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Research paper

Advancement Approach of Waste Utilization for Composites Fabrication

Sandip Nehe [1] *, Dr. B M Praveen [2]

[1]PDF Scholar, Srinivas University, Mangluru, Karnataka, India
[1]Assistant Professor, Department of Mechanical Engineering, Samarth College of Engineering & Management, Belhe, Savitrabai Phule Pune University, Pune, India
[2]Research Guide, Department of Mechanical Engineering, Srinivas University, Mangluru, Karnataka
**Corresponding author E-mail:sandipnehe34@gmail.com*

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Abstract

The main objective of this work is to solve the issues of plastic waste management (PWM) in developing countries by designing a shredding machine. This function is used for many applications like business planning as well as industrial applications with zero environmental impacts, which are used in processes in supply chain and planning. Also, the machine and composites are optimized to find better material for both shredder and wastage. Shredder machine is developed by assembling all manufactured parts which can shred 1 Kg plastic, Wood, Glass and Aluminum at once. Also testing of innovative machine by means of crush particles produced from wastages to recycle it. Moreover, the shape of plastics is very different from their equivalents while it is used in large-scale mass recycling, energy difference recycling highlights the environmental benefit of using plastics, where the SM may indicate a potential function for recycling purposes. Experimental validation of the main component is needed for finding stress & deformation. Also, the optimization solution by finding better suitable material for different components of shredder to withstand under several operating conditions is done. Work methodology depends upon the type of wastages to make composites and better suitable material for the shredder components to sustain under the heavy operating conditions.

***Keywords**: Waste Recycling, Shredding Machine, crush waste, Plastic waste Management, Solid Waste Management*

1. Introduction

The process of PR is used for recuperating scrap/waste plastic that can be recycling the material into helpful items. Since most plastics are non-biodegradable, recycling is essential for a worldwide exertion to lessen plastics in the waste branch, particularly near about eighty million metric huge loads of wasted plastic which enters the land seas at each year. The recycling process in the plastic polymers is regularly difficult because of its low thickness as well as low worth contrasted with beneficial recycling, just as the low worth of glass waste recycling. There are likewise various specialized obstructions to beat when recycling plastic. The project targets to diminish the transporting cost of plastics through cutting them into fine grain. After that the bulk amounts of these particles are given to the recycling mills that are performed in a low cost. The use of plastic shredder is to cut large parts of plastic material or things into very small particles that are easily conveyed to the recycling plant in which the shredder model is considered as an integral part of the used plastic recycles. Also we can get the idea of cutting these machines into their smaller form from the working principle of scissors. The advanced shredder has a cutter whose main function is to cut the plastic into small pieces. Furthermore, it is used to remove the amount of material, while many online directories define a shredder used to shred documents as a precautionary measure to stop theft, shredder machine types on the basis of material being precede e-waste cycling, scrap metal, PR, tire recycling, etc. There are pieces designed to support material reduction in a variety of recycling applications, including agricultural waste wood recycling. The shredding process produces finished products to reintroduce raw material, such as landscaping much.

1.1 Application

1.1.1 Wood Material

Building materials are utilized for creating constructions that incorporate numerous normally happening materials like rocks, mud, wood, sand, branches which are employed for creating structures.

1.1.2 Rubber Material

By crushing the rubber material with shredding machine we can recycle those rubber material with same quality, same strength, same bonding of the materials happens. In today's world rubber material is used in construction area's demand of rubber material is increasing day by days.

1.1.3 Aluminum Material

By crushing the aluminium waste material, we can recycle the aluminium after recycling the aluminium material we use that aluminium material to create windows material, doors material, to make some home appliances in construction area.

1.1.4 Plastic Material

By making crush particles by means of crushing it is used for building a building blocks and bricks. The recycled material formed has a high strength and used for several roofs and build structure.

The objective of Research Papers is as Follows

1. Testing innovative machines by means of crush particles produced from wastages to recycle it.
2. Experimental validation of main component in ANSYS by finding stress & deformation.
3. Applying the optimization solution by finding better suitable material for different component of shredder to withstand under several operating conditions.
4. Formation of the composite cube from wastage particles by adding the admixture and testing it to find the compressive strength.
5. Finding optimum material from all composite material.

Scope of research work includes

Plastic is a lightweight and sturdy material that can be effortlessly planned into a wide assortment of items and is utilized in a wide scope of uses. Therefore, plastic creation has expanded fundamentally in the course of recent years. Notwithstanding, the current states of their utilization and removal make numerous ecological issues. Around 4% of the world's oil and gas creation, which is non-inexhaustible, is utilized as feed for plastics, and 3 to 4 percentage is burnt through on giving effort to their creation. The greater parts of the plastic created every year are disposed of inside a year to make waste results of bundling or other momentary items. These two perceptions alone demonstrate that our present plastic use isn't manageable. Moreover, in view of the strength of polymers, disposed of lifetime plastics gather as garbage in critical measures of land and regular environments all throughout the planet. Recycling is the significant movement that is as of now accessible to decrease these effects, and it is quite possibly the most powerful territories in the plastics business today. The utilization of recycled oil offers freedoms to lessen carbon dioxide discharges and the measure of waste to be taken out. Here, we sum up recycling against other waste-decrease techniques, for example decreasing material use through corruption or item reuse, utilization of option biodegradable materials, and energy recuperation as fuel.

2. Design & Simulation

2.1 Design procedure

It's essential before proceeding toward the manufacturing process, having some knowledge regarding design of the project before to starting process of the manufacturing as well as designer also assume the minimum cost and maximum benefit after actual application. [23]

2.2 Material selection

Material selection process depends upon the strength of part. Typical part of shredder assembly includes Base, Cutter blades, Support of shredder machine, Gears Assembly, Induction electric motor, Assembly of Drive Shaft

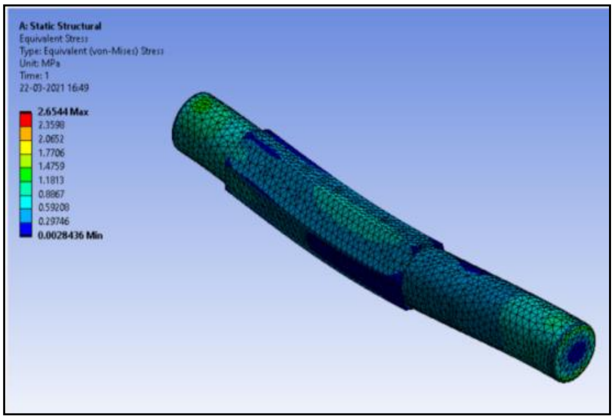
Selection of the materials depends upon the operating conditions to which the selection factors are considered. Feasibility & Flexibility, Costing & Availability, Load Pressure involvement, Functionality, Operating temperature [23]

