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Research Article

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Surveying the Durability of the Front Axle Beam of a 1.25 Ton Truck Using SCM440 Nano Crom Steel When the Truck is Overloaded

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Abstract

This article presents the results of a survey on the impact of the load when an overloaded vehicle acts on the front axle beam of a truck using SCM440 nano chromium forged steel. Using ANSYS simulation software to investigate the durability when the bridge girder is under the effect of traction force, braking force, horizontal force, and maximum upward force. The research results provide accurate parameters of the destructive strength and load-carrying capacity of the bridge girder before the vehicle is overloaded with the allowable load. Based on the survey values, the article evaluates the durability limits of the bridge girders, thereby giving appropriate advice to increase the life of the vehicle when traveling.

Keywords

Durability, Overloaded, SCM440 nano chromium steel

Introduction

To study the durability of the front beam of a truck using SCM440 nano chromium steel, the author writes the vehicle's dynamic equation, uses the finite element method, and applies the Autodesk Inventor Professional environment to determine the stress, fatigue strength and failure strength of the boom beam before overloading in the maximum tensile force, maximum braking force, maximum lateral force, and maximum upward force modes [1, 2].

Experimentation

Microstructure of bridge girders using SCM440 nano chromium forged steel

Through the analysis of the microstructure of the bridge girder using SCM440 nano chromium steel, it is shown that this is an extremely fine sorbite structure of 5 - 10 μm. To achieve this organization, the part must go through the quenching and tempering stages (Figure 1 to figure 6).

Equation of dynamics (Figure 7)

System of differential equations:

$$m_{c1}\ddot{x}_{c1} = P_{x1t}\cos\delta_{1t} + P_{x1p}\cos\delta_{1p} - P_{ylt}\sin\delta_{1t} - P_{y1p}\sin\delta_{1p} + P_{x2t} + P_{x2p} \quad (1)$$

$$m_{c1}\ddot{y}_{c1} = P_{x1t}\sin\delta_{1t} + P_{x1p}\sin\delta_{1p} - P_{y1t}\cos\delta_{1t} - P_{y1p}\cos\delta_{1p} + P_{y2t} + P_{y2p} \quad (2)$$

$$\begin{aligned} J_{zc1}\ddot{\varphi}_3 = {} & \left[P_{x1t}\sin\delta_{1t} + P_{x1p}\sin\delta_{1p} + P_{y1t}\cos\delta_{1t} + P_{y1p}\cos\delta_{1p}\right]a_1 \\ & + \left(P_{x1p}\cos\delta_{1p} - P_{x1t}\cos\delta_{1t} + P_{y1t}\sin\delta_{1t} - P_{y1p}\sin\delta_{1p}\right)b_1 \\ & + \left(P_{x2p} - P_{x2t}\right)b_2 + \left(P_{y2t} - P_{y2p}\right)a_2 \end{aligned} \quad (3)$$

$$J_y\ddot{\varphi}_1 = -\left(P_{c1t} + P_{k1t} + P_{c1p} + P_{k1p}\right).a_1 + \left(P_{c2t} + P_{k2t} + P_{c2p} + P_{k2p}\right).a_2 \quad (4)$$

$$J_y\ddot{\varphi}_1 = -\left(P_{c1t} + P_{k1t} + P_{c1p} + P_{k1p}\right).a_1 + \left(P_{c2t} + P_{k2t} + P_{c2p} + P_{k2p}\right).a_2 \quad (5)$$

$$J_x\ddot{\varphi}_2 = \left(P_{c1t} + P_{k1t} + P_{c1p} + P_{k1p}\right).b_1 - \left(P_{c2t} + P_{k2t} + P_{c2p} + P_{k2p}\right).b_2 \quad (6)$$

$$m_{A1}\ddot{\xi}_{A1} = P_{cl1t} - P_{c1t} - P_{k1t} - P_{c1t} + P_{cl1p} - P_{k1p} \quad (7)$$

$$m_{A2}\ddot{\xi}_{A2} = P_{cl2t} - P_{c2t} - P_{k2t} - P_{c2p} + P_{cl2p} - P_{k2p} \quad (8)$$

$$J_{x1}\ddot{\beta}_1 = \left(-P_{c1t} - P_{k1t} + P_{c1p} + P_{k1p}\right).b_1 - \left(P_{cl1t} - P_{cl1p}\right).b_2 \quad (9)$$

$$J_{x2}\ddot{\beta}_2 = \left(P_{c2t} + P_{k2t} - P_{c2p} - P_{k2p}\right).b_1 + \left(-P_{cl2t} + P_{cl2p}\right).b_2 \quad (10)$$

Results and Discussion

Survey and assessment of bridge girder durability

Maximum braking force

The author chooses the coefficient of longitudinal adhesion φ_x = 0,85 on good asphalt roads.

