iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** IX **Month of publication:** September 2021

DOI: https://doi.org/10.22214/ijraset.2021.38000

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue IX Sep 2021- Available at www.ijraset.com

Frame Designing and Architecture of Electric dirt bike

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Abstract: A bike frame is also a non-standard structural component of a motorcycle linking various components of the vehicle systems and providing the vehicle rigidity and strength while running on various road conditions. This study is geared toward designing the frame of a two-wheeler, two-seater motorcycle for an electrical mobility purpose, while considering strength, safety and optimum performance of the vehicle. The said study has been allotted with a two-step approach. the first step includes modelling of the frame as per structural and ergonomic considerations, the design constraints governed by the front and rear suspension, steering and transmission systems and assemblies further because the determination of loads functioning on the frame. The second step is that the strain analysis using finite element analysis software and magnificence modifications for weight reduction without affecting structural strength.

The main aim was to cut back the burden, centralize the load and lower the burden of the frame. Thus, the metal tubes were divided into primary, secondary and tertiary members supported the tube diameters and thicknesses so on reduce the final weight of the frame without affecting its strength. The centre of gravity of the frame is below the rider way thus ensuring an occasional and centralized frame weight. The trusses not only provide strength and rigidity but also safety of the actuation and essential vehicle components against impacts. The chassis is additionally a skeleton upon which parts like battery and motor are mounted. The two-wheeler chassis consists of a frame, suspension, wheels and brakes. The chassis is what truly sets the sort of the two-wheeler. Commonly used material for two- wheeler chassis is steel which is heavy in weight or more accurately in density. There are various alternate materials like aluminium alloys, titanium, carbon fibre, magnesium, etc. which are lesser in weight and provide high strength and thus are often used for chassis.

Keywords: Frame, Chassis, Finite element analysis, Analysis, Frequency Analysis, Swing arm.

I. INTRODUCTION

Despite the continuously evolving technology and innovations, the electrical two- wheelers face certain shortcomings that need to be eliminated to spice up the overall performance of the vehicle. The prime concern where more efforts must be put in is that the burden and size of the systems and components, with a view of skyrocketing range, speed, payload and grade ability of the vehicle. Weight reduction has been achieved through advances in materials, improved design and analysis methods, fabrication process optimization should be implemented to urge a minimum weight with maximum or feasible performance, supported removal of conflicting constraints, design boundaries, and elegance uncertainties, like design clearance and material defects. The frame acts as a skeleton for the vehicle on which different components are mounted using bolted applications providing them with strength and rigidity in order that they will do the vehicle. apart from component mountings, the frame provides the required stiffness and resistance against shocks and impacts on the vehicle thus protecting the rider and also the vital components of the vehicle. There are different types of motorbike frames. Back bone frame, Single cradle frame, Double cradle frame, Monocoque frame, Perimeter frame and Trellis frame are the commonly using frame types their desired operation within the vehicle. At the front of the frame is found the highest tube that holds the pivoting front fork, while at the rear there are pivot points for the cushion and swingarm. Power producing components (IC engine for a standard fuel vehicle while motor and batteries for an electrical vehicle) are mounted on the inclose such how that they are protected in cases of accidents and impacts while ensuring there is no hindrance in their smooth functioning. The frame also supports various other peripheral components like seats for riders, vehicle bodywork and accessories of the vehicle.

Apart from component mountings, the frame provides the required stiffness and resistance against shocks and impacts on the vehicle thus protecting the rider and thus the vital components of the vehicle. There are differing kinds of motorbike frames. Back bone frame, Single cradle frame, Double cradle frame, Monocoque frame, Perimeter frame and Trellis frame are the commonly using frame types. Each frame has its own advantages and drawbacks. as an example, double cradle frame can withstand heavy static and dynamic loads. So double cradle frames are ideal for off road and rough terrain purposes. Considering trellis frame, these are extremely light and compact.

Trellis frames can provide the only handling characteristics. Also trellis frame is that the foremost suitable choice, if the primary aim is many |to avoid wasting} lots of maximum weight. during this project we are trying to form a very new frame which may well be a mixture of double cradle and trellis frames. There by we are going to achieve both weight reduction and also the structural strength needed for rough terrain purposes.

II. SKETCHING OF THE PROPOSED DESIGN

Sketching has its role within the design process. That role will vary counting on the end- product being created, the dimensions and scope of the project, the individual designer's style, experience, and workflow, and therefore the purpose of design. Sketching is a wonderful thanks to quickly explore concepts. Usually, basic sketching is finished on paper. In our project we used an Android software called ‘sketch book' rather than using paper. So, we are able to edit the maximum amount as we wish with ease. Sketching is largely done to visually represent the concept that has in mind. The figure given below is that the final sketch created after multiple redrawing’s. the scale aren't important in sketching process. The way, the merchandise should appear as if is that the only consideration at this stage of designprocess.

Figure2.1 Detail nomenclature of existing chassis

III. FABRICATION OF CONCEPT DESIGN IN SOFTWARE

The next step is to fabricate the look in a very design software. We are using solid works software for fabricating the planning. Dimensions are important during this stage. SolidWorks could be a solid modeler, and utilizes a parametric feature- based approach which was initially developed by PTC (Creo/Pro- Engineer) to form models and assemblies. Design intent is how the creator of the part wants it to retort to changes and updates. for instance, you'd want the outlet at the highest of a beverage can to remain at the highest surface, no matter the peak or size of the can. SolidWorks allows the user to specify that the opening could be a feature on the highest surface, and can then honour their design intent regardless of what height they later assign to the can.

