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Citation
Abstract
Reference
Full PDF (../papers/vol14-issue5/Version-1/A1405010107.pdf)

Paper Type	:	Research Paper
Title	:	A Study on the Partial Replacement of Coarse and Fine Aggregate by Coconut Shell and Quarry Dust Mix
Country	:	India
Authors	:	Sravika.V || G.Kalyan
doi	:	**10.9790/1684-1405010107 (http://www.doi.org/)**

Abstract: In developing countries where concrete is widely used, the high and steadily increasing cost of concrete has made construction very expensive. The production of concrete requires various materials like Cement, Fine aggregate and Coarse Aggregate .Due to extensively use of concrete which lead to an increase in cost of materials. Therefore an alternate material is used for partial replacement of Fine aggregate and coarse aggregate in concrete. This project is experimented to reduce the cost of concrete. In this research work experiments have been conducted with collection of materials required and the data required for mix design are obtained by sieve analysis and specific gravity test. Sieve analysis is carried out from various fine aggregates (FA) and coarse aggregates...........

Keywords: Coconut shell, Quarry dust, coarse aggregate, Fine aggregate.

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[2]. Rock Dust as Partial Replacement for Sand in Concrete.
[3]. Yogesh Narayan Sonawane, Chetan Jaiprakash Chitte ,Waste Coconut Shell as a
[4]. Partial Replacement of Coarse Aggregate in Concrete Mix – An Experimental Study.
[5]. AmarnathYerramala et al., Properties of Concrete with Coconut Shells as Aggregate
[6]. Replacement, International Journal of Engineering Inventions ISSN: 2278-7461

Citation
Abstract
Reference
Full PDF (../papers/vol14-issue5/Version-1/B1405010812.pdf)

Paper Type	:	Research Paper
Title	:	Study of the Physicochemical and Mechanical Properties of Oil and Macadamia Walnut Shell
Country	:	México

Authors : Jesus E. Corona Andrade || Alonso Salazar Garibay || Israel Ibarra Solís || Ubaldo Gil Cruz || Atzimba N. Martinez Reynoso

: **10.9790/1684-1405010812 (http://www.doi.org/)**

Abstract: The present work, advances in the characterization of the macadamia nut are shown. The study started from the fact that the diffusion in the cultivation and processing of macadamia nut inside the country is not fully developed; On the other hand, its exploitation can be technified through a sustainable use and of low environmental impact. The objective of this research is to propose alternatives of integral use of this fruit. The methodology used included physicochemical and instrumental analysis (infrared spectroscopy). In the case of oil, the peroxide, saponification and acidity indices were obtained..........

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Citation

Abstract

Reference

Full PDF (../papers/vol14-issue5/Version-1/C1405011328.pdf)

Paper Type	:	Research Paper
Title	:	Stress Analysis of a Cross over Electric Car Chassis
Country	:	Indonesia

Authors : Tarsisius Kristyadi || Alexin Putra || Tito Santika || Liman Hartawan || Trinaldo

: **10.9790/1684-1405011328 (http://www.doi.org/)**

Abstract: This paper presents, stress analysis of a ladder type cross over electric car chassis structure using FEM. The commercial finite element package SOLIDWORK was used for the solution of the problem. Two type of chassis was analysed, solid plate beam and porforated plate beam chassis. To reduce the weight of the chassis of the cross over electric car, the chassis structure design was modified by porforating the beam so that the main beam is not solid. The boundary conditions applied to this model of chassis can be classified into four general cases: static condition., the car climb 30o..........

Keywords: chassis, electric car, cross over, stress, perforate

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[2] J.M. Miller, A. Emadi, A.V. Rajarathnam, M. Ehsani, Current status and future trends in More Electric Car power systems, Proc. 49th IEEE Conf. on Vehicular Technology, Houston, TX, 1999, 1380 – 1384(2).
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Citation

Abstract

Reference

Full PDF (../papers/vol14-issue5/Version-1/D1405012933.pdf)

Paper Type	:	Research Paper
Title	:	Influence of Aggregate Sizes on the Performance indices of Self Compacting Concrete (SCC)
Country	:	Nigeria
Authors	:	OLADAPO Silas Akinkunmi || OLOFINTUYI Ilesanmi Olanrewajub
doi>	:	**10.9790/1684-1405012933 (http://www.doi.org/)** crossref

Abstract: The development of Self-Compacting Concrete (SCC) has recently been one of the most important developments in the building industry. The paper investigates the influence of aggregate sizes of 10mm, 12.5mm and 20mm on the performance indices of Self-Compacting Concrete (SCC). Concrete mixes of 1:2:4 were produced with addition of variable plasticizer admixture of COMPLASTSP430 at 3% constant value. Specified tests for Self-compacting concrete (SCC), related to workability such as flowability, filling-ability, and passing-ability tests were carried out on fresh samples. Compressive strength of hardened cured (150 x 150 x 150), results showed a maximum compressive strength of 19.86N..........

Keywords: Self Compacting concrete, Compressive strength, workability, segregation and plasticizer

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Citation

Abstract

Reference

Full PDF (../papers/vol14-issue5/Version-1/E1405013443.pdf)

Paper Type	:	Research Paper
Title	:	An Experimental-study on Ventilation of Public Schools in Akure, Oshogbo and Ado-ekiti Cities in South-western Nigeria
Country	:	Nigeria
Authors	:	Osagie Ibhadode || F. A. Okougha || C. O. Nwafor || Nya Essang
doi	:	**10.9790/1684-1405013443 (http://www.doi.org/)**

Abstract: In this research-work, six(6) study-visits to each of ninety(90) classrooms in thirty(30) publicschools [located in three South-western Nigerian cities of Akure, Oshogbo and Ado-ekiti] were embarked upon, to obtain the values of indoor environmental-parameters [such as 'Indoor reference Windspeed(ref V)', 'Relative Humidity(RH)', 'Area of total effective Ventilation-opening(net A)', 'Classroom-dimensions(l,b and h)' and 'Occupancy(N)']; using the WM-200 Windmate wind-meter, the AcuRite 00613A1 top-digital
Hygrometer, a measuring-tape, and by visual-observation. The values.........

Keywords: ASHRAE, CIBSE, IAQ, Occupancy, Ventilation

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Citation

Abstract

Reference

Full PDF (../papers/vol14-issue5/Version-1/F1405014449.pdf)

Paper Type	:	Research Paper
Title	:	Empirical Approach for Prediction of Indoor Air Temperature of a Building
Country	:	India
Authors	:	B. M. Suman || P. K. Yadav
doi	:	**10.9790/1684-1405014449 (http://www.doi.org/)**

Abstract: In the present study a correlation between Building Index and indoor air temperature of a building has been developed. The Building Index is dependent on total peak heat load of a building. Analysis of fit linear polynomial for dataset indoor air temperature vs. Building Index has been made by MATLAB. Correlation factor for this empirical approach is 0.999 which shows the perfectness of the correlation. Prediction of indoor air temperature has been made simple by developing correlation equation through empirical approach.

Keywords: Building Index, Indoor air temperature, Peak heat load, Empirical approach, Thermal insulation

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Citation

Abstract

Reference

Full PDF (../papers/vol14-issue5/Version-1/G1405015053.pdf)

Paper Type	:	Research Paper
Title	:	MATLAB GUIDE Development for SCARA Robot
Country	:	India
Authors	:	Suyash Shrivastava
doi	:	**10.9790/1684-1405015053 (http://www.doi.org/)**

Abstract: The research work is focused on developing MATLAB GUIDE Graphical User Interface to calculate forward and inverse kinematics of 4 Degree of Freedom SCARA robot. In this research work two different GUI windows were developed for calculations of forward kinematics of SCARA robot and inverse kinematics of SCARA robot. The forward kinematics position.

Keywords: Forward or Direct Kinematics, GUIDE, Inverse kinematics, MATLAB, SCARA

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Citation

Abstract

Reference

Full PDF (../papers/vol14-issue5/Version-1/H1405015464.pdf)

Paper Type	:	Research Paper
Title	:	Fresh, Mechanical and Permeability Properties of Self Compacting Concrete with Recycled Concrete Aggregate
Country	:	India
Authors	:	Dr. Prashant O. Modani
doi>	:	**10.9790/1684-1405015464 (http://www.doi.org/)**

Abstract: The objective of this research is to evaluate the effect of the incorporation of coarse recycled concrete aggregate, on the properties of self compacting concrete. The effects of such incorporation on fresh, mechanical and permeability properties were investigated and are discussed. Two different series of concrete mixes (i.e. 30 Mpa and 40 Mpa) were prepared to test these properties. In each series, six concrete mixes with replacement ratios of 0%, 20%, 40%, 60%, 80% and 100% of natural coarse aggregate by recycled concrete aggregates were adopted. Results obtained show that self compacting concrete with recycled concrete aggregate exhibits adequate performance. However with increasing replacement of NCA the performance of concrete decreased but at higher strengths it shows improvement in all properties.