Maximum braking force $P_{pmax} = \varphi_x.m_p.G_t$ = 0,85.0,9.12622 = 9655 N. At the position of tweezers, put force $F_{x11} = F_{x12}$ = 9655/2 = 48727 N. Vertical force F_z = 0,9.12622 = 11359 N. Force F_z is also analyzed into 2 forces $F_{z11} = F_{z12}$ = 11359/2 = 5680 N.

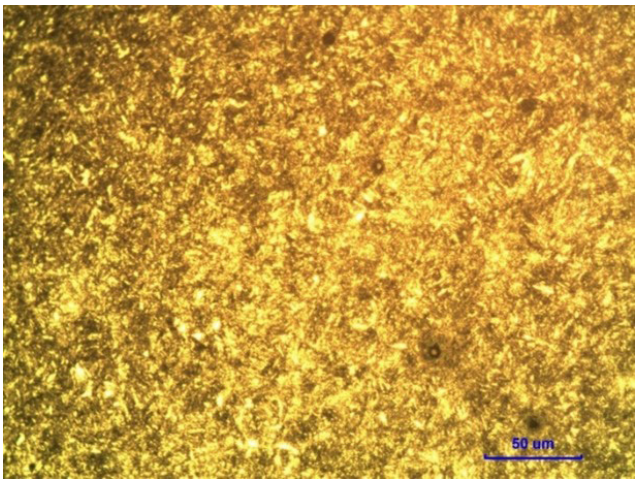


Figure 3: 4 mm from edge X400.

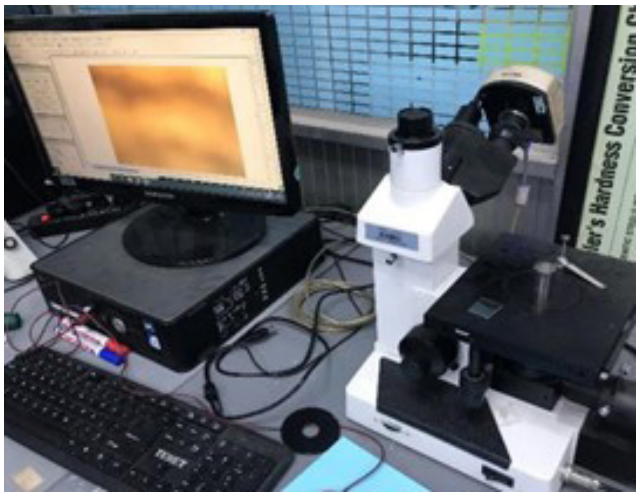


Figure 1: Microstructure testing equipment.

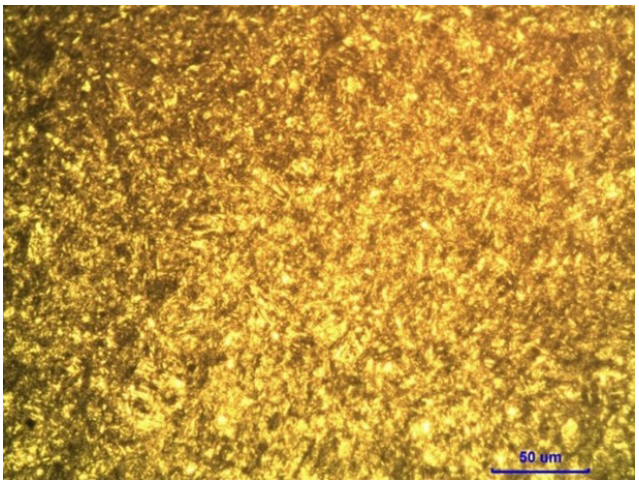


Figure 4: 3 mm from edge X400.

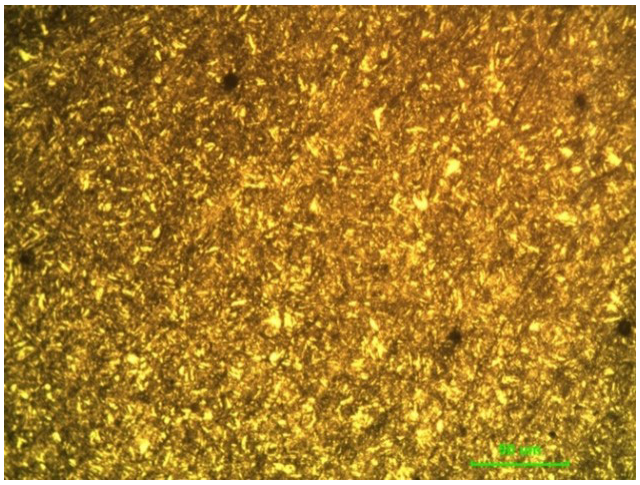


Figure 2: Bridge girder center X400.