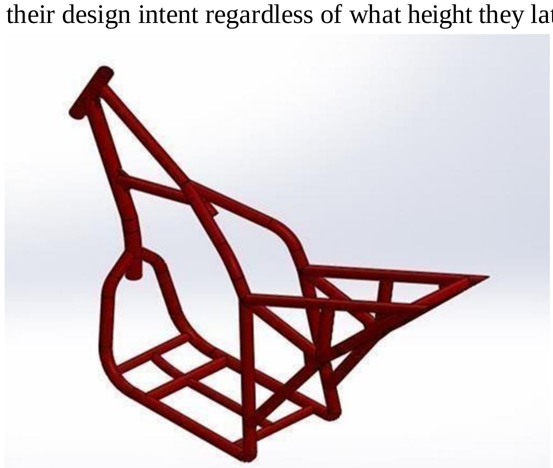

Figure 3.1 Fabricated concept design

IV. MATERIAL SELECTION

Structural steel is chosen material for the frame design. steel may be a category of steel used for creating construction materials in a very form of shapes. Many steel shapes take the shape of an elongated beam having a profile of a selected cross section. steel shapes, sizes, chemical composition, mechanical properties like strengths, storage practices, etc., are regulated by standards in most industrialized countries. it's steel, meaning it's a carbon content of up to 2.1 percent by weight.

Although both medium high carbon steels (steels with a carbon content starting from 0.31 percent to 1.50 percent) may be considered steel, these are typically used for engineering purposes. The properties of structural steel are shown in this table,

Proprieties	Value	**Units**
Density	7850	Kg/m^3
Young Modulus	2,07E+11	Pa
Poisson's ratio	0.3	
Shear Modulus	7.9615E+10	Pa
Bulk Modulus	1.725E+11	Pa
Tensile yield strength	2.5E+08	Pa
Tensile ultimate strength	2.5E+08	Pa
Limit rupture in traction	4.6E+08	Pa

Table 5.1 Material Properties

Structural steel and ferroconcrete don't seem to be always chosen solely because they're the foremost ideal material for the structure. Companies depend on the power to show a profit for any construction project, as do the designers. the value of raw materials (steel, cement, coarse aggregate, fine aggregate, lumber for form-work, etc.) is consistently changing. If a structure may be constructed using either material, the most affordable of the 2 will likely control. Another significant variable is that the location of the project. The closest steel fabrication facility is also much farther from the development site than the closest concrete supplier. The high cost of energy and transportation will control the choice of the fabric additionally. All of those costs are going to be taken into consideration before the conceptual design of a construction project is begun.

V. STATIC ANALYSIS

Structural analysis in the motorcycle frame is mainly concerned with finding out the behavior of a physical structure when subjected to force.

This action can be in the form of load due to the weight of rider and the weight of components such as batterypack and BMS, motor etc. or some other kind ofexcitation.

A. Loading Conditions and Fixed Supports

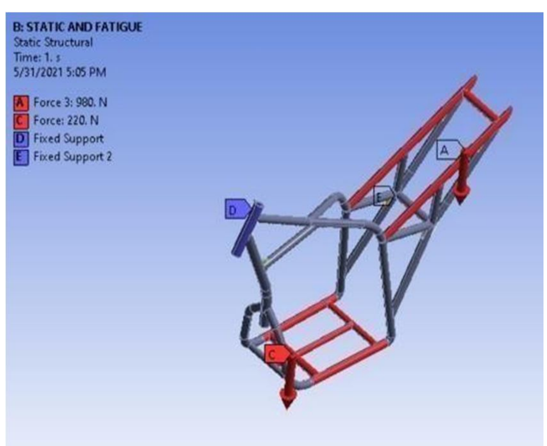

Figure 5.1 Loading conditions and fixed support

D, E are considered as fixed supports and A, C are forces acting on the structure

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B. Total Deformation

Deformation results generally is in ANSYS Workbench as total deformation or directional deformation. Both of them are accustomed obtain displacements from stresses. In total deformation, it gives a root of the summation of the square of x- direction, y-direction and z-direction.

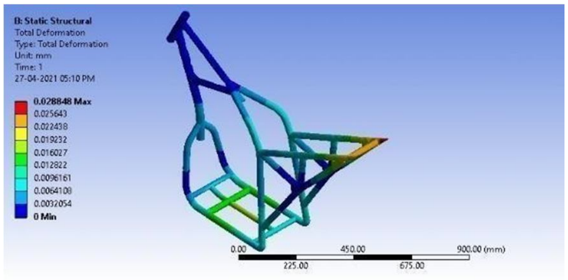

Figure 5.2 Total Deformation

	Maximum value	Minimum Value
Static Structure	0.028848 mm	0 mm

Table 5.2 Total deformation

C. Equivalent Stress

Equivalent stress is employed when there's a multiaxial stress state with multiple stress components engaging at the identical time within the structure. In such case we are able to use selected criterion to rework the entire stress tensor into one equivalent component which will be treated as a tensile stress and thus compared with material's strength easily. Various criteria is also utilizing but among them there's one with incomparably larger popularity than the others - von Mises yield criterion or otherwise maximum distortion energy criterion. It's commonly employed in engineering and during this Finite Element Analysis program, equivalent stress is employed as a default stress measure.