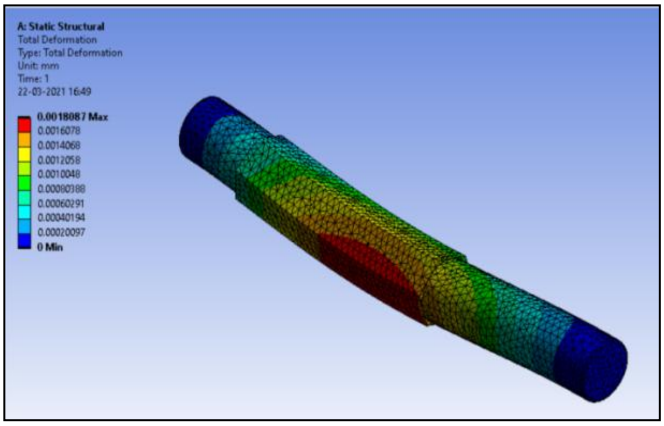
2.3 Tools/machines for designing SM

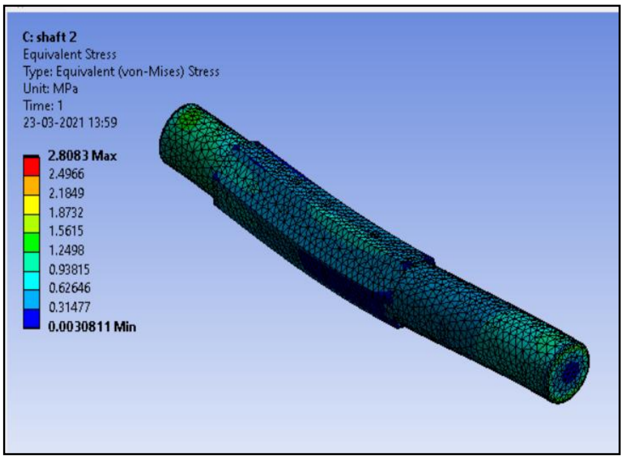
1. Crushing machine: this is prepared with the assistance of a slicing plate was utilized to cut a light steel dish and apply the shaft to the necessary measurement.
2. Machine: A collapsing machine was utilized to overlap gentle steel sheet metal into a rectangular shape.
3. Tape: A tape rule was utilized to gauge lightweight sheet metal and stem.
4. Steel Lime: Steel lime was utilized to demonstrate the deliberate length of gentle steel sheet metal; Medium carbon steel bar, and different segments, utilized the necessary estimation.
5. Vernier calliper: The Vernier calliper was utilized to quantify the inward width of the cutting edge and cogwheels.
6. Shrewd: Bench bad habit was predominantly used to hold the work piece during the cutting interaction.
7. Penetrating machine: The boring machine was utilized to bore openings in the container.
8. Electric curve welding machine: An electric bend welding machine was utilized to weld the machine edge and container.
9. Riveting weapon: Riveting firearm and pin were utilized to append the rollers and pivots to the machine outline.

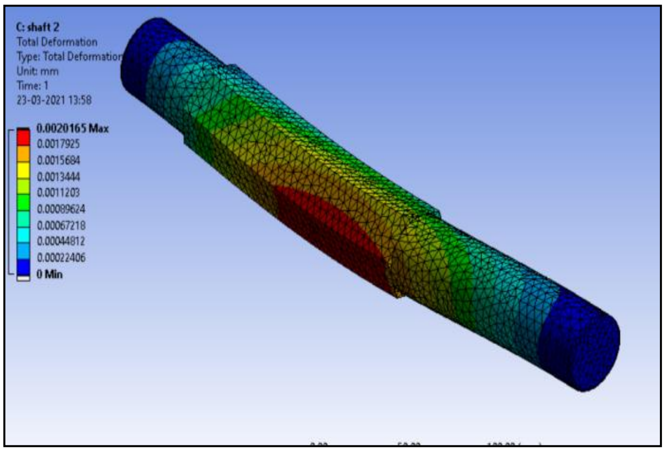
2.4 Optimization of Different Components of Shredder

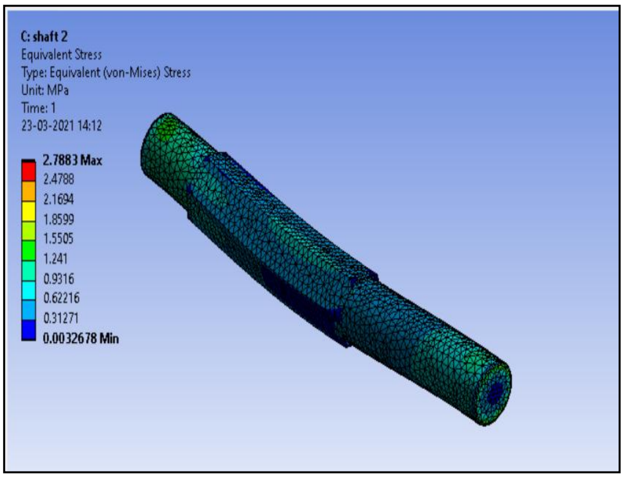
2.4.1 Optimization of Shaft

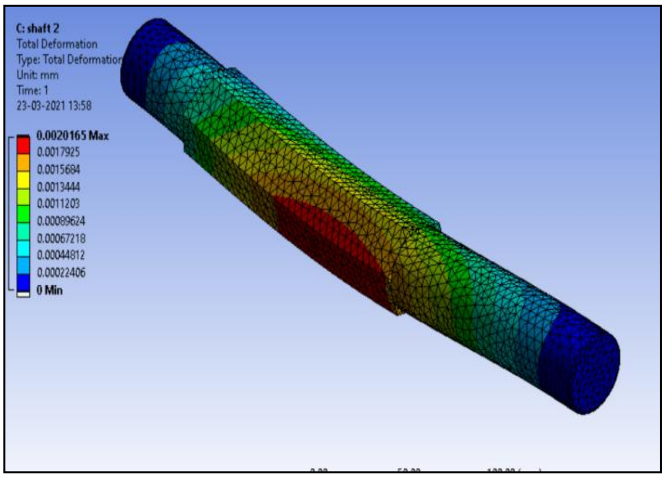


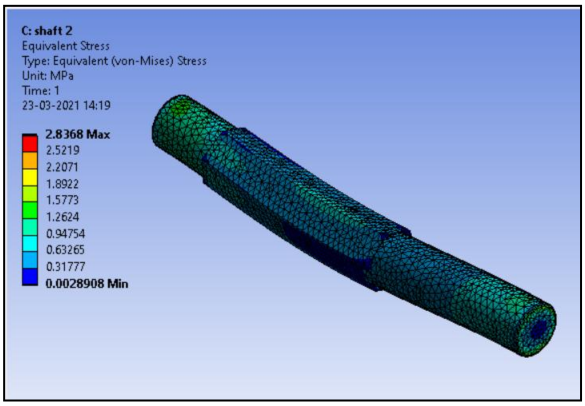












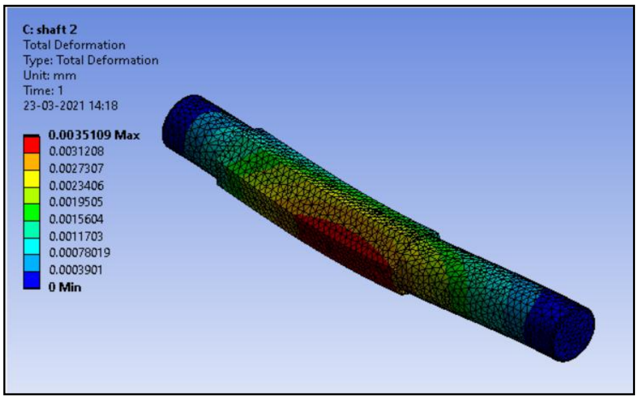


Fig. 1: Analysis of Shaft Material as Mild Steel, Stainless Steel (SS400), Aluminum (AA1100), Cast Iron by Equivalent (von- misses) stress & Total Deformation stress

Table 1: Stress & Deformation on Different Material of Shaft

Sr. No.	Component	Material	Max Deformation (mm)	Stress (N/mm^2)
1	Shaft	Mild Steel	0.0018087	2.6544
2	Shaft	Stainless Steel	0.0020165	2.8083
3	Shaft	Aluminum	0.0020165	2.7883
4	Shaft	Grey Cast Iron	0.0035109	2.8368

