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# "AN STUDY OF CONCRETE WITH FIBRES FROM JUTE THAT REINFORCED IN CONCRETE PARTIALLY AND METAKAOLIN PARTIALLY ADDED IN CEMENT AS REPLACEMENT"

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ABSTRACT- Natural fiber-reinforced composites are becoming more popular as a result of the low cost and high specific properties of the fiber. These are biodegradable and non-abrasive materials. Natural fiber composites have unique features when compared to standard fiber reinforced composites. The major goal of this research is to see if jute and coir fibers can be used as reinforcement materials in natural composites. The physical and mechanical properties of the jute/coconut coir reinforced polymer matrix composite are assessed to identify hardness, flexural, and tensile qualities in order to characterize the composite materials and gain a better knowledge of them. Due to the obvious higher wt% of jute fiber, the composite with 85 percent jute and 15% coconut has a higher tensile strength. Concrete is the most common and versatile building material, and it's typically utilized to withstand compressive forces. The different qualities of concrete can be improved by adding pozzolanic minerals as admixtures. Many modern concrete mixes include admixtures that improve microstructural characteristics while also reducing calcium hydroxide concentrations through a pozzolanic reaction. Metakaolin is a highly efficient cementitious pozzolanic material that can quickly react with excess calcium hydroxide produced by pozzolanic hydration of OPC to create calcium silicate hydrate and calcium alumino silicate hydrates. The existing supplies of natural sand are becoming depleted due to the growing rise of construction activities.As a result, it is important to substitute an alternative material for natural sand in concrete, either partially or totally, without compromising the concrete's quality.

*Keywords: Jute Fiber, Cement, Metakaolin, Aggregate, Concrete etc.*

## 1. INTRODUCTION

Concrete is one of the most frequently utilized and adaptable building materials on the planet. Cement output has increased dramatically as the world's population and construction needs have grown. Cement manufacture entails the emission of enormous amounts of damaging CO2 gases as well as the creation of other waste elements. New concepts in cement or concrete production will result in a reduction of detrimental environmental effects. Concrete is made from cement, which is used in vast amounts, yet only a small amount of concrete is recycled globally. The ongoing expansion of the global economy is driving up demand for construction materials, and substituting other elements for cement without sacrificing concrete strength can be extremely beneficial to the environment.

The use of short discrete fibers in concrete has gained popularity in recent years due to its several advantages over plain concrete. Jute is a low-cost natural fiber with a large supply. As a result, combining jute fiber and concrete could be one of the most essential ways to concrete technology development. The goal of this research is to compare the mechanical properties of jute fiber reinforced concrete (JFRC) with plain concrete for various combinations of fiber volume and length. Compressive, split tensile, and flexural strength tests were performed on cylinders and prisms of standard diameters containing JFRC, and all tests were completed after 28 days of moist curing. For a higher volume fraction of Jute fiber content, the compressive strength of concrete will be reduced less, and the ductility of concrete will gradually rise in the post-cracking stage due to the inclusion of jute fiber. The use of natural fibers in concrete results in environmentally friendly concrete, which is also known as a sustainable material [18]. Jute fibers have a small diameter and improve the flexural characteristics of concrete. Because of its shorter length, it can achieve fiber dispersion and consistency in the mix. Concrete with jute fibers has a higher permeability than concrete without. However, the amount of fibers added to the concrete should be limited to 0.5-0.6 percent by volume.

Metakaolin (MK) is a pozzolanic substance created by calcining kaolinitic clay between 500 and 800 degrees Celsius. When compared to other industrial pozzolans, MK is a manufactured product whose quality is controlled during the manufacturing process, resulting in more stable properties. MK's manufacturing technique, on the other hand, is connected with higher costs and environmental effect, making its current use commercially viable only in nations with large clay reserves.Although MK was first employed for dam construction in the 1960s, its potential in natural fiber-reinforced cementitious matrices has yet to be completely explored, and there have been just a few research on the subject. MK causes a pozzolanic reaction, in which it reacts with CH and utilizes it to generate extra cementitious materials such as calcium silicate hydrates (C–S–H), calcium-aluminium-

silicate hydrates (C-A-S-H), and calcium aluminate hydrates (C-A-H), resulting in increased cured material strength and decreased alkalinity of the responding environment.

