Characterization of Sugarcane Bagasse Banana Stem and Plastic Composite

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Abstract— On this modern age the composite materials are become the primary material for any engineering production and also they are playing a major role in engineering applications such as in automobiles, marine, aerospace, sports and various other fields because composite materials have several specific properties such as high strength to weight ratio, low cost, and ease of fabrication, high resistance to thermal which does not realize in pure material or non-composite material. Nowadays, reinforcing is done with natural fiber in place of synthetic fiber. Natural fibers are cheap and abundantly available. They are nontoxic and can be treated chemically in order to enhance the mechanical properties. In this project we will be using sugarcane Bagasse, banana stem and plastic as reinforcement of composite material. The composite formed by using waste materials need to be tested under various loading conditions to determine the improved mechanical properties. The main aspect of our project is to produce something useful out of waste materials.

Keywords: Reinforcing, Natural Fiber, Mechanical Properties, Bagasse, Banana Stem, Plastic

I. Introduction

Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. The volume and numbers of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly. Modern composite materials constitute a significant proportion of the engineered materials market ranging from everyday products to sophisticated niche applications. While composites have already proven their worth as weight-saving materials, the current challenge is to make them cost effective. The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry.

The composites industry has begun to recognize that the commercial applications of composites promise to offer much larger business opportunities than the aerospace sector due to the sheer size of transportation industry. Thus the shift of composite applications from aircraft to other commercial uses has become prominent in recent years. The introduction of newer polymer resin matrix materials and high performance reinforcement fibres of glass, carbon and aramid, the penetration of these advanced materials has witnessed a steady expansion in uses and volume. The increased has resulted in an expected reduction in costs. High performance FRP can now be found in such diverse applications as composite armoring designed to resist explosive impacts, fuel cylinders for natural gas vehicles, windmill blades, industrial drive shafts, support beams of highway bridges and even paper making rollers. For certain applications, the use of composites rather than metals has in fact resulted in savings of both cost and weight.

Some examples are cascades for engines, curved fairing and fillets of pre-existing structures that have to be retrofitted to make them seismic resistant, or to repair damage caused by seismic activity. Whilst the use of composites will be a clear choice in many instances, material selection in others will depend on factors such as working, lifetime requirements, number of items to be produced (run length), complexity of product shape, possible savings in assembly costs and on the experience & skills the designer in tapping the optimum potential of composites. In some instances, best results may be achieved through the use of composites in conjunction with traditional materials. 1.2 Definition of Composite According to Jartiz [1] ―Composites are multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics and sometimes in form‖. The weakness of this definition resided in the fact that it allows one to classify among the composites any mixture of materials without indicating either its specificity or the laws which should given it which distinguishes it from other very banal, meaningless mixtures. Kelly [2] very clearly stated that the composites should not be regarded simple as a combination of two materials. In the broader significance; the combination has its own distinctive properties. In terms of strength to resistance to heat or some other desirable quality, it is better than either of the components alone or radically different from either of them. Beghezan [3] defined as ―The composites are compound materials which differ from alloys by the fact that the individual components retain their characteristics but are so incorporated into the composite as to take advantage only of their attributes and not of their short comings‖, in order to obtain improved materials.

II. Materials and Methods

A. *Types of Fibers*

1) *Sugarcane Bagasse*

The sugar cane bagasse is a residue widely generated in high proportions in the agro-industry. It is a fibrous residue of cane stalks left over after the crushing and extraction of juice from the sugar cane. Bagasse is generally gray-yellow to pale green in colour. It is bulky and quite non uniform in particle size. The sugar cane residue bagasse is an underutilized, renewable agricultural material that consist of two distinct cellular constituents.

The first is a thick walled, relatively long, fibrous fraction derived from the rind and fibro-vascular bundles dispersed throughout the interior of the stalk. The second is a pith fraction derived from the thin walled cells of the ground tissue. The main chemical constituents of bagasse are cellulose, hemicellulose and lignin. Hemicellulose and cellulose are present in the form of hollow cellulose in bagasse which contributes to about 70 % of the total chemical constituents present in bagasse. Another important chemical constituent present in bagasse is lignin. Lignin acts as a binder for the cellulose fibers and also behaves as an energy storage system.