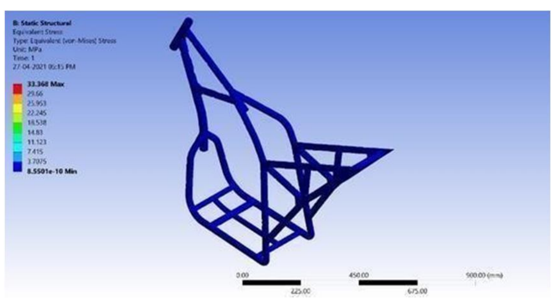

Figure 5.3 Equivalent stress

	Maximum value	Minimum value
Static structure	33.368	8.5501 ^-10

Table 5.3 Equivalent stress

VI. IDENTIFICATION NATURAL FREQUENCIES AND VIBRATION MODES

A dynamical analysis includes the study about performance of the system with an external perturbation applied on that. Talking about it, natural frequencies and vibration modes are really important to be studied and to understand them because then it may be known when the system can vibrate so some dynamical problems may be corrected or fixed during designing or testing process modifying the first structure like adding more mass, changing materials, unions.

Vibration modes are frequencies induced when frames (formed by distort elements) are oscillated, by external efforts, in numerous ways (if there's quite one) with stationary waves. They depend exclusively of geometry, materials and system configuration. for every frame (structure) exists only a bunch of frequencies that are just for it the tactic to urge the results is through ANSYS.

