Investigating the Effect of Incorporating Animal Blood into Concrete

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Abstract— Concrete has been a fundamental material in construction because of its durability and strength. Despite this, traditional beliefs and practices continue to shape construction practices, such as the idea that the incorporation of animal blood may increase the strength of concrete.

This study aimed to investigate the influence of adding animal blood, specifically pig blood, into the concrete mixture, with emphasis on its compressive strength. The samples were divided into 3 groups: the Control group, which has 0% pig's blood, Sample 1 with 5% of pig's blood, and Sample 3 with 10 % of pig's blood, based on the amount of water in the mixture.

The workability of all sample batches was measured by a slump test before casting of concrete mixture into the cylindrical mold. The test specimens were cured for 7, 14 and 28 days. The compressive strength test was performed according to ASTM standard to determine the performance of the modified concrete.

The results indicated that the incorporation of animal blood, specifically pig's blood, negatively affected the compressive strength for all curing periods, with increasing reductions as the percentage of pig's blood was increased. While the modified concrete mixtures developed strength with time, they always underperformed compared to the control group. This suggests the pig' blood can negatively affect the hydration process and cement bonding properties. These results contradict the traditional belief that animal blood strengthens the concrete.

Index Terms— **Alternative Additive, Compressive Strength, Concrete, Pig's Blood**

1. Introduction

A. Background of the Story

Concrete is known for its strength and durability, which makes it a widely used material in the building sector (Sirvaraja and Kandasamy, 2020). It consists of aggregates, water, and cement, which combine to create a solid substance that sets and hardens over time. This property has made concrete one of the leading materials used in constructing long-lasting and durable structures.

To improve the properties of concrete, scientists and engineers have been testing and experimenting with non-conventional materials and additives. Some people think that with the help of these additives, the concrete mixture becomes more workable, durable, and increases its compressive strength.

The incorporation of animal blood into a concrete mixture is unusual, but it is a traditional method used by ancient people.

In the past, some people, workers, have used this practice because they believe that animal blood would make the concrete stronger. This is partly due to the perception that the material, specifically organic materials present in the animal blood, enhances the concrete mixture.

According to Dinc-Sengoul et al. (2023), the waste animal blood would be an alternative additive in producing long-lasting construction materials. But still, despite these assertions, evidence to justify this practice is insufficient, and its efficacy in modern construction has not been studied. The research gap offers an opportunity to investigate whether animal blood could be used as a material enhancer and even alter the properties of a concrete mixture.

Researchers have been experimenting with the addition of fibers, plant extracts, and other organic substances for many years to enhance the strength of the concrete, which is why the incorporation of non-traditional material in construction is not new.

This research tests whether animal blood, specifically pig blood, plays a considerable role in the compressive strength of concrete. To confirm the traditional beliefs, the researchers perform a test to examine the viability of using pigs' blood as an additive to prepared concrete specimens.

The objective of this study is to investigate whether animal blood, specifically pig blood, is significantly responsible for the compressive strength of the concrete. The researchers' asses the viability of using pig's blood as an additive into concrete mixture to know if the traditional practice id indeed effective or not.

If effective, pig's blood would be a natural, cost-effective admixture for construction. On the other hand, if improvements or negative effects are not found, the results might prompt constructors and researchers to move away from outdated or unproven practices, promoting an evidence-based culture in construction.

Ultimately, this study seeks to assist contemporary contractors in determining whether this traditional practice should be reevaluated or regarded as a myth.

B. Statement of the Problem

The central focus of the study is to address and determine whether the addition of animal blood to concrete can enhance its strength. While some contractors believe that this traditional practice could enhance the durability of concrete, there remains insufficient scientific evidence to support this claim. Therefore, the central question of this study is: "Does adding animal blood to a concrete mixture significantly influence its compressive strength?"

Meanwhile, the other concerns of this study are outlined in the following questions:

1. Is the strength of concrete enhanced by the addition of animal blood compared to regular concrete?
2. How does the workability of concrete mixed with animal blood differ from that of regular concrete?
3. Does this traditional practice have a scientific basis, or is it merely a traditional belief?

C. *Objectives*

The researchers aim to achieve the following objectives:

1. Develop and apply a test method to determine whether the compressive strength of concrete increases with the addition of animal blood.
2. Assess the difference in workability between concrete mixed with animal blood and regular concrete.
3. Provide scientific evidence to either validate or disprove the traditional belief that using animal blood strengthens concrete.

D. *Hypothesis*

The hypotheses to be examined in this study are as follows:

Null Hypothesis (H_0): The mean compressive strength of concrete with pig's blood is not significantly different from the mean compressive strength of conventional concrete.

Alternative Hypothesis (H_1): The mean compressive strength of concrete with pig's blood significantly differs from the mean compressive strength of conventional concrete.

E. *Scope and Delimitation*

This study focuses on testing the compressive strength of concrete mixtures, both with and without the addition of animal blood. The researchers conduct the study in a controlled setting to ensure that all variables, except for the presence of animal blood, remain consistent. Before concrete cylindrical molds are tested, the mixture shall be subjected to a slump test to check its workability and ensure the consistency of the mixture. The specimens of concrete were cast using cylindrical molds and cured following the conditions specified under ASTM C31: Standard Practice for Making and Curing Concrete Specimens in the Field. The curing process continues for several days, and the compressive strength test will be carried out on the concrete to check its ultimate strength. Testing and sampling were done at three stages, 7, 14, and 28 days from the date of mixing.

The study only focuses on the compressive strength of the concrete and does not examine its tensile strength and the protection from environmental aspects such as chemicals and weather. There is only one form of animal blood, specifically pig's blood, that was applied in the mixture. Other forms of additives and the incorporation of animal blood within other forms of construction material are not the focus of this study.