Properties	Sugarcane Bagasse
Density (g/cm³)	1.2
Tensile Strength (MPa)	20-290
Young's Modulus (GPa)	19.7-27.1
Elongation Break (%)	1.1

Table 1: Properties of sugarcane bagasse

Fig. 1: sugarcane Bagasse

2) *Banana Fiber*

The natural fibers are renewable, non-abrasive, bio-degradable, possess a good calorific value, exhibit excellent mechanical properties and can be incinerated for energy recovery have low density and are inexpensive. This good environmental friendly feature makes the materials very popular in engineering markets such as the automotive and construction industry. The incorporation of natural fibers with glass fiber improve the tensile and flexural strength and these composites can be used for medium strength applications. Natural fibers present important advantages such as low density, appropriate stiffness and mechanical properties and high disposability and renewability. Moreover, they are recyclable and biodegradable. There has been lot of research on use of natural fibers in reinforcements. Banana fiber, a ligno- cellulosic fiber, obtained from the pseudo stem of banana plant (Musa sepientum), is a bast fiber with relatively good mechanical properties. Banana plant is a large perennial herb with leaf sheaths that form pseudo stem. Its height can be 10-40 feet (3.0-12.2 meters) surrounding with 8-12 large leaves. The leaves are up to 9 feet long and 2 feet wide (2.7 meters and 0.61 meter).The chemical composition of banana fiber is cellulose, hemicellulose, and lignin.It has strong moisture absorption quality. It absorbs as well as releases moisture very fast.It is bio- degradable and has no negative effect on environment and thus can be categorized as eco-friendly fiber. At present the banana fiber is a waste product of banana cultivation, therefore without any additional cost these fibers can be obtained for industrial purposes. Banana fiber is a bast fiber with relatively good mechanical properties. Banana fiber has good specific strength properties comparable to those of conventional material, like glass fiber.

In the recent past, banana fiber had a very limited application and was primarily used for making items like ropes, mats, and some other composite materials. With the increasing environmental awareness and growing importance of eco-friendly fabrics, banana fiber has also been recognized for all its good qualities and now its application is increasing in other fields too such as apparel garments and home furnishing

Fig. 2: Banana Fiber

However, in Japan, it is being used for making traditional dresses like kimono, and kamishimo since the Edo period (1600-1868). Due to its being lightweight and comfortable to wear, it is still preferred by people there as summer wear. Banana fiber is also used to make fine cushion covers, bags, table cloths, curtains etc. Rugs made from banana silk yarn fibers are also very popular world over.

B. Plastic

Tensile strength: The tensile strength or the toughness of the plastics are dependent on the materials that are used in the production of the plastic. Usually, the tensile strength or the toughness of the plastics are less when compared to the alloys such as steel. Lightweight: They weigh less than that of the metals which makes their transportation easy or carrying them from one place to another becomes easy. Reactivity towards chemical: When plastics are compared with natural polymers such as cotton, wool, etc, plastics are not affected by the acids and alkalines.

1) Appearance: Usually plastics are transparent and can be coloured to desirable colours. Also, they can be moulded into shapes depending on their usages. Thermal conductivity: The thermal conductivity of plastics is low. That's the reason why they meltdown when they are brought in contact with the heat.
2) Electrical conductivity: Plastics are good insulators or bad conductors of electric current. This property or characteristic of plastic makes them popular in the manufacturing of switches, bulb-holders, the outer covering of the wires, etc.

Physical properties	Density	0,9-1,53 [g/cm³]
	Thermal conductivity	0,1 [W/mK]
	Linear thermal expansion coefficient	$73{,}8 \cdot 10^{-6}$ [m/mK]
	Temperature range of usefulness	-20-80 [°C]
Mechanical properties	Tensile strength	22 [MPa]
	Tensile modulus	1360 [Mpa]
	Tensile elongation	6 [%]

Table 2: properties of plastic

Fig. 3: Plastic

C. Epoxy Resin

Epoxy refers to any of the basic components or cured end products of epoxy resins, as well as a colloquial name for the epoxide functional group. Epoxy resins, also known as polyepoxides, are a class of reactive prepolymers and polymers which contain epoxide groups.