Keywords: recycled aggregate, self compacting concrete, permeablity, strength

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Citation

Abstract

Reference

Full PDF (../papers/vol14-issue5/Version-1/I1405016568.pdf)

Paper Type	:	Research Paper
Title	:	Design and Fabrication of a Solar Powered Vehicle and its Performance Evaluation
Country	:	India
Authors	:	Amar Kumar Das || Pravukalyan Prusty || Manas Milan Saktidatta Ojha
doi	:	**10.9790/1684-1405016568 (http://www.doi.org/)**

Abstract: Recently rapid population growth, high volume of energy demand and depletion of fossil fuels intend to search for an alternative energy source in automobile industry. An abundant source of renewable energy like solar energy is proved as a better option to meet such challenge. The vehicle leaves no emissions like conventional IC engines to control the green house effect and other natural hazards. The design of the vehicle consists of PV cells, motors and other mechanism for both cost effectiveness and environment friendly to optimise the energy efficiency. The paper shows the design and analysis of a solar propelled vehicle and its performance test in terms of mileage, speed and emissions.

Keywords: Solar panel, BLDC motor alternative energy source, solar propelled vehicle, PV cells.

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Citation

Abstract

Reference

Full PDF (../papers/vol14-issue5/Version-1/J1405016979.pdf)

Paper Type	:	Research Paper
Title	:	Exercitation of Knowledge Translation and Implementation Science: Transportation Engineering Case Study
Country	:	Nigeria
Authors	:	Kevin Gaspard, P.E || Zhongjie "Doc" Zhang, Ph.D. || P.E, Adele Lee
doi	:	**10.9790/1684-1405016979 (http://www.doi.org/)** crossref

Abstract: The prolific utilization of research results has become of paramount importance in Engineering as well as other organizations. There is an abundance of publications on implementation science and knowledge translation in the health care industry, perhaps more so than in Engineering. In this article, the authors briefly summarized knowledge translation methods from several organizations including the Louisiana Transportation Research Center (LTRC). They also introduced methods from the fields of psychology, persuasion, and marketing that can be beneficial to knowledge translation...........

Keywords: Implementation Science, Knowledge Management, Knowledge translation, Engineering Implementation, Persuasion skills, Engineering Management, GIS web applications, Knowledge Broker

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Citation

Abstract

Reference

Full PDF (../papers/vol14-issue5/Version-1/K1405018085.pdf)

Paper Type	:	Research Paper
Title	:	CFD Analysis of GOE 387Airfoil
Country	:	Egypt
Authors	:	Mohamed A. Fouad Kandil || Abdelrady Okasha Elnady
doi>	:	**10.9790/1684-1405018085 (http://www.doi.org/)**

Abstract: In this paper, we have obtained lift and drag forces for GOE 387 airfoil using CFD. The analysis of the two-dimensional subsonic flow over a GOE 387 airfoil at various angles of attack and operating at a Reynolds number of 3 x105 is presented. The geometry of the airfoil is created using ANSYS Design Modeler. CFD analysis is carried out using FLUENT 17.2 at various angles of attack from -5°to 20.°The motivation behind this research is to study the flow field over GOE 387 airfoil and obtain the aerodynamic characteristics of this airfoil. Lift coefficient and drag coefficient are plotted against theangle of attack. Variations of velocity distribution are plotted in form of contours for 3 x105 Reynolds number.

Keywords: Airfoil, Angle of Attack, CFD, Drag Coefficient, Lift Coefficient

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Citation

Abstract

Reference

Full PDF (../papers/vol14-issue5/Version-1/L1405018689.pdf)

Paper Type	:	Research Paper
Title	:	Refinement of Gas generation estimates from anaerobic lagoons Case Study Dandora Waste water Treatment Plant in Kenya
Country	:	Kenya
Authors	:	Stephen Kihanya || Kay White || David Kimingi || Dr Semion Dulo || Dr. Zablon Oonge
doi>	:	**10.9790/1684-1405018689 (http://www.doi.org/)**

Abstract: The volume of biogas generated within the anaerobic ponds at the Dandora Estate Sewage Treatment Plant (DESTP) has been estimated based on empirical calculations (refer to graph). The biogas production considers seasonal temperature variations, rainwater dilution of the DESTP influent as well as the composition and calorific value of the sewage. In order to determine the quantity of biogas produced in the anaerobic ponds, a relationship between BOD5 removals across anaerobic treatment lagoons as a function of volumetric loading rate, i.e. g BOD5/m3.d was developed using published data. On average DESTP has been generating 7,900m3/day of methane at 52% BOD loading. This would be expected to raise to 15,800 at 100% capacity of 160,000m3/day which has a potential of generating 8 123MWh per month. Currently all this gas is being released into the atmosphere and has a greenhouse effect.

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Citation

Abstract

Reference

Full PDF (../papers/vol14-issue5/Version-1/M1405019092.pdf)

Paper Type	:	Research Paper
Title	:	Implementation of Nano Composite Material in Oil and Gas Industry
Country	:	India
Authors	:	Md Maajith Sohail G || Bharath S
doi>	:	**10.9790/1684-1405019092 (http://www.doi.org/)**

Abstract: Magnesium alloy, the most favorable compound in the field of Science and Engineering. The Magnesium Alloy having Low-Density and High-Strength showed record levels of Specific Resistance and Specific Module in Both Low and High Temperature. Lighter than all Engineering Materials. A silicon carbide is a highly hard ceramic commonly used in industrial cutting blades. The Combination of these two Materials has bought a Magnesium Nano-composite with a 'Record Breaking' Strength to Weight Ratio. This Magnesium based Material, composed of 86% of Magnesium and 14% of Silicon Carbide particles, invented by the researchers in University Of Applied Sciences in Los Angeles. This material said to be the World's Strongest Metal with extreme Lightweight. In the Field of Oil and Gas.............

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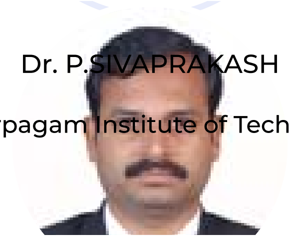

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Stress Analysis of a Cross over Electric Car Chassis

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Abstract : *This paper presents, stress analysis of a ladder type cross over electric car chassis structure using FEM. The commercial finite element package SOLIDWORK was used for the solution of the problem. Two type of chassis was analysed, solid plate beam and porforated plate beam chassis. To reduce the weight of the chassis of the cross over electric car, the chassis structure design was modified by porforating the beam so that the main beam is not solid. The boundary conditions applied to this model of chassis can be classified into four general cases: static condition., the car climb 30^o. the car is passed through a descend road about 30^o and when the car is brake from 40 km/h until stop for 5 second. Output parameter analysed include stress, deflection and safety factor. It was concluded that perforate the plate beam reduce the chassis weight and did not have significant affect on the chassis safety factor, stress and deflection hence suitable for electric car.*

Keywords: *chassis, electric car, cross over, stress, porforate*

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I. Introduction

Now days, the increased demands on electric car have been increased not only on cost and weight, but also on improved complete vehicle features. Electric drive vehicles are becoming an attractive alternative to combustion engine cars with global gradual fossil fuel prices rise. In addition, increasing energy prices also have led to an increase interest in the development of electric vehicles. In addition, concerns over climate change and reduction of greenhouse gas emissions, and dependence of economies on foreign energy sources, have also become an initiative for extensive research on the use of electric cars as an alternative [1, 2, 3]. Cars with electrical drive systems represent a solution for the future, and will in a steadily increasing degree be seen on the roads. The history of electric cars is closely related to the history of batteries [4, 5, 6]. Electric cars appear to be the most suitable candidates to fulfill the environmental demands. In electric cars, efficiency of energy usage is very important. Indonesia is a large country. Roads in Indonesia generally have varied terrain. Cross over type vehicle is suitable for Indonesia. In order for an electric car cross over type to perform at its best it must have adequate structure, this means it must have a stiff frame. Since most of the car's weight is between the front and rear suspension, frame stiffness is absolutely the key between these points where it will not easily bend. For the electric car, stiffness is very important. Apart from safety requirements the chassis structure in itself should also provide torsional and bending stiffness as well as direct support for the front suspension and steering system mounting points. Some value of the safety factor for various condition of loading and material of structures was recommended by Vidosic [7]. Two aspects of frame stiffness should be considered which are beaming and torsional. Therefore the chassis is considered as the most important element of the vehicle as it holds all the parts and components together. In this study, an attempt is made to design an cross over electric car chassis that would reduce the weight and able to provide high specific strength and high specific stiffness, and easy to be manufactured. The main structure is ladder sturcture. Ladder chassis is thought to be one of the most established types of car chassis or vehicles chassis that is still utilized by the greater part of the SUVs till today. As its name indicates, ladder chassis takes after a state of a ladder having two longitudinal rails entomb connected by a few horizontal and cross supports. It should be noted that this ‘ladder’ type of frame construction is designed to offer good downward support for the body and payload and at the same time provide torsional flexibility, mainly in the region between the gearbox cross member and the cross member ahead of the rear suspension.

