ANIMAL MANURE IN CONCRETE HOLLOW BLOCKS

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***Abstract*— This research aimed to assess the compressive strength of load-bearing concrete hollow blocks with varying proportions of horse, cow, carabao, and goat manure. Standard materials for concrete hollow blocks were utilized alongside dried farm animal manure, which was prepared by drying and pulverization. The mixture ratio adhered to typical standards: 1/2 cement, 1 bucket of water, and 7 buckets of sand and aggregates. Following creation, the blocks were left to cure for 7-14 days according to Philippine standards, then subjected to compressive strength testing using a Universal Testing Machine (UTM) and pH evaluation. Results indicated that the addition of animal manure generally met the Philippine standard compressive strength of 5.14 MPa and exhibited proper bonding, with pH levels falling within the 9.0-9.5 range. However, blocks containing carabao manure failed to meet both the compressive strength and pH standards.**

***Keywords*— concrete hollow blocks, animal manure, compressive strength, building materials, sustainable construction**

I. INTRODUCTION

Concrete hollow blocks (CHB) are fundamental components in building and infrastructure, crafted from a blend of cement, water, and aggregates, undergoing hydration to solidify into robust blocks [1]. In the Philippines, CHB stands as a prominent walling material due to its cost-effectiveness and ease of installation [2]. Despite its widespread usage, enhancing the standard CHB remains a pursuit among researchers. A significant critique lies in its relatively low compressive strength, especially pertinent given the escalating threat of natural disasters necessitating fortified building materials, CHBs included.

While significant strides have been made in utilizing waste materials for sustainable construction, such as fly ash, animal waste, and plastic, the industry predominantly adheres to traditional cement mixes [3]. Recent research highlights the potential of integrating natural waste materials into concrete mixes, particularly in the creation of CHBs. Findings suggest that these materials can serve as additives, enhancing properties like water absorption and reducing weight [4],[5],[6].

Drawing from literature on incorporating natural waste materials into concrete mixes, it's evident that animal manure proves effective as an additive. However, there's a dearth of comparative evaluations with commercially prevalent CHBs, particularly concerning strength. Thus, this study aims to utilize horse, goat, cow, and carabao manures as additives to traditional concrete mixes for CHBs, comparing their compressive strength to that of conventional CHBs.

Cagayan Valley, a region rich in agriculture, provides ample resources for collecting animal manure. With a significant agricultural output increment in 2019, utilizing animal manure for CHB production aligns with resource efficiency [1]. This study evaluates CHBs with added animal manure, assessing their compressive strength across varying manure content levels, aiming to validate their viability for industrial application.

II. RELATED WORKS

The study indicated that the density of dry compacts decreased with increasing amounts of fly ash and horse dung [4]. Upon soaking in water at elevated temperatures, compacts exhibited increased thickness due to void filling and porosity reduction, particularly pronounced with higher concentrations of fly ash and horse compost. The water retention capacity also rose by 20% with increased content of these additives, demonstrating their ability to absorb up to 16.25% of water. However, excessive expansion of raw setting pitch powder with fly ash particles may not be advantageous. It was noted that a mixture of horse dung and fly ash is commonly used in construction applications. Efflorescence analysis indicated minor liability, with a lean salt coating covering around 10% of the brick's visible area, primarily attributed to lime concentration rather than fly ash and cement composition .

Investigating thermophysical characteristics, horse dung fibers showed the most promising results, exhibiting improved compressive and flexural strength values when compared to plastic fibers and granules [7]. Another study explored the utilization of coconut shell fibers (CSF) in CHBs, meeting ASTM slump, compressive strength, and water absorption tests. CSF demonstrated potential as a partial aggregate replacement, offering comparable compressive strength and water absorption characteristics to traditional aggregates. However, further research on aggregate parameters' impact on workability and compressive strength is warranted [3].

Incorporating cow dung ash into concrete showed potential for specific floor and wall applications, albeit with increased water requirement as the ash content rises [6]. The study evaluated soil mortar mixed with cow dung, demonstrating acceptable water absorption and shrinkage characteristics, particularly at 20% cow dung content, suggesting its viability as a low-cost alternative to cement mortar for certain structural elements [6].

Carabao dung ash met ASTM chemical test standards for cement in terms of Loss on Ignition, Magnesium Oxide, and Sodium Oxide, albeit exceeding recommended levels for Silicon Dioxide, Aluminum Oxide, Ferric Oxide, and Potassium Oxide. Adjustments with carbon, lye, or coal were suggested to reduce these levels [8]. However, it fell short of ASTM standards for Calcium Oxide and Sulfur Trioxide, suggesting the need for lime or powdered shell additives to boost compressive strength [8].

