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Enhancing Stiffness of Caliper Bracket on Four Wheeler Disc Brake

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Abstract

Brakes are most important component of any vehicle. The disc brakes are used in rear wheel brakes of four wheelers to provide better braking. These disc brakes contain brake caliper brackets to hold the pads of the brakes. These caliper bracket must withstand the forces generated during braking and also should withstand heavy load during emergency or sudden braking. These caliper brackets must possess high stiffness to resists deformation due to load applied which leads to crack development. Due to low stiff materials used in brackets leads to squeal which is another major concern. Hence in this paper the existing caliper bracket is analyzed for its static strengths using ANSYS depending upon the loading conditions and improvement is made on the bracket according to the results obtained.

Keywords: deformation, stiffness, Young's modulus

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INTRODUCTION

Disc brakes are most common in four wheelers to make braking precise and to gain good stopping force. One of the important parts in disc brake is brake caliper where caliper bracket is used. In brake caliper the hydraulic pressure pushes out one of the piston. This causes the outer portion of the caliper and the piston to squeeze the rotor between two brake pads. The frictional forces which are produced are conveyed at this pad interface.

A caliper bracket holds the pads and attaches the caliper to the spindle. Thus, the caliper bracket must withstand all the braking forces at the wheel under heavy braking. It should not over deflect while withstanding the forces. If the stiffness of the bracket reduces large deformations occurs and even a structural failure. After large deformation, cracks will begin to appear soon after fracture. Material with low stiffness will cause brake squeal. [1–3]

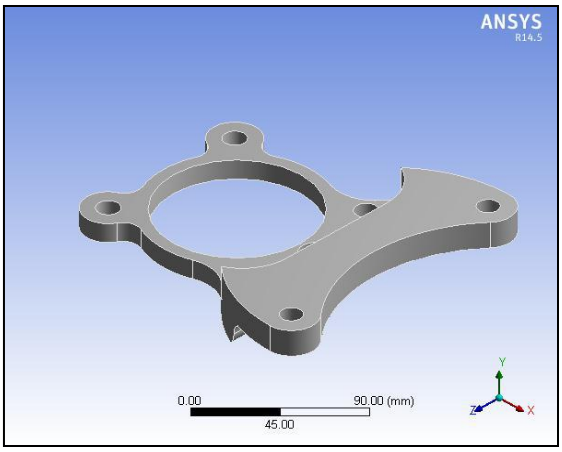

Fig. 1. *Brake Caliper Bracket.*

MODEL DEVELOPMENT

The 3D model of the caliper bracket is developed in SolidWorks using the measurement taken. The model developed is shown in Figure 1. The material used for making the caliper bracket is Aluminum 7075.

Although Aluminum 7075 has many advantages, their Young's modulus only has the value of 72 GPa which is very low. Hence, it is analyzed for its deformation due to various loads applied during braking. The analysis is done by using ANSYS.

ANALYSIS OF EXISTING MODEL

The solid model developed is now imported into ANSYS Workbench and the material property of Aluminum 7075 is provided. Now meshing is done for the imported model. After meshing, the forces are applied along z-direction with forces acting on same and opposite directions and load ranging from 1KN, 3KN, 5KN. After that, the model is analyzed for corresponding deflections, stress and strain values. The mesh developed is shown in Figure 2 (Figures 3–10, Tables 1–6). [4, 5]