To reduce of weight of the chassis structure design was modified by perforating the beam so that the main beam is not solid. The characteristic of the chassis was checked by stress analysis. This paper presents, stress analysis of a ladder type cross over electric car chassis structure using FEM. The commercial finite element package SOLIDWORK was used for the solution of the problem. Two type of chassis was analysed, solid plate beam and porforated plate beam chassis. The porforated plate beam chassis that form a ladder chassis is the new contribution in electric car thechnology. This paper is divided to (5) five parts, and starting with introduction. Literature review is the second part that discuss of previous study followed by stress analysis procedure in the third part. In the fourth part is presented the result and discussion and conslussion will be presented in the last section.

II. Literatur Review

Many researchers had conducted analysis on chassis of various vehicles. Abd Rahman et. al. investigated stress analysis on a truck chassis using finite element method [8]. Finite element result had shown that the critical point of stress occurs at opening of chassis which is in contact to the bolt. Thus it is important to reduce stress magnitude at the specific location. Previous FEA agrees well with the maximum deflection of simple beam loaded by uniformly distributed force. Ebrahimi et. al. constructed a car model and its components analysis were carried out [9]. Sane et. al. performed stress analysis on a light commercial vehicle chassis using iterative procedure for reduction of stress level at critical locations[10].Koszalka et. al. accomplished stress analysis on a frame of semi low loader using FEM[11]. Two versions of frame design were analyzed, focusing on the part of beam where the highest stresses were located.

Rane et.al [12] did their work in the use of optimization techniques for redesign of the forklift chassis by the use of finite element analysis. Author focused their work on the study of the optimum material distribution to get an idea of the load flow path based on which new design with higher strength to weight ratio as compared with original design could be obtained. Assembly fitment parameters/functional requirements were to be kept as it is. Methodology used by the author for structural optimization was in three phases. In first phase chassis was subjected to topology optimization to obtain optimum density plots to reduce its weight. In second phase after topology optimization, size optimization is performed to obtain the optimal thickness of all the structural members. The output model is run for remaining load cases in the third phase. Author concludes how optimization techniques can be used as a tool in finite element analysis for achieving weight reduction. Through optimization techniques weight of the chassis was reduced by around 14.5 %.

Marco et al. [13] focused their study on weight reduction of the automotive chassis by using structural optimization method linked with finite element analysis. Various optimization techniques were explained. The methods were briefly introduced, and some applications were presented and discussed with the aim of showing their potential. A particular focus was given to weight reduction in automotive chassis design applications. The author provided a quick overview on structural optimization methods. Author explained how topology and topometry optimizations were more suitable for an early development stage, whose outcome could be further refined through size and shape optimizations.

Prabhakaran et al. [14] focused their work towards weight reduction of chassis by performing structural analysis. Basic calculations for the chassis frame were done analytically based on the bending theory and values of stress and deflection were obtained. Finite element analysis for the existing chassis was performed for overload condition and stress and deflection values were obtained. For weight reduction design modifications were made by doing a sensitivity analysis. In sensitivity analysis section modulus and flange width were kept constant. Three cases were considered for weight reduction in which thickness and height of the flange were varied. Comparison of the results showed that out of three cases third case resulted in about 6.7% of weight reduction

III. Methodology

The main objective of the study is to obtain a preferable design safety factor, maximum stress and deflection for a cross over electric car chassis using finite element method. Two model of ladder chassis was analysed, there are solid plate beam and porforated palte beam chassis. The analysis was conducted using Commercial version of SOLIDWORK.. There are three main steps, namely: preprocessing, solution and postprocessing. The preprocessing (model definition) step is critical. A perfectly computed finite element solution is of absolutely no value if it corresponds to the wrong problem. This step includes: define the geometric domain of the problem, the element type(s) to be used, the material properties of the elements, the geometric properties of the elements (length, area, and the like), the element connectivity (mesh the model), the physical constraints (boundary conditions) and the loadings [15].

The next step is solution, in this step the governing algebraic equations in matrix form and computes the unknown values of the primary field variable(s) are assembled. The computed results are then used by back substitution to determine additional, derived variables, such as reaction forces, element stresses and heat flow. Actually the features in this step such as matrix manipulation, numerical integration and equation solving are carried out automatically by commercial software [16].

The final step is postprocessing, the analysis and evaluation of the result is conducted in this step.

Model

Components of cross over electric car chaissis is shown in Fig. 1 (a,b,c). The beam is porforated at vertical (Fig. 1.a. and horisontal beam plate (Fig. 1.b).

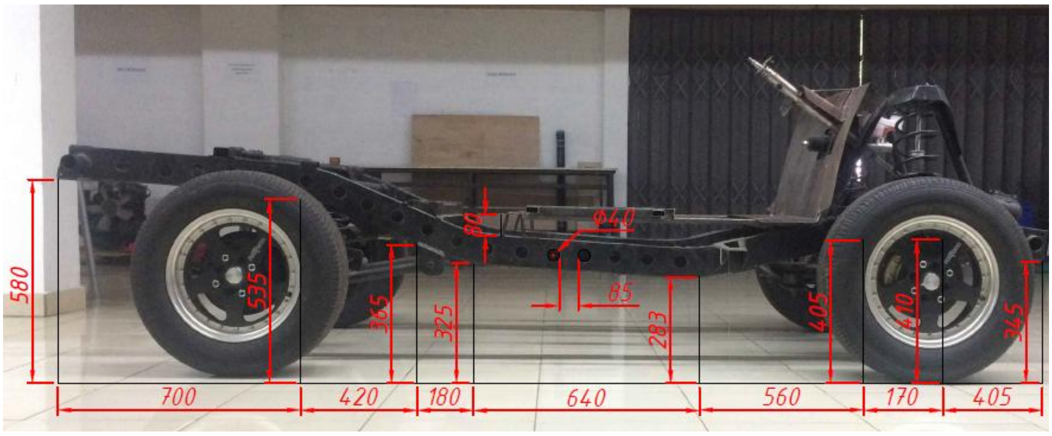

Figure 1 a. General structure of cross over electrical chassis and showing porforated plate beam at vertical