MOD E	FREQUENC Y
1	68.576
2	151.53
3	169.04
4	176.79
5	188.88
6	244.8
7	281.34

Table 6.1 Modes and frequency

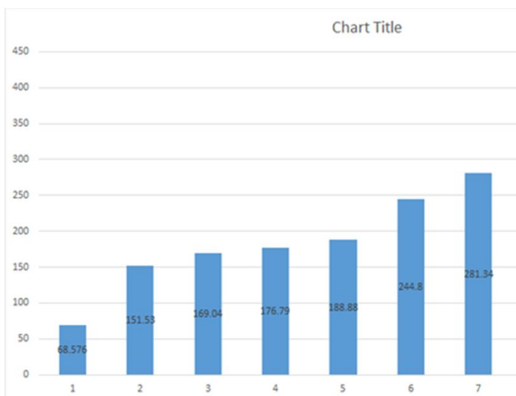

Figure 6.1 Mode vs Frequency Chart

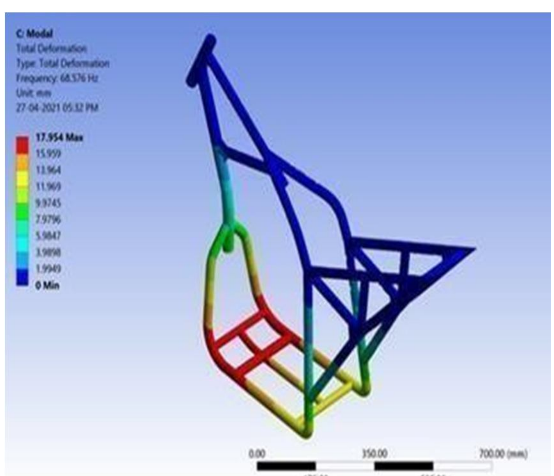

Figure 6.2 1st mode of vibration

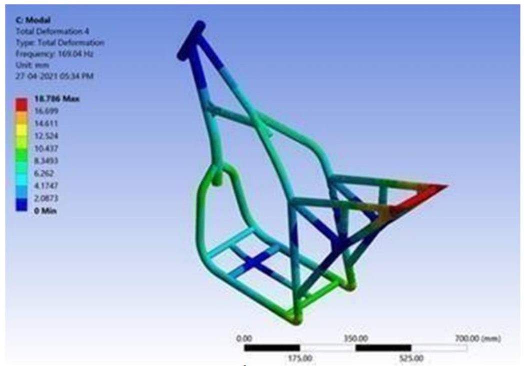

Figure 6.3 2nd mode of vibration

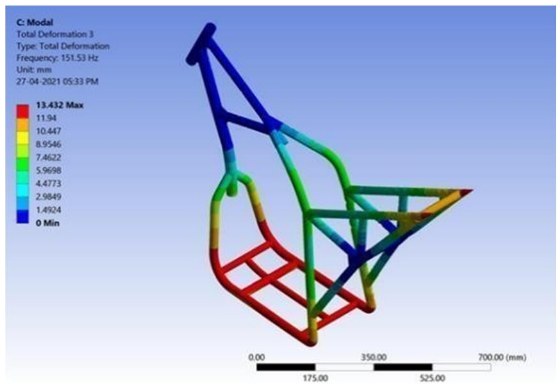

Figure 6.4 3rd mode of vibration

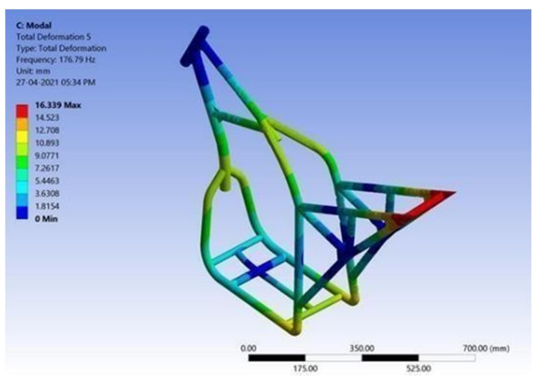

Figure 6.5 4th mode of vibration

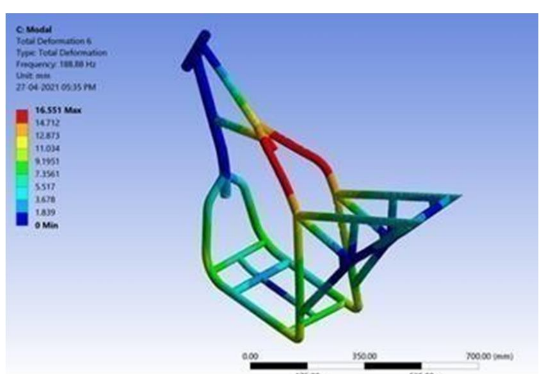

Figure 6.6 5th mode of vibration

The first mode of vibration for the frame could be a bending mode in horizontal direction. during this mode shape, the frequency is 68.576 Hz. The beam is tending to bend about the foundation section's minimum moment of inertia. The second modes of vibration is additionally bending mode having natural frequency
151.53 Hz. The third mode of vibration is additionally bending mode in vertical direction. The frequency of the third mode shape is 169.04 Hz. The fourth mode of vibration is twisting about the basis, the frequency is laid low with tip rotational moment of inertia. The frequency of the fifth mode is 176.79 Hz. The fifth mode of vibration is bending and twisting mode in horizontal with frequency 188.88 Hz. The sixth mode shape is twisting with natural frequency 244.8. The seventh mode shape is twisting with natural frequency 281.34 Hz.

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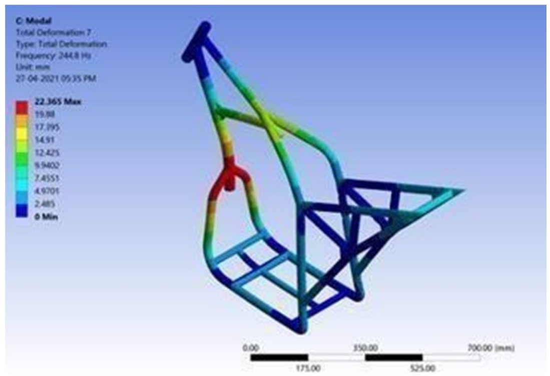

Figure 6.7 6th mode of vibration

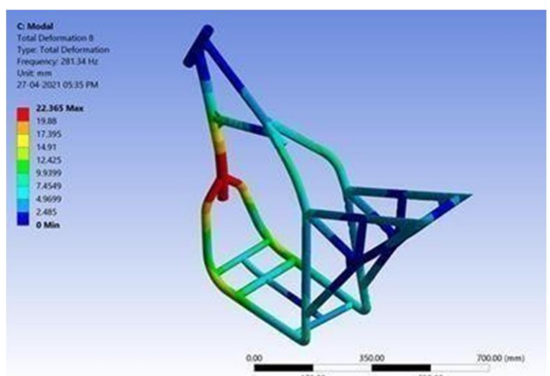

Figure 6.8 7th mode of vibration

VII. FATIGUE ANALYSIS

Fatigue failure is defined as the movement of a structure to fracture by means of progressive brittle cracking under repeated alternating or cyclic stresses of an intensity considerably below the yield strength. Although the fracture is of a brittle type, the time to propagate is slow, found by both the intensity and frequency of the stress cycles. All structures and mechanical components that undergoes Cyclic loading can fail by fatigue. Fundamental requirements during design and manufacturing to avoid fatigue failure are different for every different case and will be considered during the planning phase.90% of the mechanical failure occurs due to fatigue failure.

A. Fatigue Analysis in Bike Frame

A motorcycle frame system is a load bearing structure that always appears to suffer fatigue damage after running for a long time, indeed the fatigue life of the frame finally decides the service life of a motorcycle.
In our work, we predicted the fatigue life of a motorcycle frame by carrying out a simulation work on Ansys Software based on the finite element analysis method. 90% of the mechanical failure occurs due to fatigue failure.

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B. Stress Analysis

The Fatigue stress analysis was conducted on the model for the loading condition and the maximum and minimum stress which occurs on the frame was found.