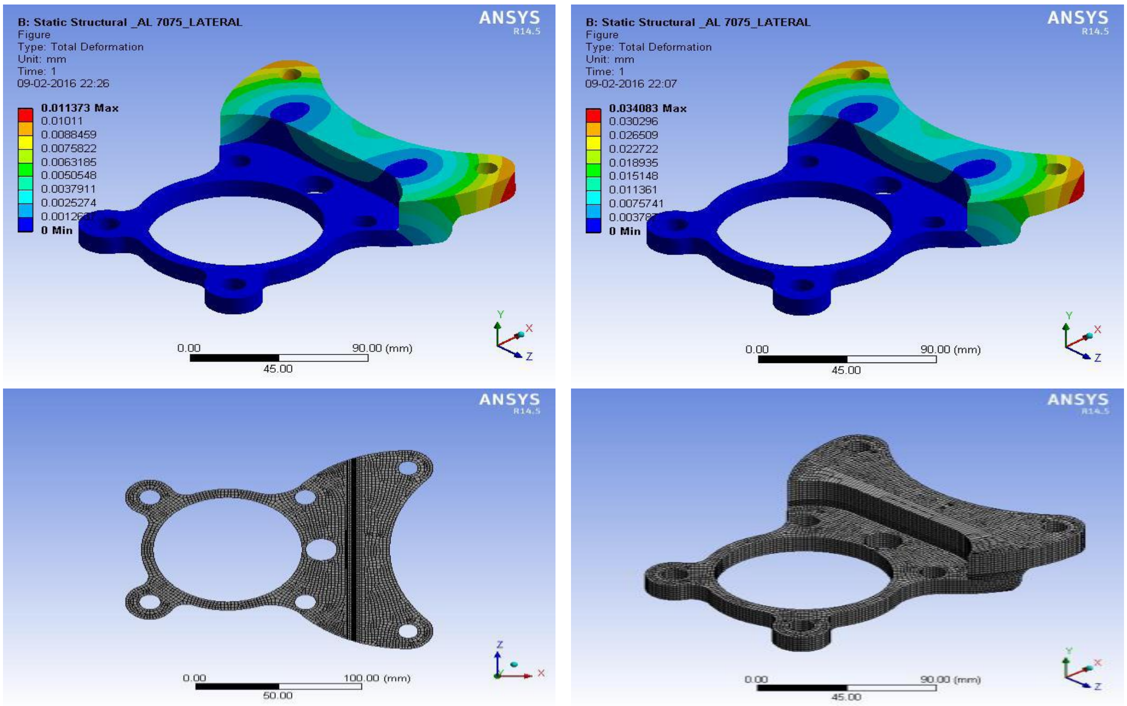

Fig. 2. *Meshes Developed on Existing Model.*

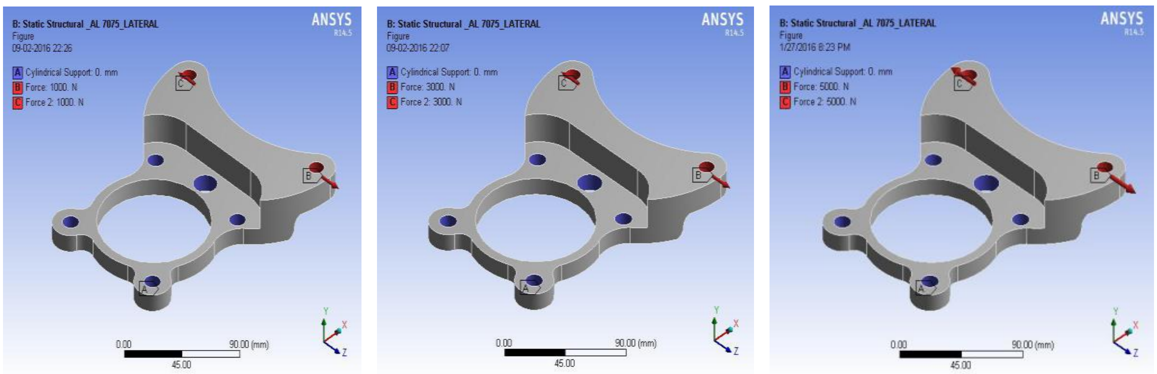

Fig. 3. *Loads Acting Along z-Axis and Opposite Directions.*

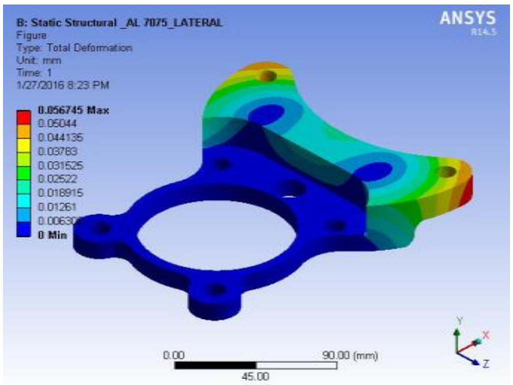

Fig. 4. *Deformation Values for Loads Acting Along Opposite Direction.*

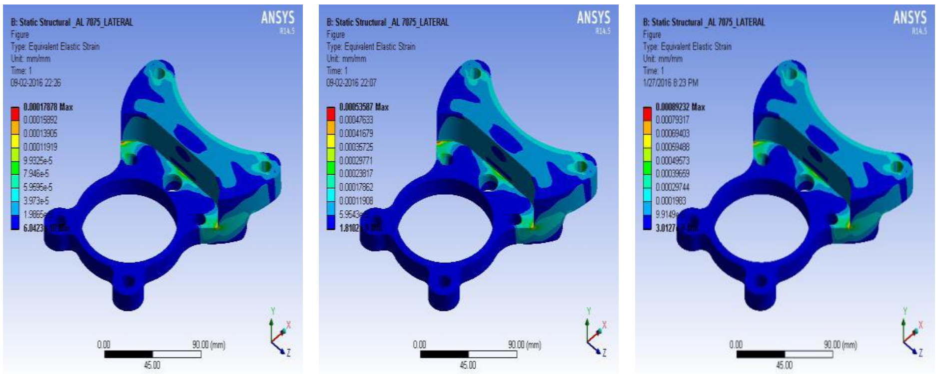

Fig. 5. *Strain Values for Loads Acting Along z-Axis and Opposite Directions.*

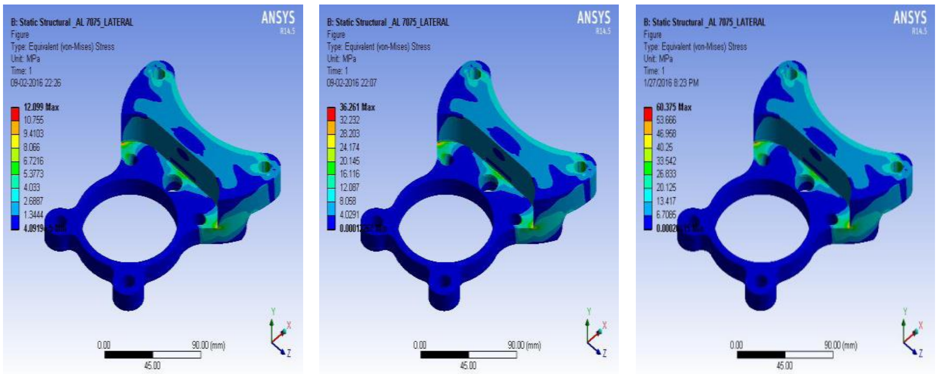

Fig. 6. *Stress Values for Loads Acting Along z-Axis and Opposite Direction.*

Table 1. *Maximum Deformations, Strain and Stress Values for Loads Acting Along z-Axis and Opposite Directions.*

Material	**Load condition**		**Loads**		
			1KN	**3KN**	**5KN**
Aluminum 7075	Loads acting along z-axis and opposite direction	Max Deformation (mm)	0.011373	0.034083	0.056745
		Max strain	0.00017878	0.00053587	0.00089232
		Max stress (MPa)	12.099	36.261	60.375