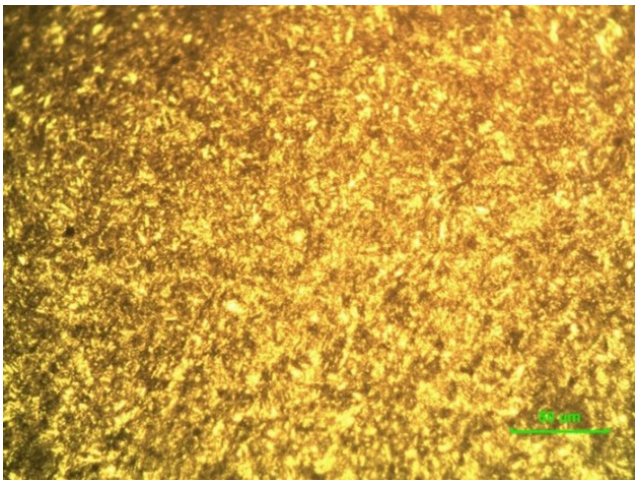


Figure 5: 2 mm from edge X400.

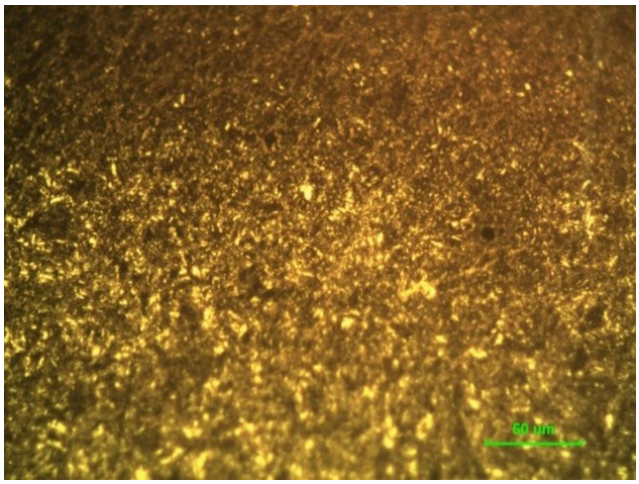


Figure 6: 1 mm from edge X400.

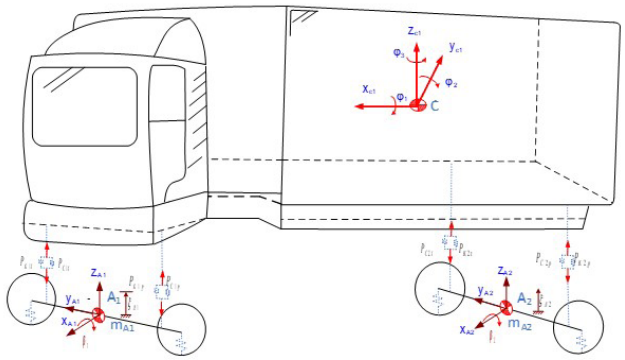


Figure 7: Spatial model describing dynamics in cars.

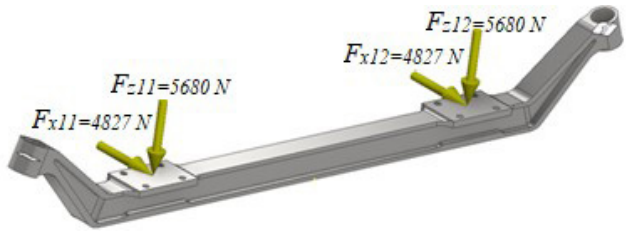


Figure 8: Constraint condition of the front beam in case of moving vehicle transmitting the maximum braking force.

Based on figure 8 to figure 11, it shows that when the vehicle is overloaded by 50%, the braking force of the vehicle also increases significantly because the weight placed on the front girder of the vehicle also increases, when the girder is subjected to braking force. At maximum, at the moment of braking, the bridge girder is bent forward due to the inertia force of the vehicle and cargo when overloaded by 50%. The maximum displacement appearing on the girder is 1,197 mm and is located in the center of the girder. The maximum stress on the bridge girder is 116.3 MPa, this value is less than the breaking limit of the material which is 490 MPa, so in this case, the girder ensures a durable condition [3].