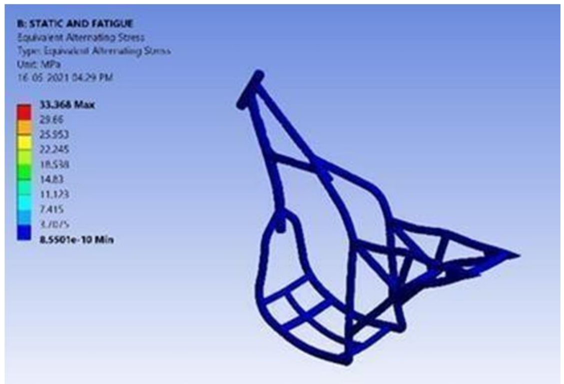

Figure 7.1 Stress Analysis Isometric View

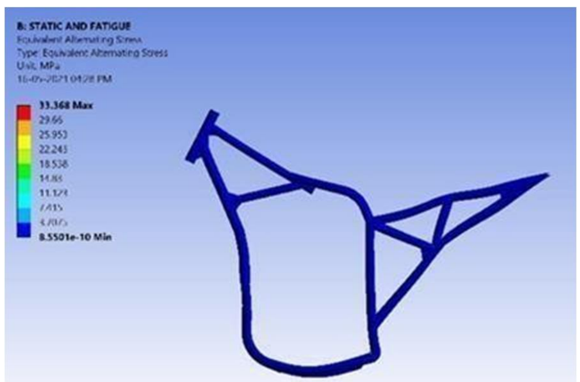

Figure 7.2 Stress Analysis Sideview

The minimum and maximum stress was found to be 8.55 e-10 MPa and 33.546 MPa. The result obtained shows the model isable to resist such forces in fatigue loading.

C. Fatigue Life

Fatigue life illustrates how long a product will last before the entire failure of the product. Fatigue is that the weakening of a structure subjected to repeated loads and is progressive and localized structural damage. The stress values which will cause the fatigue damage could also be much less than yield strength of the structure The fatigue lifetime of the frame is incredibly important to define the service lifetime of the motorcycle.

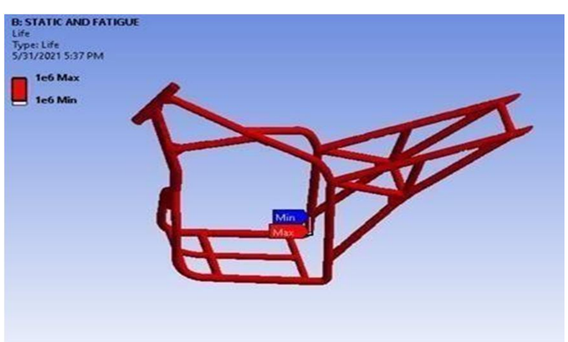

Figure 7.3 Life Analysis

D. Factor of Safety

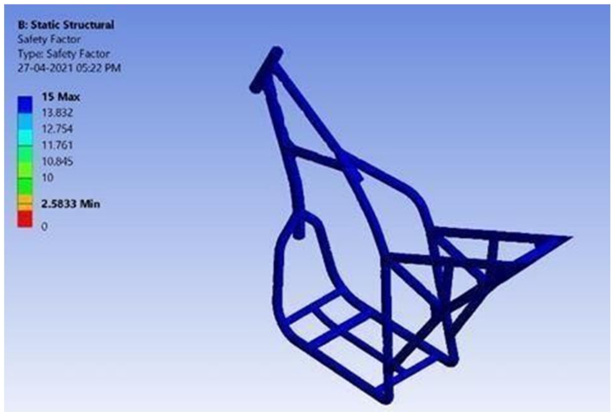

Figure 7.4 FOS Analysis

The FOS was found to be 2.583 which means the frame is able to resist even 2.6 times the normal load acting on it.

E. Conclusion

The work aims at the fatigue life of a bike frame after fatigue failure because of the operational loads. the stress was calculated employing a finite element model consisting of the surface elements.

Under Fatigue loading, the result shows the frame is safe, gives good life, and is 2.5 times stronger than the loading condition.

VIII. ANALYSIS ON SWING ARM

The motorcycle Swing arm is also a key component of the rear suspension of a motorcycle. The swing arm is connected to the rear wheel of the motorbike to the foremost chassis, and it regulates the rear wheel-road interactions with the help of spring and shock. Single-sided and double- sided swing arms area unit the two basic style exists. The vertical stiffness will have an effect on the motorbike setup and manufacture unpredictable behavior if not rigid enough. The lateral and torsional stiffness have an effect on the motorbike response throughout cornering and conjointly the motorbike weave mode.

A. Analysis on Swing Arm

CAD modelling of the swing arm wasdone using Solid works software. The 3D model of a swing arm was designed and all the FEM calculations were done. As a calculation model, shell model was created based on the Solidworks model. Subsequently discrete model of S4R elements (19 820 elements) and S3R elements (19 elements) are created , which indicates relatively good quality of discrete model. Regions where bearings of shock absorbers and axle bearings where placed, separate mesh regions were isolated.

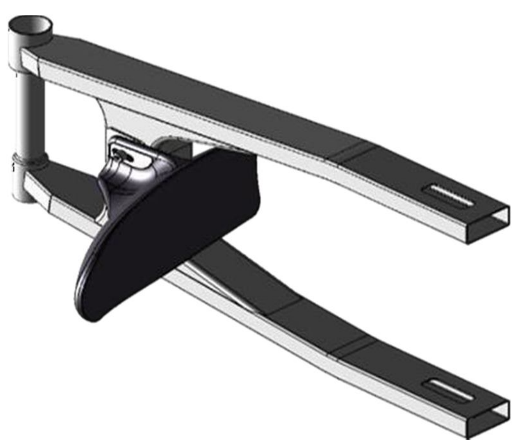

Figure 8.1 3D Model of Swing arm

B. Weight and Acceleration

The swing arm has cylindrical frictionless supports which is attached to the chassis, and the other end has the bearings during which the rear wheel axle is rotating. The spring dampers are mounted on the welded plate. During static running condition, the dampers exert forces because of the dead weight of the motorbike and weight of the swing arm, acting on the rear side of the motorcycle (B Smith, et al, 2015). This load acts as a pressure on the swing arm on rear lateral faces where the wheel hub is mounted. Considering these two conditions, one critical condition may be the simultaneous application of those two loads. This condition must be analyzed. Thus, net load on swing arm are often calculated. The load which is able to be distributed equally on the 2 side beams just in case when the motorcycle is running straight. The load are functioning at an angle of about 50^o at which the damper is mounted.