Lastly, a bench-scale investigation showcased the potential of heated conductive concrete slabs in reducing antibiotic-resistant bacteria (ARB) and antibiotic-resistant genes (ARGs) in beef cattle manure [9]. While promising, further research at pilot or full scale is necessary to validate these findings and understand their broader implications on manure quality and microbial population dynamics [10].

III. Methods

A. *Preparation of Materials*

The initial phase involves gathering the necessary materials, including animal manures sourced from local farm owners and standard components for creating concrete CHBs (Cement, Aggregates, Water, CHB molder, pail, shovel).

The animal manures are dried for 3-4 days to achieve temperature equilibrium, then pulverized to a suitable size as illustrated in Figures 1-4. These manures are subsequently incorporated into the concrete mix as an admixture in varying proportions.

Fig. 1. Pulverized cow manure to be added to the concrete mixture.

Fig. 2. Pulverized goat manure to be added to the concrete mixture.

Fig. 3. Pulverized horse manure to be added to the concrete mixture.

Fig. 4. Pulverized carabao manure to be added to the concrete mixture.

B. *Construction of the CHB*

The objective is to produce 3 load-bearing wall CHBs per mixture, with 3 sets for each concrete mix containing added animal manure (Goat, Carabao, Cow, Horse). Specific ratios and sizes are adhered to during the mixing process, in line with Philippine standard specifications for CHBs as shown in Table I.

TABLE I. HOLLOW BLOCK COMPOSITION

CHB SPECIMEN	CONTENT	CEMENT RATIO	WATER RATIO	AGGREGATES RATIO
Cow Manure CHB (CWCHB)	20g	0.5	1	7
	25g	0.5	1	7
	30g	0.5	1	7
Goat Manure CHB (GCHB)	20g	0.5	1	7
	25g	0.5	1	7
	30g	0.5	1	7
Horse Manure CHB (HCHB)	20g	0.5	1	7
	25g	0.5	1	7
	30g	0.5	1	7
Carabao Manure CHB (CRBCHB)	20g	0.5	1	7
	25gg	0.5	1	7
	30	0.5	1	7

Fig. 5. Molder used for 40 cm length CHBs

Following the standard mixture ratio, the concrete mix for CHBs with added animal manure maintains the same size and composition. The mold utilized must meet Philippine standard product dimensions for CHBs (40 cm length, 20 cm height, and 10 cm or 15 cm depth) as depicted in Figure 5. A hired professional concrete hollow block maker oversees the mixing process to ensure optimal results. Once removed from the mold, the CHBs are covered with plastic sheeting or tarpaulin and kept damp and shaded for 7-14 days for effective curing prior to testing.

C. *Testing and Evaluation*

The compressive strength of the CHBs with added animal manure is determined using a Universal Testing Machine after a curing period of 7-14 days. The maximum load of the CHBs, all with a cross-sectional area of 4000mm2, is recorded and compared against the Philippine standard compressive strength requirement of 800 psi or 5.14 MPa.

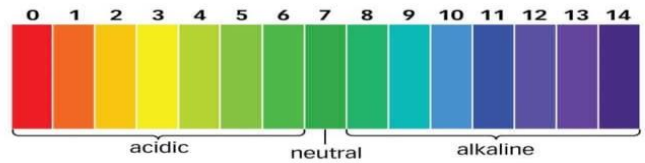

Fig. 6. pH scale

A pH test is conducted on the samples to ascertain their pH value. The calibration of pH paper is initiated using three pH calibration standards shown in Figure 6. A portion of the concrete sample is then collected and mixed with distilled water, and the resulting mixture is allowed to rest before conducting the pH test. The recorded pH values are evaluated against the baseline standard pH of 9.0-9.5 for properly bonded concrete products.

IV. RESULTS AND DISCUSSION

Figures 7 to 10 present a visual representation of the constructed concrete wall CHBs (CWCHB) containing varying amounts of animal manure. Fig. 7 displays CWCHBs with 20g, 25g, and 30g of cow manure from top to bottom. Similarly, Fig. 8 showcases CWCHBs with incremental amounts of goat manure (20g, 25g, and 30g) arranged from top to bottom. In Fig. 9, CWCHBs with increasing quantities of horse manure (20g, 25g, and 30g) are depicted sequentially. Finally, Fig. 10 exhibits CWCHBs containing ascending levels of carabao manure (20g, 25g, and 30g) arranged in a top-to-bottom fashion. These figures provide a visual comparison of CHBs with different manure compositions, aiding in the assessment of their physical characteristics and potential suitability for construction purposes.