Maximum horizontal force

When the car moves into a corner, the front axle will be

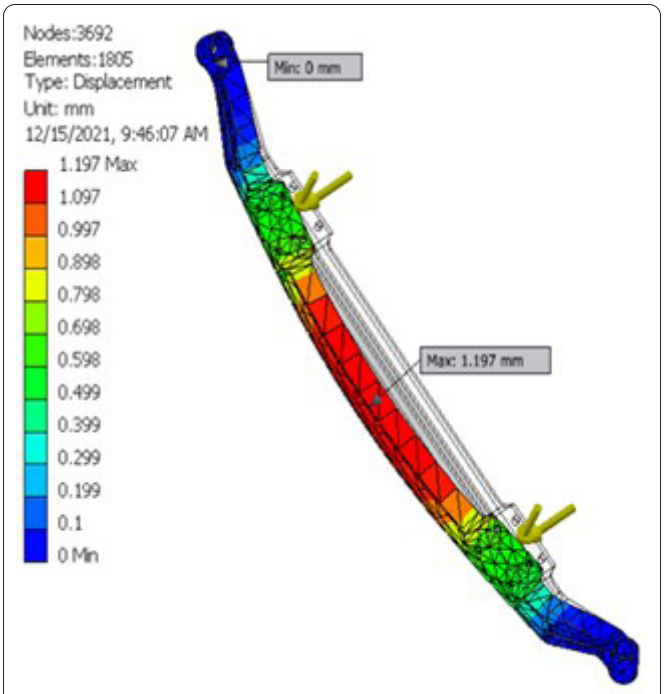


Figure 9: Displacement of bridge girder before vehicle transmits maximum braking force.

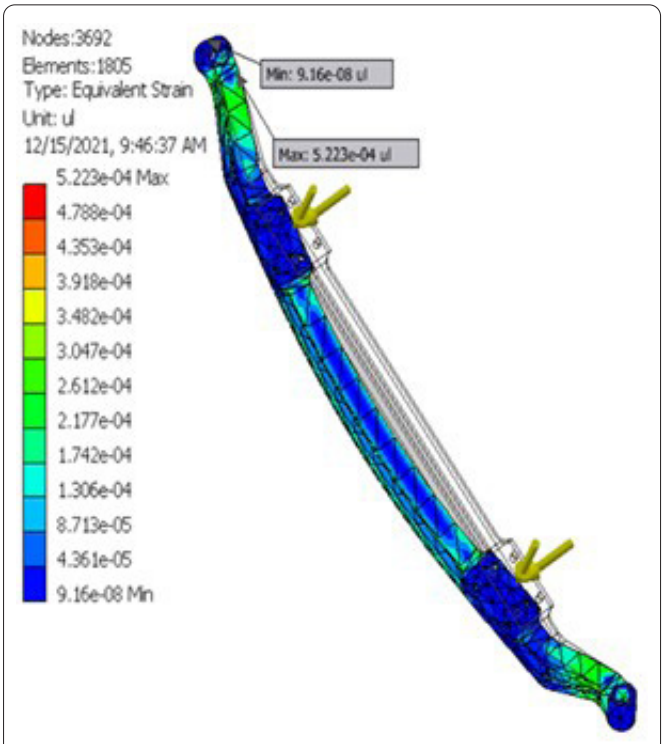


Figure 10: Total deformation of the bridge girder before the vehicle transmits maximum braking force.

under the effect of a vertical reaction F_z:

$$F_{z11} = \frac{G_t}{2}\left(1 + \frac{2\varphi'_{max}.hg}{B}\right) = \frac{12622}{2}\left(1 + \frac{2.0,6.1,1}{1,4}\right) = 12261N$$

$$F_{z11} = \frac{G_t}{2}\left(1 - \frac{2\varphi'_{max}.hg}{B}\right) = \frac{12622}{2}\left(1 - \frac{2.0,6.1,1}{1,4}\right) = 360N$$

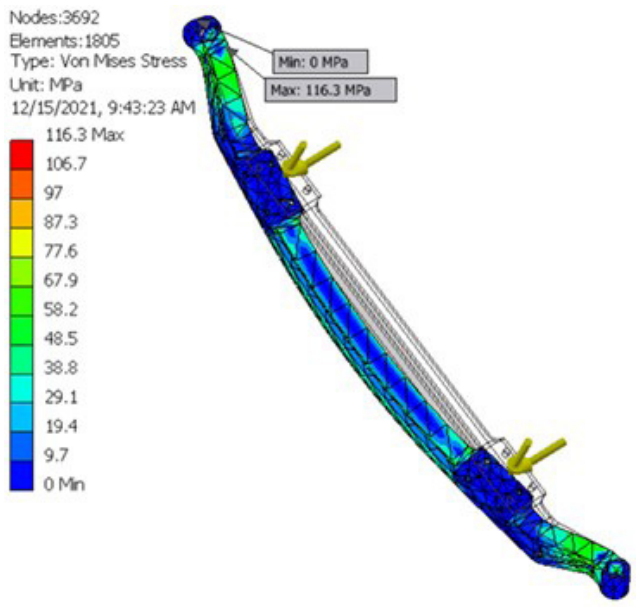


Figure 11: Equivalent stress of the bridge girder before the vehicle transmits maximum braking force.