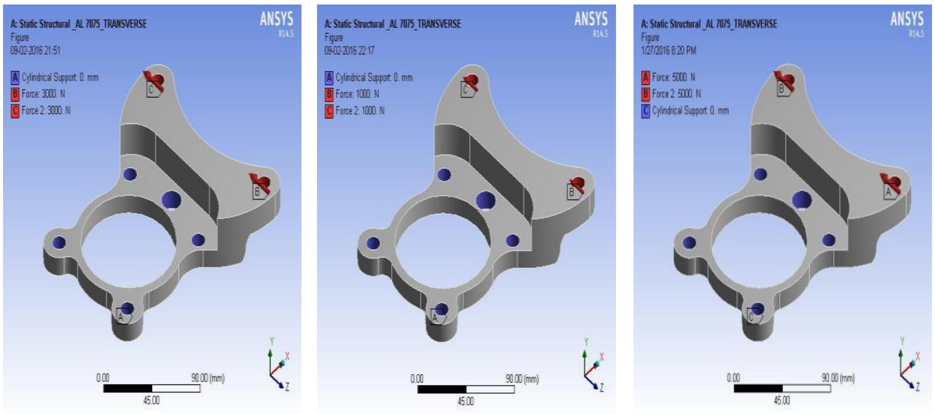

Fig. 7. *Loads Acting Along z-Axis and Same Directions.*

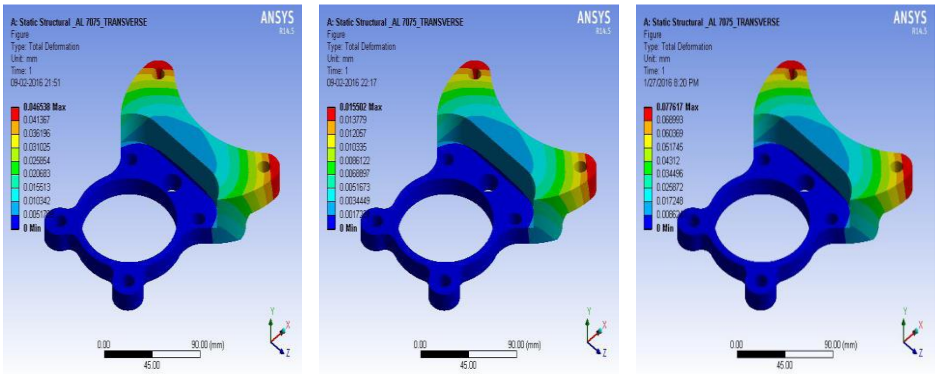

Fig. 8. *Deformation Values for Loads Acting Along z-Axis and Same Directions.*

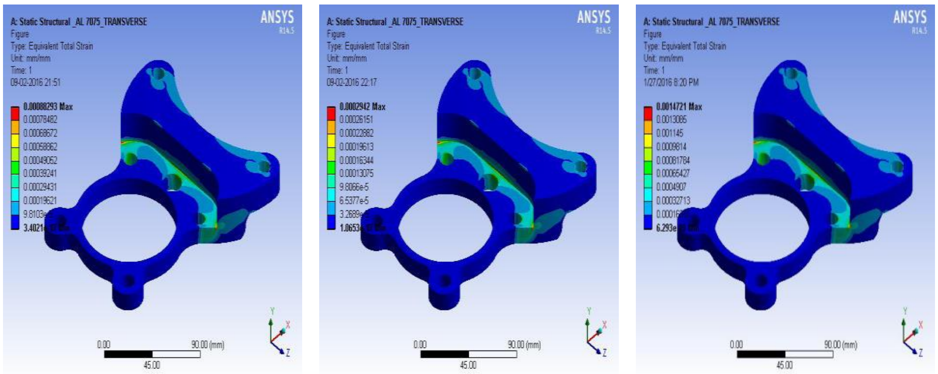

Fig. 9. *Strain Values for Loads Acting Along z-Axis and Same Directions.*

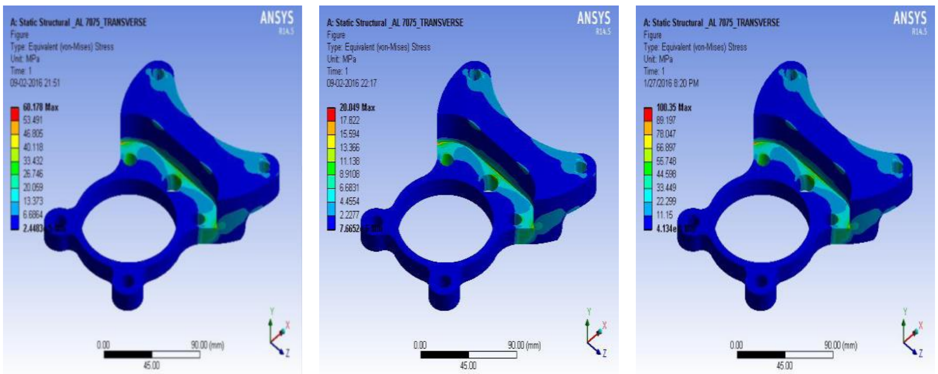

Fig. 10. *Stress Values for Loads Acting Along z-Axis and Same Direction.*

Table 2. *Maximum Deformations, Strain and Stress Values for Loads Acting Along z-Axis and Same Directions.*

Material	Load Condition		Loads		
			1KN	3KN	5KN
Aluminium 7075	loads acting along z-axis and same direction	Max deformation (mm)	0.015502	0.046538	0.077617
		Max strain	0.0002942	0.00088293	0.0014721
		Max stress (MPa)	20.049	60.178	100.35

Table 3. *Stiffness Values for Various Loads Applied.*

Material	Load	Stiffness	
		Loads acting on opposite direction	Loads acting on same direction
Aluminium 7075	1KN	87,927.5477	64,507.8054
	3KN	88,020.4207	64,463.4492
	5KN	88,113.4902	64,418.8773

METHODS FOR INCREASING STIFFNESS

For increasing stiffness of a material, the possible solutions are:

(1) Modifying material geometry.
(2) By choosing material having high young's modulus value.

If the geometry of the bracket is modified then the whole caliper assembly has to be redesigned. Hence other possible way for enhancing stiffness is by choosing material with high young's modulus value. [6–11]

ANALYSIS OF THE NEW MATERIAL

While looking for material with high Young's modulus value, ductile cast iron FCD450 with Young's modulus value of 170 GPa is selected. It has high strength, good machining and toughness. It has physical property nearly close to steel. On the selected material, the same forces and load are applied and the results are obtained accordingly (Figures 11–17). [12–18]