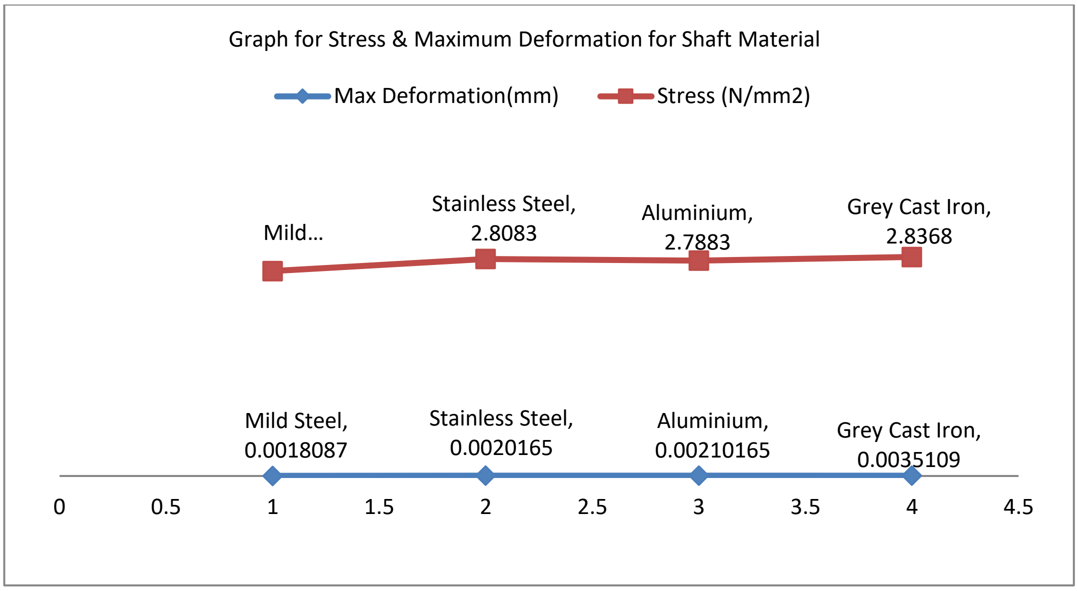
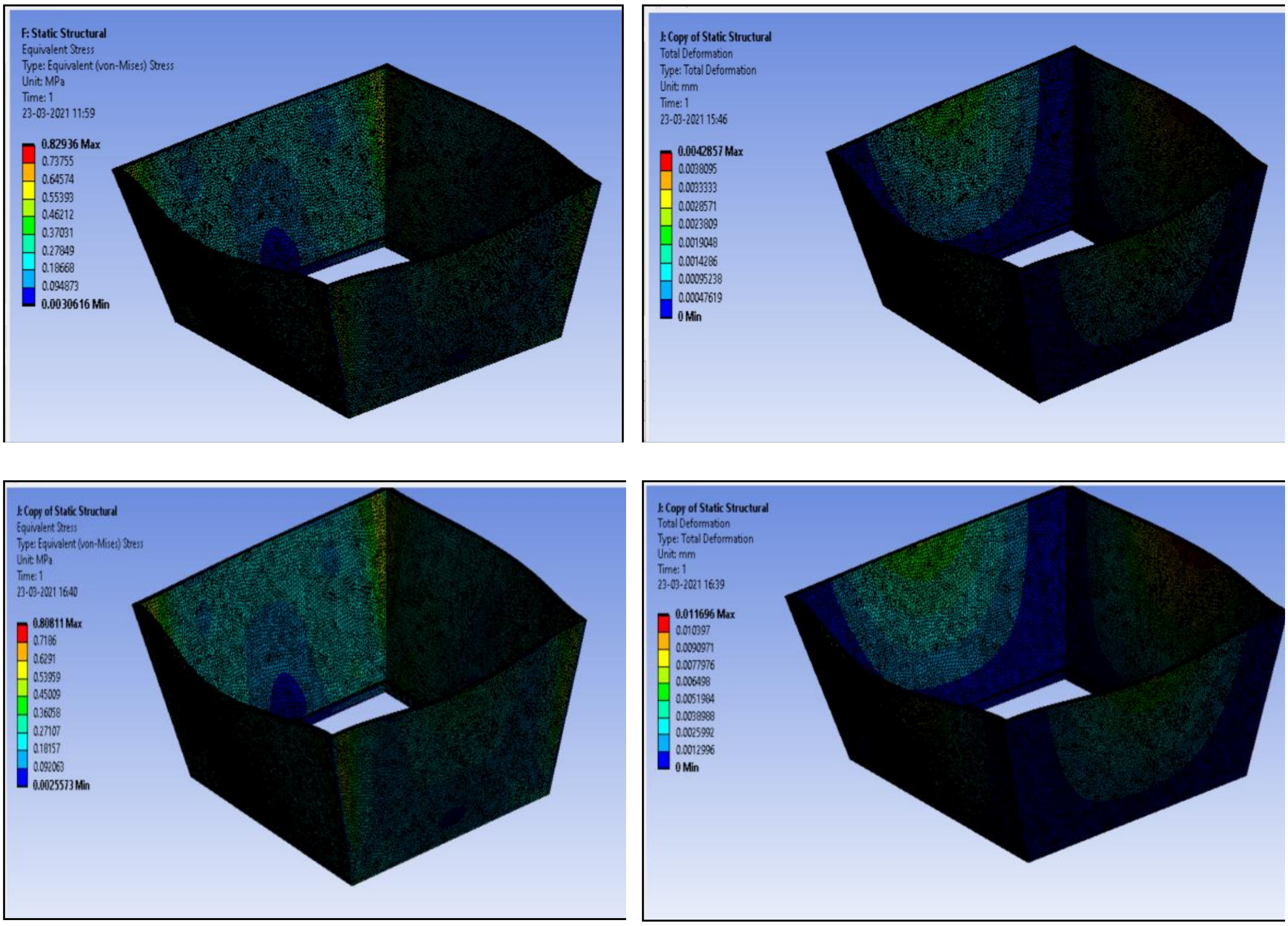


Fig. 2: Stress and maximum deformation for shaft material

Hence from the above analysis Mild Steel material is best suitable optimum solution (selected) for shaft because it is having less deformation & equivalent von-misses stress.

2.4.2 Optimization of Hopper



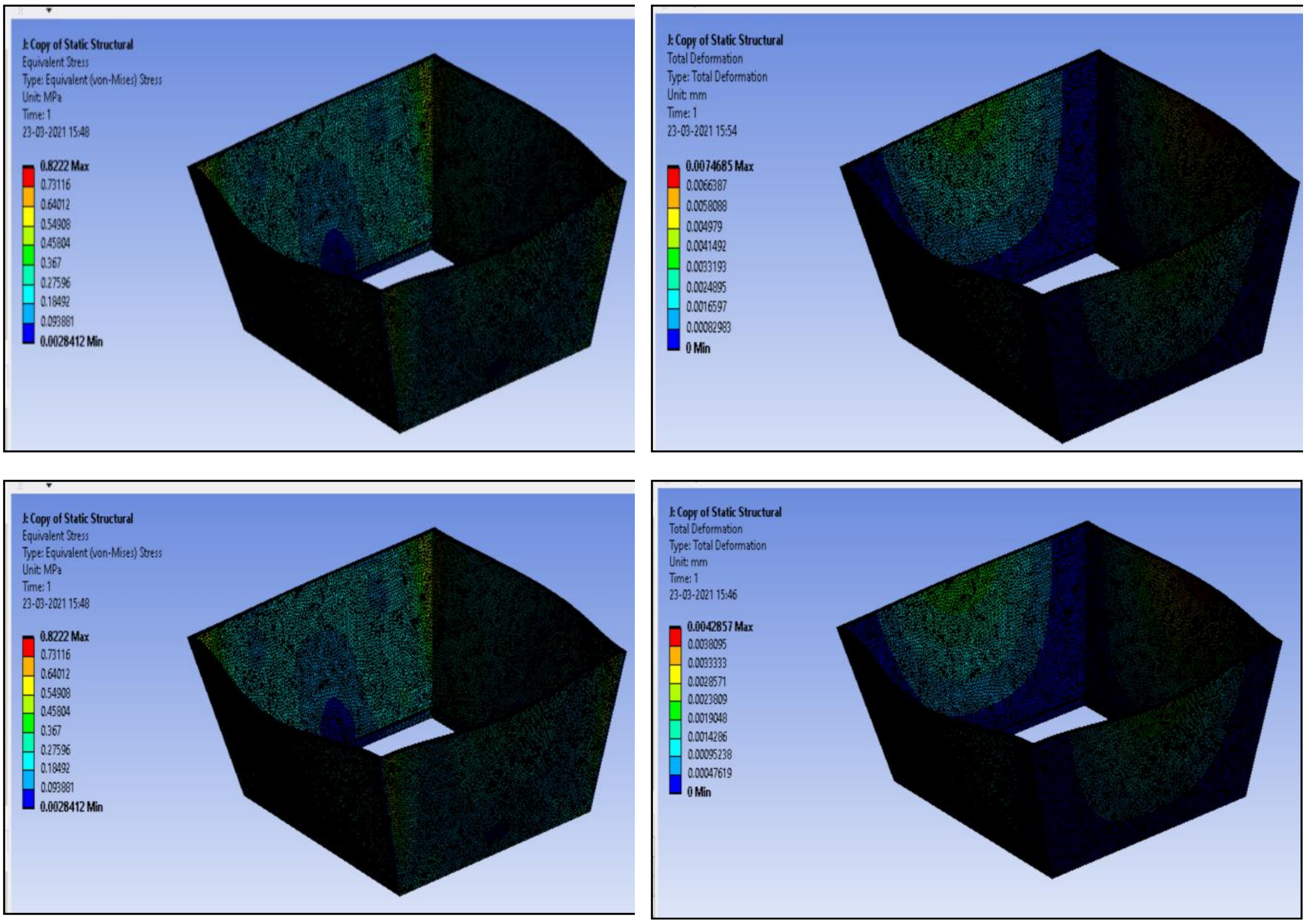


Fig 3: Analysis of Hopper Material as Mild Steel, Stainless Steel (SS400), Aluminum (AA1100), Cast Iron by Equivalent (von- misses) stress & Total Deformation stress

