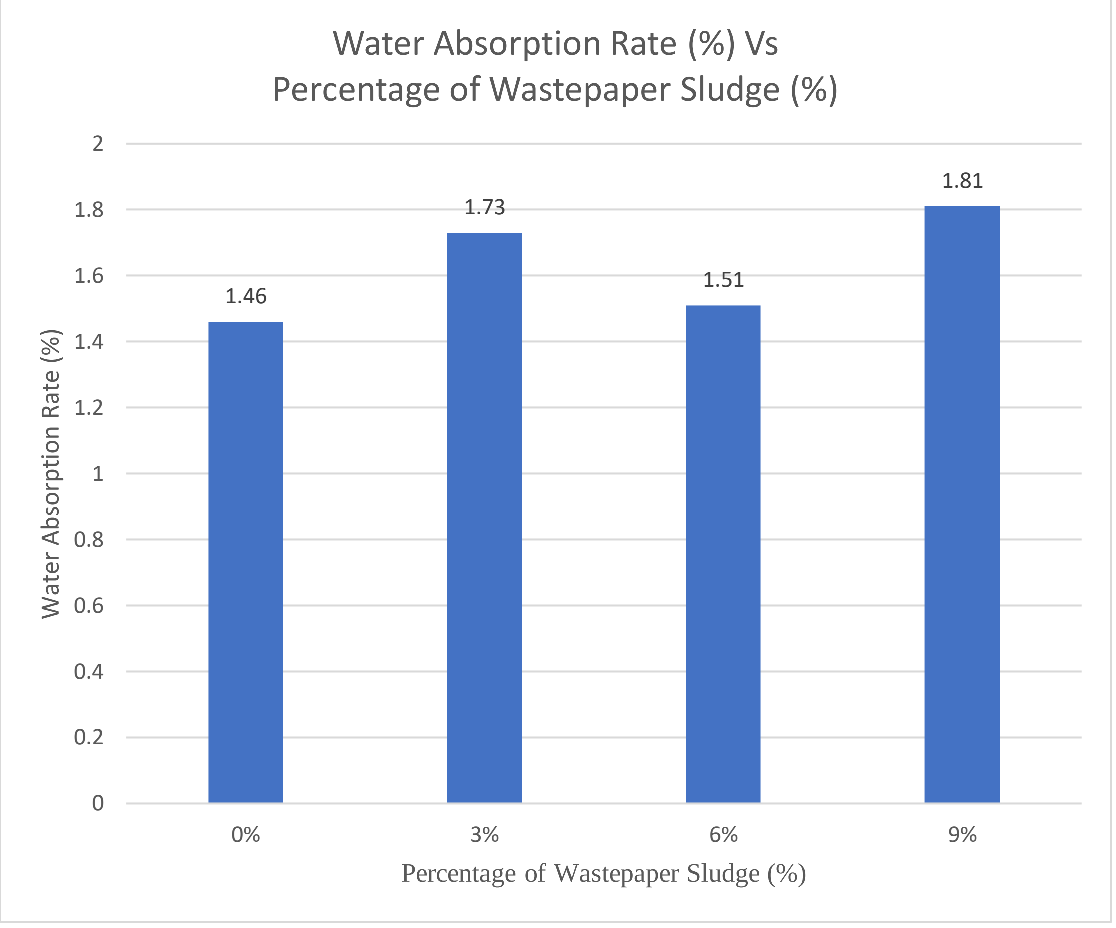


Chart 4.5.1: Water absorption test for 28 days of curing

The Water Absorption Rate test is conducted to determine the amount of water absorbed under specified conditions, typically using three cubes to determine the average percentage rate. Table 4.3.1 presents data from a water absorption test based on the percentage of wastepaper sludge replacing sand to see the amount of water absorbed over 28 days. Remarkably, the average water absorption rate at 0% wastepaper sludge is 1.46%, increasing to 1.73% at 3%, then declining to 1.51% at 6%, and when back up to 1.81% at 9%. The data indicates a pattern of variable water absorption rate as the content of wastepaper sludge increases. The table illustrates that a replacement of 9% wastepaper sludge can attain the maximum 28-day water absorption rate. Furthermore, the varying pattern of a higher water absorption rate with a higher sludge concentration is visually represented in Chart 4.2.1.

CHAPTER 5

CONCLUSION

5.1 Introduction

This section will conduct a thorough and in-depth analysis of the data presented in Chapter 4, closely examining the research that was done. The principal aim of this study is to investigate the feasibility of using wastepaper sludge as a replacement for sand in the manufacturing of concrete. This chapter seeks to offer a comprehensive assessment of the viability and efficacy of using wastepaper sludge in the construction industry by closely examining the project's findings. Using the in-depth analysis and discussions from Chapter 4, it will also clarify the implications of these findings and provide incisive suggestions that can be highlighted and put into action.