F. *Significance of the Study*

This study provides valuable contributions to the following groups:

Construction Professionals: Civil engineers and construction laborers gain awareness of both the benefits and drawbacks of using animal blood in concrete mixing, aiding them in making informed decisions.

Construction Companies: The study offers insights into alternative materials, such as pig's blood, that may enhance the compressive strength of concrete.

Students, particularly those studying civil engineering, can use this research as a reference for investigating innovative concepts and materials, enriching their related literature and future projects.

G. *Conceptual Framework*

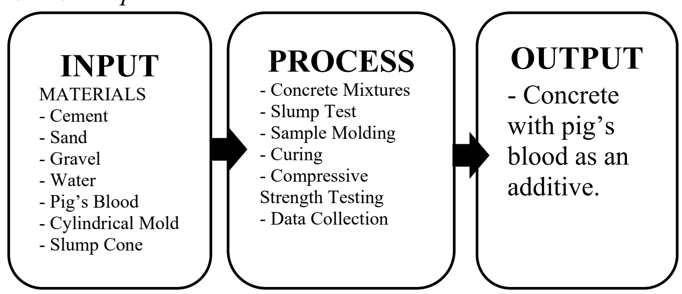

Fig. 1. Conceptual Framework

The figure above illustrates the conceptual framework of this study, which experimentally investigates the effect of incorporating pig's blood into a concrete mixture at a specific ratio. The provided materials were used to evaluate the properties of the resulting concrete. An extensive test procedure was implemented during the study to ensure accurate results. The integration of the input and process phases produces the output: a concrete mixture with pig's blood as an additive.

H. *Definition of Terms*

- **Pig's Blood** - is from pigs, which are often used in culinary dishes and sometimes in animal feed. Hwang, J. (2021). In this study, it is an additive to the concrete mixture.
- **M20 grade concrete** - This grade of concrete holds the highest compressive strength of approximately 2900 psi (20 MPa) in Normal Grade Concrete, Idiata, Ojo-Kyode et al. (2022).
- **Water Cement Ratio** - significantly affects the strength and the durability of concrete because it is the ratio of the mass of water to the mass of cement used in the concrete mixture. Mehta, P. K., & Monteiro, P. J. M. (2020).
- **Slump Test** - is a test to measure the workability of the concrete mixture as well as its consistency by determining the measurement of slumps when the cone mold is lifted. Certified MTP. (2024).
- **Curing Time** - is the duration during which the concrete is maintained in a moist condition to ensure

proper hydration and to achieve its full strength. It typically lasts for at least 28 days. Heidelberg Materials UK. (2024).

- **Compressive Strength** - is referred to as the ability of the material to resist the axial load without breaking, Neville, A. M., & Brooks, J. J. (2020).

2. Review of Related Literature

Concrete is one of the most widely utilized materials in construction due to its capacity to support heavy weights and endure various weather conditions. According to Babalola et al. (2021), concrete is the most commonly used man-made material globally, second only to water in terms of consumption, and is greatly needed for various construction projects both now and in the future. It is difficult to think of a world without concrete. Concrete is a mixture containing various components like cement, aggregates, and water. The strength of concrete, especially its compressive strength, is very important. As stated by Lysett (2022), the most widely accepted way to measure concrete strength is through compressive strength testing. It is the key factor utilized to determine whether a particular concrete mix can withstand the structural tensions imposed on it. Several parameters influence the strength of concrete, such as the proportion of water, cement, and aggregates used, as well as its curing period. Sosa et al. (2021) expressed that the cement forms a thin covering on the aggregate particles, which prevents water and also prevents water from being absorbed by the aggregates. In a certain case, the aggregates don't get well saturated, therefore making significant changes in mixing water could lead to adding free water that increases the effective water-to-cement ratio. Moreover, they concluded that dry aggregates are not fully saturated at the time of mixing, and that substitution of different types of aggregate may cause the effective water-to-cement ratio of a concrete to vary by as much as ± 0.02. The low margin is expected because natural aggregates have low water absorption. The significant reason behind this is due to their inherent rigidity and low porosity. Ezenweke's study in 2022 highlights that concrete compressive strength is affected by the aggregate size, shape, and surface texture. The study observed that smaller aggregates are fully covered with cement paste when mixing; on the other hand, larger aggregates are well coated. The Concrete strength can also be determined by the curing period, when it is properly covered. Having a longer curing time, it can be assumed that it has higher compressive strength. To enhance the quality of concrete, additives are often utilized. Additives are materials that are mixed into a normal concrete mixture to make it more durable. In the study of Al-Kharasheh et al. (2023) found that adding basalt fibers can improve the distribution of pore sizes. Basalt Fiber can enhance the durability of concrete by reducing fractures, blocking water, and harmful substances; in other words, basalt fiber improves the quality and integrity of concrete.

Another study by Chen et al. (2022) shows in their results that when adding supportive cementitious materials, the strength of high-quality concrete has improved.

In the study of Pazderka and Hajkova (2024), according to them, mixing crystalline admixtures can have a significant effect on the compressive strength of concrete. It was found that there is a huge increase from 46.7 MPa to 56.2 MPa after 28 days of curing. Moreover, a study disclosed that some compound additives could also improve the cement usage by 7% to 45% and not just the compressive strength of concrete (Gallegos-Villela et al. 2021). Natural Additives, namely waste materials of animals, could shake the modern engineering technique and materials. According to Prkic (2022), the ancient Romans added animal blood to the concrete mixture, believing the improvement of durability due to the presence of hemoglobin in blood creates small air voids that act as a barrier to freeze-thaw damage and improve the consistency of the concrete. This practice has a significant effect when it comes to concrete weathering and cracking.