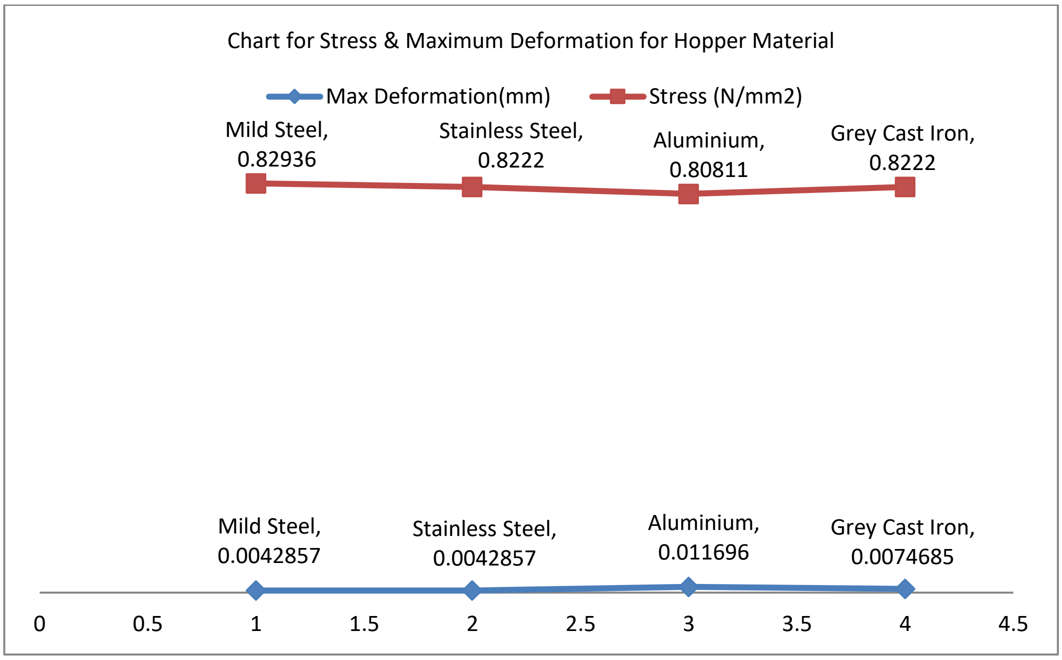


Fig. 4: Stress and maximum deformation for hopper material

Table 2: Stress & Deformation on Different Material of Hopper

Sr. No.	Component	Material	Max Deformation (mm)	Stress (N/mm^2)
1	Hopper	Mild Steel	0.0042857	0.82936
2	Hopper	Stainless Steel	0.0042857	0.8222
3	Hopper	Aluminum	0.011696	0.80811
4	Hopper	Grey Cast Iron	0.0074685	0.8222

2.4.3 Optimization of Blade

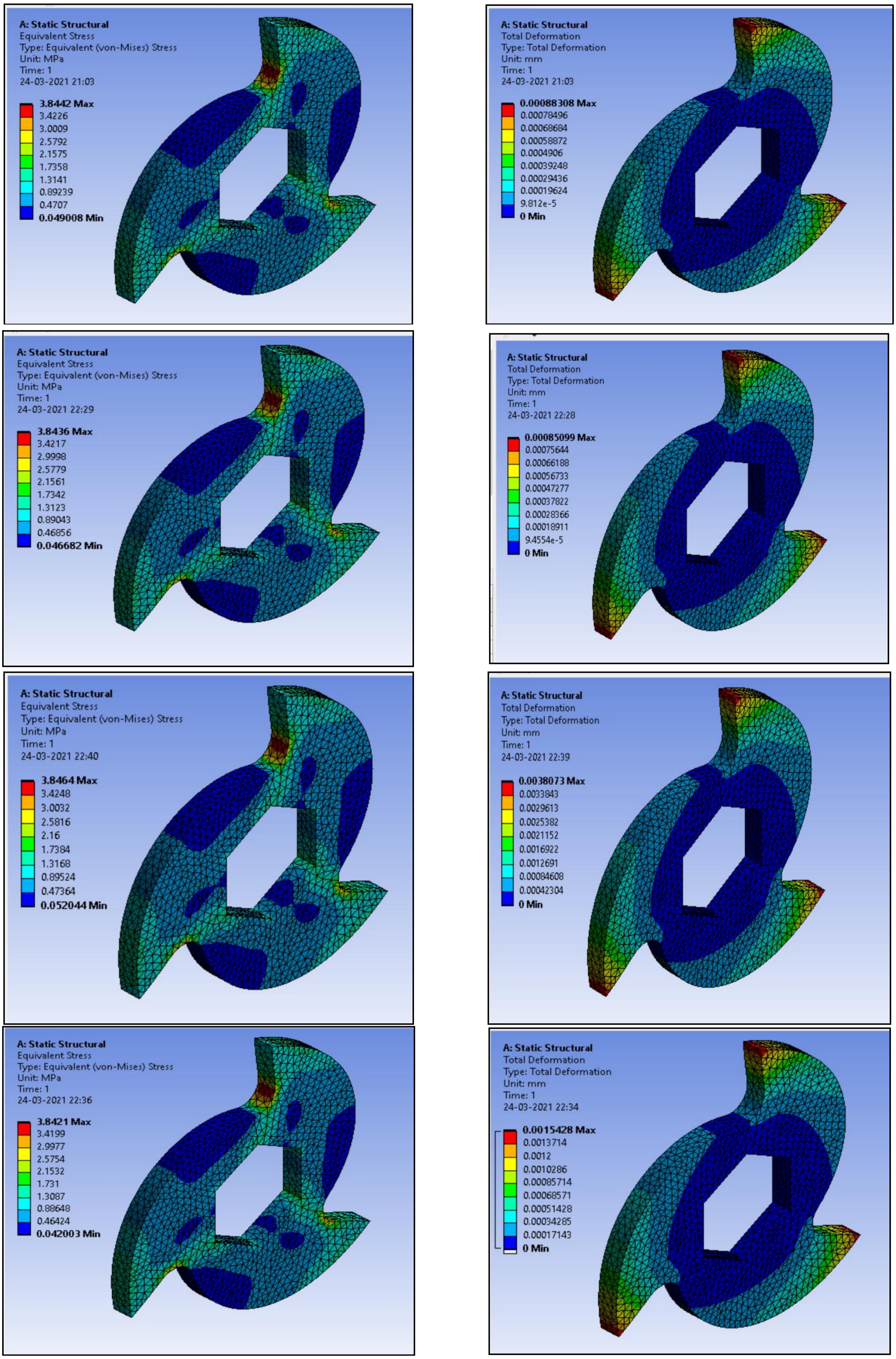


Fig 5: Analysis of Blade Material as Stainless Steel (SS400), Mild Steel, Magnesium, Grey Cast Iron by Equivalent (von- misses) stress & Total Deformation stress

Table 3: Stress & Deformation on Different Material of Blade

Sr. No.	Component	Material	Max Deformation (mm)	Stress (N/mm^2)
1	Blade	Mild Steel	0.00085099	3.8436
2	Blade	Stainless Steel	0.00088308	3.8442
3	Blade	Magnesium	0.0038073	3.8464
4	Blade	Grey Cast Iron	0.0015428	3.8421