Epoxy resins may be reacted (cross-linked) either with themselves through catalytic homopolymerisation, or with a wide range of co-reactants including polyfunctional amines, acids (and acidanhydrides), phenols, alcohols and thiols (usually called mercaptans). These co-reactants are often referred to as hardeners or curatives, and the cross-linking reaction is commonly referred to as curing Reaction of polyepoxides with themselves or with polyfunctional hardeners forms a thermosetting polymer, often with favorable mechanical properties and high thermal and chemical resistance. Epoxy has a wide range of applications, including metal coatings, use in electronics/electrical components/LEDs, high tension electrical insulators, paint brush manufacturing, fiber reinforced plastic materials, and adhesives for structural and other purposes.

D. Araldite HY 951 Epoxy Hardener

The Araldite HY 951 Epoxy Hardener is mixed with epoxy resin for coating or encapsulating electronic components which work at low voltages. This hardener is a clear liquid with a flash point of 110 degrees centigrade, mix ratio 100:10 and specific gravity is 0.98 gm/cm3 at 25 degrees centigrade. The hardener is capable of producing medium-viscosity adhesives in order to bond ceramics, glasses, rubbers, plastics and other substrates. Mix this hardener with resin thoroughly at room temperature. You can easily apply this hardener over the large surfaces of substrates. The Araldite HY 951 Epoxy Hardener is admired for good resistivity against chemical & atmospheric conditions, excellent mechanical strengthand better electrical properties

E. Preparation of the Specimens

1) Method 1(Sugarcane Bagasse, Banana fiber, and Plastic)

a) Materials required

- Sugarcane Bagasse
- Banana fiber
- Plastic
- Epoxy resin
- Beaker(250 ml)
- Stirrer
- Magnetic stirrer
- Hardener(Araldite HY 951 Epoxy Hardener)
- Digital balance meter
- Stop watch
- Roller
- Brush
- Die or Pattern
- Silica gel

b) Procedure

- At first bottom of mold is covered by a plastic sheet.
- Gel coat is applied to the plastic sheet by using a brush.
- 150 gm of epoxy resin is taken in a beaker.
- Resin was mixed with hardener in the ratio of 10:1.
- Roll stock sugarcane bagasse is manually placed on the mold.
- Laminating resin is applied by pouring and brushing.
- Then pieces of plastic is placed over the resin coating
- Laminating resin is applied by pouring and brushing
- Roll stock banana fiber is manually placed over it.
- Laminating resin is applied by pouring and brushing.
- FRP Roller or Paint Roller is used to consolidate the laminate through wetting the reinforcement and remove the entrapped air.
- Subsequent layers of banana reinforcements are added to build laminate thickness.
- Mold was kept in the sunlight for 48hrs.

F. Mechanical Behaviour Testing

The materials exhibiting in universe exhibits several mechanical characteristics. The composite material thus manufactured is tested for several mechanical characteristics. The different tests are explained below:

1) Tensile Test

ASTM D638, ISO 527

a) Scope

Tensile tests measure the force required to break a specimen and the extent to which the specimen stretches or elongates to that breaking point. Tensile tests produce a stress-strain diagram, which is used to determine tensile modulus. The data is often used to specify a material, to design parts to withstand application force and as a quality control check of materials. Since the physical properties of many materials (especially thermoplastics) can vary depending on ambient temperature, it is sometimes appropriate to test materials at temperatures that simulate the intended end use environment.

b) Test Procedure

Specimens are placed in the grips of the Instron at a specified grip separation and pulled until failure. For ASTM D638 the test speed is determined by the material specification. For ISO 527 the test speed is typically 5 or 50 mm/min for measuring strength and elongation and 1 mm/min for measuring modulus.