In some traditional construction practices, people have used animal by-products, such as blood or bones, as additives in construction materials. According to Saha et al. (2023), incorporating wasted animal blood reduces capillary water absorption and enhances the freeze-thaw resistance of lime-based mortars. The related review of literature shows that using animal blood as an additive in concrete mixture is a possible and sustainable option compared to commercially produced additives. Therefore, this study assumes that animal blood can increase the concrete's strength. More studies by Burgess in 2022 found that due to the presence of oxygen in animal blood, it can reduce the weight of concrete. A study of Khanzadeh and Fathollahi (2020) expounds how the air entrainment structure in cement paste is affected by the presence of protein in blood. They compared the results with those obtained from concrete mixtures that used commercially produced additives. The researchers used experimentation to test the concrete's compressive strength and analyze the air entrainment properties of cement pastes, which included the size and distribution of air voids, whole air content, the number of micro pores with a diameter under 300 µm, and the specific surface area of air voids. On the other hand, research was conducted on solidified cement paste containing varying amounts of air-entraining substances. The results of the test are a higher intensity of action and better air entrainment properties compared to the commercially produced air-entraining additive. Hence, the analysis concluded that the blood protein admixture was more effective than the industrialized additives.

Pig blood's plasma has been developed (concrete mixture) because of its water retention and high protein properties. Studies have shown that when processed (e.g., spray-dried plasma), it has been used to boost or improve the compressive strength of concrete due to the upgraded binding capacity. These findings align with its use in the production of blood powder, where the protein content plays a role in forming a more cohesive mixture when added to concrete (Nguyen et al., 2024)

In the past, many organic additives – especially proteinaceous and polysaccharide compounds – were added to mortars to improve their performance (Sickels-Taves and Allsopp, 2019). Romans and Chinese utilized and were already using animal blood as an additive in their construction materials. The Romans included pig blood to enhance the durability and water resistance of the concrete. On the other hand, Chinese reputedly added pig blood in lime mortars to improve the setting and integrity of the structure. It is one of the most significant technological advancements in Chinese history (Peng Zhao et al., 2020). In another study, according to Besa et. al. (2021), superstitious beliefs of the Filipinos were rooted in pre-colonialism up to the present. Most Filipino tribes during pre-colonial times were Animist. Therefore, the superstitious in the construction practices of buildings, residential houses, and the like can be explained where they came from. According to Amat (2020), these beliefs could lead to fortune or bad luck. A rooted culture and tradition could not be easily changed by science or evidence because it became their way to honor their ancestors' beliefs.

Construction practices could be affected by culture and beliefs, knowing that Filipinos are very superstitious believers. The beliefs in the phrase of "Oro, Plata, Mata" in construction practices in the Philippines, which translates to "Gold, Silver and Death," is one of the well-known superstitions. It dictates the number or design of the staircase steps (Filipino Homes, 2022). Others believed that putting coins before concrete pouring into foundations or footings is a tradition that is widely practiced by most construction workers. According to them, this tradition could attract fortune and wealth. This procedure is sometimes accompanied by pig or chicken blood that acts as an offering that also prevents the bad spirits from wandering around the house (Bria Homes, 2020; Esquire, 2019).

This related literature shows that additives in concrete mix play an important role and contribute to the advancement of construction materials and practices. This study aims to gather evidence to prove or refute to Filipinos that mixing pig blood in concrete can affect its strength. In the modern era, science and technology provide and highlight successful case studies. There is evidence that can persuade people to believe in science over superstition, which could help them have better, safer, and sustainable practices that can significantly benefit their lives. (Lumina Homes, 2023)

In contrast, the researchers found that mixing pig's blood in concrete negatively affects the compressive strength of the concrete. According to Sediqer et al. (2013), blood can affect the mechanical properties of concrete. The 28-day compressive strength of the concrete decreased by 34.22 percent, while the splitting tensile strength decreased by 30.85 percent compared to the controlled concrete mixture. More study shows that incorporating blood in a concrete mix has no significant effect on the strength of the concrete in a positive manner. According to the study by Alireza et al. (2015), incorporation of blood in concrete makes the cement very brittle. During their experimentation process, nine samples from one group were broken during the removal from the molds. Their surfaces were compromised so that cracks from the sample were present; hence, the ideal compressive strength from their study was not obtained.

US patent of Charles Laleman in 1980, he noted that pig's blood contains proteins such as hemoglobin, which can be the cause of the air pockets that were present in the samples of this study. About this, cement hydration was also caused by the contamination of the concrete mixture with pig blood. Organic compounds such as blood proteins could affect and hinder the formation of C-S-H during cement hydration. Cement Hydration is a continuous process of chemical reactions during concrete mixing that occur when water combines with cement. (JK Super Cement, 2024)

Water viscosity at 37 degrees Celsius is 0.6913 mPa.s, while blood viscosity at 37 degrees Celsius is 3.5 to 5.5 mPa.s. About their viscosity, blood has a non-Newtonian nature that increases air entrapment and results in a slight reduction in workability of the concrete mixture. (Nader et al., 2019)

The Interfacial Transition Zone (ITZ) of concrete is the region of cement that is around the aggregate particles. A microstructure change occurs in the cement paste because of the presence of the aggregates. This region is less dense and more porous in contrast with the cement paste, which makes it more significant in the mechanical properties of concrete. Addition of additive substances like pig blood in the concrete mixture can harm and damage the function of the ITZ, and can impair the structure. The reason is that it complicates the hydration stage of cement, due to the proteins and lipids being organic substances found in blood. This can cause a thinner ITZ to be formed, which has lower bonds between the cement paste and aggregates, making it weaker and more porous. The result of compromised and weaker ITZ leads to internal failure, micro-crackings, and ultimate reduction of concrete's compressive strength. (Scrivener et al,. 2004).