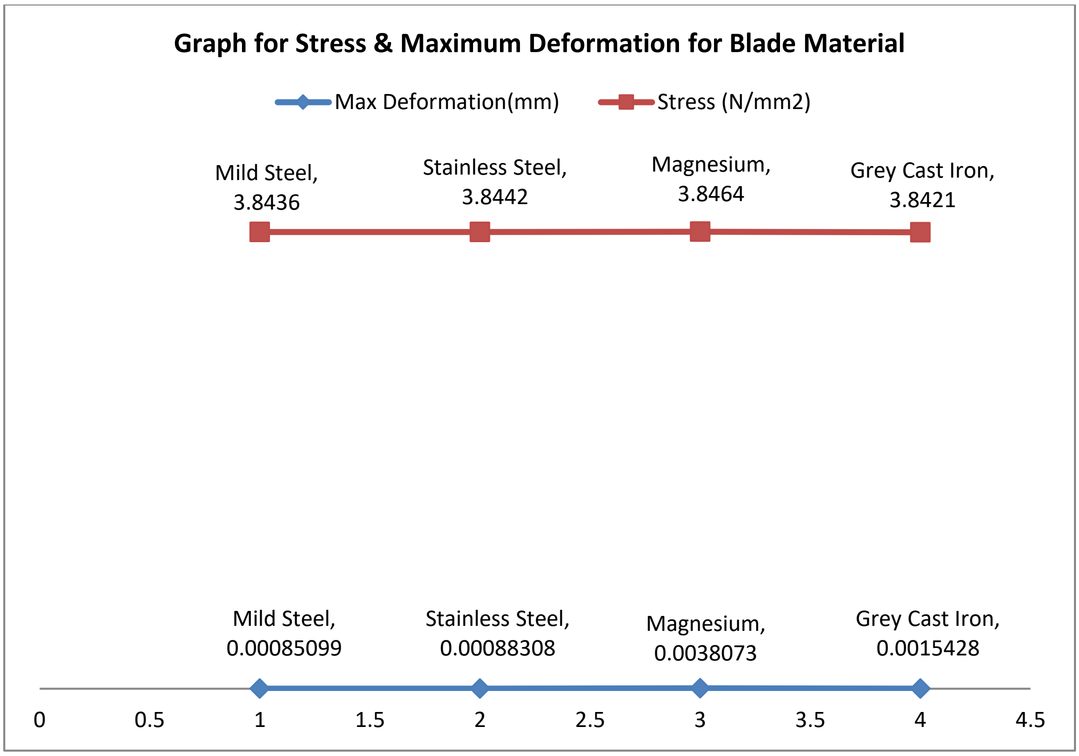


Fig. 6: Stress and maximum deformation for blade material

3. Experimentation & Validation

3.1 Results on Compressive Strength

Compressive strength of the composite is nothing but the ability of that particular material to sustain under the static as well as the dynamic load. The compressive strength is found by adding the admixture into the crushed waste material of aluminum, wood, rubber and plastic. Admixture is kept near about the 28 days and after that it is processed. It takes time to bind all the mixture well so that it can ensure the higher strength. Maximum load applied on the composite so that it can withstand higher sustainability under the various load conditions. Compressive strength of any material is maintained high because if there is dynamic load applied on any particular product there will be the chances of the breakage of the material. In such condition the costing incurred for the formation of the composite parts is many times much higher. Test method used for the testing is 516-1959. [5]

3.1.1 Results on Compressive strength of Composite Cube of All Mixture [27]

Compressive strengths of any material is maintained high because if there is dynamic loads applied on any particular product there will be the chances of the breakage of the material. In such condition the cost incurred for the formation of the composite parts is many times much higher. Compressive strength of the composites is nothing but the ability of that particular material to sustain under the static load. Dependability of the compressive strength depending upon the stresses induced in that particular material.

Table 4: Result table for compressive strength of composite cube of all mixture

Observation Table & Test Results: Composite Cube- All Mixture						
Sr. No.	Test Particulars	1	2	3	Average	Test Method
1	Length (mm)	150.6	150.7	150.3	--	--
2	Width (mm)	150.3	150.4	150.5	--	--
3	Height (mm)	150.8	150.6	150.7	--	--
4	Weight(kg)	8.852	8.860	8.812	--	--
5	Cross Sectional Area (mm^2)	22635	22665	22620	--	--
6	Density (kg / m^3)	2593	2596	2585	--	--
7	Max Load(KN)	496.5	487.6	532.1	--	--
8	Compressive Strength (N/mm^2)	28.7	29.2	27.6	28.5	IS 516: 1959
9	Approximate Specified Compressive strength (N/mm^2)	"19.9"	"19.9"	"19.9"	--	--

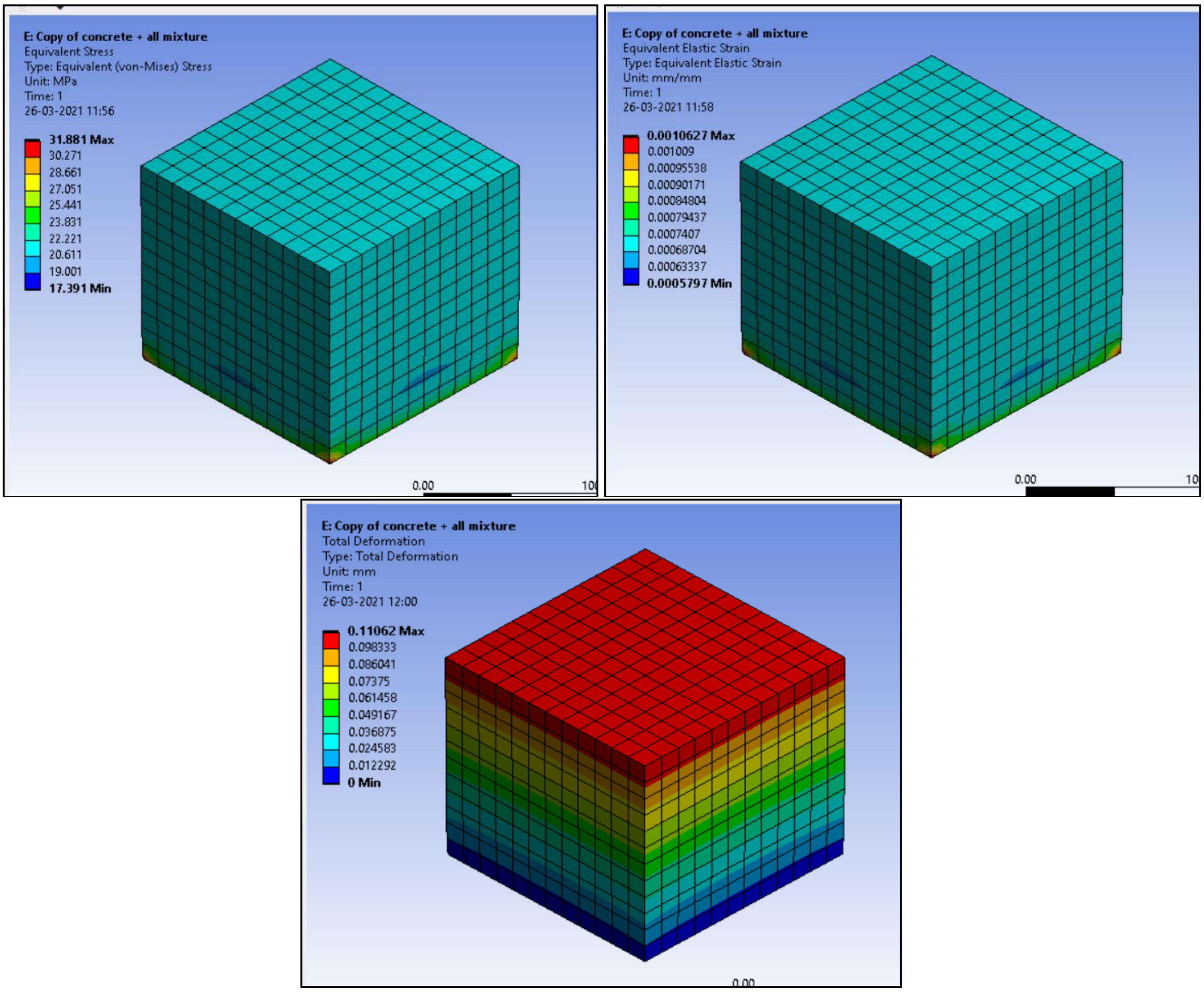


Fig 7: Equivalent (von-misses) stress, Equivalent elastic strain & Total deformation on composite cube of all mixture material