**METAKAOLINE**

In paste, mortar, and concrete operations, metakaolin (MK) was used up to 30% as a partial replacement for cement. MK is created in this project by calcining kaolin clay cement mortar with a high volume MK as a component ingredient (up to 50%). Temperatures ranging from 700 to 900°C were used. Cement was tested as a clay substitute after 28 days. The MK's two major oxides are silica and alumina. By partially replacing cement with MK, the curing process can be sped up. Mechanical and durability properties of cement-based composites the reaction, the fineness of MK, and the speeding up of cement hydration, which is equivalent to silica fume, could all be to blame for the increase in concrete compressive strength when MK is used.MK is being used as a cement substitute. Although the permeability of cement-based systems containing MK may increase in the influence of MK, the pore structure is refined. The pore refinement of pastes appears to be improved the most when cement is replaced with 20% MK. Because MK is a pozzolanic substance, it lowers the amount of Calcium Hydroxide (CH) in a cement-based system. When cement is partially replaced with MK, the combo of pore refining and decrease in CH leads to better durability.

Metakaolin is made up of active forms of silica and alumina that, like other mineral admixtures, combines with calcium hydroxide at room temperature to generate calcium silicate hydrate (C-S-H)-gel, which boosts concrete density and decreases porosity. As a result, the concrete's permeability is reduced while its durability is increased. When used in concrete, it will function as filler, entering into the spaces (space) between the cement particles, making the concrete more impermeable.

**JUTE IN CONCRETE**

Engineers must use suitable technology to use natural fibers and local building materials as efficiently, financially, as much as potential in order to generate good performance but low-cost fiber-reinforced cementitious components (FRCCs) for house building and other necessitates in several more developing countries, where natural fibers of different origin are available in abundance.


**Fig. 1 Jute Fibers & Coconut Fibers [4]**

Jute fiber is a three-dimensional composite made up mostly of cellulose, hemicelluloses, and lignin, with tiny quantities of protein and inorganic materials. When compared to other fibers such as sisal, bamboo, coir, and hemp, jute has a high tensile strength. Apart from its tensile strength, jute fiber is also heat resistant.

Natural fibers derived from plants are divided into three groups based on the plant component from which they were collected. The first is the so-called fruit fiber (e.g., coir, cotton), which is derived from the plant's fruits. The second type of fiber may be discovered in the plant's stems (e.g., jute, flax, ramie, hemp, etc). Bast fiber is a term for certain types of fibers. The fibers taken from the leaves are the third group (e.g., sisal, date palm, oil palm, etc.).

Polymer altered jute fibers have been chosen as a reinforcing component in cement concrete, with the polymer acting as a chemical bridge between the jute and the cement solely on a single side and the cement on the other. Polymer altered jute fiber is expected to function as a flexible reinforcing component in cement concrete due to its flexibility, enabling it to transmit both static and dynamic loads while also absorbing some of the stress. In cement concrete, an optimal weight fraction of polymer modified jute fiber may lead to outstanding mechanical qualities. Alteration of jute fiber with polymer is expected to lessen the possibility of deterioration.

Jute fiber is completely biodegradable and recyclable, making it eco-friendly. Jute, is also known as The Golden Fibers, is a natural fiber with a gold and silky sheen. Jute is a low-cost vegetable fiber that is obtained from the vast or skin of the plant's stem. In terms of usage, worldwide consumption, production, and availability, it is the second most important vegetable fiber after cotton. It has a high tensile strength, low resilience, and allows fabrics to breathe easier. As a result, jute is best suited for bulk packaging of agricultural materials. It aids in the production of high-quality industrial yarn, cloth, net, and bags.It's one of the most versatile natural fibers, with applications in packaging, textiles, non-textiles, building, and agriculture. When yarn is bulked, it has a lower breaking tenacity and a higher breaking extensibility when combined as a ternary blend.For the construction of low-cost homes, concrete with Jute fiber was utilized as roofing and ceiling material, as well as wall panels. Applications where energy absorption is the major requirement or where impact damage is anticipated to occur, such as shatter and earthquake resistant buildings, benefit from their unique acceptance. Other suitable uses include cellular foundation rafts and beams,

pavements, slabs, and different types of shell constructions. Of course, the capacity of designers and builders to take advantage of static and dynamic strength parameters, energy-absorbing qualities, material performance features, acoustic and thermal behavior is required for all conceivable uses of concrete containing Jute fiber.