Studies on the incorporation of pig's blood into concrete show both positive and negative outcomes. Some historical and contemporary research highlights the possible advantages of pig blood, including freeze-thaw strength, reduced weight, and enhanced binding through its protein content, according to Prkic 2022, Nguyen et al. (2024 and Saha et al. (2023. These investigations imply that with proper processing, it can contribute to the durability of the concrete as well as its consistency. However, there are also experimental studies which indicate negative effects, mainly decreased in compressive strength, brittleness, and interference with cement hydration and Interfacial Transition Zone, according to Sediqer et al., 2013, Alireza et al.,2015, and Scivener et al., 2004. The conflicting findings underscore the importance of further research to establish whether pig blood holds potential as a sustainable additive in modern concrete technology.

3. Methodology

The research methods, design, instruments, and procedures used in examining the impact of pig's blood as an additive on the compressive strength and workability of concrete were presented in this chapter. It provides the overall strategy of the study, such as materials and equipment used, testing procedures, and statistical methods applied to analyze the gathered data.

A. *Research Method*

The researchers use a quantitative research strategy in this study to determine if incorporating animal blood into the concrete mixture improves its compressive strength. Seekumar (2023) explains that quantitative research involves gathering and analyzing data in numerical form to examine, forecast, or manipulate certain variables. Its general purpose is to test a hypothesis or a theory in an attempt to determine if one should either accept or reject it according to the results obtained. The goal of this study is to determine if the traditional practice can indeed enhance the strength of concrete.

Three sets of samples were used by researchers, and the compressive strength of each sample was tested at 7 days, 14 days, and 28 days intervals upon mixing. A compression testing machine was used to test the strength at each interval. Statistical techniques like Analysis of Variance (ANOVA) were used to test the data and interpret the results efficiently.

B. Research Design

The researchers utilize a true experimental design, with both independent and dependent variables in the quantitative approach. The independent variable was the quantity of animal blood used in the concrete mixture, while the dependent variable was the compressive strength of the concrete, including factors like curing time and compressive strength.

All other variables, such as the quantity and form of cement, water content, aggregate volumes, and curing period, were kept constant to remove any possible effects in the results.

C. Process Flowchart

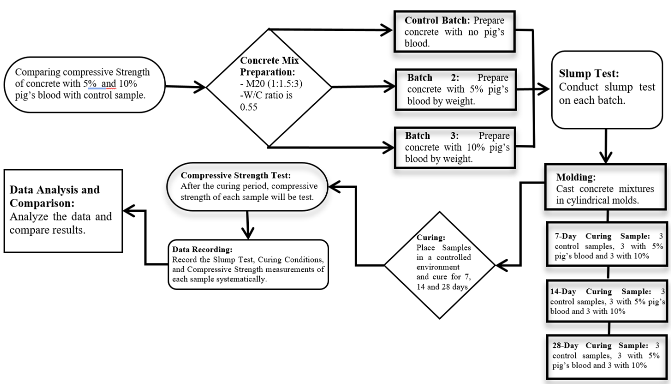

Fig. 2. Process Flowchart

The figure above shows the process of the experiment for this study. The goal is to compare the compressive strength of the concrete with 0%, 5%, and 10% of pig's blood. The experiment uses M20 grade of concrete (1:1.5:3) with a strength of 2900 psi or 20MPa and can be applied to structural elements like columns. The mix ratio of this is 1:1.5:3 for cement, sand, and gravel. A water/cement ratio of 0.55 was used. According to Sahu (2019), the lower w/c ratio tends to have higher strength. The optimal w/c ratio varies depending on a project, but normally between 0.40 and 0.60 for general-purpose concrete.

Three batches of concrete mixtures were prepared for the experiment, batch 1 for the control group with 0% pig's blood, batch 2 for the mixture with 5% pig's blood by weight of water, and batch 3 for the mixture with 10% pig's blood by weight of water as well. All mixtures were tested for the slump test to ensure the uniformity of the mixture and workability as per standard specifications.

After the slump test, concrete mixtures were cast into polyvinyl chloride (PVC) pipe with exact number of samples for each mixture at each period of curing and testing. Nine samples were made for 7 days, 14 days, and 28 days curing period: three control samples with 0% pig's blood, three concrete mixtures with 5% pig's blood, and three concrete mixtures with 10% pig's blood. The samples were stored in a controlled curing environment. A compressive strength test was carried out after each curing period to check their strength. Throughout the experiment, slump test, workability, and compressive strength of the samples were measured systematically. The data gathered allows the researchers to compare the results.

D. Research Locale

This research was conducted in two different locations. The slump tests happen at the College of Engineering and Architecture (CEA) Laboratory at the University of the Assumption in the City of San Fernando, Pampanga. On the other hand, the concrete mixtures, casting of samples, and the curing process were accomplished at CDCP in San Simon, Pampanga, at the residence of one of the researchers, which provides adequate space for these activities.

The researchers provide the needed materials for the experiment. After curing periods of 7 days, 14 days, and 28 days, the cured samples were carefully transferred from San Simon to the University of the Assumption for compressive strength testing. The university is equipped with a Universal Testing Machine (UTM), which was used to precisely evaluate the compressive strength of the concrete.

