GENERATIVE SHAPE DESIGN AND REAR UPRIGHT OFAUTOMOTIVE USING FUSION 360

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Abstract

The uprights used in formula cars are particularly constructed in accordance with the specifications of the vehicle and tested to ensure that they will function better and withstand the varied stresses placed on them during acceleration, braking, cornering, and repetitive loading. Formula cars are built for fast speeds and exceptional performance, thus the upright should be able to safely hold the largest loads possible. A hefty or excessively big upright, however, could increase the unsprung mass and impair a vehicle's performance. Lessening the weight of the vehicle without sacrificing performance and removing any potential for failure under maximum loads that might occur during intended performance are the major objectives when developing an upright. The availability of material, affordability, and ease of machining are other crucial factors that must be taken into account while creating an upright.

Keywords: Generative shape design, rear upright, fusion 360, ANSYS stimulation

1. Introduction

A part of a car called an upright joins the wheel hub to the upper and lower control arms. Abhijeet Das, among others. [1]conducted The Society of Automotive Engineers India, also known as SUPRA SAEINDIA, hosts a national-level competition every year. The chosen undergraduate and graduate engineering student teams will design, develop, build, and race a compact open-wheel, open cockpit race car. Teams must come from every part of India. The Front and Rear Upright Assemblies of the SUPRA SAEINDIA race car are being built as part of this thesis project. An upright assembly serves as a physical link and mounting point between the hub and wheel assembly, the suspension arms, and the braking components in addition to holding them.

[2] is carried out For the Formula One student sports car, the main goals of this project are to build a lightweight upright that can withstand a variety of stresses, to suggest a material to lower the weight of the upright, and to provide a manufacturing method for the selected material. By applying several load routes in hyper mesh and building the design using the RAPID PROTOTYPING method, validation on the upright for the chosen material on hyper mesh is done to see if the chosen design can survive the loads arriving upon it. Ayush Garg and companions' analysis Heavy mechanical demands are placed on the components of formula racing vehicles, and these loads change as the components age. Maintaining the performance, dependability, and durability of the vehicle requires knowing a component's lifespan and replacing it as necessary. This document describes the uprights for a Formula SAE vehicle's fatigue life analysis, as well as design optimization based on the results to extend the life. The front and back uprights were constructed using the 2018 SAE rulebook formula and the CATIA 3D modelling programme. Utilizing Optimum Dynamics, the analysis parameters are generated using simulations and logics of the vehicle design parameters.

Along with others, Pathri Bhargav Prajwal. [4] These are the conclusions reached following the conclusion of the study and optimization. For the uprights, aluminium has been used as the material. The upright's weight can be reduced by up to 5% while still having a 15% reduction in stress concentration because of its optimised weight. The first and last results are listed below as a result of the pressures produced in the 659 gramme upright that I was given: - The component's initial stresses, which are 330 MPa for load case 1, are 333 MPa for load scenario 2. Unexpectedly, as demonstrated below, the pressures significantly decrease after the alteration. For load case 1, the component's final stresses are 281 MPa. The component's final stresses for load scenario 2 are 315 MPa. As a result, the stress value in the load case 1 has lowered by 14.8% when compared to the beginning and end values. The stress value is decreased by 5.4% for load scenario 2. In the case of the weight, the overall weight has decreased by 6%[4]. We can infer from looking at the upright constructed of aluminium 6061-T6 that it is lightweight and has the required strength and specifications. The historically used cast-iron uprights have a higher weight to strength ratio (FOS). It makes it feasible for the vehicle to easily traverse difficult terrain.

2 Material selection

2.1. Al-7075 Aluminum Alloys are very resistant to corrosion. They are a good low-temperature alloy because they get stronger at extremely low temperatures. When exposed to extremely high temperatures, they lose strength. The 7075 alloy of aluminium is quite strong.