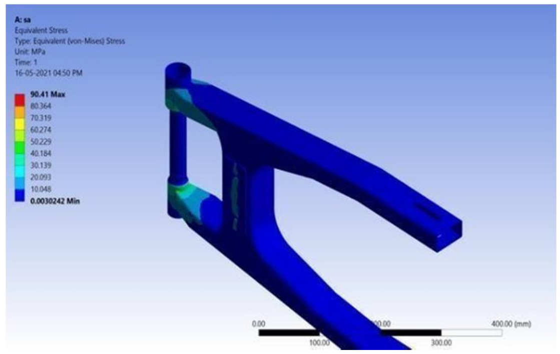

Figure 8.2 Total Deformation in acceleration

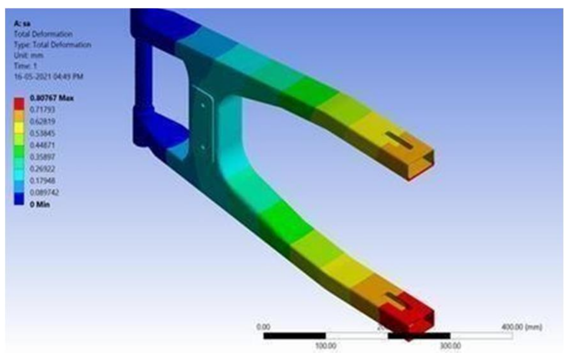

Figure 8.3 Equivalent Stress in acceleration

	MAXIM UM	MINIMUM
TOTAL DEFORMA TI ON	0.8076 mm	0
EQUIVALEN T STRESS	90.71M Pa	0.0030242 MPa

Table 8.1 Result in acceleration

C. Weight and Deceleration

This condition is analogous to the one mentioned above the difference being that the pressure because of braking are going to be in wrong way. The minimum braking and maximum deceleration was evaluated experimentally. For rear braking, the most deceleration was found when braking at a speed of 20 kmph to 0kmph in 1.3 seconds. From this value, the most deceleration is -4.273 m/s2. Considering the inertia of the bike, acceleration (B Smith, et al 2015),and the longitudinal force acting on the swing arm. Again, considering area of cross- section, longitudinal pressure on Swingarm is 10.44 MPa. This pressure is applied with boundary conditions as in first case.

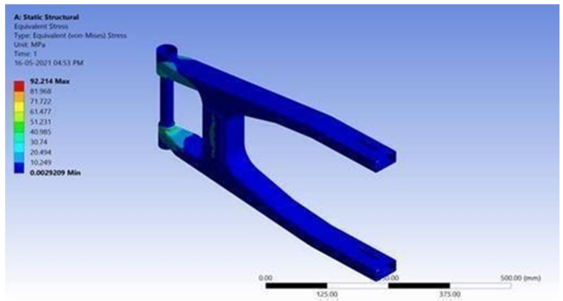

Figure 8.4 Total Deformation in decceleration

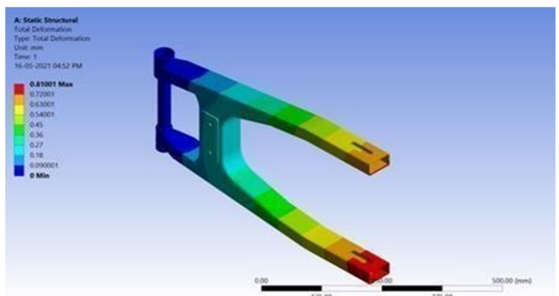

Figure 8.5 Equivalent Stress in decceleration

	MAXIM U M	MINIM U M
TOTAL DEFORMA TI ON	0.81001m m	0
EQUIVALEN T STRESS	92.214MP a	0.0029M Pa

Table 8.2 Result in decceleration

D. Cornering Conditions

Cornering is one amongst the important criteria in design on motorcycle components. During cornering, different components are subjected to variation in loads in magnitude additionally as direction. just in case of swing arm, high lateral forces act in unbalanced state. The magnitude of variation depends upon the angle of inclination and also the vehicle speed (B Smith, et al, 2015). Loads and boundary conditions- it's assumed that

	MAXIMU M	MINIMUM
Total Deformatio n	6.621mm	0.00148mm
Equivalent Stress	453.3MP a	0.001448M Pa

Table 8.3 Result in cornering

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E. Fatigue Analysis

20% more load are transferred to the inner side during cornering. Thus, the inner side beam will have 70% of the overall weight and remaining 30% of the weight acting on the outer side beam. If we consider a maximum cornering angle of 40o, and divide the forces into vertical and horizontal components, there'll be torsional and lateral imbalance on the center part.