E. Research Instrument

This research aims to determine if incorporating pig's blood into concrete can improve its compressive strength. To make sure that the accuracy and reliability of the results, the researchers follow the guidelines set by the American Society for Testing and Materials (ASTM), such as:

1. ASTM C31/C31M: Standard Practice for Making and Curing Concrete Test Specimens in the Field
2. ASTM C143/C143M: Standard Test Method for Slump of Hydraulic-Cement Concrete
3. ASTM C39/C39M: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

This research follows some ASTM standards to ensure proper testing procedures. ASTM C31/C31M lays out the guidelines for preparing and curing concrete test specimens, such as cylinders and beams, using samples taken from fresh concrete under actual field conditions. This standard emphasizes proper handling and curing of the specimens to produce dependable strength test results. The information gathered from these tests can be used to check if the concrete meets required strength levels and to support quality control of the mix.

ASTM C143/C143M states the method for process of the slump test, which is used to evaluate the stability and workability of freshly mixed hydraulic-cement concrete. The process involves filling a cone-shaped mold with concrete, lifting the mold, and measuring how much the concrete flow from its original height.

ASTM C39/C39M layout the process for determining the compressive strength of cylindrical concrete specimens. It plays a critical role in construction by double-checking whether the concrete being used meets design strength requirements. The process contains applying a steady axial load to a cured cylinder until it fails, giving the necessary data about the material's performance.

F. Material Preparation

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1) Concrete

Concrete is a commonly used construction material created from combining cement, water, fine, and coarse aggregates, and sometimes different. When mixed with water, cement acts as an adhesive, allowing the components to harden into a solid, and durable mass. Because of its strength, adaptability, long service life, and being low cost, concrete has become a primary material in modern construction.

In the past years, there has been an evolving change in concrete technology toward more viable alternatives to reduce the strain on natural resources. Many of these innovations involve recycling industrial waste or byproducts in the production of so-called green concrete. Seashells have emerged as a promising material for helping manage marine waste. Researchers have explored using them as substitutes for traditional aggregates, either partially or fully replacing sand and gravel. For example, Depot (2022) conducted experiments using mollusk shells in concrete mixes, adjusting the ratio of shells to cement based on a standard control mix to evaluate their performance as aggregate replacements.

2) Pig's Blood

Pig's blood has been used in many cultural and industrial frameworks due to its unique composition. This dark, protein-rich liquid that is high in hemoglobin and other nutrients has been harvested from food processing to traditional medicine and other industrial uses.

In the traditional construction, pig's blood served as a natural binder in materials such as mortar and plaster. Its thick properties help support the site's process and may also contribute to improved flexibility and durability of the building material.

3) Water/Cement Ratio

The water-to-cement (w/c) ratio plays an important role in determining the strength and durability of concrete. This ratio is commonly chosen based on the required performance characteristics of the mixture. As stated in the ACI 318 Building Code, concrete that is exposed to water and designed to have low permeability should maintain a w/c ratio no greater than 0.6, with a minimum compressive strength of 23 MPa (or 4000 psi).

In general, increasing the w/c ratio may cause to lower concrete's compressive strength and durability, as the excess water can result in a weaker internal structure. Contrary, reducing the w/c ratio too much can affect compaction, as it creates larger gaps between the cement particles and aggregates (Panda et al., 2020).

The researchers aim to explore how the addition of pig's blood affects the workability and compaction of concrete. The research specifically investigates how pigs' blood interacts with essential concrete components like cement and water. To maintain consistency across test samples, a w/c ratio of 0.55 was used throughout the experiment.

4) Concrete Mixture

M20 grade of concrete was used in this study, which has the highest strength out of the mixtures of normal-grade concrete and has a compressive strength of approximately 2900 psi or 20 MPa. Idiata, Ojo-Kyode et al. (2020) stated that M20 has a mix ratio of 1:1.5:3 of cement, sand, and gravel.

5) Ratio of Pig's Blood

Three different pig's blood percentage was used: 0%, 5% and 10%, which was computed based on the amount of water used in the concrete mixture.

G. Data Collection

The data for this research was collected through compressive strength tests that take at the laboratory and testing facilities of the University of Assumption, in Unisite Subdivision, Brgy. Del Pilar, San Fernando, Pampanga. These tests follow the ASTM C39 standard, providing the procedure for evaluating the compressive strength of cylindrical concrete specimens.

Concrete samples comprise different proportions of pig's blood undergo curing periods of 7, 14, and 28 days. A total of three sets of tests were executed, one for each curing duration to assess how the additive influences strength development over time.

1) Formulation of Samples

This study includes the preparation of three definite concrete mixtures to evaluate the impact of adding pig's blood to the mix. Each formulation was tested in three separate test to ensure the reliability and consistency of the results. The mixtures include a control sample with no pig's blood (0%), Sample 1 with 5%, and Sample 2 with 10% pig's blood. The percentage of pig's blood was calculated based on the total volume of water used in the mix.

All mixtures stick to the M20 grade concrete ratio of 1:1.5:3 for cement, sand, and gravel, following the statement outlined by Idiata, Ojo-Kyode et al. (2022).

Table 1
Concrete Mixture Ratio with Pig's Blood

Mixture	Cement (kg)	Sand (kg)	Gravel (kg)	Water (kg)	Pig's Blood (kg)
Control Group – 0%	1	1.5	3	0.55	0
Sample 1 – 5%	1	1.5	3	0.55	0.0275
Sample 2 – 10%	1	1.5	3	0.55	0.055

2) Preparation of Molds

As stated in ASTM C31, concrete test cylinders should have a length that is twice their diameter. For compressive strength testing, standard dimensions are typically 12 inches in height by 6 inches in diameter, or 8 inches by 4 inches. In this study, the researchers use a PVC pipe as an alternative mold, following the 8 x 4-inch dimensions for height and diameter, respectively.

3) Measurement of Concrete Mixture

The researchers strictly measure and prepare the concrete mixture for each sample, which includes the control group, Sample 1, and Sample 2, to ensure accuracy and consistency in the measurements.