5.2 Conclusion

In conclusion, the goal of this study was successfully accomplished by comparing the compressive strength and water absorption rate of traditional concrete with concrete that contains wastepaper sludge. The results of the investigation showed that the 6% specimen had the highest compressive strength measured for concrete containing wastepaper sludge, at 18.7N/mm2. Furthermore, for the same specimen, the water absorption rate was significantly lower at 1.51%. Notably, though, traditional concrete performed better than the concrete containing wastepaper sludge, with a slightly lower water absorption rate of 1.46% and a compressive strength of 26.7N/mm2. Despite this, the study shows that using green technology to produce building materials from waste materials like wastepaper sludge from industrial processes has a number of significant advantages. This approach not only reduces waste disposal activities but also contributes to the preservation of the environment's sustainability by promoting eco-friendly practices in construction. Embracing green technologies not only paves the way for resource efficiency but also aligns with the overarching goal of preserving the ecological balance and promoting a greener, more sustainable future for generations to come.

5.3 Recommendation

After the comprehensive analysis conducted in this study, several key recommendations emerge for future research endeavours focusing on wastepaper sludge. Primarily, it is suggested that exploring the utilization of additives in the manufacturing process of wastepaper sludge concrete could significantly enhance the attainment of optimal compressive strength outcomes. This avenue of investigation holds promise for advancing the efficiency and durability of concrete derived from wastepaper sludge materials. Furthermore, it is imperative for researchers to delve deeper into assessing the environmental implications associated with the production of concrete utilizing wastepaper sludge as a base material. Understanding the ecological footprint and sustainability aspects of such practices is crucial for fostering environmentally conscious construction methodologies and promoting greener infrastructure solutions. By delving into these areas, future studies can contribute valuable insights to the field, paving the way for more sustainable and innovative approaches in waste management and construction practices.

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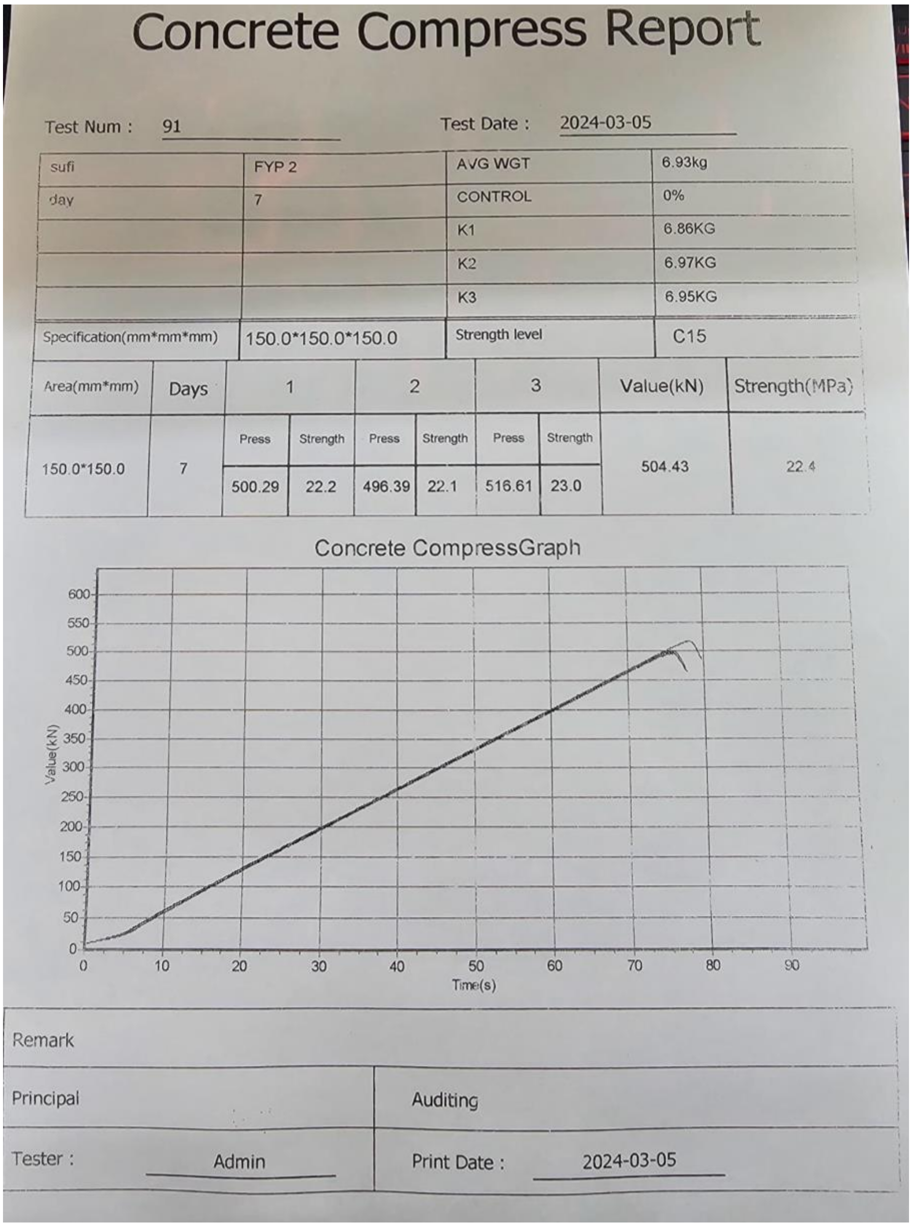
APPENDIX 1