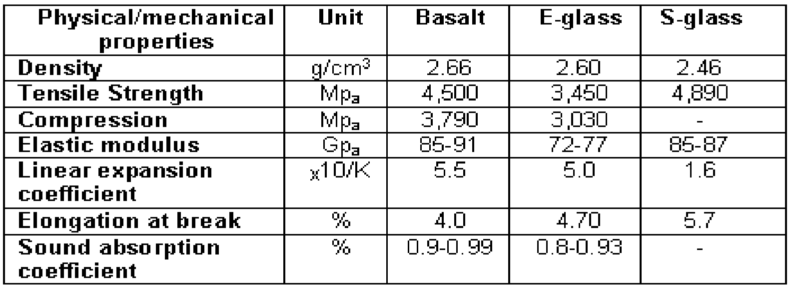
Element	Content (%)
Aluminum, Al	90
Zinc, Zn	5.6
Magnesium, Mg	2.5
Copper, Cu	1.6
Chromium, Cr	0.23

TABLE1: Chemical Composition of the aluminum 7075 alloy.

2.2. Basalt fibre

Basalt fibre is a material made from extremely fine fibres of basalt, which is composed of the minerals plagioclase , pyroxene, and olivine. It is similar to fiberglass, having better physic mechanical properties than fiberglass, but being significantly he is used as a fire proof textile in the aerospace and automotive industries and can also be used as a composite to produce products such as camera tripods.

Table 2. Mechanical and Physical properties of Basalt fiber



Physical/mechanical properties	Unit	Basalt	E-glass	S-glass
Density	g/cm^3	2.66	2.60	2.46
Tensile Strength	Mp_a	4,500	3,450	4,890
Compression	Mp_a	3,790	3,030	-
Elastic modulus	Gp_a	85-91	72-77	85-87
Linear expansion coefficient	$_x10/K$	5.5	5.0	1.6
Elongation at break	%	4.0	4.70	5.7
Sound absorption coefficient	%	0.9-0.99	0.8-0.93	-

3.0 Methodology

Fundamental Conditions for an Upright Design The upright transfers forces and moments from the road and wheel to the suspension and vice versa for braking, driving, and steering. Two bearings that can withstand both axial and radial forces must support the upright. For the purpose of transmitting torque, the driving shaft of the driving axle is coupled to the side of the upright with respect to the homo-kinetic joints.

Chassis bearings can transmit axial force in either a single row or double row configuration, with angular contact being the most prevalent design. A drum or disc brake is linked to the upright. Using screws or nuts and a single central nut, a rim is attached to a hub Depending on how the car's suspension is configured, the upright of a racing car can be built in a number of different ways. For production cars, the uprights are produced from steel or grey cast iron. For race cars, weight is a critical component.

As a result, the uprights are constructed with expensive materials and cutting-edge manufacturing processes. The upright architecture is largely influenced by the type of suspension and manufacturing techniques used. The upright and wheel, along with the whole back hub assembly, are visible.

3.1 Fusion 360Autodesk

Software for the building, engineering, manufacturing, media, education, and entertainment industries is produced by the American corporation Autodesk, Inc. A gallery displaying the work of Autodesk's clients is located at the company's San Francisco facility. Based in San Rafael, California, is Autodesk. The firm has locations across the globe. Its American offices are located in the states of California, Oregon, Colorado, Texas, Michigan, New Hampshire, and Massachusetts. Its Canadian offices are located in Ontario, Quebec, and Alberta.

In 1982, John Walker, who cowrote early versions of AutoCAD, started the company. The company's flagship computer-aided design (CAD) tool, AutoCAD, and Revit software are primarily used by architects, engineers, and structural designers to design, draw, and model buildings and other structures. Numerous projects, notably the One World Trade Center and Tesla electric automobiles, have used Autodesk software.