Maximum horizontal force:

$$F_{y11} = F_{z11}.\varphi'_{\max} = 11618.0,6 = 7573N$$

$$F_{y12} = F_{z12}.\varphi'_{\max} = 360.0,6 = 216N$$

Based on figure 12 to figure 15, in case the vehicle turns to any side due to the inertia force towards the other side, the vertical load placed on the flange on the other side of the bridge girder is larger. the turning side of the bridge girder. As a result, the maximum girder displacement is 0.3258 mm and is located on the non-rotating side flange of the girder. In this case, the breaking strength, the front girder ensures the durable condition because the equivalent stress of the bridge girder is 45.83 MPa which is smaller than the failure limit of the material which is 490 MPa [3].

Maximum upward force

The force F_z is decomposed into 2 forces:

$$F_{z11} = F_{12} = K_d \frac{G_t}{2} = 1,3.\frac{12622}{2} = 8204N$$

These two forces are applied at 2 flanges caught with tweezers and fixed at the two deflecting joints of the bridge girder (Figure 16).

Through the values of figure 17 to figure 19, the maximum total displacement is 0.2551 mm and is in the middle of the girder. The maximum stress is 42.44 MPa in this case, the ultimate strength of failure, the stress value is less than the breaking limit of the material, which is 490 MPa, so the bridge girder still ensures the durable condition. In overload mode 50% still ensures durability because this case does not generate dynamic loads acting on the wheels, generating impact forces on the bridge girders, so in case the vehicle moves on the road, the dynamic load is good. applied to the wheels is almost zero,

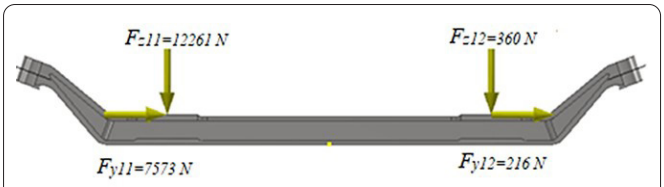


Figure 12: Constraint conditions of the front beam in the case of maximum lateral force transmission.

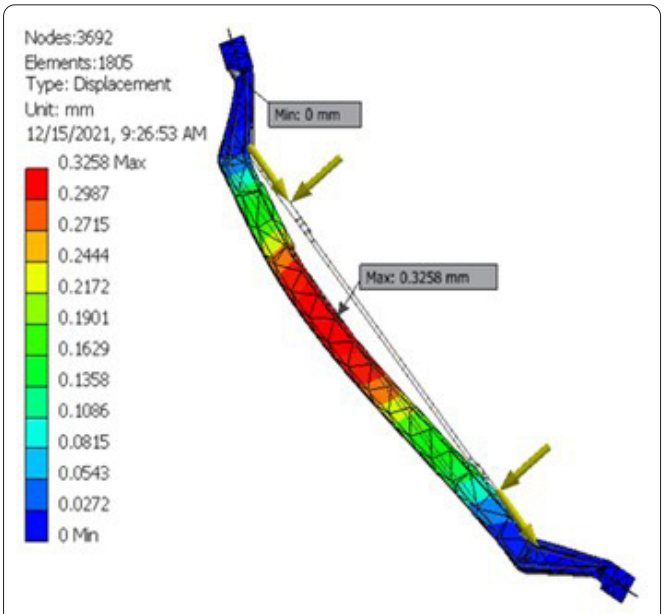


Figure 13: Total displacement of the bridge girder before the vehicle transmits the maximum horizontal force.