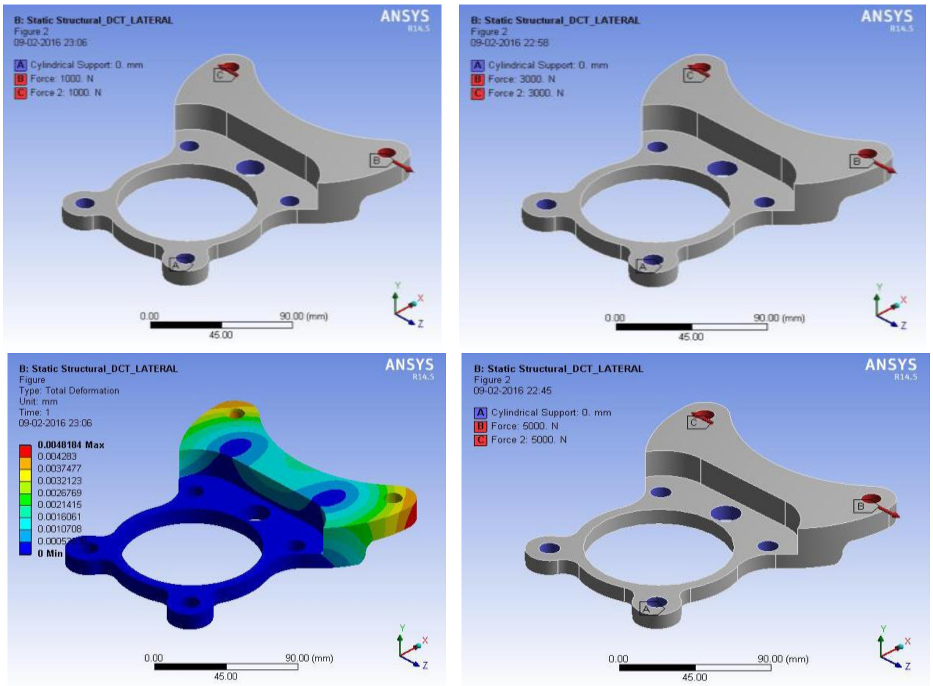

Fig. 11. *Loads Acting Along z-Axis and Opposite Directions.*

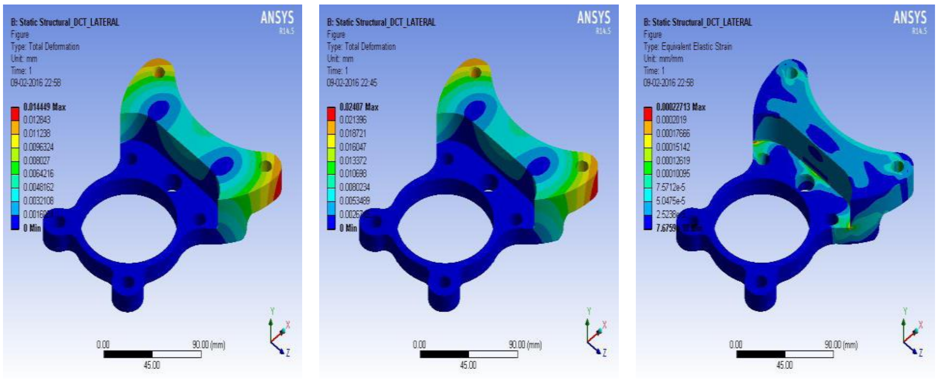

Fig. 12. *Deformation Values for Loads Acting Along z-Axis and Opposite Directions.*