## 2. LITERATURE REVIEW

**Filip Majstorovi´c et-al., [2022] –** The given study was on the effect of Portland cement replacement with metakaolin to determine the mechanical behavior of flax fabric-strengthened cementitious matrices (TRCM). The composition of cementitious matrices and in-situ flax fibers were decided by the use of X-ray diffraction and thermo gravimetric evaluation, even as the reinforcement efficiency of the textile and mechanical conduct of TRCMs was investigated by way of 3-factor bending exams and finite element analysis. High quantities of computer substitute with metakaolin furnished a calcium hydroxide-loose environment, extra appropriate for the natural fibers, to keep away from their degradation and embrittlement and, for that reason, notably contribute to the ductility of the cement-primarily based composite material. [1]

**Gaurav Chand et-al., [2021] –** The present study proposed a sustainable way to the non-eco-friendly method of cement manufacturing, without compromising the satisfaction of produced concrete. Inside the number one levels of the research undertaken, cement is replaced with distinct cementitious substances like glass powder, metakaolin and silica fume exclusive probabilities by weight. After carrying out mechanical houses tests, the most useful substitute probabilities are obtained and therefore a quaternary combo of hybrid concrete is prepared to contain cement + glass powder + metakaolin + silica fume, within the ratio 60:20:05:15thier. The final check outcomes show a boom in compressive electricity of hybrid concrete via 13.42% compared to manipulate mix after 28 days of curing. Additionally, a moderate discount of 11.44% strength at 28 days in acidic surroundings is noticed as opposed to the 17.92% reduction on top of things mixed in equal surroundings. The micro structural investigation performed underneath scattered electron microscope (SEM) validates the development of energy imparting compounds like calcium silicate hydrate (C–S–H) and calcium alumino-silicate hydrate (C-A-S-H), leading to the dense formation of microstructure. [2]

**R. Rajkumar et-al., [2021]** – The current work covers an experiment that was carried out to explore the flexural behavior of Reinforced Concrete beams using metakaolin as a partial replacement for cement and marble powder as a partial substitute for river sand in the concrete preparation process. In this experiment, the percentage replacement of cement by metakaolin was 0, 2, 4, 6, and 8% by weight of cement, and the percentage replacement of sand by marble powder was 20, 15, 10, 5, and 0%. The mechanical characteristics of normal and modified concrete, such as compressive and split tensile strength, are investigated. Five RC beams, each measuring 150 200 1500 mm, were cast and tested under four-point loading. The first fracture load, ultimate failure load, and beam deflection were all measured. Metakaolin and marble powder can be implemented as alternate construction materials at lower % replacement levels, according to the findings. [3]

**Chandra Prakash Singh et-al., [2021] –** The research aimed to determine the properties of jute and coir fibers, to utilize them as reinforcement materials in the concrete. For this, the hardness, flexural strength and tensile properties of the fibers were examined. To obtain the best result, varying percentages of jute fibers and coconut choirs were added to the concrete to make different batches for testing. Among all the batches, the maximum tensile strength was found to be in the one with the higher percentage of jute fibers. The mixed batch with 85% jute fibers and 15% coconut fibers gave the maximum tensile strength. The mixed batch with 50% jute fibers and 50% coconut fibers was found to be a little brittle and ductile. The results were concluded that composite specimens are far better than coir specimens. [4]

**M Arun Kumar et-al., [2021] –** The author had taken self-compacting concrete with the metakaolin and plastic fiber introduced in the concrete. Their influence had been taken as an item for the research study. The plastic fibers were added to self-compacting concrete with five different ratios of 0%, 0.25%, 0.5%, 0.75% and 1%respectively. The fresh mix batches were subjected to the L-box test, U-box test and V-box test. The hardened mix batched was subjected to split tensile test, flexural strength test and compressive strength test. The fresh concrete properties proved that the passing and filling capability of self-compacting concrete was weak due to the introduction of plastic fiber. The hardened concrete properties showed that the metakaolin and plastic fiber had a great impact on the strength of self-compact concrete. [5]