H. Data Gathering Procedure

The researchers conduct experiments to determine if the addition of pig's blood improves the compressive strength of concrete. For this study, M20 grade concrete was used, with a mix ratio of 1:1.5:3 for cement, sand, and gravel, and a water-to-cement (w/c) ratio of 0.55.

The following procedures were used to gather the necessary data for the study:
Materials Needed:

1. Portland Cement (Type 1 for general use)
2. Sand (Manufactured Sand)
3. Gravel (3/4 in size)
4. Water
5. Pig's Blood (5% and 10% by weight)

1) Mixing Process

The researchers use manual mixing to combine all the materials needed to create a concrete mixture.

2) Slump Test

The researchers follow the procedure of the slump test according to ASTM C143/C143M using M20 grade of concrete.

The Slump Test is a standardized method for determining the consistency and workability of fresh concrete. According to ASTM C143/C143M, this procedure is applicable for hydraulic-cement concrete, including M20. Below is a detailed step-by-step guide for performing the slump test.

In this study, the equipment required is as follows:

- Slump cone: A truncated cone with the following dimensions: Base diameter: 200 mm, Top diameter: 100 mm, Height: 300 mm.
- Tamping rod: A steel rod with a diameter of 5/8 inch (16 mm) and rounded ends.
- Base plate or a mixing pan: A clean, smooth, horizontal, and non-porous surface.
- Scoop: For filling the slump cone with concrete.
- Measuring tape: for measuring the slump.

3) Procedure Steps

The step of the slump test according to ASTM C143/C143M using M20 is the following:

1. The researchers prepare the equipment needed for the experiment.
2. To ensure a smooth flow of experimentation, the researchers clean the internal surface of the slump cone thoroughly to remove debris or moisture.
3. After cleaning the internal surface of the slump cone, the researchers position the dampened slump cone on a flat, non-absorbent surface. The researchers ensure that it is stable and secure by standing on the two-foot pieces on either side of the mold.
4. The researchers fill the cone with fresh M20 concrete in three distinct layers, namely:
   a. First Layer: Fill approximately one-third of the cone (about 2-5/8 inches or 70 mm). Use the tamping rod to tamp this layer 25 times uniformly across its surface, ensuring that strokes are distributed evenly and penetrate the layer below.
   b. Second Layer: Add enough concrete to fill the cone to about two-thirds full (approximately 6-1/8 inches or 160 mm). Tap this layer again with 25 strokes, penetrating the first layer.
   c. Third Layer: Overfill the cone slightly above its top (approximately 8 inches or more). Tap this layer with another 25 strokes, ensuring penetration into the second layer.
5. After tamping all three layers, the researchers strike off excess concrete at the top using a straightedge or trowel to create a level surface.
6. The researchers carefully lift the slump cone vertically in a steady motion within approximately 5 ± 2 seconds without any lateral movement. This action allows the concrete to slump.
7. Moreover, the researchers measure the vertical distance from the top of the cone to the highest point of the slumped concrete. After that, the researchers record this measurement as the slump value in inches or millimeters.
8. Then, the researchers ensure that all equipment is clean and free from any previous concrete residues.
9. The test should be performed immediately by the researchers after mixing to ensure accurate results.
10. The maximum size of coarse aggregate should not exceed 1.5 inches (37.5 mm) for this test method to be applicable.
11. Therefore, the researchers know that the results that if slumps exceed about 9 inches (230 mm) may not be significant due to a potential lack of cohesion in the mix.
12. This procedure provides a reliable assessment of concrete workability, which is essential for ensuring quality in construction projects involving M20.

Table 2
Slump Ranges

Degree of Workability	Ranges of Slump	
	mm	inches
Very Low	0-25	0-1
Low	25-50	1-2
Medium	50-100	2-4
High	100-175	4-7

Very Low – Low water content. Stiff and dry consistency that is difficult to handle and place. Force is required to compact and consolidate.
Low – Moderate water content. More consistent and easier to handle, and place than very low workability concrete.
Medium – Exact water content and consistency. The most desirable value for beams and slabs.
High – High water content. Fluid consistency that can be placed and consolidated without using excessive force.

4) Casting of Concrete

The prepared concrete mixtures were poured into the cylindrical molds to create test specimens. There were nine cylindrical samples of each concrete mixture ratio to have enough data for compressive strength analysis.

5) Curing

The mechanical properties of concrete are also determined by the length of its curing time. Curing is done after placing the concrete and is influenced by moisture retention and temperature conditions. With a constant water-cement ratio, extended curing times tend to produce higher compressive strength. Effective curing techniques, including water immersion, spraying, or covering with materials that retain moisture, ensure optimal hydration of the cement. In this research, the concrete samples were immersed in water for curing and kept away from direct sunlight to maintain uniform curing conditions. This arrangement is to evaluate the influence of pig's blood as an additive on the compressive strength of concrete after 7, 14, and 28 days of curing.

6) Compressive Strength

In civil engineering, strength is a common property that shows a material's ability to endure stress without failure, which is often called cracking in structures. The strength and durability of concrete are affected by factors such as its elastic modulus, impermeability, and resistance to environmental conditions. These properties are mostly directed by the cement paste matrix and the interfacial transition zone (ITZ). This research investigates the potential of using pigs' blood as an additive in concrete to determine its impact on compressive strength. The aim is to know whether the modified concrete can achieve a compressive strength similar to that of M20 grade concrete, which has a standard compressive strength of 20 MPa (or 2900 psi).

I. Analysis of Data

The data analysis, interpretation, and discovery were completely assessed in this study. The effects of pig's blood additives on the concrete mix that is made of cement, aggregates, and water were carefully investigated. Graphs and tables were used to organize and present the data in a clear and easy-to-understand way.