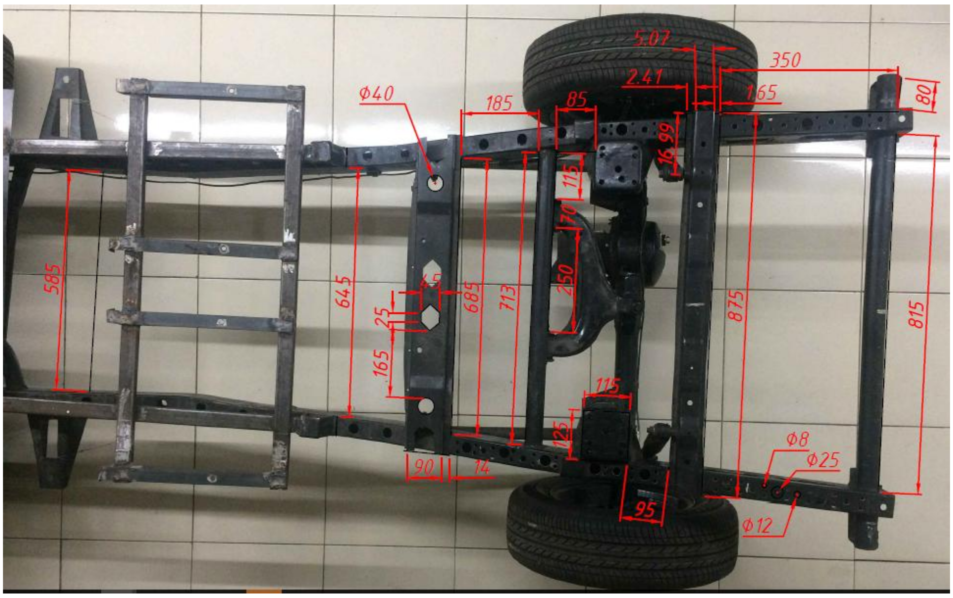

Figure 1.b. Showing porforated plate beam at horisontal direction

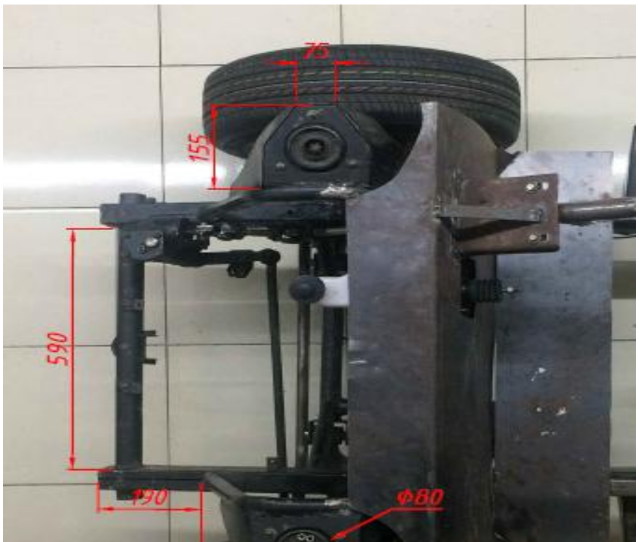

Figure 1.c. Front part of chassis

Due to uncertainty in estimating the vehicle loads and the dynamic and oscillating nature of it, the quasi-static method is used to conceptual design of ladder frame (chassis). In order to design a chassis at the first step, the force exerted on the chassis and its location is determined. Then, note to the boundary condition, bending moments and shear forces diagrams along the chassis are extracted. Finally, appropriate profile section which reduces the weight and endures loads is selected from handbook [17] and Maximum allowable stress and strain theories are used to design a chassis. In this analysis, following basic equation were used:
Bending moment *M*b(*x*) and shear force *V*(*x*) along the chassis are [17]:

$$V(x) = -\int w(x)\, dx \quad (1)$$
$$M_b(x) = \int V(x)\, dx \quad (2)$$

Where w(x) is expanded load on chassis

Regarding the bending moment and shear stress diagrams maximum normal stress along the chassis can be evaluated from [17]:

$$\sigma_{max} = N(M_{b\ max}/S_{\ min}) \quad (3)$$

where σmax is maximum normal stress, *N* is dynamic factor load (includes safety factor) and *S*min is minimum section module. Therefore, according to maximum allowable stress, the section module is determined by considering the dynamic load factor. Optimal section module should be larger than *S*min and have minimum density to reduce chassis weight. Maximum strain theory, which is based on the maximum allowable chassis deflection, is more conservative than maximum stress theory. The relation between chassis strain and bending moment is described as follows [17]:

$$E.I.y(x) = \int dx \int M_b\ (x)\ dx + C_1x + C_2 \quad (4)$$

where *E* and *I* are modulus of elasticity and inertia moment of chassis respectively. *y*(*x*) is function of deflection along chassis deflection, and *C*1, *C*2 are constant coefficients.
In elasto-static problem, each element forms a stiffness matrix [K], relating force [F] and displacements [u] at nodes. The size of stiffness matrix is equal to the number of nodes per element multi;plies by the number of freedom per nodes, as the following [17]:

$$[F]=[K][u]. \quad (5)$$

In eigenvalue problem te characteristic matrix is formed as

$$\{[K]-\omega^2[M]\}[U]=0 \quad (6)$$

Where M is the mass matrix, ω^2 is eigenvalues and u is eigen vector.

In this study two model of electrical chassis are developed, there are solid plate beam model and porforated plate beam model. Figure 2 show the solid plate beam model of cross over electric car chassis and firgure 3 show the porforated plate beam.

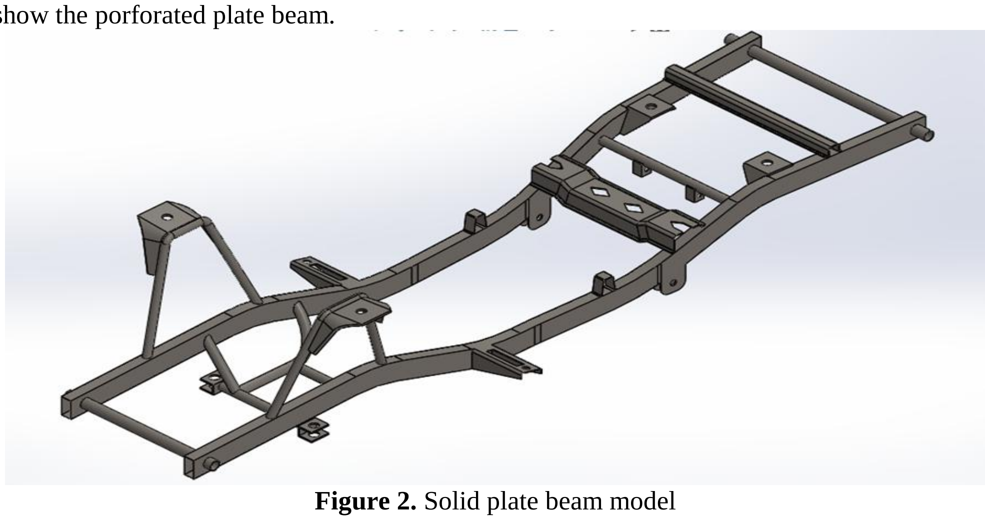

Figure 2. Solid plate beam model

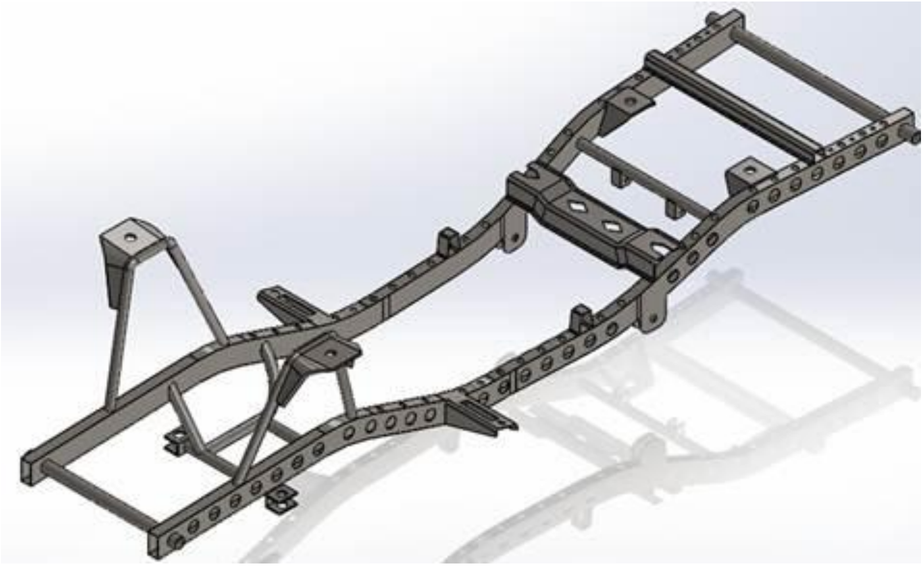

Figure 3 Perforated plate beam model

Load

The cross over electric car chassis model is loaded by static forces from battere, motor and passenger. For this model, batere load is 27 batere with 25 kg each, motor load is 45 kg and 2 passenger with 70 kg each. Position of each load is described in Figure 4 below. In this situation the peperties of material is described in the following Table 1.