**Roja A. Nambiar et-al., [2021] –**The research aimed to figure out the characteristics of excessive performance Concrete (HPC) by using partially changed silica fume (10%) and fly ash (20%) with concrete. in this analysis, compressive energy of concrete values for distinct trial combo ratios turned into determined on the 7th, 14th and 28$^{th}$day. using this outcome, samples are cast with a consistent water-to-cement percentage (w / c = zero.28), retained for curing. The observer's number one intention is to observe and pick out the most suitable dosage of super plasticizer, alternative cement with one of a kind ratios of silica fume and fly ash and compare the mechanical characteristics like compressive and break up tensile electricity of HPC with Silica Fume and Fly ash with addition of herbal fiber (jute) and later on observe afterwards look at the sturdiness properties like vorticity, acid assault, etc. the subsequent result showed that the concrete also works better in mechanical and sturdiness characteristics with jute at 1 per cent than every other concrete. [6]

**A. Banjo Akinyemi et-al., [2020] –** The author has introduced bamboo in the concrete and the mixed batches of the same had been subjected to some treatments like hot water, microwave-assisted sodium hydroxide and sodium hydroxide. The specimens were subjected to curing for 7, 14 and 28 days. They were also subjected to mechanical testing on those days. Among all the microwave tests, the microwave-assisted alkali treatment showed the best results. [7]

**Levente Ferenc Toth et-al., [2020]** –The study was about understanding the behavior of tribological behavior of the concrete reinforced with inorganic and organic materials. The basalt and jute fibers were the inorganic and organic materials respectively. For the research, 12 different tribo composites were developed and were tested in contrast to AISI 100Cr6 steel counter face. Although, the evidence that the composites when blended with PTFE gave the lowest coefficient of friction and longest service life and $MoS_2$ jam-packed tribo composites had the highest coefficient of friction. The leading wear mechanisms for the failure of all investigated composites were thermal degradation and delaminating, and abrasion. [8]

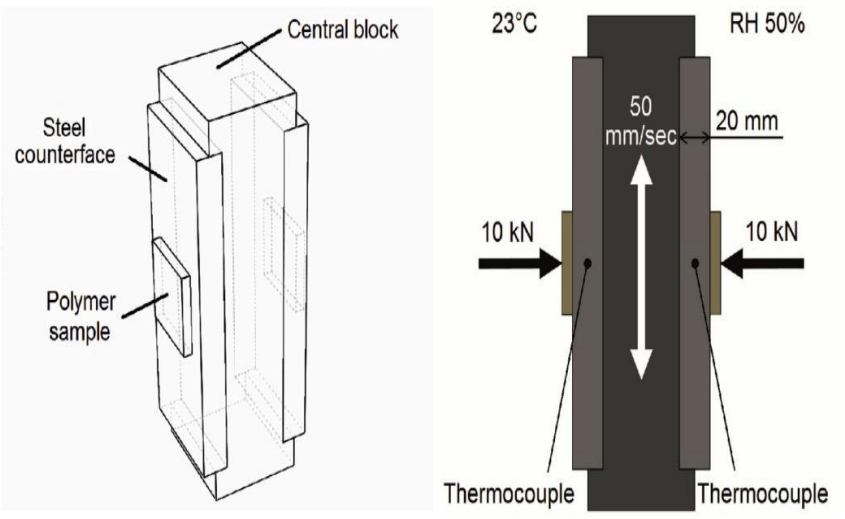


**Fig. 2 Schematic representation of reciprocating flat-on-flat tribotester [8]**

**M Kalaivani et-al., [2020] –** Plastic waste is the primary purpose of environmental pollution and for this reason; it should be recycled or reused to lessen it. This study investigates the impact of using plastic waste as an alternative for quality aggregate. The pet plastic bottle is injurious to land and fitness, therefore the usage of plastic waste inside the concrete will cause shield the surroundings and human health. The partial replacement of great aggregate and coarse combination is the primary components within the concrete. In India heaps of plastic wastes are produced according to 12 months for this reason way of reusing inside the concrete can decrease the wastages. The jute fiber is one of the natural fibers and it is used in plastic waste concrete to grow the cut-up tensile electricity and flexural strength of the concrete. The prevailing examination has been conducted on M20 grade concrete, with the aid of changing fine aggregate through pet plastic waste for varying possibilities such as five, 10, 15 and 20%. The pet plastic concrete is optimized as 10% from the mechanical homes of concrete. The jute fiber is brought for 0.25, 0.5, 0.75, and 1% for diverse proportions by using the quantity of optimized plastic waste concrete. The homes of sparkling and hardened concrete were evaluated and compared. The experimental effects of partner specimens show that the mechanical residences of plastic waste concrete increase with 0.25% of jute fiber in concrete. Utilization of M Sand and pet plastic aggregates in concrete leads to limit the fee of production and leads to sustainable environments. The herbal fibers in the concrete boom the strength of concrete. [9]