Specimen size

Test : Tensile Test

Area :143.14 mm^2

Diameter : 13.50 mm Shape : Round

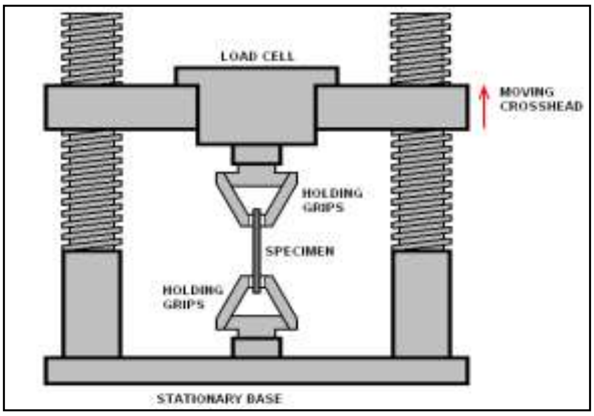

Fig. 4: Tensile Testing Setup

2) Flexural Property Testing

ASTM D790, ISO 178

a) Scope

The flexural strength measures the force required to bend a beam under three point loading conditions. The data is used to select materials for parts that will support loads without flexing. Flexural modulus is used as an indication of a material's stiffness when flexed. Since the physical properties of many materials (especially thermoplastics) can vary depending on ambient temperature, it is sometimes appropriate to test materials at temperatures that simulate the intended end-use environment.

b) Test procedure

Most commonly the specimen lies on a support span and the load is applied to the centre by the loading nose producing three point bending at a specified rate. The parameters for this test are the support span, the speed of the loading, and the maximum deflection for the test. These parameters are based on the test specimen thickness and are defined differently by ASTM and ISO. For ASTM D790, the test is stopped when the specimen reaches 5% deflection or the specimen breaks before 5%. For ISO 178, the test is stopped when the specimen breaks. Of the specimen does not break, the test is continues as far a possible and the stress at 3.5% (conventional deflection) is reported.

Fig. 5: Flexural Testing Setup

Specimen size

Test : Flexural Test Area

: 147.20 mm²

Diameter : 13.69 mm

Shape : Round

2.7.3 Compression Testing

a) Scope

The goal of a compression test is to determine the behavior or response of a material while it experiences a compressive load by measuring fundamental variables, such as, strain, stress, and deformation. By testing a material in compression the compressive strength, yield strength, ultimate strength, elastic limit, and the elastic modulus among other parameters may all be determined. With the understanding of these different parameters and the values associated with a specific material it may be determined whether or not the material is suited for specific applications or if it will fail under the specified stresses

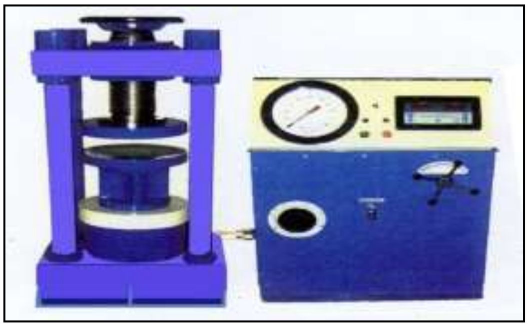

Fig. 6: Compression Testing Setup

b) Test Procedure

A compression test is any test in which a material experiences opposing forces that push inward upon the specimen from opposite sides or is otherwise compressed, "squashed", crushed, or flattened. The test sample is generally placed in between two plates that distribute the applied load across the entire surface area of two opposite faces of the test sample and then the plates are pushed together by a universal test machine causing the sample to flatten. A compressed sample is usually shortened in the direction of the applied forces and expands in the direction perpendicular to the force. A compression test is essentially the opposite of the more common tension test

c) Specimen Size

Test : Compression Test

Area :493.92 mm²

Width : 22.05 mm

Thickness : 22.40 mm

Shape :Rectangle

3) Hardness testing

a) scope

Brinell hardness testing is a general method for measuring the bulk hardness of metallic and polymer materials. Although hardness testing does not give a direct measurement of any performance properties, hardness of a material correlates directly with its strength, wear resistance, and other properties.

b) Test Procedure

To start the test, the indenter is "set" into the sample at a prescribed minor load. A major load is then applied and held for a set time period. The force on the indenter is then decreased back to the minor load. The brinell hardness number is calculated from the depth of permanent deformation of the indenter into the sample, i.e. the difference in indenter position before and after application of the major load. The minor and major loads can be applied using dead weights or springs. The indenter position is measured using an analog dial indicator or an electronic device with digital readout.

Specimen Size

Test : Hardness Test

Area :493.92 mm²

Width : 22.05 mm
Thickness : 22.40 mm
Shape :Rectangle

III. RESULTS AND DISCUSSIONS

The mechanical properties of this composite material is evaluated through several tests and their results are discussed below.