TEST DATA



Concrete Compress Report

Test Num : 91 Test Date : 2024-03-05

sufi	FYP 2	AVG WGT	6.93kg
day	7	CONTROL	0%
		K1	6.86KG
		K2	6.97KG
		K3	6.95KG
Specification(mm*mm*mm)	150.0*150.0*150.0	Strength level	C15

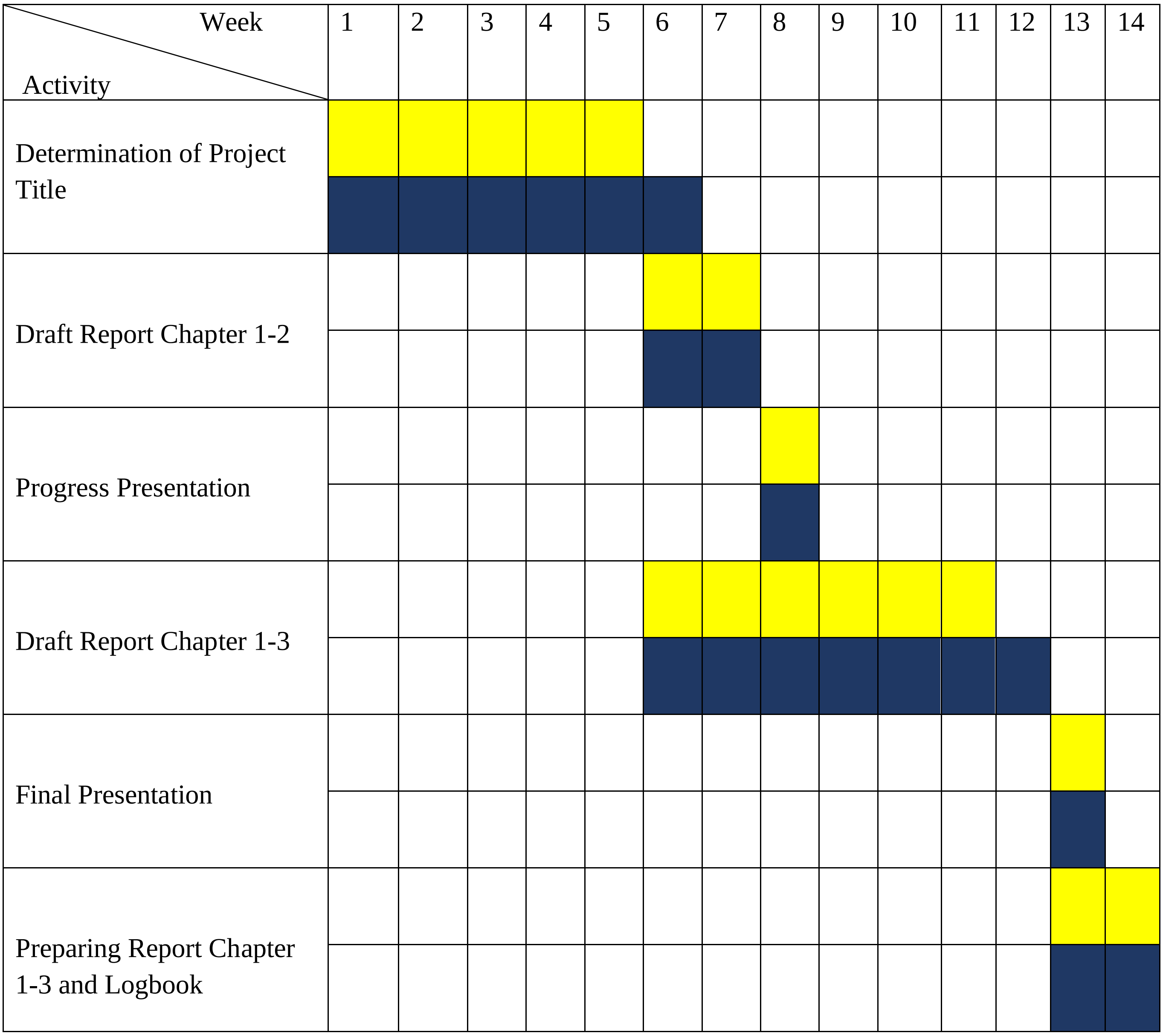
Area(mm*mm)	Days	1		2		3		Value(kN)	Strength(MPa)
		Press	Strength	Press	Strength	Press	Strength		
150.0*150.0	7	500.29	22.2	496.39	22.1	516.61	23.0	504.43	22.4