The results from the compressive strength and slump cone tests were analyzed to assess the effect of pig's blood on the workability and compressive strength of the concrete mix, to know the ideal proportion for getting maximum strength. To test the hypothesis, a One-Way ANOVA was conducted, comparing the mean values of the control and experimental groups to determine if there is a notable difference in their results.

4. Results and Discussion

This chapter presents the analysis and interpretation of the data collected throughout the study. The relationships between water, aggregates, cement, and pig's blood additives were explored in detail. The results from both the slump cone test and compressive strength test were examined to determine the optimal percentage of pig's blood additives needed to achieve the highest concrete strength and workability.

A. Concrete Workability

The ability of concrete to be laid, compacted, and finished uniformly is referred to as workability. Workability is influenced by several variables, such as cement quantity, water content, aggregate properties, admixtures, and material proportions.

The slump test, which assesses how easily concrete flows, is frequently used to determine how workable concrete is. It illustrates how easily the concrete may reach complete compaction. Consistency and plasticity are examples of workability qualities that enable the material to be formed, compressed, and finished with little effort and without segregation.

Table 3
Fresh Concrete Slump Values

MIX	Average Slump (mm)	Average Slump (in)
Control Mix	177.8	7
Sample 1 with 5% Pig's Blood	114.3	4.5
Sample 2 with 10% Pig's Blood	114.3	4.5

The researchers evaluated the workability of various mixtures using the slump cone test. Based on Table 3, the Control mix exhibited the highest average slump, indicating the highest workability, with an average slump value exceeding 175 mm to collapse—an ideal range for typical slump testing. In contrast, Samples 1 and 2 demonstrated strong workability, with average slump values ranging from 100 to 175 mm, albeit lower than the Control mix.

B. Compressive Strength Test

According to ASTM C39/C39M, the concrete cylindrical samples, with and without pig's blood additives were tested for compressive strength at 7, 14 and 28 days. The samples were loaded axially to failure in order to determine their compressive strength.

C. Observations

The table below present the comparison of data of compressive strength of the sample mixtures without pig's blood and with 5% and 10% pig's blood according to their curing time 7, 14 and 28 days from the data collected using the ASTM C39/C39M of the Laboratory of University of the Assumption.

Table 3.1
Average Compressive Strength of Concrete Samples at 7-days curing period

Sample	Average Compressive Strength (MPa)
Control	15. 975686
With 5% Pig's Blood	12.808178
With 10% Pig's Blood	12.217765

The table above shows the average compressive strength values of the three mixtures tested at 7 days, comparing the Control group with samples containing 5% and 10% pig's blood. The sample with 5% pig's blood exhibited a lower compressive strength than the Control group, failing to meet the minimum required compressive strength. Similarly, the sample with 10% pig's blood demonstrated the lowest strength and also did not satisfy the minimum strength criteria. These findings suggest that the inclusion of pig's blood in concrete negatively impacts its early-age compressive strength, with greater reductions observed as the percentage of pig's blood increases. The complete tabulation of individual results can be found in Appendix A.

Table 3.2
Average Compressive Strength of Concrete Samples at 14-days curing period

Sample	Average Compressive Strength (MPa)
Control	18.624733
With 5% Pig's Blood	16.244579
With 10% Pig's Blood	16.020501

The table above presents the average compressive strength of the three mixtures tested at 28 days, showing an increase in strength for all mixtures compared to their 14-day result. Between the two mixtures with the additive, this time the 10% pig's blood showed the highest percentage increase. However, even with this increase, the samples with pig's blood still had lower compressive strength than the control group, which indicates that adding pig's blood hurts the strength of concrete. The complete tabulation of individual results can be found in Appendix A.

Table 3.3
Average Compressive Strength of Concrete Samples at 28-days curing period

Sample	Average Compressive Strength (MPa)
Control	22.303301
With 5% Pig's Blood	18.485764
With 10% Pig's Blood	17.981693

The table above presents the average compressive strength of the three mixtures tested at 28 days, showing an increase in strength for all mixtures compared to their 14-day result. Between the two mixtures with the additive, this time the 5% pig's blood showed the highest percentage increase. However, despite the improvement, both mixtures with pig's blood still had lower compressive strength than the control group. This indicates that while the concrete continues to gain strength over time, the addition of pig's blood hurts its overall compressive strength. The complete tabulation of individual results can be found in Appendix A.

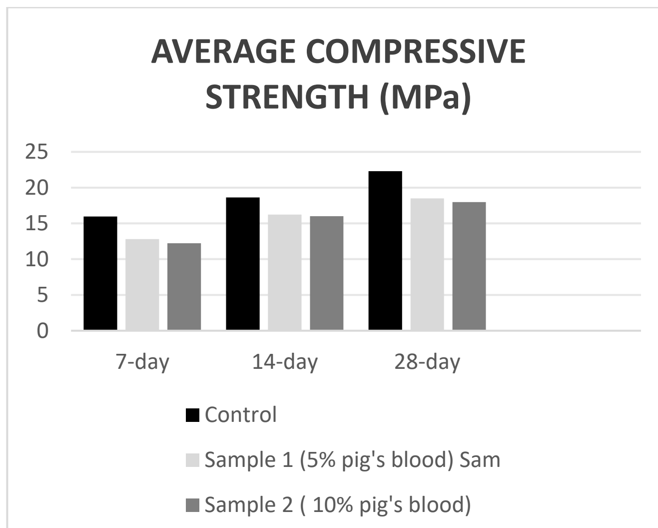

Fig. 3. Summary of average compressive strength results of concrete samples

D. Test of Hypothesis

The researchers use One-way ANOVA (Analysis of Variance) to determine if there was a significant difference between the data of the control group and the experimental group. According to Bevans (2020), ANOVA checks whether the groups, the independent variable's levels create are statistically different from each other by determining if their mean is different from the overall mean of the dependent variable. If the mean of at least one group differs statistically from the overall mean, then the null hypothesis is rejected. The value of the mean of the experimental group for every curing period was compared with the control group to determine whether there was a significant effect on the compressive strength due to the addition of pig's blood. The null hypothesis is "The mean compressive strength of concrete with pig's blood is not significantly different from the mean compressive strength of conventional concrete." The decision rule to reject the null hypothesis is if $p \leq \alpha$ or $F \geq F$ critical; otherwise, H_o is not rejected.