Although AutoCAD software is what makes Autodesk most well-known, the company also creates a wide range of design, engineering, entertainment, and consumer products. The manufacturing industry employs Autodesk's digital prototyping software, such as Autodesk Inventor, Fusion 360, and the Autodesk Product Design Suite, to visualise, simulate, and analyse real-world performance using a digital model. The company's Revit line of building information modelling software allows users to visually examine the planning, construction, and management of a building before it is produced.
The Media and Entertainment section of Autodesk creates software for visual effects, colour grading, and editing, as well as animation, game development, and design visualisation. [8] Maya and 3ds Max are both 3D animation programmes used for video game production and film visual effects.

3.2 Fusion 360

Autodesk's Fusion 360 is a cloud-based 3D CAD, CAM, and CAE design tool. The platforms it is available on include Windows, Mac, and in-browser. Similar to other 3D programmes like Solidworks, Siemens NX, Inventor, or Catia in terms of functionality. It is an extremely feature-rich tool that is cost-free for amateurs and small enterprises to use.

3.3 Designing process step by step

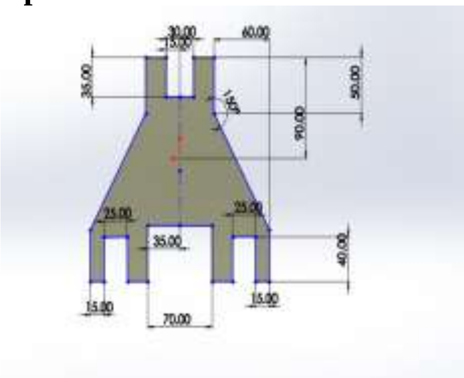


Figure 1: Measurement Of Upright

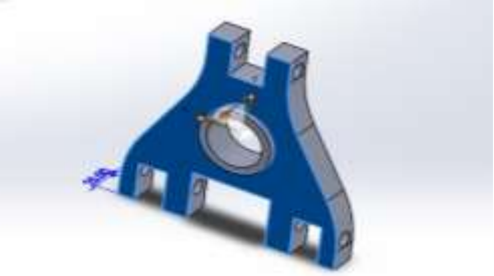


Figure 2: 3D Design Of Upright

Figure 3: Generative Shape Design 1

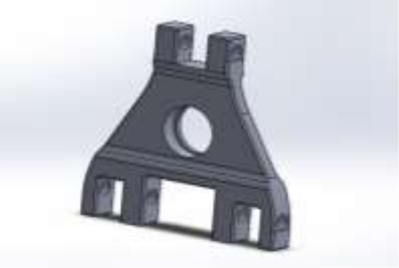


Figure 4: Generative Shape Design 2

Figure 5: Generative Shape Design 3

4 ANALYSIS PROCESS

4.1 Analysis process Material properties

Al-7075 :

Young’s modulus: - 71.7E^10 Pa
Poison ratio: 0.33
Density: 2770 Kg/m^3
Yield strength: 503 Mpa

Basalt fibre :

Young’s modulus: - 8.5E^10 Pa
Poison ratio: 0.2
Density: 2670 Kg/m^3
Yield strength: 625 Mpa

4.2 Design Analysis Process step by step

4.2.1 Meshing

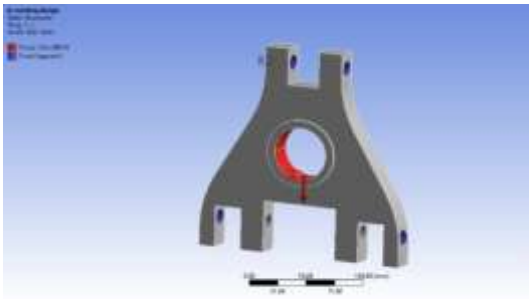
To resolve the results of finite element analysis, the meshing method, which entails expanding tiny particles using elements and nodes, is helpful. The number of elements and nodes will change depending on whether the element size is increased or lowered. If the element size is little, there will be a lot of elements and nodes, and if the element size is large, there won't be as many elements and nodes. When using very small elements—just 1mm in this thesis—the results will be more precise for real-time applications. Additionally, this meshing is referred to as fine mesh.