3.1.2 Results on Compressive Strength of Composite Cube of Aluminum

Table 5: Result table for compressive strength of composite cube of aluminum

Observation Table & Test Results: Composite Cube- Aluminum						
Sr. No.	**Test Particulars**	**1**	**2**	**3**	**Average**	**Test Method**
1	Length (mm)	150.6	150.7	150.3	--	--
2	Width (mm)	150.3	150.4	150.5	--	--
3	Height (mm)	150.8	150.6	150.7	--	--
4	Weight(kg)	8.852	8.860	8.812	--	--
5	Cross Sectional Area (mm²)	22635	22665	22620	--	--
6	Density (kg / m³)	2593	2596	2585	--	--
7	Max Load(KN)	496.5	487.6	532.1	--	--
8	Compressive Strength (N/mm²)	28.9	27.6	29.5	28.6	IS 516: 1959
9	Approximate Specified Compressive strength (N/mm²)	"19.9"	"19.9"	"19.9"	--	--

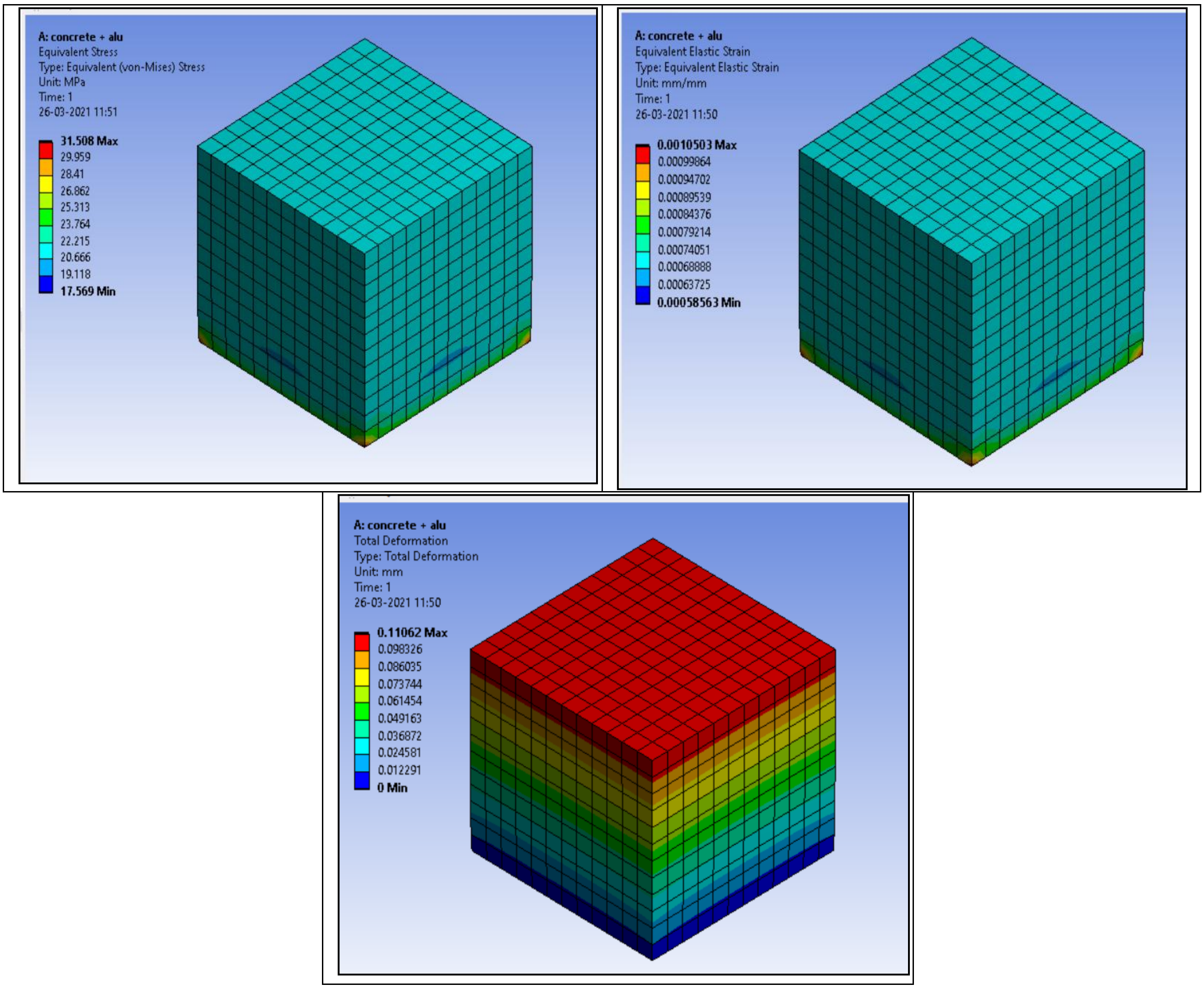


Fig 8: Equivalent (von-misses) stress, Equivalent elastic strain & Total deformation on composite cube of aluminum

3.1.3 Results on compressive strength of Composite Cube of Rubber

Table 6: Result table for compressive strength of composite cube of rubber

Observation Table & Test Results: Composite Cube- Rubber						
Sr. No.	Test Particulars	1	2	3	Average	Test Method
1	Length (mm)	150.6	150.7	150.3	--	--
2	Width (mm)	150.3	150.4	150.5	--	--
3	Height (mm)	150.8	150.6	150.7	--	--
4	Weight(kg)	8.852	8.860	8.812	--	--
5	Cross Sectional Area (mm²)	22635	22665	22620	--	--
6	Density (kg / m³)	2593	2596	2585	--	--
7	Max Load(KN)	496.5	487.6	532.1	--	--
8	Compressive Strength (N/mm²)	25.9	26.9	28.5	27.1	IS 516: 1959
9	Approximate Specified Compressive strength (N/mm²)	"19.9"	"19.9"	"19.9"	--	--