The table below shows the computed F-values and p-values for the compressive group.

Table 3.4
One-way ANOVA (Analysis of Variance) Test of Compressive Groups

Curing Period	F value	F crit	P value
7 days	8.17235	5.14325	0.01936
14 days	13.0378	5.14325	0.00654
28 days	7.79704	5.14325	0.02145

Table 3.4 shows a significant difference between the groups, $F(2, 6) = 8.17235$, $p = 0.01936$ for 7-day, $F(2, 6) = 13.0378$, $p = 0.00654$ for 14-day and $F(2, 6) = 7.79704$, $p = 0.02145$ for 28-day, exceeding the critical value of 5.143 at the 0.05 significance level. This indicates that the observed variation between groups is unlikely to have occurred by chance. Given that the p-value is below the conventional threshold of 0.05, the null hypothesis is rejected. This means that there is a significant difference between the compressive strength of concrete with pig's blood and the compressive strength of conventional concrete, regardless of the curing period. The complete tabulation can be found in Appendix A.

5. Summary

Three samples were used by the researchers to evaluate the concrete: the control mixture, a 5% blood mixture, and a 10% blood mixture. The mixtures were compared based on their compressive strength after 7, 14, and 28 days of curing as well as their workability as determined by the slump cone test. It seeks to identify the type of mixture that work best with the given parameter.

To ascertain which mixture configuration, yield the best results, a number of tests are carried out. The slump cone test is a preliminary concrete test used to determine the workability of each mixture. Table 3 shows that while the control combination has very high workability, samples 1 and 2 both have great workability with high average slump.

The next test that was conducted using ASTM-C39 on the combination after 7, 14, and 28 days of curing was the compressive strength test. Table 4 displays the average compressive strength over seven days for the Control, Sample 1, and Sample 2 mixtures. With a 15.98 MPa compressive strength, Control has the highest of the three. When compared to the control mixture's minimum compressive strength, samples 1 and 2 both show lower values. Based on these findings, it can be concluded that, towards the end of the seventh day following curing, the addition of blood has a detrimental influence on the compressive strength. The average compressive strength of the three mixtures after 14 days of curing is summarized in Table 5. With an average of 18.62 MPa, samples 1 and 2 both produce less than the control mixture. The average compressive strength of the three combinations following a 28-day curing period is shown in Table 6. With an average compressive strength of 22.30 MPa, the control sample once again had the highest compressive strength. After 28 days of curing, samples 1 and 2 once more fell short of the minimum necessary compressive strength.

6. Conclusion

The purpose of this study is to assess how pig blood affects concrete mixtures. Three samples—a control mix with 0% pig blood, Sample 1 with 5% pig blood, and Sample 2 with 10% pig blood—were used by the researchers to examine the impact of pig blood as an additive. Pig blood's impact on the combinations was assessed using compressive strength tests.

The findings show that adding pig blood to concrete reduces its compressive strength during all curing times (7, 14, and 28 days). Even while the pig blood samples showed increasing strength over time, their compressive strength was always less than that of the control group. Additionally, the strength decreased more when the percentage of pig blood increased, indicating that pig blood can affect the concrete's bonding or hydration processes.

The concrete mixtures containing pig blood showed lower slump values than the control group, according to the slump test, which indicates that they were less workable. Pig blood affects the mixture's fluidity, as seen by the decrease in workability even though the adjusted mixtures were still within an acceptable range. According to the study's findings, adding pig blood to concrete is not a good idea because it could weaken the material's structural integrity.

The researchers used a one-way ANOVA test for the hypothesis testing. The findings showed that, over a range of curing times, the compressive strength of concrete containing pig blood differed statistically significantly from that of standard concrete. This result suggests that the structural performance of the material is impacted over time by the addition of pig blood.

These results contradict the conventional belief that animal blood strengthens concrete.

A. Recommendation

The researchers' recommendations are based on the findings from previous studies as well as the results obtained from the experiments conducted in this study.

1. Transportation of Samples: The researchers recommend using improved transportation materials, such as foam or anti-vibration padding, to maintain the integrity of the samples during transit to the testing facility.
2. Curing Tank: It is recommended to use a curing tank with a sealed top to minimize potential errors caused by external factors, such as high temperatures or varying weather conditions.
3. Universal Testing Machine (UTM) Alignment: Proper alignment of the samples during testing with the UTM is essential to ensure that the applied load is both centered and evenly distributed.
4. Sample Size and Repetition: It is recommended to

increase the sample size and incorporate repetition into the research design to improve reliability. Additionally, future studies should account for external factors, such as weather conditions.

5. Blood Additive: The researchers recommend using purer blood, ideally freshly extracted at the time of slaughter, to ensure consistency and accuracy.
6. Tensile Strength Testing: Future research could investigate the impact of pig's blood as an additive on the tensile strength of concrete.
7. Concrete Mixer: The use of a concrete mixer is recommended to ensure more consistent and accurate mixing of the concrete.

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