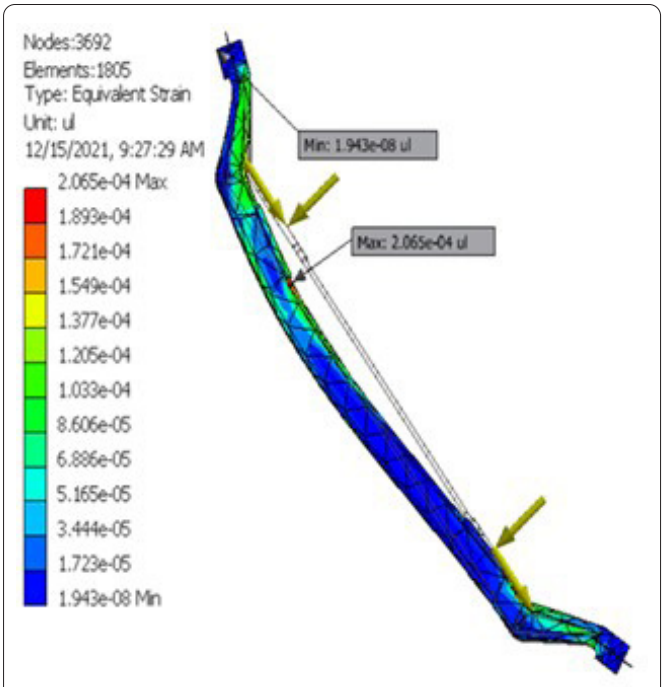


Figure 14: Total deformation of the bridge girder before the vehicle transmits the maximum lateral force.

so it does not cause great stress, it is still within the permissible limit, but the driver needs to limit the cases of overloading the vehicle to ensure the safety factors for the vehicle and not

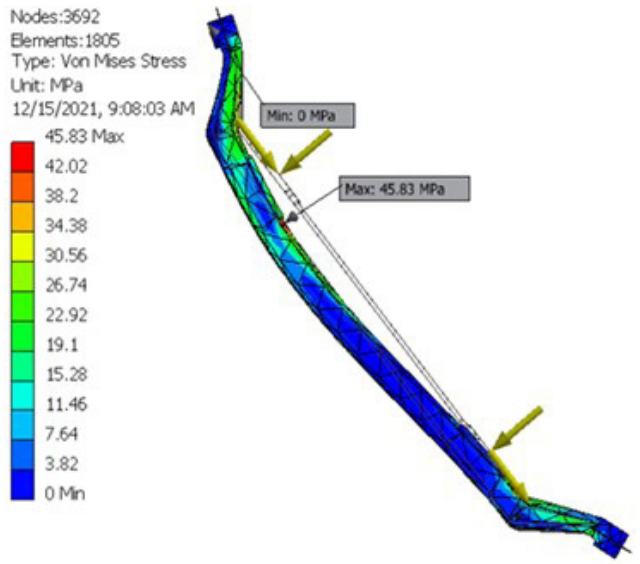


Figure 15: The equivalent stress of the bridge girder before the vehicle transmits the maximum lateral force.



Figure 16: Constraint conditions of beams before the vehicle moves with maximum upward force.

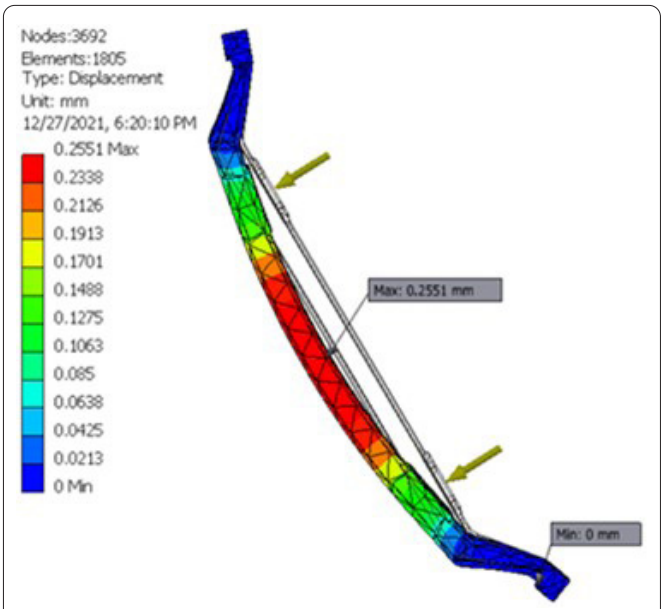


Figure 17: The total displacement of the bridge girder before the vehicle moves with maximum upward force.

reducing the life of the bridge girder as well as the safety when participating in traffic as well as going through bad roads will not ensure the fatigue strength of the bridge girder [3].