**Olatokunbo M. Ofuyatan et-al., [2020] –** The research was aimed to look at the properties of self-compacting concrete (SCC) evolved in the use of eggshell powder (ESP) and granulated ground blast furnace slag (GGBFS) as partial cement replacement. The coarse combination effect became 21.6% and the water absorption of the great aggregates became 24 wt%. 10 wt% partial substitutes were choicest for glide-ability and workability. Self Compacting Concrete with 20 wt% partial replacements had the best compressive electricity at 41.34kN/mm2 and 42.4kN/mm2 for ESP and GGBFS respectively after28 days of curing. SCC with 20 wt% partial replacements had the best flexural electricity at 3.2kN/mm2 for both ESP and GGBFS after 28 days of curing. From the micro structural evaluation, partial alternative with mineral admixtures improved the interfacial interactions among parts of the concrete and GGBFS SCC gave a better interfacial interaction among the concrete materials than ESP SCC. In summary, GGBFS had higher fresh, difficult and micro structural houses than ESP. [10]

Mechanical properties of polyester and vinyl ester based tribocomposites. All deviations are related to ±1σ.

| Materials | Tensile strength [MPa] | Flexural strength [MPa] | Hardness Shore-D |
|---|---|---|---|
| UPE/B/PTFE/2 | 152.9 ± 6.1 | 92.5 ± 4.6 | 82 ± 2.05 |
| UPE/B/POM/2 | 150.4 ± 7.5 | 94.4 ± 3.7 | 80 ± 2.00 |
| UPE/B/$MoS_2$/2 | 148.6 ± 4.5 | 95.9 ± 2.8 | 84 ± 2.10 |
| UPE/B/PTFE/4 | 156.2 ± 7.8 | 96.2 ± 4.3 | 81 ± 2.03 |
| UPE/B/POM/4 | 152.5 ± 3.8 | 93.5 ± 3.5 | 74 ± 1.85 |
| UPE/B/$MoS_2$/4 | 150.4 ± 8.3 | 92.2 ± 2.1 | 79 ± 1.98 |
| UPE/J/PTFE/2 | 29.1 ± 2.3 | 23.4 ± 1.2 | 76 ± 1.90 |
| UPE/J/POM/2 | 28.4 ± 1.2 | 31.4 ± 0.9 | 73 ± 1.14 |
| UPE/J/$MoS_2$/2 | 26.3 ± 1.8 | 32.5 ± 2.4 | 75 ± 1.88 |
| VE/B/PTFE/4 | 329.1 ± 16.4 | 149.9 ± 4.1 | 82 ± 2.05 |
| VE/B/POM/4 | 332.2 ± 15.4 | 151.3 ± 3.6 | 78 ± 1.95 |
| VE/B/$MoS_2$/4 | 327.1 ± 12.8 | 148.6 ± 2.8 | 85 ± 2.13 |

**Fig. 3 Mechanical properties of polyester and vinyl ester-based tribocomposites [8]**

| Materials | Values |
|---|---|
| Cement | 440 kg/ $m^3$ |
| Water | 157 kg/ $m^3$ |
| CA | 919.512 kg/ $m^3$ |
| FA | 1033.32 kg/ $m^3$ |
| w/c ratio | 0.4 |
| Admixture | 0.9% |
| **Cement: FA: CA = 1: 2.34: 2.08** | |

**Fig. 4 Value of mix proportion [5]**

## 3. COMPRESSIVE STRENGTH

The 0.25% volume fraction of the jute fiber gave the maximum tensile strength [4]. The addition of poly tetra fluoro ethylene would reduce the compressive strength of the mix [7]. The author stated that the addition of metakaolin decreased the compressive strength and increased the workability [5]. The increment in the quantity of plastic waste lowered the value of its compressive strength of it [9]. With an increment of 1% fiber, the compressive strength increased, but with a 2% increment, it got decreased [3]. When self-compacting concrete was partially replaced by 20% by weight of the eggshell powder and granulated ground blast furnace slag, the highest compressive strength was recorded [10]. The results showed an increase in compressive strength with 30,

45 and 50% replacement of sand with marble powder [3]. The final test results show an increase in compressive strength of hybrid concrete by 13.42% compared to the control mix after 28 days of curing [2].