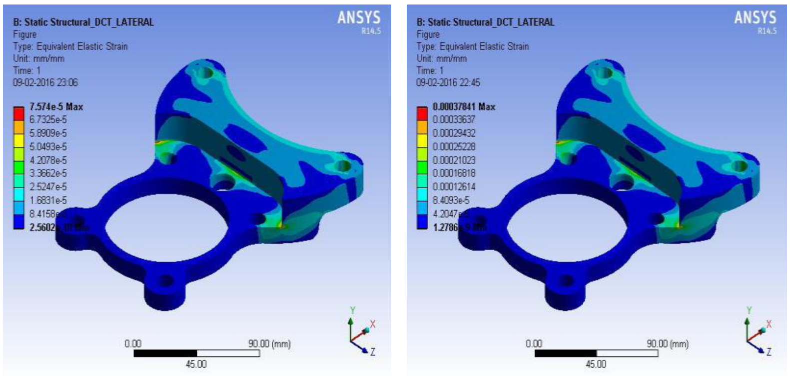

Fig. 13. *Strain Values for Loads Acting Along z-Axis and Opposite Directions.*

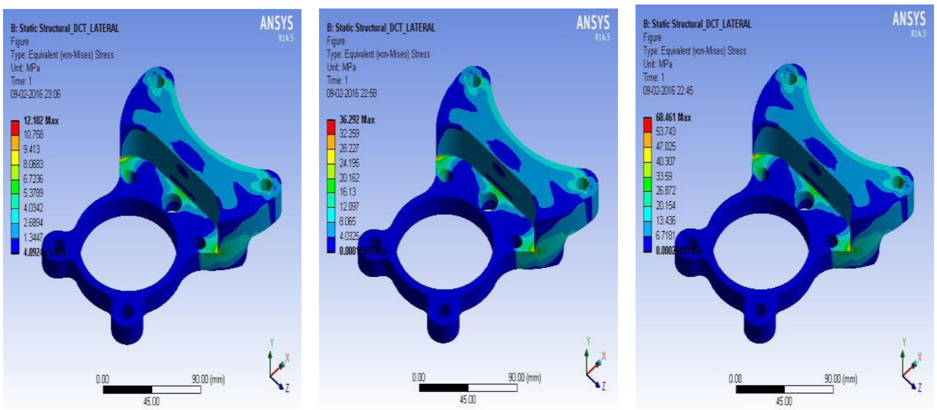

Fig. 14. *Stress Values for Loads Acting Along z-Axis and Opposite Directions.*

Table 4. *Maximum Deformations, Strain and Stress Values for Loads Acting Along z-Axis and Opposite Direction.*

Material	**Load Condition**		**Loads**		
			1KN	**3KN**	**5KN**
Ductile Cast Iron FCD450	Loads acting along z-axis and opposite direction	Max Deformation (mm)	0.004283	0.01444	0.02407
		Max strain	7.574e-5	0.00022713	0.00037841
		Max stress (MPa)	12.102	36.292	60.461

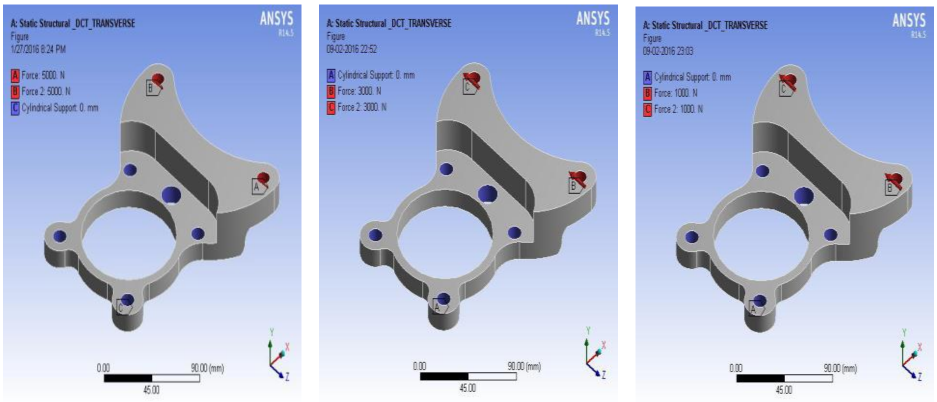

Fig. 15. *Loads Acting Along z-Axis and Same Directions*.

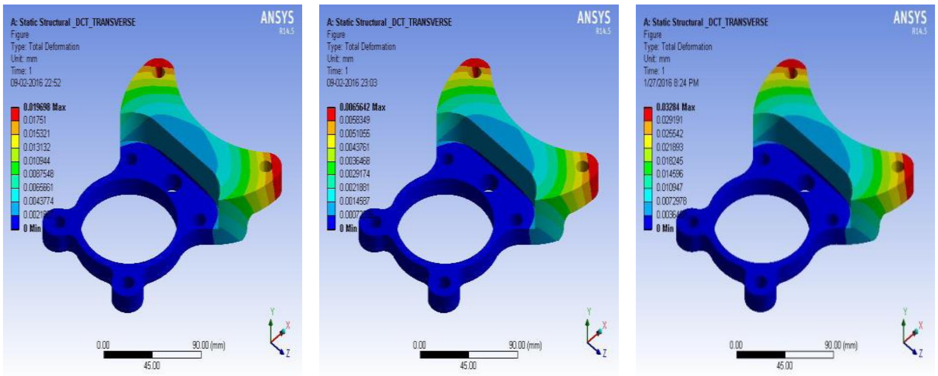

Fig. 16. *Deformation Values for Loads Acting Along z-Axis and Same Directions*.