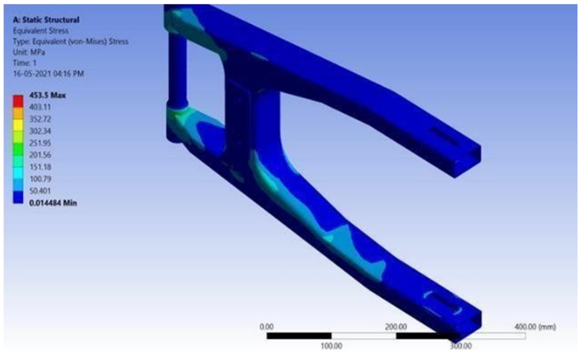

Figure 8.6 Equivalent Stress in cornering

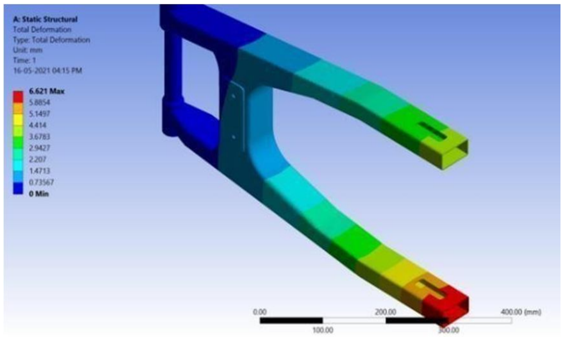

Figure 8.7 Total Deformation in cornering

General applicability of the stress-life method is restricted to circumstances where continuum, "no cracks" assumptions may be applied. the benefits of this method are simplicity and easy application, and it offers some initial perspective on a given situation. it's best applied in or near the elastic range, addressing constant amplitude loading situations in what has been called the long-life regime (Sunup Kumar, 2012). Fully reversed horizontal and vertical components of weights were applied to the small-arm. Cylindrical frictionless support was applied to the opposite end. These parameters are somewhat less for the modified part. This problem may be fixed either by employing a good surface finish or coating the give an acceptable material to extend the endurance limit of the component. Based upon this the security factor variation and lifetime of the side beam was evaluated. Following are the results obtained.

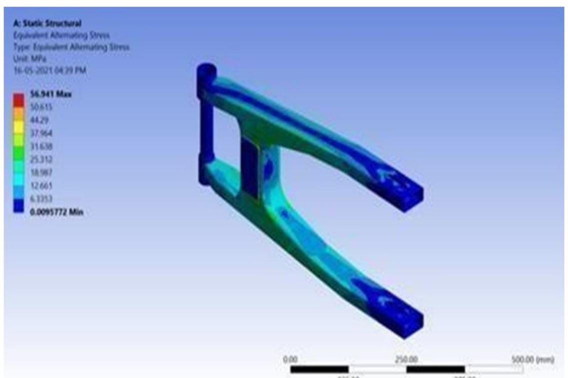

Figure 8.8 Equivalent Stress in fatigue

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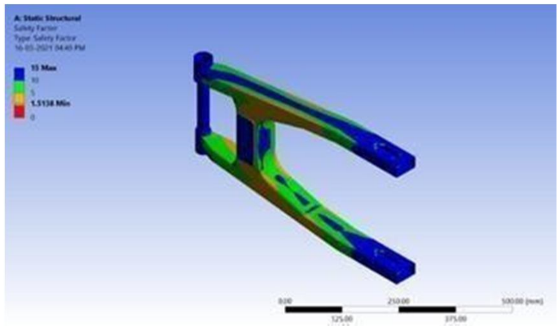

Figure 8.9 Safety factor in fatigue

	MAXIMUM	MINIMUM
FACTOR OF SAFETY	15	1.5138
EQUIVALENT STRESS	56.941MPa	0.095572MPa

Table 8.4 Result in fatigue analysis

F. Static Analysis

The value of vertical stiffness of the side beam must be less than the suspension stiffness. The FE model was assumed to be linear and during vertical loading only the

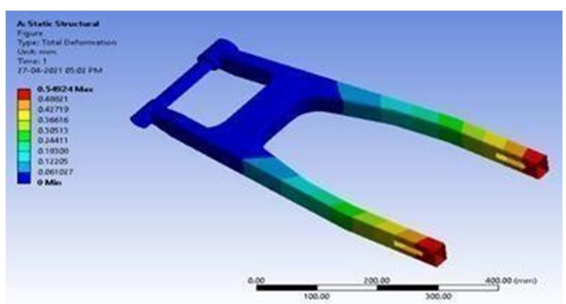

Figure 8.11 Total deformation in static

	MAXIMUM	MINIMUM
TOTAL DEFORMATION	0.54924	0
EQUIVALENT STRESS	56.941MPa	0.095572MPa

Table 8.5 Result in static analysis

IX. CONCLUSION

1) From the static analysis, the equivalent stress and the deformations caused by maximum load of 500 N was applied. The FE strains and deflections at maximum loading were calculated and intermediate results calculated using linearity. For evaluation purposes vertical load of 500 N was applied in time step of 1 second and along with frictionless cylindrical support.