The car moves with maximum vertical force when one-wheel passes over the bump

In bad road conditions, a wheel passes through a bumpy road with height h, currently, a reaction force $F_{12}^{'}$ appears on one wheel. This force through the wheel acts through the one-side deflection joint of the front girder with a dynamic load twice the static load (Figure 20), so:

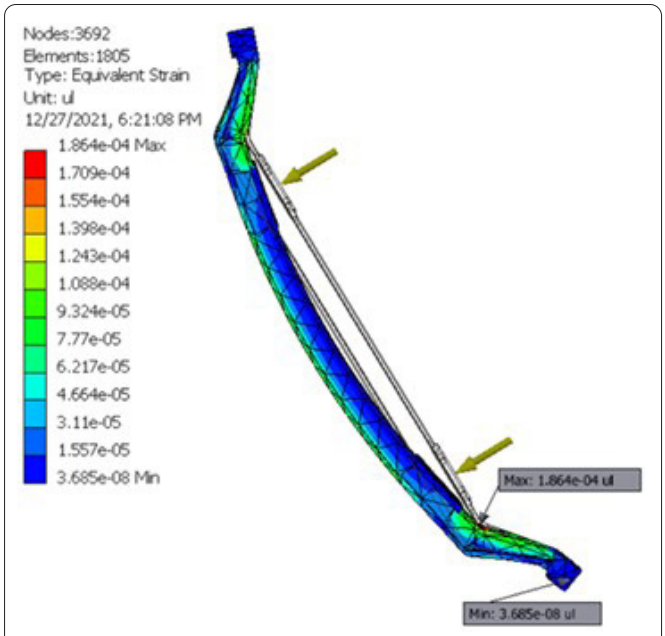


Figure 18: Deformation of the total bridge girder before the vehicle moves with maximum upward force.

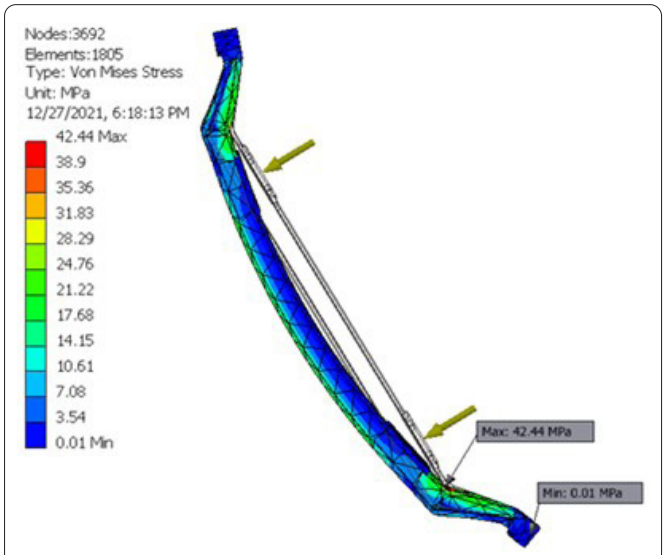


Figure 19: Equivalent stress of bridge girder before vehicle moving with maximum upward force.

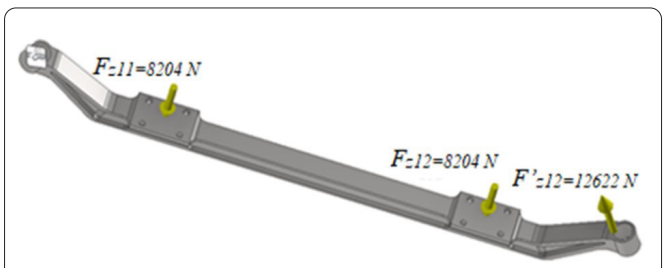


Figure 20: Constraint conditions of front beam in case of vehicle moving with maximum vertical force when one wheel is bumping upward.

$$F_{12}^{'} = 2.\frac{12622}{2} = 12622N$$

The vehicle takes the dynamic load factor K_d = 1,3, the force acting on the bridge girder in front of the car when the two wheels go through the bump:

$$F_{z11} = F_{z12} = K_d.\frac{G_t}{2} = 1,3.\frac{12622}{2} = 8204N$$

Based on the values of figure 21 to figure 23, the maximum total displacement value is 42.68 mm and is located on the side of the undulating ascending wheel of the girder. The maximum stress is 502.4 MPa if the front girder is operated in this condition, the girder will be damaged because it has exceeded the allowable strength limit. In this case, the breaking strength, the stress value is 490 MPa larger than the ultimate strength of the material, so the bridge girder cannot guarantee the strength condition due to the dynamic load acting from the pavement. On one side of the wheel and adding the weight of the goods that the vehicle is overloaded by 50%, it generates a very large equivalent stress force. In overload mode 50% does not guarantee the strength to the allowable strength, causing the girder to be subjected to large bending and torsion causing dangerous cross-section [4-6].

Conclusion

Through the survey results of the front bridge beam of a 1.25-ton truck using SCM440 nano chromium threaded steel with 50% overload, it shows that when the vehicle moves with the greatest braking force, the largest horizontal force and the largest vertical force are obtained. displacement, strain, and maximum stress are still within the bearing value of the girder.

