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(RESEARCH ARTICLE)

Potential of rice husk ash as cement alternative in constructing bricks: Utilization for "Gulayan sa Paaralan" program

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Abstract

This research aims to investigate the "Potential of Rice Husk Ash as Cement Alternative in Constructing Bricks: Utilization for 'Gulayan sa Paaralan' Program". The success of this study provides cheaper option of construction materials. The pandemic experience of the Philippines, economic deterioration became a challenge. Prices of prime commodities continuously increases, including the construction industry. Nowadays, there are various cement alternative being utilized inside and outside of the country. Some part here in the Philippines use fly ash as a cement alternative. But fly ash is not readily available in Laguna. That is why the researchers look for an alternative that is readily available, inexpensive and do not harm the environment. In this study, the researchers examine the potential of rice husk ash and they constructed bricks in which they plan to use for the beautification of school's garden.

In accordance with the governing specification of American Standard of State Highway and Transportation Officials (AASHTO) and American Society for Testing and Materials (ASTM), the researchers conducted a standardized laboratory test.

After series of test, researchers concluded that rice husk ash is not a significant alternative to cement as it reduce the strength and durability of the brick made out of it. However, since the chemical composition, fineness test, and water absorption test of rice husk ash and rice husk ash bricks passed the requirements of American Society for Testing and Materials, the researchers inferred that rice husk ash could still be used as additive in creating a decorative bricks.

Keywords: Rice husk ash; Cement; Bricks; Potential; Alternative

1. Introduction

Philippines currently experience economic deterioration. There is an increased in the price of common commodities. Every industry was affected by the inflation even the construction industry. But constructing and developing establishment is inevitable to progress. Bricks are essential material that serve as the foundation of every structures and establishments. It is made up of sand, gravel, water, and cement mixture that is mould into a rectangular prism shape. These bricks give stability, durability, and strength to the building one's is constructing. That is why it is important that the materials use in constructing these bricks are appropriate for its purpose. Like for the cement one's will going to use. Cement is a binding agent that hardens the concrete mixture needed in making bricks. Nowadays, there are a lot of commercial cement that is available for us to use. These cements vary in quality, specification, and price.

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There are studies that support the use of different alternative to cement in constructing bricks. Some part here in the Philippines even utilize the use of Fly ash as a cement alternative. But fly ash is not readily available here in Laguna. Also, fly ash which is made up of pulverized coal contain mercury, cadmium, and arsenic that pollutes the nearby water system, wildlife and environment (Dale, 2023). That is why the researchers looked for an alternative that is readily available, inexpensive and do not harm the environment. Which lead them to the idea of utilizing the Rice Husk Ash (RHA) as a cement alternative. Rice husks are protective coating of rice grain that is being removed during the milling process. It is an agricultural waste that most of the time do not serve any purpose. But since Santa Cruz, Laguna, Philippines is an agricultural area which means there are plenty of agricultural waste here like the rice husk after the milling. We all know that Philippines' one major problem is proper waste disposal. And this agricultural waste is hard to dispose, since burying it consume land that could be used to plant crops and burning it takes time as it does not readily/easily burn on open flare.

In this study, the researchers uncovered the potential of rice husk ash as cement alternative in constructing bricks. With that, series of investigations has been conducted by the researchers to provide the community an inexpensive and sustainable alternative that would cater their building and constructing needs. Inflation of common commodities have a huge impact to everyone. That is why the success of this research would somehow gives opportunity to the construction industry to have a price wise but durable bricks that they could utilize.

1.1. Statement of the Problem

This study aimed to find out the potential of rice husk ash as an alternative to cement in constructing bricks. As the researchers go along with the study, they have answered the following questions:

- What are the similarities and differences between the rice husk ash and commercial cement's properties in terms of
  - Fineness; and
  - Chemical composition?
- What is the potential of rice husk ash as an alternative to commercial cement in constructing bricks in terms of:
  - Water absorption;
  - Compressive strength; and
  - Flexural strength?
- Is rice husk ash a significant alternative to commercial cement in constructing bricks?