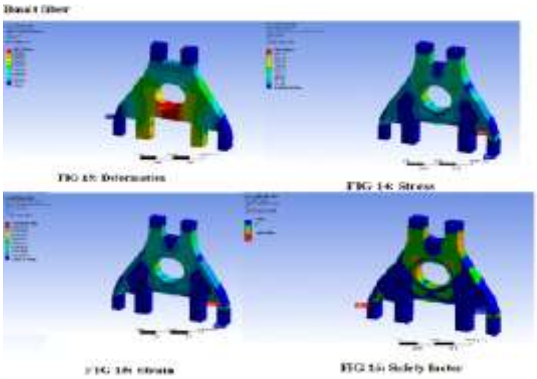
4.2.2 Boundary conditions

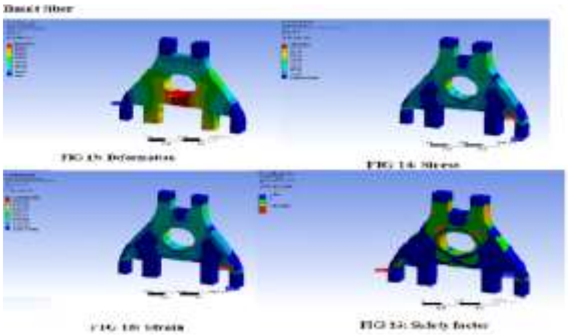
Fixed support →select holes, and then apply

Apply fixed support after choosing the holes.

Applying 1.5e5N of force to the centre of an object will cause it to have a minimal factor of safety above 1.5, making this force acceptable. In addition, the object or material's maximum bearing capacity The object was optimised, different materials were selected, and the same amount of load was applied in order to improve the object's performance and strength. The results are displayed below.







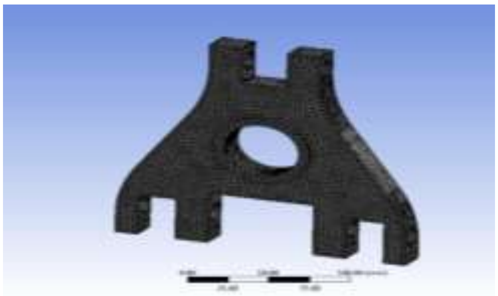


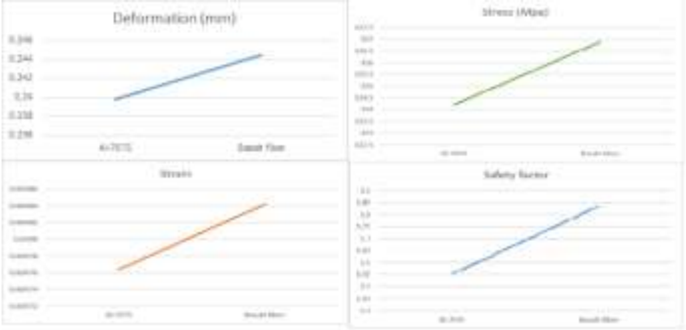
Figure6, 6: Analysis of Optimized design1 for AL-7075 *Figure7,9: Analysis of Optimized design1 for Basalt fiber*

5 Results

Table 2: Comparison

Optimized Design 1	**Al-7075**	**Basalt fiber**
Deformation (mm)	0.2398	0.24454
Stress (Mpa)	324.2	326.88
Strain	0.0047639	0.0048419
Safety factor	1.5515	1.8355