A. Tensile test

The different specimen samples are tested in tensile testing machine(UTM) and the samples are left to break till the ultimate tensile strength occurs. Force- displacement curve is plotted for the determination of breaking stress and breaking load. The test results are explained below.

SI.NO	Specimen	Tensile strength (Mpa)	Tensile Modulus (Mpa)
1	Sugarcane Bagasse	45	1710
2	Banana fiber	42.476	249.85
3	Plastic	37.23	1551.321

Table 3: Tensile P Properties Of Composite

1) Displacement Vs Force Graph

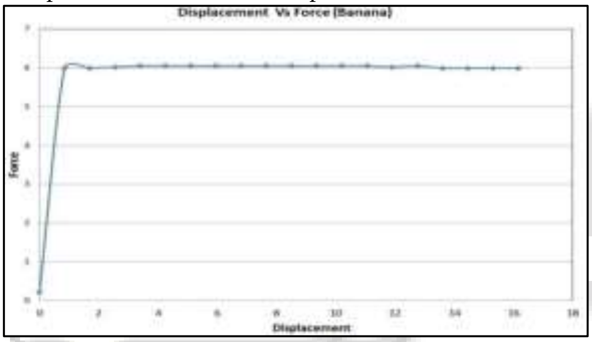

Fig. 7: Displacement Vs Force (Banana)

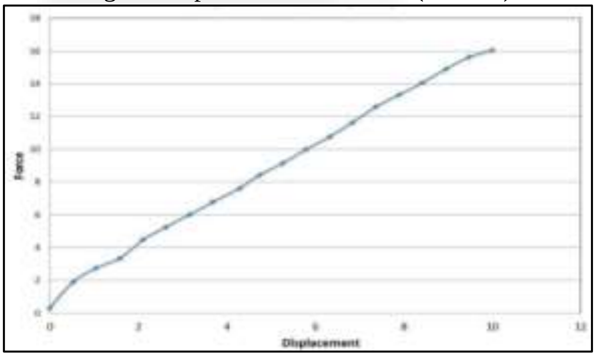

Fig. 8: Displacemet Vs Force (Sugarcane bagasse)

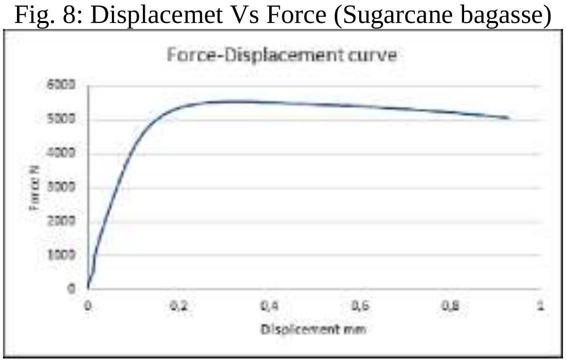

Fig. 9: Displacement vs force (plastic)

B. Flexural Test

The flexural strength of the samples are tested and their results are shown in the following table

SI.NO	Specimen	Flexural Strength(Mpa)	Flexural Modulus(Mpa)
1	Sugarcane bagasse	25.91	442.14
2	Banana fiber	2.134	23.37
3	Plastic	40	2500

Table 4: Flexural properties of composite

1) Displacement Vs Force Graph

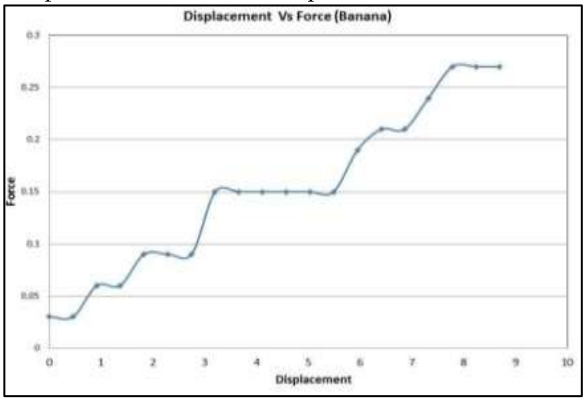

Fig. 10: Displacement Vs Force (Banana)