1.2. Significance of the Study

The researchers believed that this study uncovered the potential of rice husk ash as cement alternative in constructing bricks.

The result o-f the study merit the following:

- **Department of Public Works and Highways**. The department benefit from this study as they could develop a plan that would cut their expenses through the use of agricultural waste products like rice husk ash as an additive to their concrete use in construction and maintenance of the national infrastructure.
- **Department of Education.** The institution benefit from this study as they could use the bricks that the researchers produced for its "gulayan sa paaralan" program. The brick could be use as decorative brick and could be utilized as plant box.
- **Environment.** The researchers repurposed the rice husk that served as its method of waste disposal, since rice husk is already considered as agricultural waste. Through that the environment benefit from it as it reduced the accumulation of agricultural waste.
- **Community.** The study gave the community a option to utilize the rice husk ash as an additive to cement to cut down their constructing expenses. With the current state of our nation's economy having an inexpensive and efficient option is what our community needs.
- **Future researcher.** The results of this study may be used as foundation for future research. It also could provide them to data to further study the potential rice husk ash as an alternative cement in constructing bricks.

1.3. Scope and Limitation of the Study

This study revolved around the "Potential of Rice Husk Ash as Cement Alternative in Constructing Bricks". With that this research tackled the following objectives: compare the properties of rice husk ash and commercial cement; test the

potential of rice husk ash as cement alternative in constructing bricks; and determine if rice husk ash is a significant alternative in constructing bricks. Further, since this study is in quantitative research design, the researchers dealt with numerical data that was gathered through series of tests on the properties of rice husk ash like its fineness and chemical composition. The researchers tested the different mechanical and physical parameter of the rice husk ash bricks like the compressive strength, flexural strength, and water absorption using a standardized laboratory tests. The result was then interpreted by the laboratory where the tests was conducted. All in all, this study encompassed the second semester of the academic year 2022-2023.

However, this study excluded the other properties of the rice husk ash that do not affect its potential to be a cement alternative in constructing bricks. The product of this study is limited to bricks and the researchers did not be explore any other construction material as it may broaden their study. Moreover, this study did not investigate the other beneficial uses of rice husk ash aside from its use as cement alternative.

2. Material and Methods

2.1. Design

This study is a quantitative study in which determined the potential of rice husk ash as cement alternative in constructing bricks. Quantitative research focused on numerical data to objectively compare two variables (Research Guides, 2023). In this study the two variables that the researchers compared are the rice husk ash and the commercial cement. The potential of the rice husk ash as cement alternative depends on how far or near the result of the chemical analysis and fineness of rice husk ash cement to commercial cement. Also, this study found out how the rice husk ash decreased the strength and durability of the brick compare to commercial brick that is made out of the traditional cement.

In this scientific inquiry the researchers have the ash sample and brick sample undergone a standardize test. The laboratory where the chemical composition and fineness of the rice husk ash and commercial cement will be analyze requires 5 kilos per test according to AASHTO M 295 and ASTM C618-98 specification respectively. While on the other hand 3 samples of brick per each test (water absorption, compressive strength, and flexural strength) were require by the DOST- Forest Products and Research Development Institute to guarantee the accuracy of the results.

The results of the test was interpreted using comparative analysis in which the researchers found out the similarities and differences between the chemical and physical properties of rice husk ash as well as the commercial cement. Further, the mechanical and physical properties of the bricks made out of rice husk ash and commercially available brick made out of cement was also compared as it provide data for the assessment of the potential of rice husk ash as cement alternative in constructing bricks.

The product of this study will be utilize for the “Gulayan sa Paaralan” Program of the Department of Education to beautify the school garden of the researchers’ chosen school. Having that idea, the researchers assure the institution that the bricks made out of rice husk ash are suitable to be utilized as decorative brick.