Fig. 10 Comparison of Materials for result Optimal Design 2



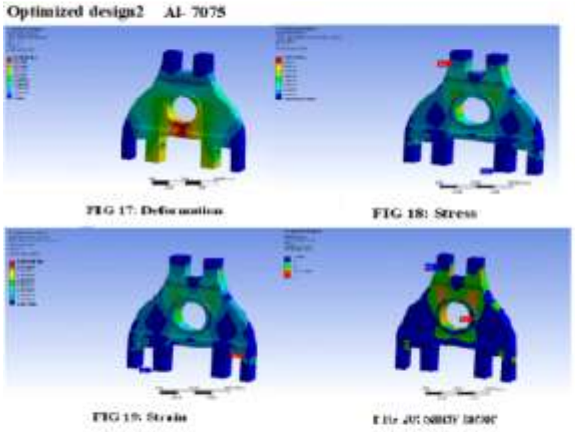


FIG 17: Deformation FIG 18: Stress FIG 19: Strain FIG 20: Safety factor

Figure 8: Optimized design2 for Al-7075

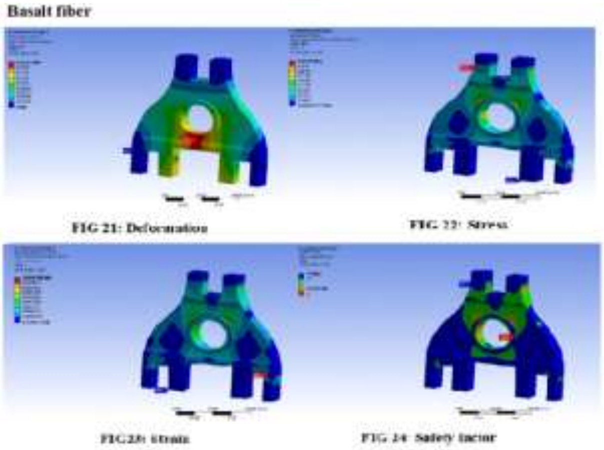
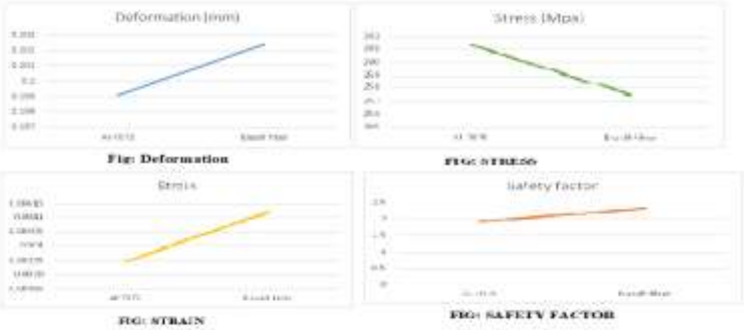


FIG 21: Deformation FIG 22: Stress FIG 23: Strain FIG 24: Safety factor

Figure 12: Optimized design2 for Basalt fiber

Table 3: Comparison

optimized design 2	**Al-7075**	**Basalt fiber**
Deformation (mm)	0.19911	0.20242
Stress (Mpa)	261.34	257.47
Strain	0.0039447	0.0041189
Safety factor	1.9247	2.3303



Graph 13: Comparison of Materials

5.1 Natural frequency

A sound wave is created when an object vibrates. The disruption that permeates the medium is caused by the vibrating object. The voice chords of a person, a vibrating string, or the soundboard of an instrument could all be the vibrating object that causes the disturbance. It might also be the diaphragm of a radio speaker, the guitar, violin, or the resonating tines of a tuning fork. Any vibrating object will produce sound. Whether the sound is melodic or noise, a vibrating object creates the sound wave. Nearly all objects will vibrate when touched, struck, plucked, strummed, or otherwise disturbed. When an object is hit, struck, plucked, strummed, or subjected to other disruptive forces, it vibrates naturally at one or more of the following frequencies known as its natural frequency. A system oscillates at the same frequency it naturally does when it is disturbed. When struck, a middle-hit guitar string oscillates back and forth. It is possible to determine if a string's vibration frequency is consistent by repeatedly plucking it ten times in a succession. The string vibrates at its natural frequency when it is pulled. A natural frequency is also present in the pendulum.