Table 1. The properties of chassis material

Name	Alloy Steel
Model type	Linear Elastic Isotropic
Default failure criterion	Max von Mises Stress
Yield **strength**	6.20422e+008 N/m^2
Tensile strength	7.23826e+008 N/m^2
Elastic modulus	2.1e+011 N/m^2
Poisson's ratio	0.28
Mass density	7700 kg/m^3
Shear modulus	7.9e+010 N/m^2
Thermal expansion coefficient	1.3e-005 /Kelvin

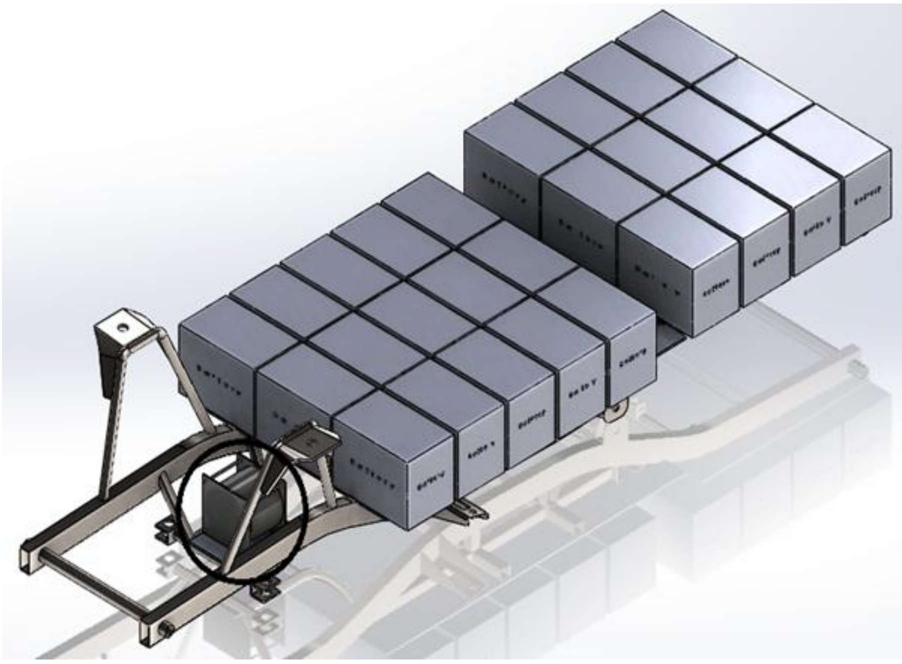

Figure 4 Load position of chassis

Boundary Condition

The boundary conditions applied to this model of chassis can be classified into four general cases: the first boundary condition case applied in static condition. The second case of boundary condition is applied when the car climb 30^o. in this condition the load concentration will move on rear part. The third case of boundary condition is applied when the car is passed through a descend road about 30^o. In this situation the load concentration move at front part of chassis. And the fourth case of boundary condition when the car is brake from 40 km/h until stop for 5 second. All condition represent the actual condition for electric car operation in Indonesia street. Parameter analysed for above boundary condition include stress, deflection and safety factor where all parameter are applied at solid plate beam chassis and perforated plate beam chassis.

IV. Result And Discussion

Figure-5 (a and b) shows a comparison between the stresses among the solid plate and perforated plate beam chassis at static condition. For the solid plate beam, maximum tress is about while maximum stress for perforated plate chassis is about . This figure clearly that porporate the beam plate does not have significant effect of stress at static condition..