2.2. Research Instrument

In this research, the researchers gathered data with the use of standardized tests. Tests were conducted in a laboratory specifically the DOST - Forest Products Research and Development Institute and Universal Testing Laboratory and Inspection Inc.-Calamba City, Laguna. With the helped of the helped of the Science Research Specialist and Chemist the researchers has determine the chemical composition of the rice husk ash and cement. Rice husk ash and commercial cemnet was subjected to AASHTO M 295 in which various chemicals were identified namely: Silicon dioxide, Aluminum oxide, Ferric oxide, magnesium oxide, sulfur trioxide, tricalcium silicate, dicalcium silicate, loss on ignition, and insoluble residue. These chemicals are needed as it give the pozzolan cement like rice husk ash the ability to bind with other raw materials that is use in making bricks. The rice husk ash was also subjected to ASTM C618-98 and it has identified the fineness of the rice husk ash as well as the cement. Afterwards, the bricks made out of rice husk ash cement and commercially available brick made out of cement was tested using the governing specification of ASTM C140. In this specification, the concrete specialist assessed the water absorption, compressive strength, and flexural strength of the bricks. To assure accuracy, it was done using three samples.

The results that the researchers have gathered were interpreted by the research analyst and chemist from the above mentioned laboratories.

2.3. Materials and Procedure

In turning the rice husk into an ash, the researchers used rice husk and make shift carbonizer made out of circular tin can and clay soil. Then they employed variety of raw materials specifically: sand, gravel, clay soil, grout powder, admixture, rice husk ash, and water. Further the researchers utilized the following tools namely: hand shovel, brick trowel, wood moulder, large tin can, strainer, and measuring cup.

The research procedures utilized were as follows:

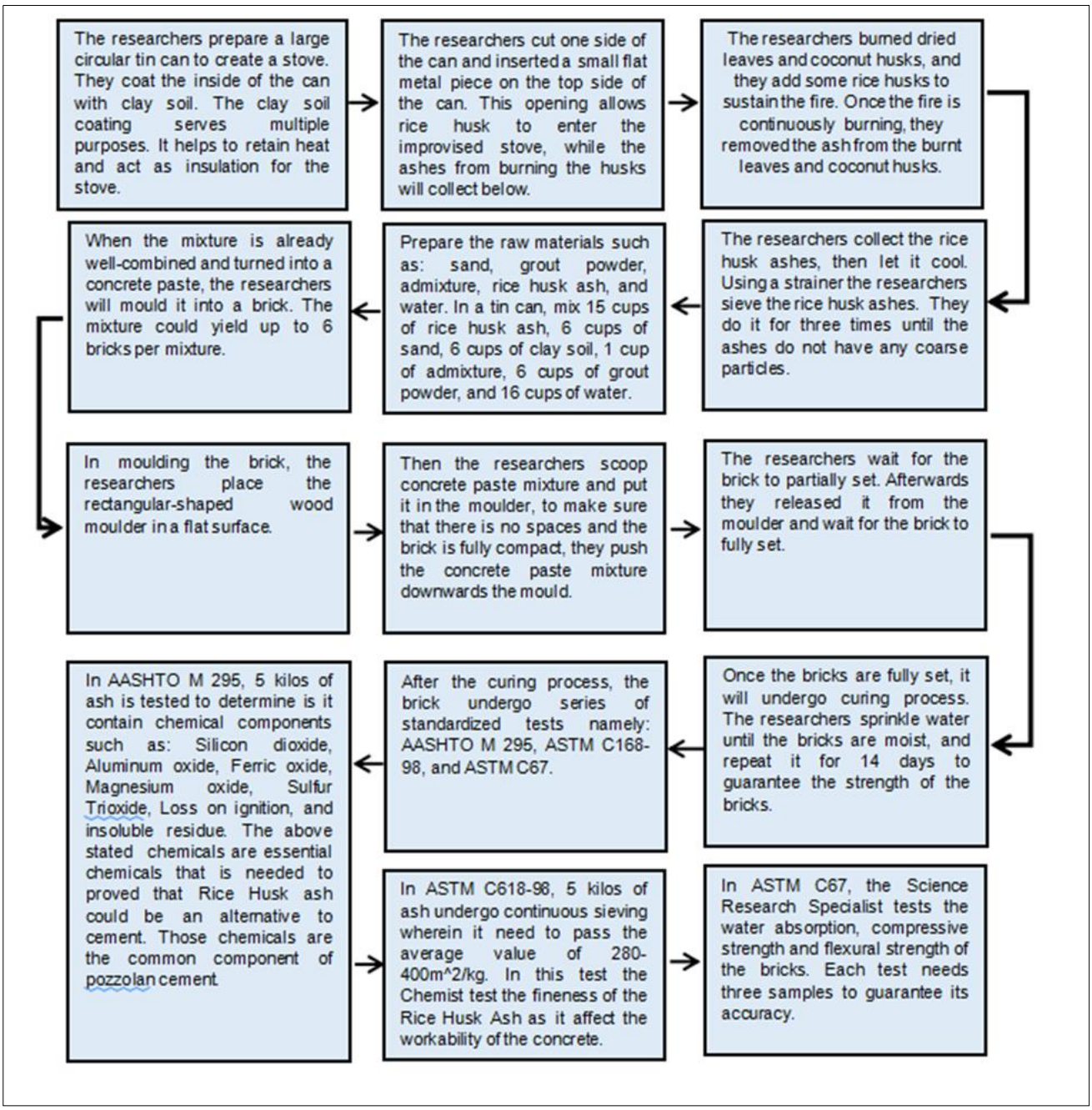

Figure 1 Research Procedures

In process of making a rice husk ash brick the researchers prepared a large circular tin can to create a makeshift carbonizer. The can was coated with clay soil to retain heat and act as insulation. One side of the can is cut, and a small flat metal piece is inserted to allow rice husks to enter the stove while collecting the ashes below. To make bricks, the

researchers gathered raw materials such as sand, gravel, admixture, rice husk ash, and water. They mixed these materials in specific proportions in a tin can, sieve the rice husk ashes, and molded the concrete paste mixture into bricks. After the bricks became partially set, they released it from the molder, and waited for it to be fully set before undergoing a curing process. During curing, the bricks are sprinkled with water for 14 days to ensure strength. After curing, the bricks undergone various tests, including chemical analysis, fineness test, compressive strength test, flexural strength test, and water absorption test.

3. Results and Discussion

This chapter presents the results, analysis and interpretation of data gathered from the laboratory test from Universal Testing Laboratory and Inspection INC. and Department of Science and Technology - Forest Products Research and Development Institute. The said data were presented in tabular form in accordance with the specific questions posited on the statement of the problem.

3.1. Similarities and Differences between the Properties of Rice Husk Ash and Commercial Cement

Table 1 Chemical Composition of Rice Husk Ash

Chemical found on 5kgs of Rice Husk Ash	Governing Specification	Test Method	Results (in Percentage)	Standard	Remarks	
					Passed	Failed
Silicon dioxide (SiO_2) + Aluminum Oxide (Al_2O_3) + Ferric Oxide (Fe_2O_3)	ASTM C618	Quality Test	79.0	50.0 min	✓	
Sulfur Trioxide (SO_3)	ASTM C618	Quality Test	0.62	5.0 max	✓	
Loss on Ignition	ASTM C618	Quality Test	0.76	6.0 max	✓	
Moisture Content	ASTM C618	Quality Test	2.34	3.0 max	✓	

It will be noted in Table 1 that rice husk ash contains various chemicals such as: 79% of Silicon dioxide, Aluminum oxide, and Ferric oxide as well as 0.62% of Sulfur Trioxide. It also indicates loss on ignition (0.76%) and moisture content (2.34%). The result demonstrate that under the governing specification of ASTM C618, Rice Husk Ash passed as binding, filler, compressive strength enhancer. More over its loss on ignition which is the mass of the ash that is loss when it was heated is very low having 0.76%. Moisture content of a cement alternative affect the strength and durability of the concrete that is why having 2.34% of moisture content could possibly affect the brick's strength but not drastically as it not reach the maximum amount of the allowed moisture content of a cement.