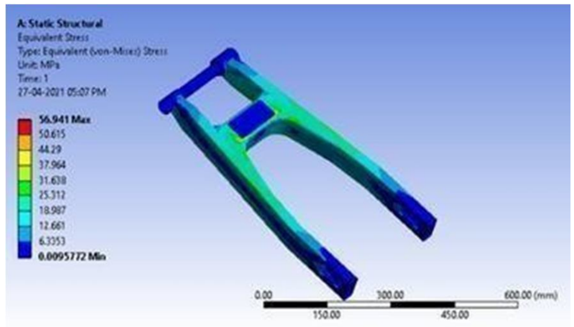

Figure 8.10 Equivalent Stress in Static

The loads are found by simulating design in static load conditions. The stress values obtained shows that the design is capable of handling the loads acting on the frame. Also, the deformations obtained are very minimal. This level of deformations doesn't affect the structural integrity of the frame. So, the frame design is capable of handling static loads.

2) From the Natural frequency analysis, the natural frequencies at different modes were obtained and the behavior of the design in different mode shapes were analyzed.
3) From the fatigue analysis the results obtained shows that the frame has good life value and strength and is able to resist the forces acting upon and givesa Standard FOS Value.
4) FEA analysis of swing arm in 5 different conditions were conducted. For each analysis the maximum and minimum value equivalent stress and total deformation have been noted and none of them exceeds more than the limit and affects the structural integrity of the swing arm. The maximum stress value and deformation is 90.7MPa and 6.691mm.

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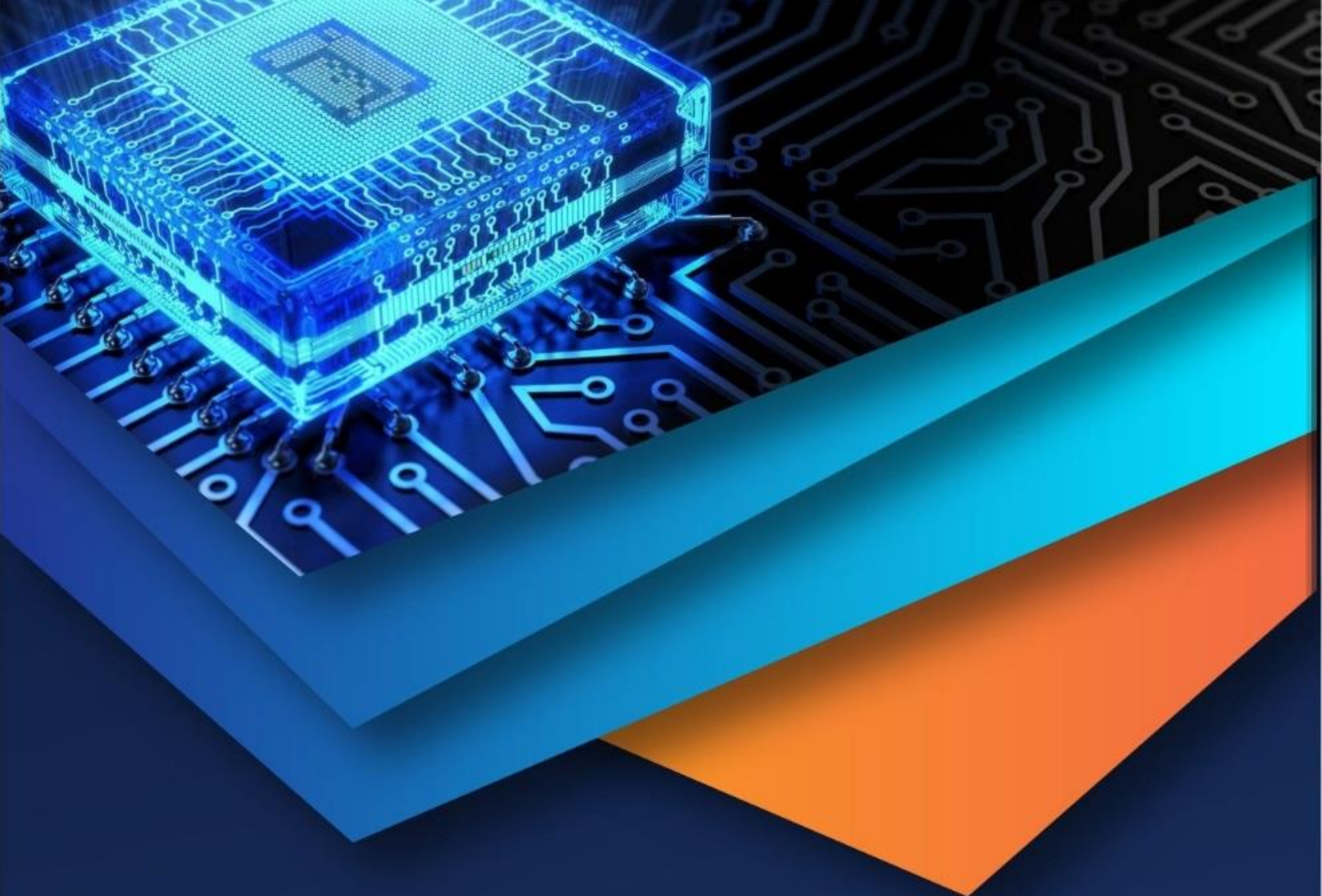

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