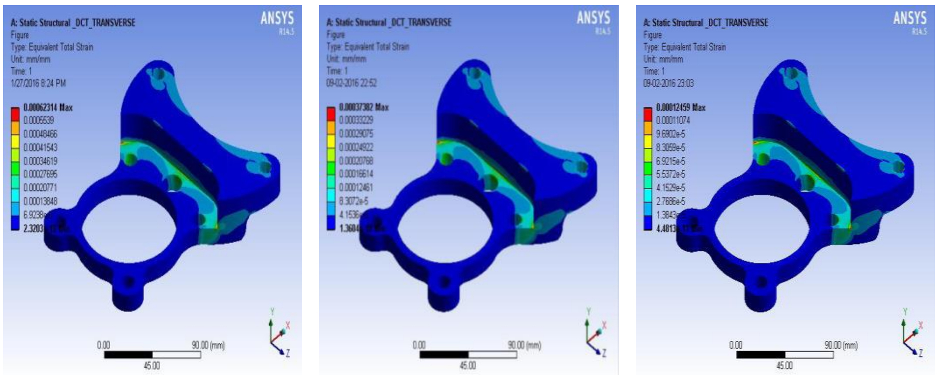

Fig. 17. *Strain Values for Loads Acting Along z-Axis and Same Directions.*

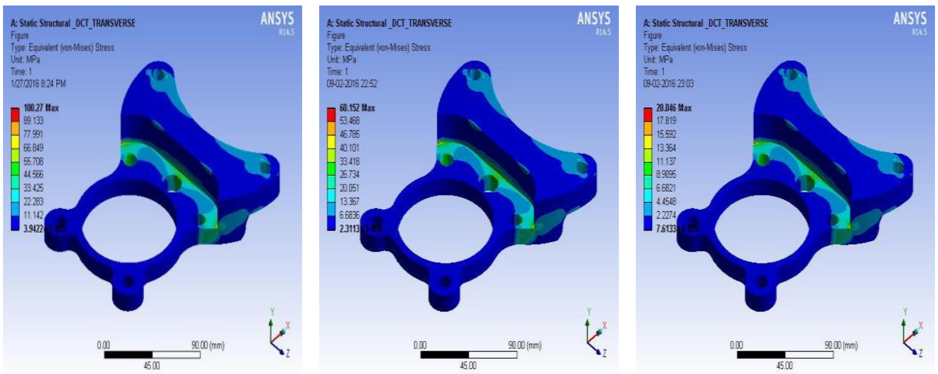

Fig. 18. *Stress Values for Loads Acting Along z-Axis and Same Direction*.

Table 5. *Maximum Deformations, Strain and Stress Values for Loads Acting Along z-Axis and Same Directions*.

Material	Load condition		Loads		
			1KN	3KN	5KN
Ductile Cast Iron FCD450	Loads acting along z-axis and same direction	Max Deformation (mm)	0.0065642	0.019698	0.03284
		Max strain	0.00012459	0.00037382	0.00062314
		Max stress (MPa)	20.046	60.152	100.27

Table 6. *Stiffness Values for Various Loads Applied*.

Material	Load	Stiffness	
		Loads acting on opposite direction	Loads acting on same direction
Ductile Cast Iron FCD450	1KN	233,481.205	152,341.489
	3KN	207,756.233	152,299.726
	5KN	207,727.462	152,253.35

CONCLUSION

Thus, the existing bracket is analyzed for its deformations, strain, stress values and new material is also analyzed for its corresponding values. By comparing Tables 3 and 6, we conclude that, the stiffness value of the brake caliper bracket can be improved by choosing the Ductile Cast Iron FCD450. Hence, it will withstand more loads during heavy or emergency braking and will not lead to cracking.

With the improved stiffness there will be greater reduction in break squeal, and therefore, the life of the brake caliper bracket will be increased. [17–20]

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