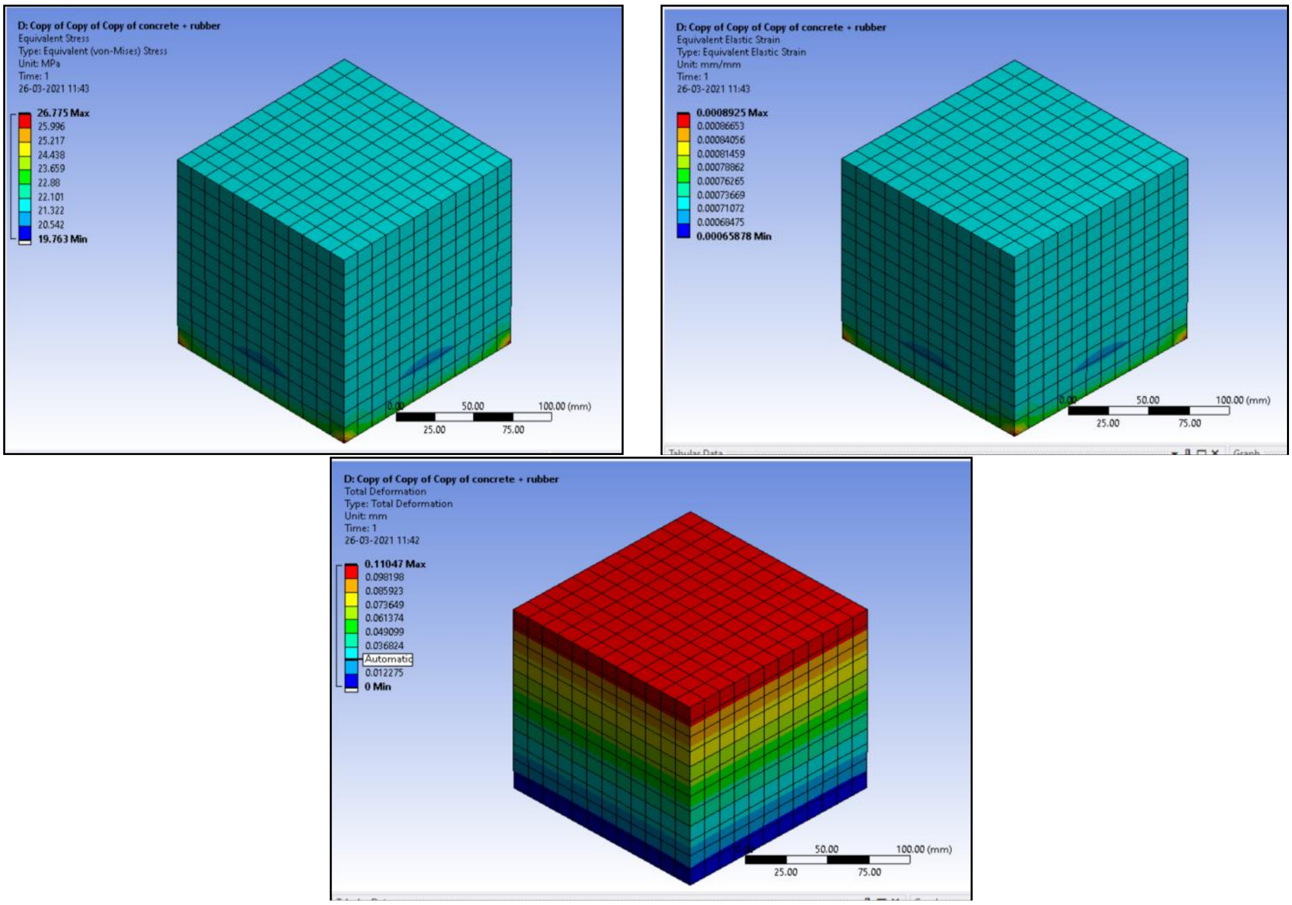
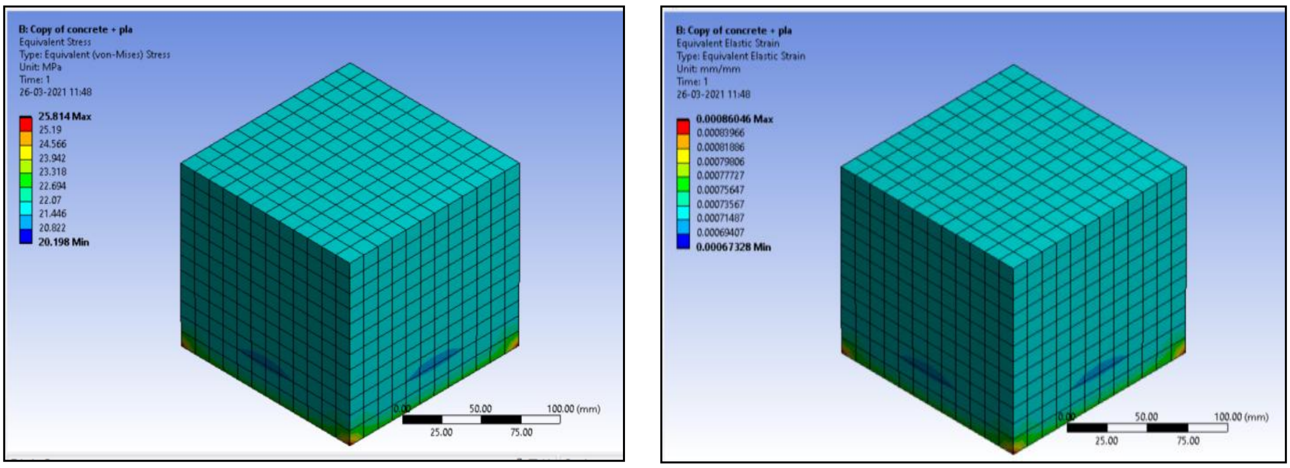


Fig 9: Equivalent (von-misses) stress, Equivalent elastic strain & Total deformation on composite cube of Rubber

3.1.4 Results on Compressive Strength of Composite Cube of Plastic

Table 7: Result for compressive strength of composite cube of plastic

Observation Table & Test Results: Composite Cube- Plastic						
Sr. No.	Test Particulars	1	2	3	Average	Test Method
1	Length (mm)	150.6	150.7	150.3	--	--
2	Width (mm)	150.3	150.4	150.5	--	--
3	Height (mm)	150.8	150.6	150.7	--	--
4	Weight(kg)	8.852	8.860	8.812	--	--
5	Cross Sectional Area (mm²)	22635	22665	22620	--	--
6	Density (kg / m³)	2593	2596	2585	--	--
7	Max Load(KN)	496.5	487.6	532.1	--	--
8	Compressive Strength (N/mm²)	24.9	26.5	29.5	26.9	IS 516: 1959
9	Approximate Specified Compressive strength (N/mm²)	"19.9"	"19.9"	"19.9"	--	--



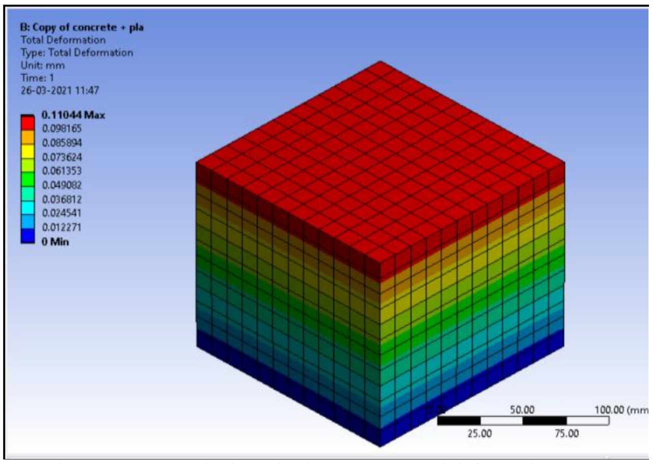


Fig 10: Equivalent (von-misses) stress, Equivalent elastic strain & Total deformation on composite cube of Plastic

3.1.5 Results on Compressive Strength of Composite Cube of Wood

Table 8: Result table for compressive strength of composite cube of wood

Observation Table & Test Results: Composite Cube- Wood						
Sr. No.	Test Particulars	1	2	3	Average	Test Method
1	Length (mm)	150.6	150.7	150.3	--	--
2	Width (mm)	150.3	150.4	150.5	--	--
3	Height (mm)	150.8	150.6	150.7	--	--
4	Weight(kg)	8.852	8.860	8.812	--	--
5	Cross Sectional Area (mm²)	22635	22665	22620	--	--
6	Density (kg / m³)	2593	2596	2585	--	--
7	Max Load(KN)	496.5	487.6	532.1	--	--
8	Compressive Strength (N/mm²)	21.9	23.4	24.8	23.3	IS 516: 1959
9	Approximate Specified Compressive strength (N/mm²)	"19.9"	"19.9"	"19.9"	--	--