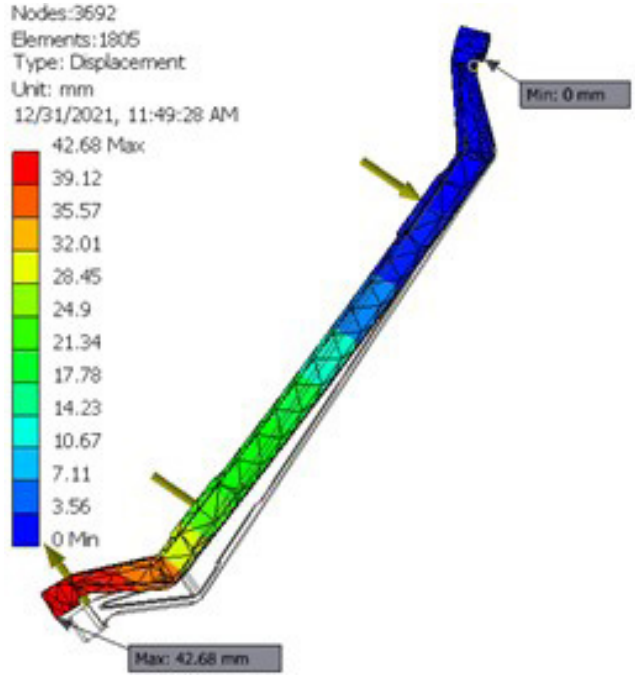


Figure 21: Total displacement of the bridge girder before the vehicle moves with maximum vertical force and one front wheel goes up and down.

but when the vehicle is moved with maximum vertical force and one side of the wheel passes over the bump, the values of displacement, strain, and stress beyond the specified level of durability may be destroyed. Therefore, the car should not be run in this case.

Acknowledgments

None.

Conflict of Interest

None.

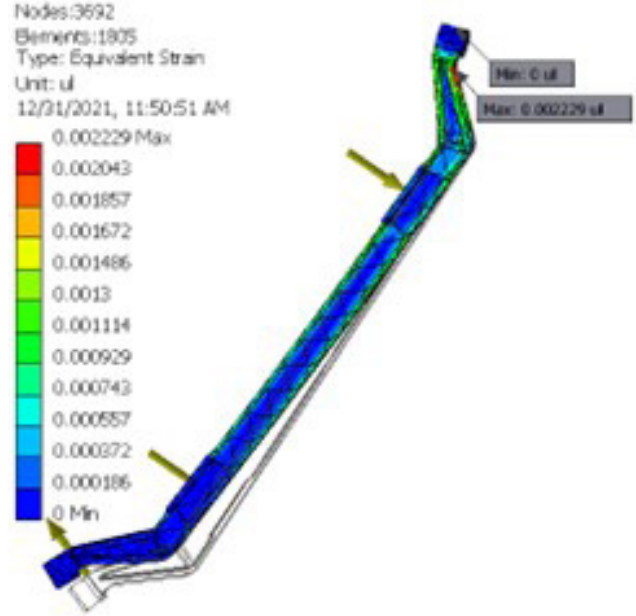


Figure 22: Total deformation of the bridge girder before the vehicle moves with maximum vertical force and one front wheel goes up and down.

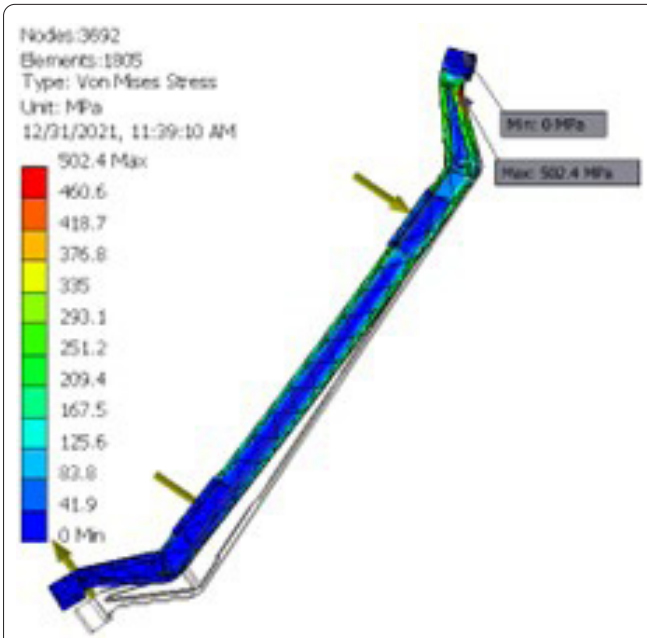


Figure 23: Equivalent stress of bridge girder before vehicle moving with maximum vertical force and one front wheel bumping upward.

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