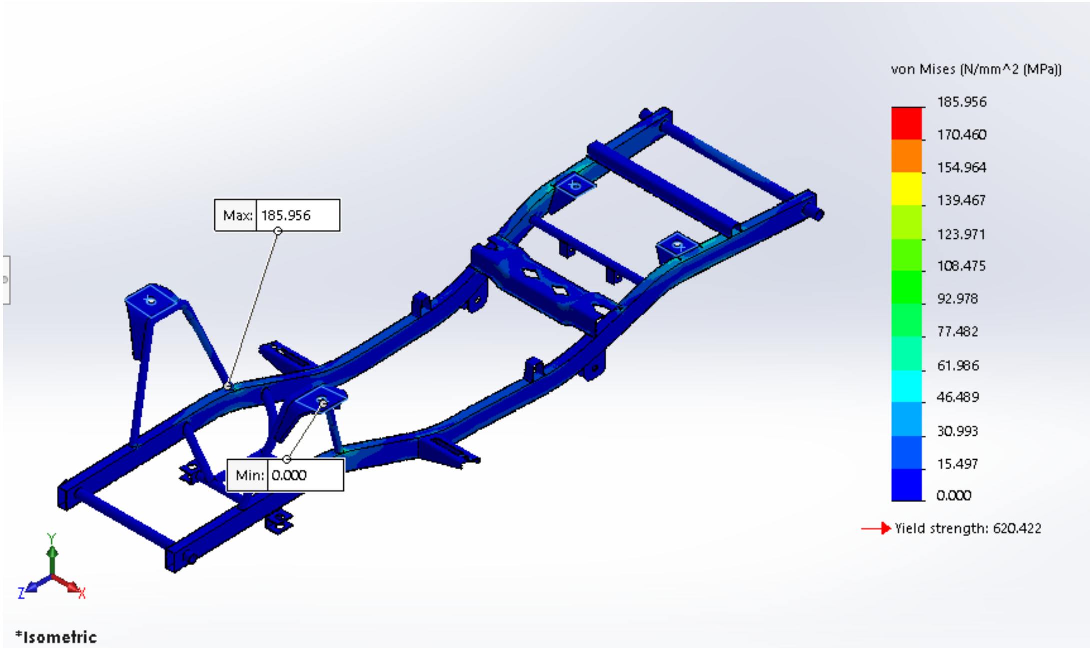

Figure 5.a. Solid plate beam stress at static condition

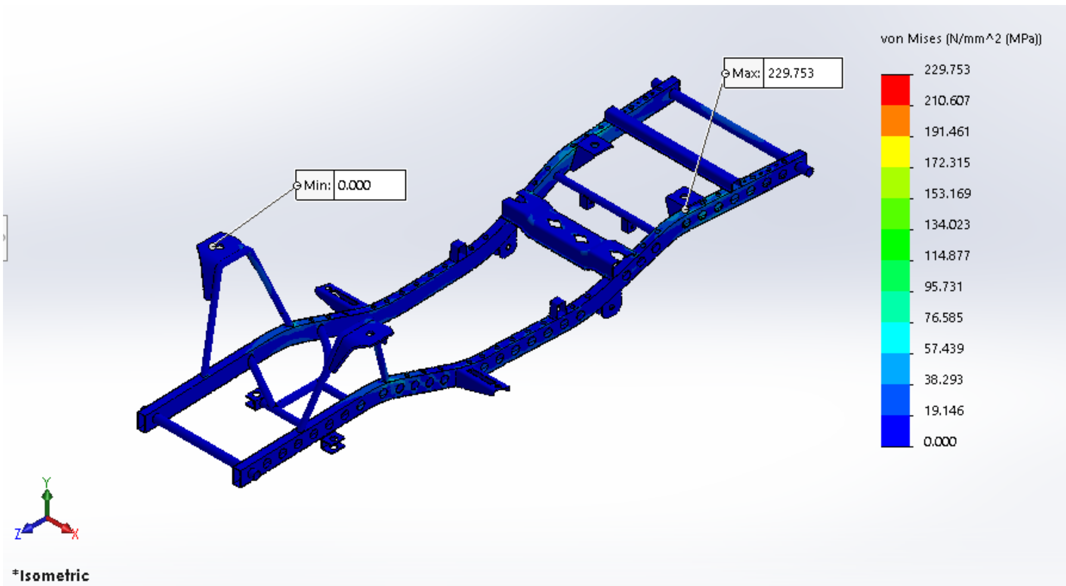

Figure 5.b. Perforate plate beam stress at static condition

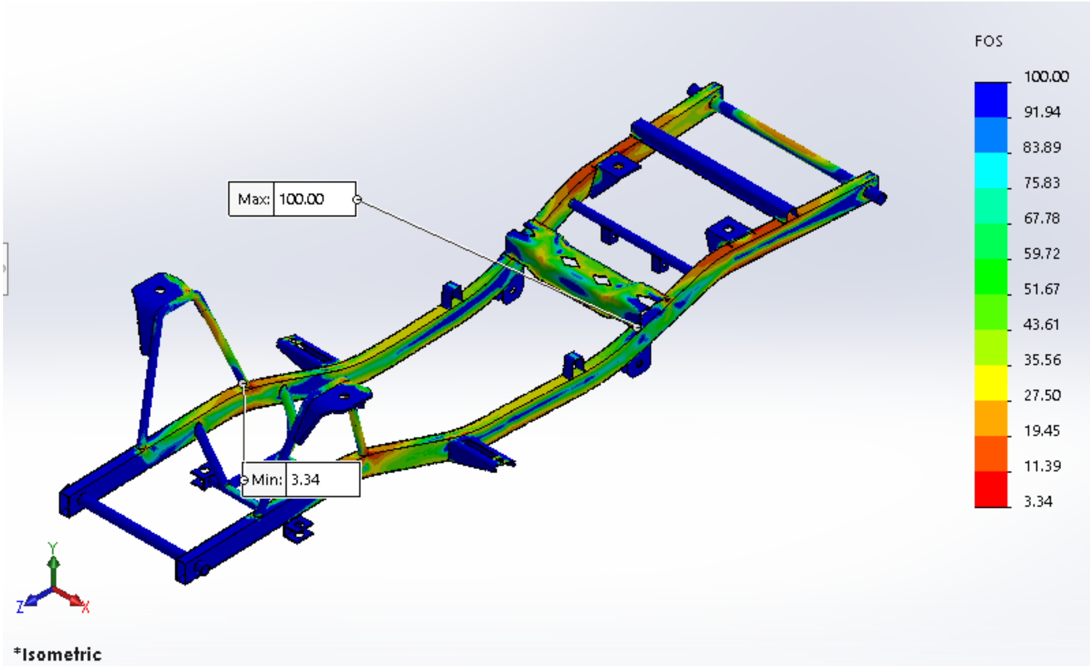

Figure 6.a Safety Factor of solid plate beam chassis at static condition

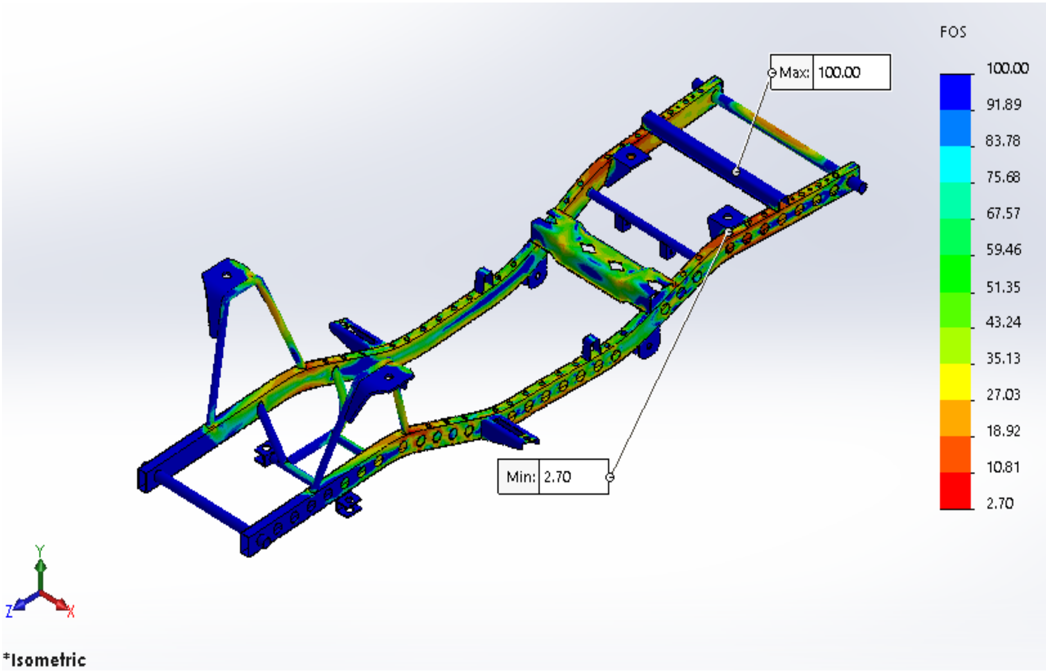

Figure 6.b. Safety Factor of perforated plate beam chassis at static condition

Safety factor analysis of both solid and perforated beam at static condition is described at Figure 6.a and Figure 6.b. It can be seen that minimum safety factor of solid plate beam chassis is 3.34 while perforated plate beam have 2.7 or lower than solid plate. Although the safety factor is lower than solid plate, the perforated plate beam still satisfy for electric car chassis where still more than 1. Similar result is shown at Figure 7.a and 7.b for deflection of both solid and perforated plate beam at static condition. Maximum deflection of solid plate beam is 1.141 mm and deflection of porforated plate beam is 1.312 at the same location.

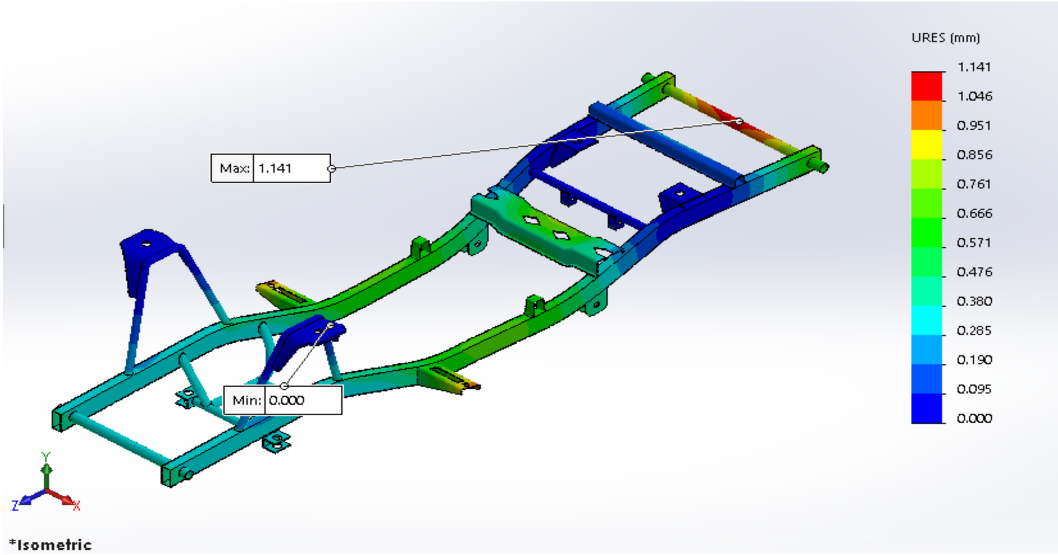

Figure 7.a Deflection of solid plate beam chassis at static condition

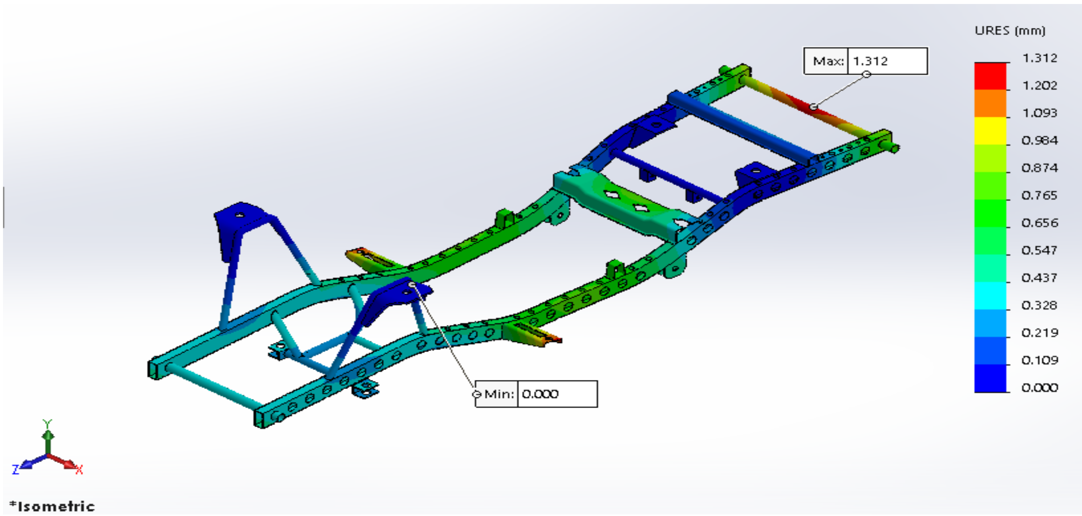

Figure 7.b Deflection of perforated plate beam chassis at static condition

The second case of boundary condition is applied when the car climb 30^{o}. In this condition the load concentration will move on rear part. In this case, result of stress computation are shown at Figure 8.a for solid plate beam chassis and Figure 8.b for perforated plate beam chassis. From these figure it can be seen that maximum stress of solid plate beam 205.84 Mpa and lower than perforated plate beam of 324.599 Mpa stress.