Concrete CompressGraph

Remark	
Principal	Auditing
Tester : Admin	Print Date : 2024-03-05

APPENDIX 2

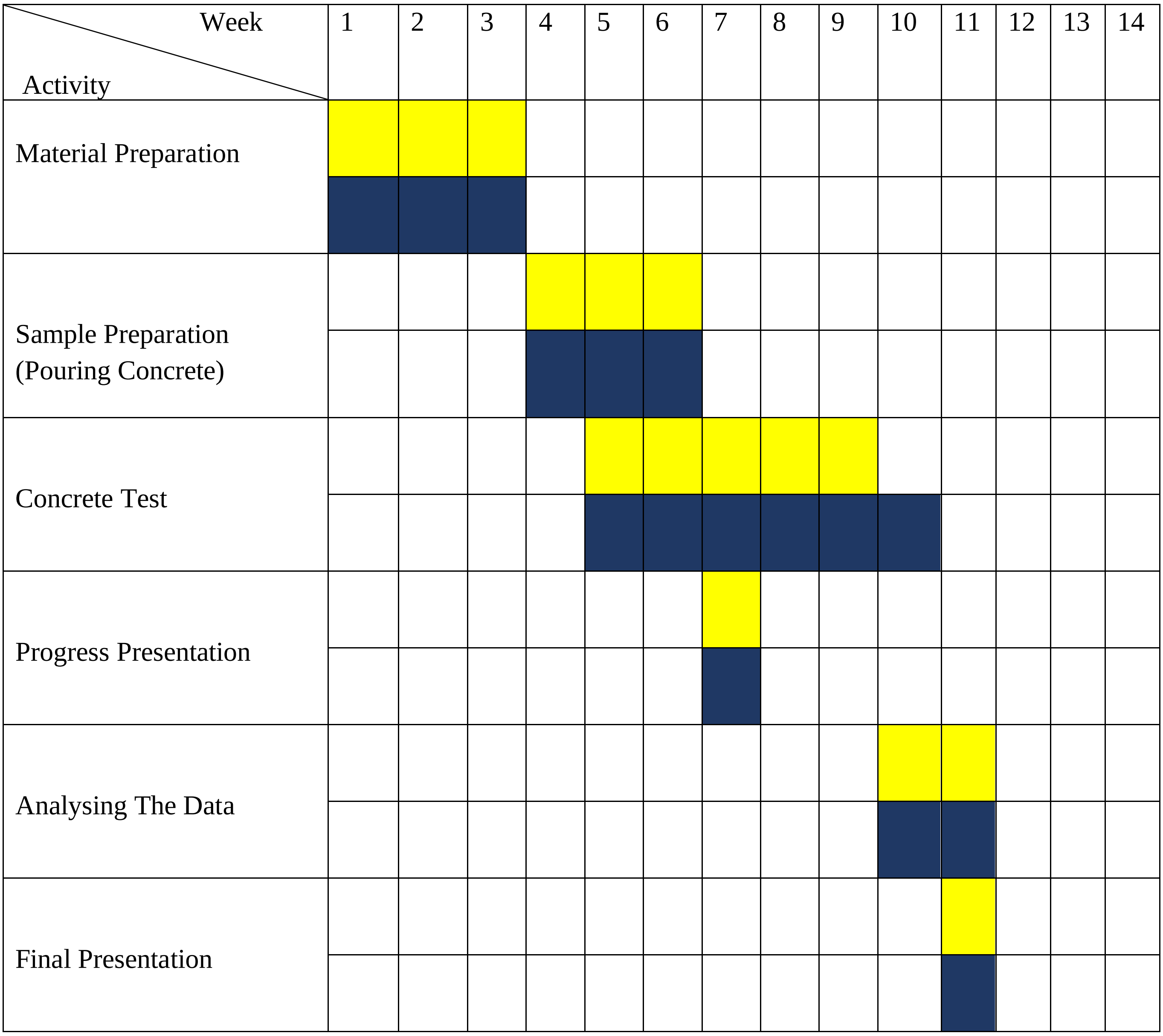
FINAL PROJECT GANTT CHART 1



Planned work	
Real work	

APPENDIX 3

FINAL PROJECT GANTT CHART 2



Planned work	
Real work	