Table 2 Chemical Composition of Commercial Cement

Chemical found on 5kgs of Pozzolan Cement	Governing Specification	Test Method	Results (in Percentage)	Standard	Remarks	
					Passed	Failed
Magnesium oxide (MgO)	ASTM C-150	ASTM C114	2.69	6.00	✓	
Sulfur Trioxide (SO3)	ASTM C-150	ASTM C114	1.34	3.0 max	✓	
Loss on Ignition	ASTM C-150	ASTM C114	1.39	3.0 max	✓	
Insoluble residue	ASTM C-150	ASTM C114	0.37	0.75	✓	

The Silicon dioxide, Aluminum oxide, Ferric oxide and Sulfur Trioxide content of rice husk ash contribute to its potential to be a cement alternative. It is due to the fact that the above mentioned chemicals have binding and strengthening properties necessary for construction materials like cement (Fediuk et. al, 2020). Low level of moisture content and loss on ignition imply that rice husk ash as a cement alternative will not impose adverse effect as the time went on. Concrete's structure and durability will not be drastically affected by the presence of moisture and heat since concrete made out of rice husk ash could endure those kind of deteriorating factors (Ngo et. al., 2018).

There are numerous cement alternative that is being utilized around inside and outside the Philippines. What would be the edge of rice husk ash among the other alternative? Its workability and nature friendly properties. According to the study of Kobbe (1994), as cited by Fediuk et. al. (2020), sulfur containing concrete is advantageous in decreasing the brittleness and flammability of the construction material. With proper curing process, the sulfur-containing material would reach its full potential.

Data shown in table 2, that commercial cement sample contain 2.69% of Magnesium oxide, 1.34% of Sulfur trioxide, 0.37% of insoluble residue, and has 1.39% of loss on ignition. This indicate that the sample given by the researchers passed the governing specification of ASTM C-150 which means its quality meets the standard of the Type 1 Portland (Pozzolanic) cement.

Though, rice husk ash and pozzolan cement underwent different test, the above indicated results only shows that in terms of chemical composition if you will compare rice husk ash to cement they most likely to have the same properties. Magnesium oxide and Silicon dioxide, are the components of cement and rice husk ash respectively, that affect its strength, durability and setting time. If you could notice both of the sample passed the specified standard for the same amount of sample. They may not have the same chemical composition since they are made out of varied material but their chemical components have the same properties that suffice the requirements needed for it to be accepted as an alternative.

Table 3 Fineness of Rice Husk Ash

Physical Property	**Governing Specification**	**Test Method**	**Retained Particle (in percentage)**	**Standard**	**Remarks**	
					Passed	**Failed**
Fineness	AASHTO M295	Wet-seived on 45 micrometer no. 325 sieve	7.2	34 max	✓	

The physical property of the rice husk ash specifically its fineness, is reflected in Table 3. Using a 45 micrometer No. 325 sieve, the testing center measure the fineness of the rice husk ash which is 7.2% of retained particle through the process of wet seiving. The result showed a very low value and as stated by the lab chemist who tested the sample this amount is acceptable this only indicate that rice husk ash has a fine particle that passed the governing specification of AASHTO M295.

Table 4 Fineness of Commercial Cement

Physical Property	**Governing Specification**	**Test Method**	**Specific Surface (in cm^2/gram)**	**Standard**	**Remarks**	
					Passed	**Failed**
Fineness	ASTM C-150	ASTM C204	3280	2800 min	✓	

Based on the table 4, commercial cement has 3280 cm^2/gram surface which passed the specification of ASTM C-150. Using a Blaine Air Permeability Apparatus, the lab chemist identify the definite fineness of the cement. It is essential that a cement has an acceptable fineness as it affect the hydration rate also known as the setting time of the cement as it being mould into bricks.