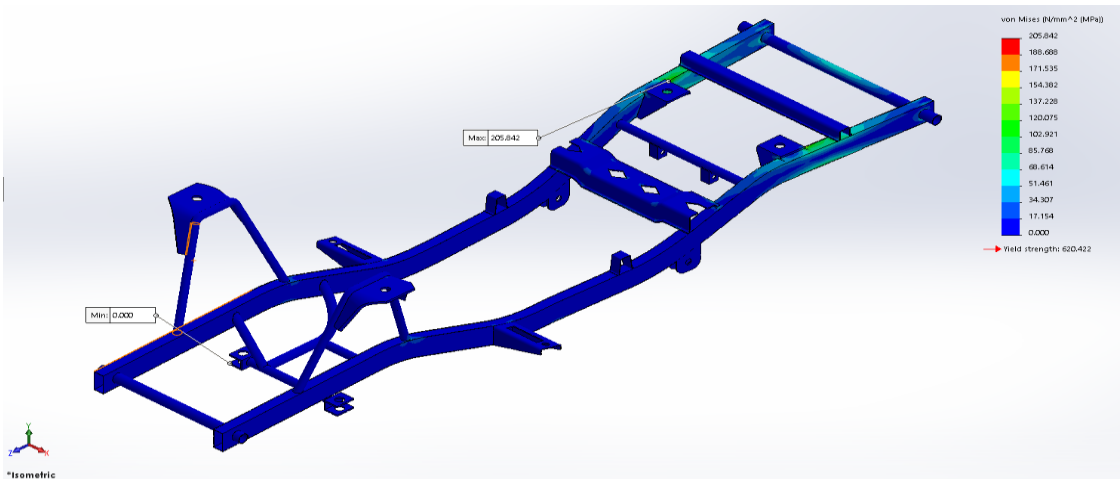

Figure 8.a. Solid plate beam stress at climb condition

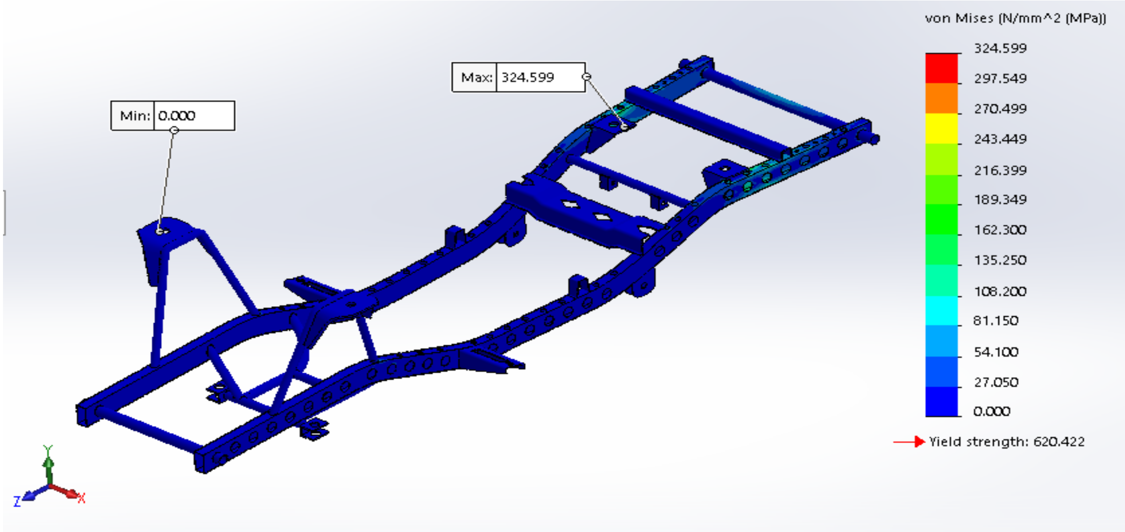

Figure 8.b Porforated plate beam stress at climb condition

Similarly at climb condition, the maximum deflection of solid plate beam is 2.433 mm and for perforated plate is 2.765 mm. The result of computation are shown at Figure 9.a for solid plate beam and Figure 9.b for porforated plate beam.

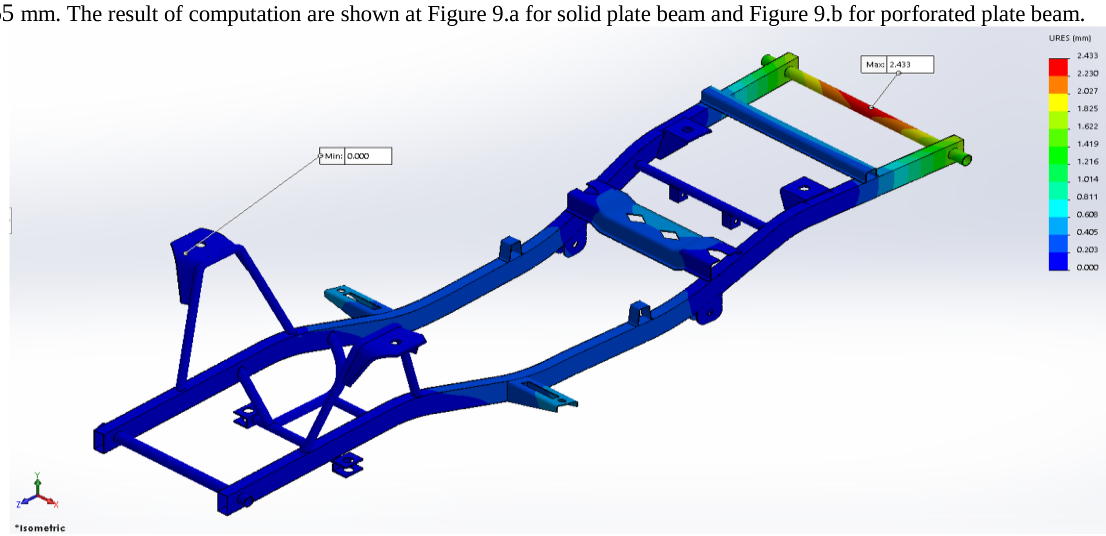

Figure 9.a Deflection of solid plate beam at climb condition

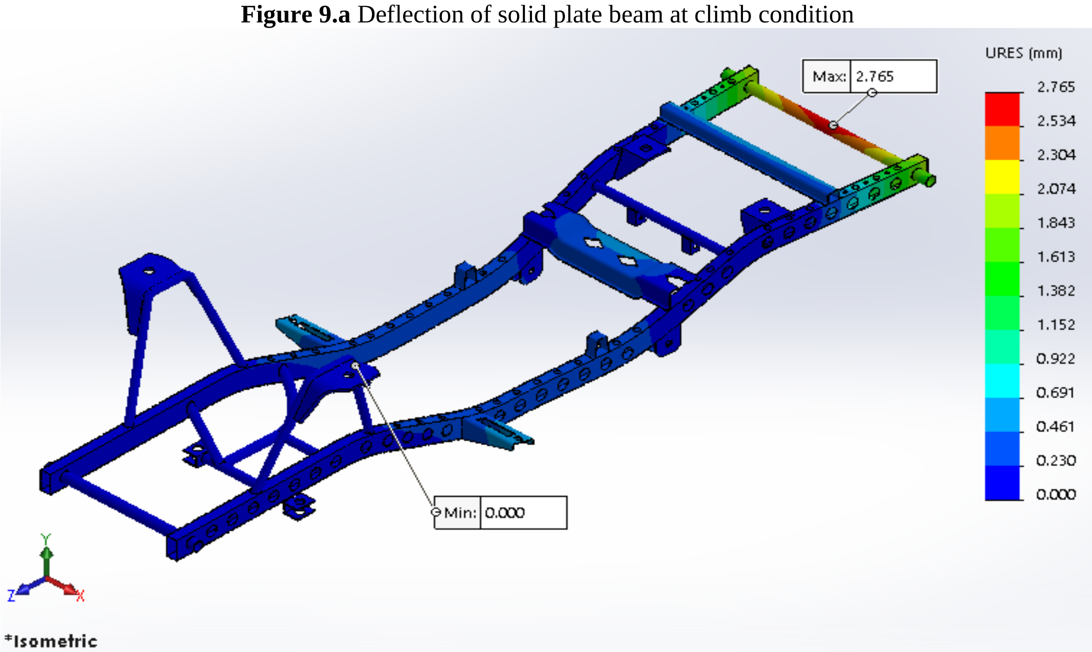

Figure 9.b Deflection of porforated plate beam at climb condition

Figure 10.a and 10.b show safety factor of solid plate beam chassis and perforated plate beam respectively at climb condition based on computation result. The safety factor of both chassis type are above 1 although safety factor of perforated plate chassis lower than solid plate.