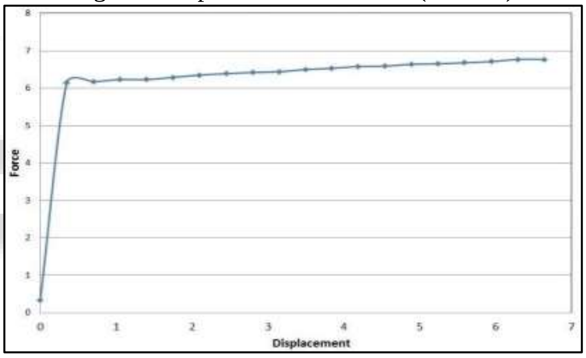

Fig. 11: Displacement vs Force (Sugarcane bagasse)

C. Compression Test

SI.NO	Specimen	Compression Strength(Mpa)	Compression Modulus(Mpa)
1	Sugarcane bagasse	80.951	2495.34
2	Banana fiber	40.856	1288.86
3	Plastic	40	1500

Table 5: Compression properties of composites

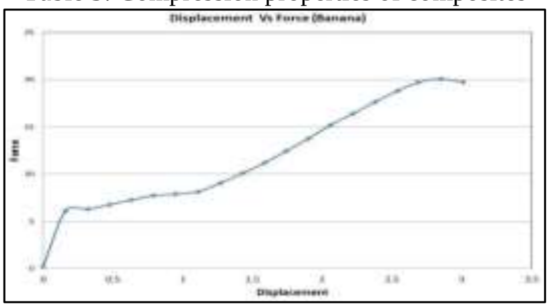

Fig. 12: Displacement vs Force (Banana fiber)

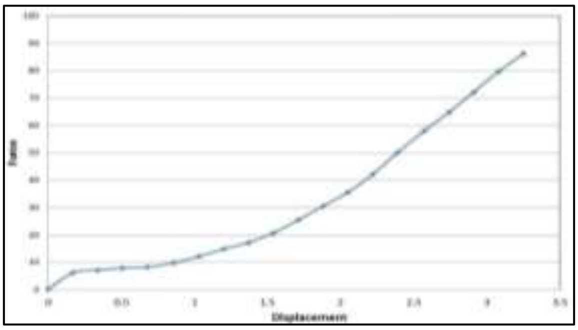

Fig. 13: Displacement Vs Force(Sugarcane bagasse)

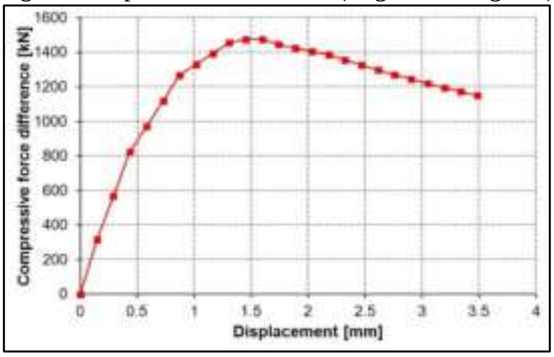

Fig. 14: Displacement Vs Force (Plastic)

D. Hardness Test

SI.NO	Specimen	Hardness Strength(HRB)
1	Sugarcane bagasse	73
2	Banana fiber	62
3	Plastic	92

Table 6: Hardness Properties of Composite

IV. Conclusion

This Experimental investigation of mechanical behaviour of sugarcane bagasse, banana fiber and plastic composite leads to the following conclusions.

- This work shows that successful fabrication of a fiber reinforced composites with different fiber lengths is possible by simple hand lay-up technique.
- The composite was characterized and synthesized through the various mechanical tests and also the results were compared.
- The mechanical property such as tensile strength and flexural bending strength of polyester resin has been improved by a great extent due to the presence of plastic and banana fiber reinforcement.
- Natural fiber reinforced composites are used in many engineering applications, because of its superior properties such as specific strength, low weight, low cost, fairly good mechanical properties, non-abrasive, ecofriendly and bio-degradable characteristics. Incorporation of natural fibers with GFRP can improve the properties and used as an alternate material for fiber reinforced composites.
- From all the results, it is observed that banana fiber can be used as a replacement for plstic in several industrial applications, since natural fibers are highly biodegradable and environment friendly.

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