1. All things in the universe have a natural frequency, and many things have more than one
2 If you know an object’s natural frequency, you know how it will vibrate.
3 If you know how an object vibrates, you know what kinds of waves it will create.
4 If you want to make specific kinds of waves, you need to create objects with natural frequencies that match the waves you want.

In addition, mechanical vibration is essentially a play between inertial and elastic forces.

5.2 Dynamic analysis results

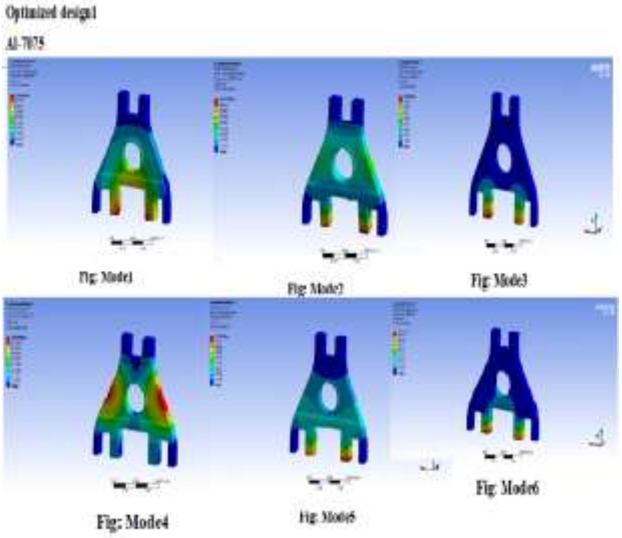


Figure 12: Optimized design1 for **Al-7075**

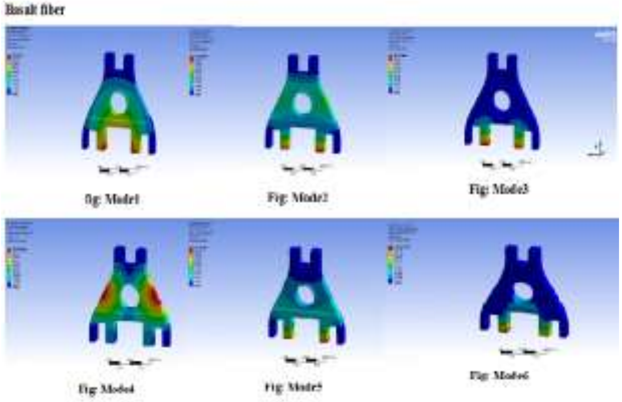


Figure 13: Optimized design1 Basalt fiber

Tables 5: Frequency Generated

Optimized design 1	**Al-7075**	**Basalt fiber**
Mode 1 (hz)	2060.6	2586.8
Mode 2 (hz)	3224.3	4462.6
Mode 3 (hz)	3469.2	4823.6
Mode 4 (hz)	4079.8	5654.6
Mode 5 (hz)	4519	6242.8
Mode 6 (hz)	4939.6	6819.5