3.2. Potential of Rice Husk Ash as Cement Alternative in Constructing Bricks

Table 5 shows the result of the water absorption test conducted to both commercial and Rice husk ash brick. After 24 hours of being soak in the water, rice husk ash absorbed 16.5 percent of water while commercial brick absorbed 8.4 percent of water. It may shows different result but it both passed the water absorption test.

Table 5 Comparison between Rice Husk Ash Bricks and Commercial Cement in terms of Water Absorption

Brick	Absorbed Water (in percentage)	Standard Amount (Maximum Percentage)	Remarks	
			Passed	Failed
Rice Husk Ash	16.5	25	✓	
Commercial	8.4	10	✓	

Table 6 Comparison between Rice Husk Ash Bricks and Commercial Cement in terms of Compressive Strength

Parameter	Commercial Brick	Rice Husk Ash
Maximum Load (in Newton)	53,847.42	720.79
Compressive Strength (in Mega Pascal)	7.69	0.12

Compressive strength of both commercial brick and rice husk ash brick is indicated in table 6. Commercial brick manage to endure 53, 847.42 Newton of load while rice husk ash only manage to endure 720.79 Newton of load. Further, the commercial brick's compressive strength is 7.69 MPa while rice husk brick is 0.12 MPa. This result indicates that compared to a first class commercial brick, the compressive strength of rice husk ash decreased by 7.57 MPa making it classified as a third class brick also known as decorative brick.

Table 7 Comparison between Rice Husk Ash Bricks and Commercial Cement in terms of Flexural Strength

Parameter	Commercial Brick	Rice Husk Ash
Modulus of Rupture (in Mega Pascal)	4, 373.33	150.52
Stress at Proportional Limit (in Mega Pascal)	4, 300.08	148.38
Modulus of Elasticity (in Giga Pascal)	10, 487.73	176.36

Flexural strength could be identify by measuring the modulus of rupture, stress at proportional limit and modulus of elasticity. In table 7, the researchers indicated the comparison between commercial brick and rice husk brick for the said parameters. The result shows that commercial brick has 4, 373.33 MPa of modulus rupture while rice husk brick has 150.52 MPa. The stress at proportional limit of Commercial brick is 4, 300.08 MPa while rice husk brick has 148.38 MPa. For its modulus of elasticity, commercial brick has 10,487.73 GPa and rice husk brick has 176.36 GPa.

4. Conclusion

Based from careful analysis and interpretation of the findings of the study, it was concluded that rice husk ash is not a significant alternative to cement in constructing bricks and therefore accept the null hypothesis of this study.

Rice husk ash contain chemical composition that is suitable to bind with construction material use to make a brick. It also passed the water absorption test required for light weighted brick. Unfortunately, rice husk ash brick did not passed the requirement for it to be utilize as engineering or first class brick since its compressive and flexural decreased drastically as they compare the result conducted to both first class brick and the rice husk brick. Even though rice husk brick did not passed the requirement it could still be use as third class brick or what we called decorative bricks. Third class bricks do not need to have high compressive and flexural test it only need to passed the water absorption test. The

said brick function as plant box, securing a downspout, path way, pavement, partition wall, and many non-load bearing part of the structure.

Recommendation

For the development and continuous innovation of the study, the following is being recommended to the future researchers:

- Explore various fine and coarse aggregates that could be use in order to increase the strength of the rice husk brick.
- In burning the rice husk, follow the standard temperature which is 500 to 700 degree Celsius, to ensure the quality of the rice husk ash and its appropriateness to be utilize as a cement.
- Follow the standard curing time of 28 days with consistent moisture exposure to enhance the compaction process of the concrete.
- Ignitability of the rice husk brick should be test in order to identify if it could function as refractory or fire exposed brick.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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