Fig. 7. CWCHB with 20g, 25g, 30g cow manure from top to bottom

Fig. 8. CWCHB with 20g, 25g, 30g goat manure from top to bottom

Fig. 9. CWCHB with 20g, 25g, 30g horse manure from top to bottom

Fig. 10. CWCHB with 20g, 25g, 30g carabao manure from top to bottom

TABLE II. COMPRESSIVE STRENGTH (MPA) RESULTS FOR THE CHB SAMPLES

Mixtures	Animal Manure Added			
	0g	20g	25g	30g
CCHB	5.38	-	-	-
CWCHB	-	3.25	19.25	11.10
GCHB	-	6.36	5.73	6.19
HCHB	-	6.14	6.51	7.27
CRBCHB	-	2.31	1.34	2.60

All samples demonstrated noteworthy outcomes as shown in Table II, meeting or surpassing the Philippine standard compressive strength threshold of 5.14 MPa, with the exception of the CHB sample containing 20g of cow manure in the concrete mix, which yielded a compressive strength value of 3.25 MPa, and the entirety of CHB samples with added carabao manure. Despite the slight deviation observed in one cow manure sample, the overall performance aligns with previous findings from analogous concrete-related studies utilizing cow manure, which reported similar outcomes [6]. Given the precedent of cow manure usage in concrete studies, these results were largely expected. Conversely, the results obtained for CHB samples incorporating carabao manure mirrored anticipated trends, consistent with prior research indicating challenges in achieving desired compressive strength levels [8].

The outcomes from samples containing goat manure were particularly unexpected, as there is limited literature available on the utilization of goat manure in concrete-related studies. In light of these findings, there were minimal preconceptions regarding the performance of CHBs with goat manure, making the observed results intriguing. Conversely, the compressive strength values obtained from samples with added horse manure were within expectations, given the established reputation of horse manure as a viable concrete additive in previous concrete-related studies [4].

TABLE III. PH VALUE RESULTS FOR THE CHB SAMPLES

Mixtures	Animal Manure Added			
	0g	20g	25g	30g
CCHB	8.50	-	-	-
CWCHB	-	8.50	10.50	10.00
GCHB	-	10.50	10.50	9.50
HCHB	-	9.50	10.50	10.50
CRBCHB	-	8.50	8.00	8.50

The pH levels of the CHB samples with added Cow manure with the exception of the sample with 20g added, all the CHB samples with added Goat manure and added Horse manure all exceeded or met the baseline of 9.00 - 9.50. this indicates that majority of the CHB samples bonded properly, evident from the results with the exception of the aforementioned sample with 20g of cow manure added to the concrete mix as well as all the samples with added carabao manure. These samples did not meet the pH levels of the standard for concrete, indicating that they did not bond properly thus explaining why their compressive strength value also failed to meet the standard as indicated in Table III.

V. CONCLUSION

This study concludes that the manures of goat, cow, and horse that added in Concrete Hollow Blocks when evaluated in terms of their compressive strength, pass and meet the compressive strength standards of the Philippine CHB. The evaluated pH values also back up this conclusion as the results indicate that the products for the sample with exception of the CHBs with carabao manure all bonded properly as they met the pH baseline standard for concrete products. This implies that the CHBs with added goat, cow and horse manures can be sold in the market and can be used as an alternative building material for structures that require load bearing CHBs as not only do they pass the standard but also have compressive strength on par on even above the commercial.

The researchers also in the process of conducting the study that the following should be recommended for the sake of future research. First is to incorporate the concrete slump test in the process of mixing the concrete to test workability of freshly mixed concrete as well as to identify the proper amount of water content needed for the concrete material. This is also to condition the soil and use to assess the fluidity and plasticity of the soil. Second, the researches could also increase curing time to 28 days for the most efficient method of increasing the material's ultimate strength. Third, the researchers can also play around the standard ratio of 1/2: 1: 7 for concrete mixes to see if another ratio could result better CHB, and finally, the researchers recommend to try changing the preparation of the animal manures to be used to see if it will have an effect on the overall CHB.

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