Optimized design2

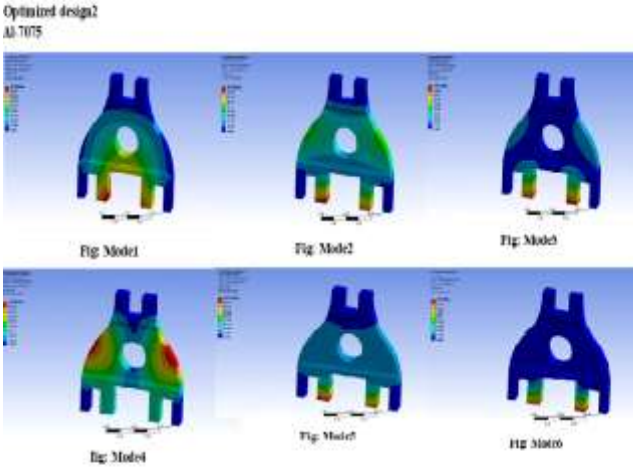


Figure 14: Optimized design2 for **Al-7075**

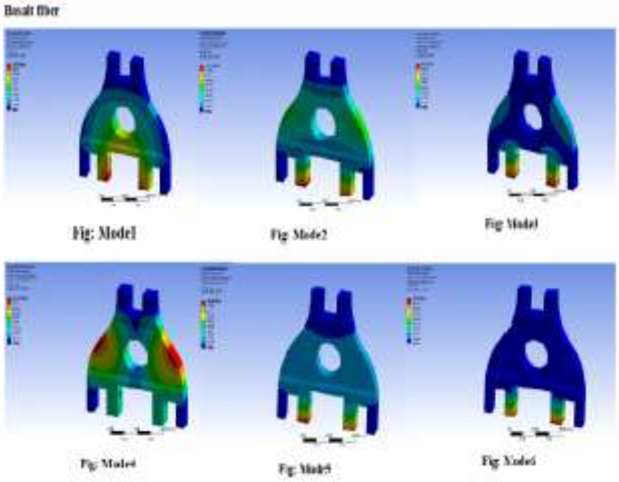


Figure 15: Optimized design2 for **Basalt fiber**

Tables 6: Frequency Generated

Optimized design 2	**Al-7075**	**Basalt fiber**
Mode 1 (hz)	2108.7	2924.7
Mode 2 (hz)	3165.7	4382.8
Mode 3 (hz)	3406.7	4735.6
Mode 4 (hz)	3717.5	5156
Mode 5 (hz)	4624.6	6391.2
Mode 6 (hz)	4984	6880.3

4.0 Results

Table 7: Frequency Generated

Existing design	**Al-7075**	**Basalt fiber**
Mode 1 (hz)	1861.3	2580.1
Mode 2 (hz)	2916.1	4031.5
Mode 3 (hz)	2998.9	4162.5
Mode 4 (hz)	3705.7	5132.1
Mode 5 (hz)	4325.8	5975.4
Mode 6 (hz)	4619.7	6377.9

Table 8: Frequency Generated

Optimized design 1	**Al-7075**	**Basalt fiber**
Mode 1 (hz)	2060.6	2586.8

Mode 2 (hz)	3224.3	4462.6
Mode 3 (hz)	3469.2	4823.6
Mode 4 (hz)	4079.8	5654.6
Mode 5 (hz)	4519	6242.8
Mode 6 (hz)	4939.6	6819.5

Table 9: Frequency Generated

Optimized design 2	Al-7075	Basalt fiber
Mode 1 (hz)	2108.7	2924.7
Mode 2 (hz)	3165.7	4382.8
Mode 3 (hz)	3406.7	4735.6
Mode 4 (hz)	3717.5	5156
Mode 5 (hz)	4624.6	6391.2
Mode 6 (hz)	4984	6880.3

6.0 Conclusion

The Ansys workbench tool was used to analyse the rear upright model in this study, which was built using the Fusion 360 tool, optimised using generative shape design, and subjected to both structural and dynamic boundary conditions. In this instance, extra material made of basalt fibre was used for the investigation in order to enhance item performance and reduce weight.

The results of the structural study show that an object made of the material al-7075 can sustain a load of up to 1.5e5N. By converting to basalt fibre material, the same object's strength increased by approximately 24% while maintaining 2% less weight than al-7075 material. Among other things, optimised designs also strengthen when basalt fibre is utilised in place of the original design.

In this case, dynamic analysis is also done to better comprehend each item. In order to determine the natural frequencies of each design and material, the results of the dynamic analysis are used. This is done because some materials may perform well under static boundary circumstances but badly under dynamic conditions. If the natural frequency range is wider, every substance or object has a bigger standing capacity to prevent resonance.

According to the findings of the dynamic analysis, basalt fibre has close to 30 to 40% greater high frequency range values than al-7075 materials, which indicates it can sustain more intense vibrations. The improved Design 2 will improve the object's performance in terms of strength and also be able to boost the dynamic stability of the object as the project comes to a close.

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