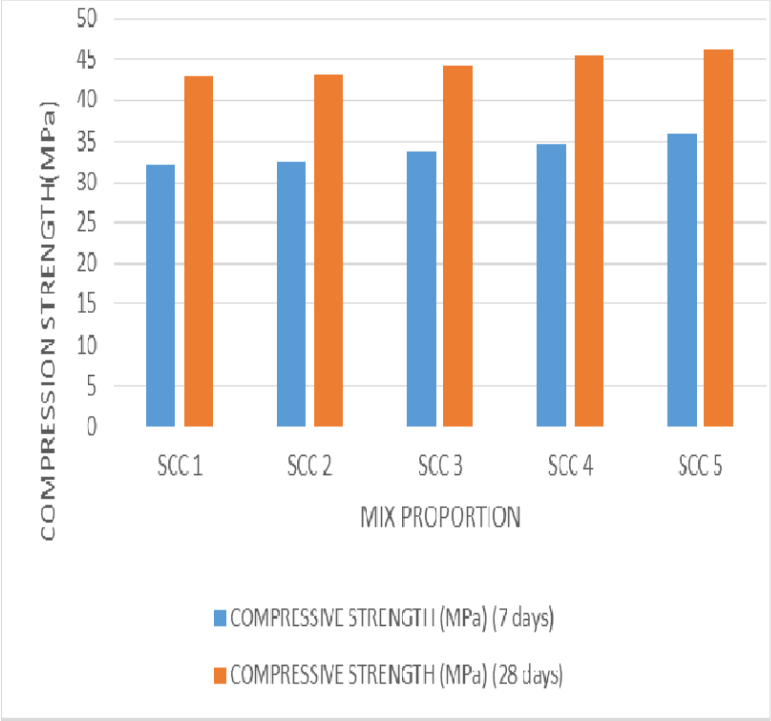


**Fig. 5 Value of compressive strength [5]**

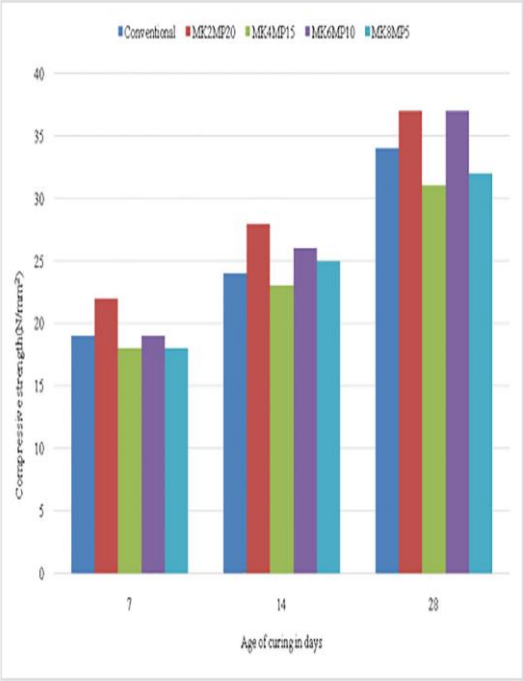


**Fig. 6 Comparison of compressive strength [3]**

## 4. WORKABILITY

The usage of mineral admixture increases the workability and reduces the cement content in concrete [5]. The increase in the percentage volume of plastic aggregates in concrete will reduce the workability of fresh concrete [9]. It was found that metakaolin will accelerate the setting time of cement pastes [3].

## 5. TENSILE STRENGTH

The composition of 85% jute and 15% coconut provides higher tensile strength because of the higher wt % of the jute fiber [4]. Due to the addition of fly ash since fly ash will attain maximum strength at 56th day similarly split tensile strength was increasing and when more fibers were added it starts decreasing [6].

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