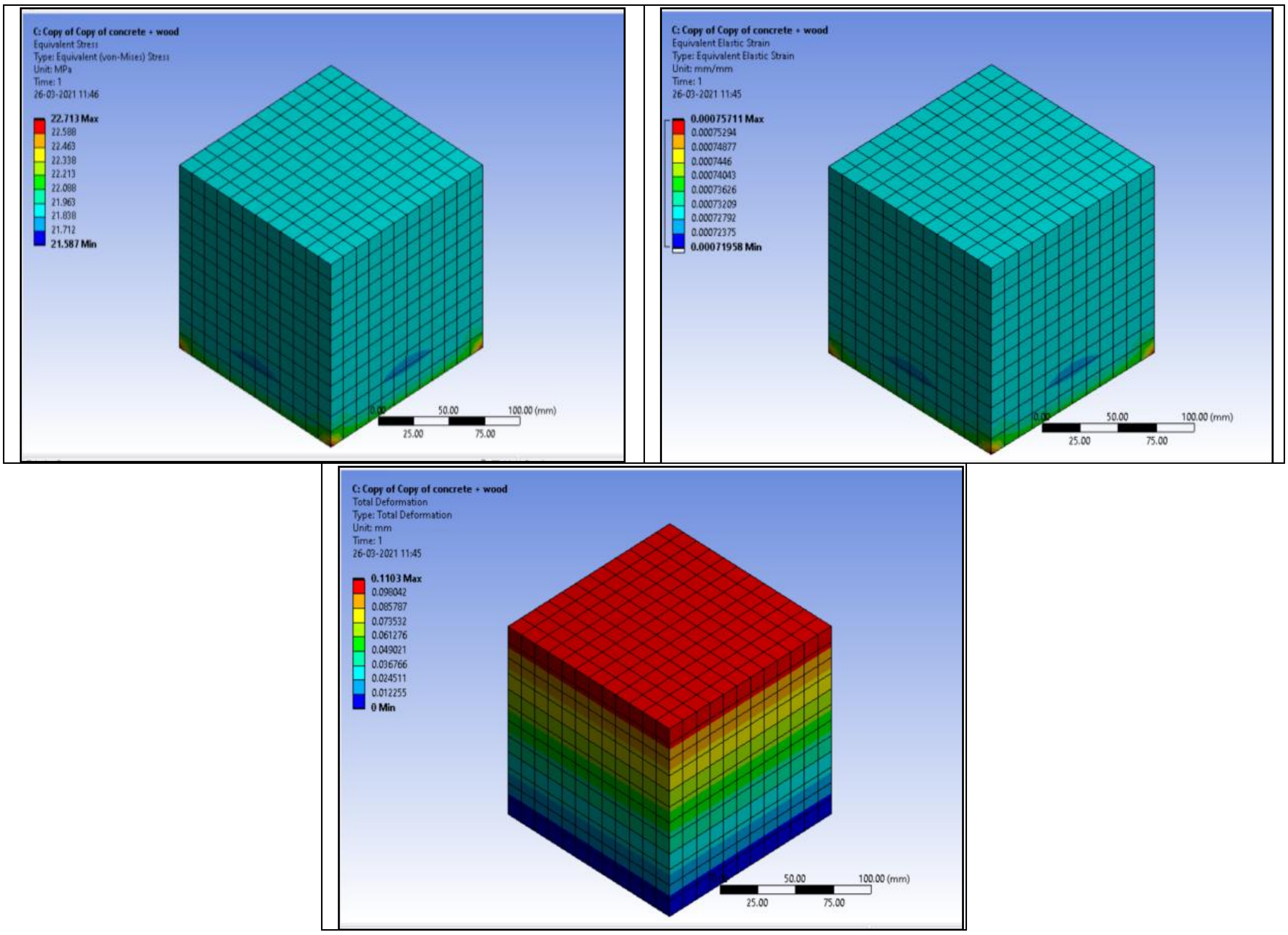


Fig 11: Equivalent (von-misses) stress, Equivalent elastic strain & Total deformation on composite cube of Wood

Table 9: Analysis of total deformation, equivalent (von-misses) stress, equivalent elastic strain & compressive strength of all composite.

Sr. No	Material	Deformation (mm)	Strain	Stress (N/mm$^{2)}$	Compressive Strength (N/mm^2)(Expt.)	Average Compressive Strength (N/mm^2) (Expt.)
1	Concrete + All Mixture	0.11062	0.0010627	31.881	28.7	28.5
2	Concrete + Aluminum	0.11062	0.0010503	31.508	28.9	28.6
3	Concrete + Rubber	0.11047	0.0008925	26.775	25.9	27.1
4	Concrete + Plastic	0.11044	0.0008604	25.814	24.9	26.9
5	Concrete +Wood	0.1103	0.0007571	22.713	21.9	23.3

4. Cost Benefit Analysis of Materials of Shredder Machine Components

4.1 The maximum allowable stress for unit in MPA

Mild steel	yield strength	247	ultimate strength	841
Stainless steel	yield strength	215	ultimate strength	505
Grey cast-iron	yield strength	410	ultimate strength	700
Aluminum	yield strength	241	ultimate strength	290
Magnesium	yield strength	460	ultimate strength	515

Hear considering FOS as 4

4.2 Now the allowable stress is to be less than the below

Mild steel	yield strength	61.75	ultimate strength	210.25
Stainless steel	yield strength	53.75	ultimate strength	126.25
Grey cast-iron	yield strength	102.5	ultimate strength	175
Aluminum	yield strength	60.25	ultimate strength	72.5
Magnesium	yield strength	115	ultimate strength	128.75

4.3 Cost for materials in market survey

- **Mild steel**

Thickness	Min Price	Max Price
1-2 mm	Rs 42/Kg	Rs 50/Kg
3-4 mm	Rs 43/Kg	Rs 54/Kg
4-5 mm	Rs 42/Kg	Rs 56/Kg

- **Stainless steel**

304 SS Sheet is sold by Kg & Piece. Most of the products range from Rs 150 to Rs 400 per Kg and Rs 100 to Rs 300 per Piece.

- **Aluminum**

The average aluminum price is INR 143.67 per kg. MCX aluminum opened at INR 142.80 per kg today, down from yesterday's closing at INR 143.55 per kg.

- **Grey cast-iron**

Feb 2021 119.90

- **Magnesium pallets**

311 rupees/Kg

- **Shaft**

Central shafts are found in the axle drives of utility vehicles, where all other elements derive their rotational speed by way of the transmission.

Length of the shaft	350 mm
Dia. of the shaft	40 mm
Hexagonal mean dia.	40 mm as well

Hence Mild steel is selected for the fabrication of Shaft, hence cost effective and design is also safe.

- **Blade Ring**

We call the Blade Ring Here we are using blade ring as support for blade to maintain the constant gap between the two blades

Hexagonal mean diameter	40mm
Outer diameter	62mm

Hence Stainless steel is selected for the fabrication of Blade Ring, hence cost effective and design is also safe.

- **Casing**

Casing or Machine block is provided to protect the inner elements from several conditions like raining or any other revetment protection
Height 150 mm
Width 250 mm
Thickness 5mm
Hence Mild steel is selected for the fabrication of Casing, hence cost effective and design is also safe.

- **Separate Plate**

Separator plate is provided to maintain the gap between the two blades and also to provide the insertion of material chip obtained during shredder.

Height	140mm
Width	75.5mm
Thickness	8mm
Radius	30 mm

Hence Mild steel is selected for the fabrication of Casing, hence cost effective and design is also safe.

- **Side Casing**

Casing or Machine block is provided to protect the inner elements from several conditions like raining or any other revetment protection

Height	150mm
Width	252mm
Thickness	5mm

Hence Mild steel is selected for the fabrication of Side Casing, hence cost effective and design is also safe.

- **Hopper**

A hopper is a storage container used to dispense granular goods by the use of a chute to restrict flow, occasionally helped by mechanical agitation

Height	100mm
Width	260 - 202
Thickness	5mm
Angle	106.7 degree

Hence Aluminum is selected for the fabrication of hopper, hence cost effective and design is also safe.

- **Blade**

A blade is a tool, weapon, or machine component with an edge that is used to penetrate, cut, slice, or scrape surfaces or materials. Blades are often made from harder materials than the ones they will be used on. Blades have traditionally been manufactured from flaking stones like flint or obsidian, as well as metals like copper, bronze, and iron. Modern blades are typically constructed of steel or ceramic. Blades are one of humanity's oldest tools, still used for combat, food preparation, and other uses.

Inner diameter	40 mm hexagonal mean cut
Outer diameter	120mm

The stress strain and deformation obtained for mild steel and stainless steel are essentially identical. Stainless steel is regarded for its strong corrosion resistance. This is best suited for specific applications and challenging settings. Stainless steel is approximately 200 times more resistant to corrosion than mild steel. As a result, mild steel is used to fabricate the blade, which is both cost-effective and safe.

5. Conclusion

- Design and development of all innovative component of shredder machine is done, design done on the basis of actual stress and allowable stresses induced on the component in the form of von-misses stress and also by finding the deformation induced in parts to resist against the failure.
- All the manufactured parts are assembled to make prototype. Different type of fabrication procedure is used to assemble all parts of shredder machine.
- According to design and development I construct a shredder machine which will shred 1 kg of plastic, wood, glass, Aluminium to convert heavy material into small particle after crushing. The capacity of shredder depends upon the size of the hopper. Hopper design in the way that it takes one kg of plastic at time, because out of all four materials only the plastic is the heavy material in size.
- Test of innovative machine by means of crushed produced from wastages to recycle it is done. It is effectively ensuring that the output of crushed part is in the form of smallest part not in the form of heavy part.
- Cutter is deigned in the way that it is validated in the ANSYS to make ensure the forces acting on that could not damage its point. So that cutter design is the main component design to make ensure better efficiency of project.
- Optimization solution is applied in the report to find the better solution. Optimization is done in at the stage of manufacturing and at the result stage. In the stage of manufacturing the optimization of material stress is done. Generally, material having lesser equivalent von- misses stress and lesser de-formation is optimized. Also in testing stage material optimized in the way that finding the better material form all four materials to ensure best crushing strength of the material. The Aluminium ma-terial is optimized.
- The results obtained in the form of crushing strength or compressive strength of the material. As the compressive strength of the material is greater than it can withstand. That material having high-er compressive strength, they can withstand deformation and strain.

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