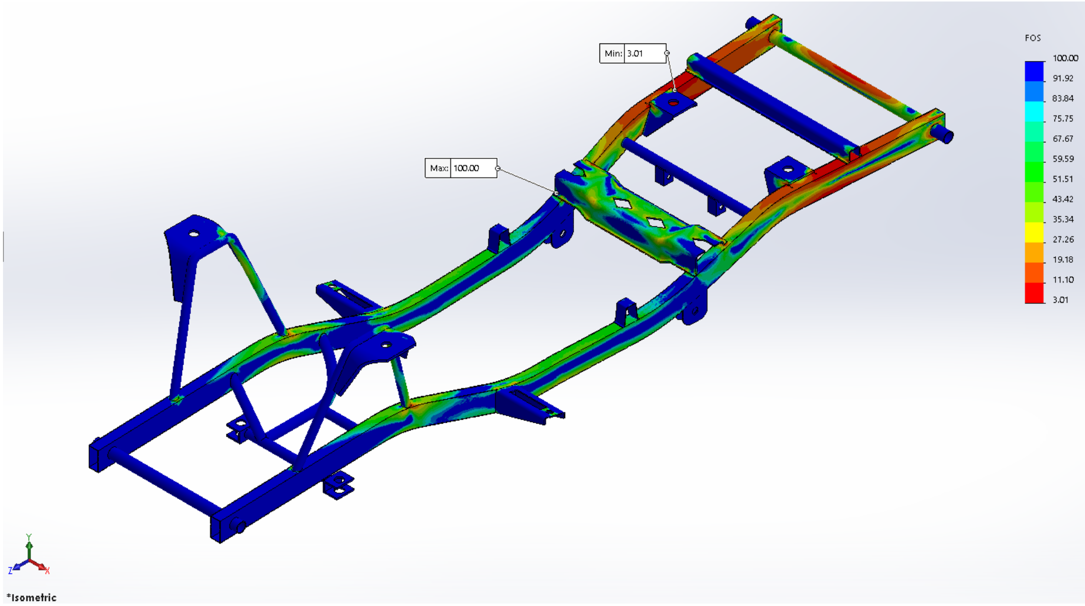

Figure 10.a Safety factor of solid plate beam at climb condition

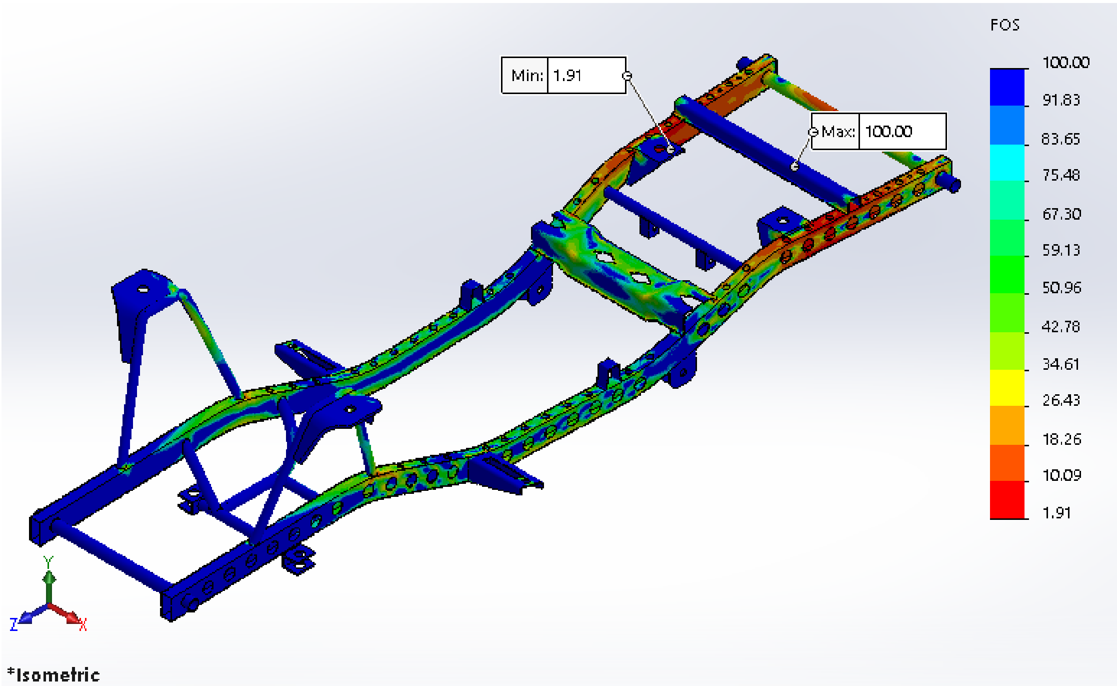

Figure 10.b Safety factor of perforated plate beam at climb condition

Computation result of chassis at descend road for both chassis are shown at Figure 11, 12, and 13. In this situation the load concentration move at front part of chassis. The result of computation have the same tendency as the previous case unless the position of maximum deflection, maximum stress and minimu safety factor Where it is concentrated on the front of chassis. Detail of value of these parameter can be seen at following figure.

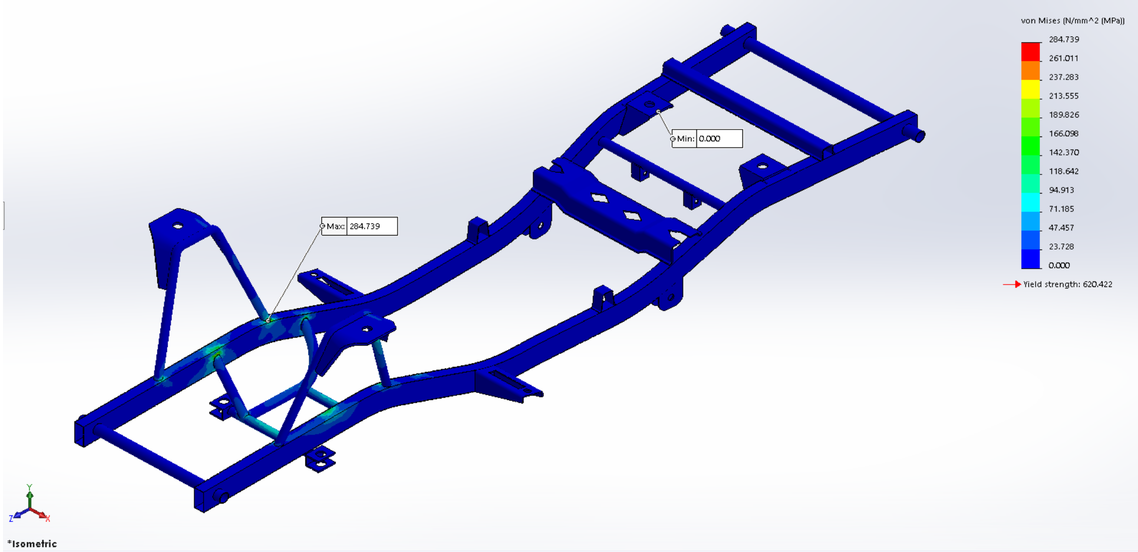

Figure 11.a Solid plate beam stress at descend road condition

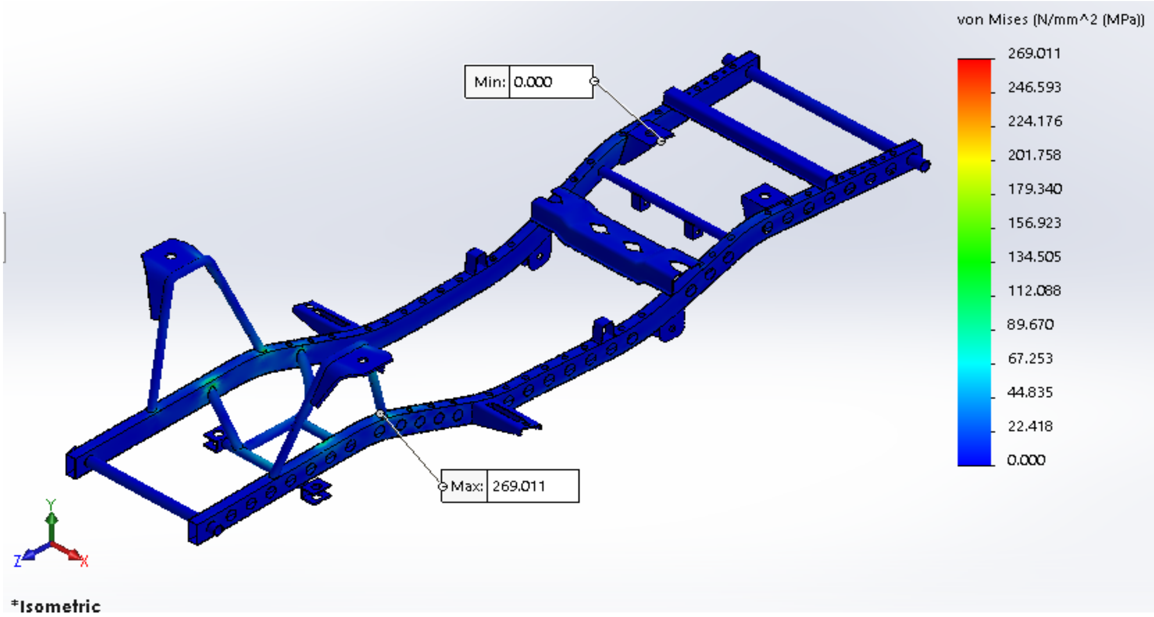

Figure 11.b Perforated plate beam stress at descend road condition

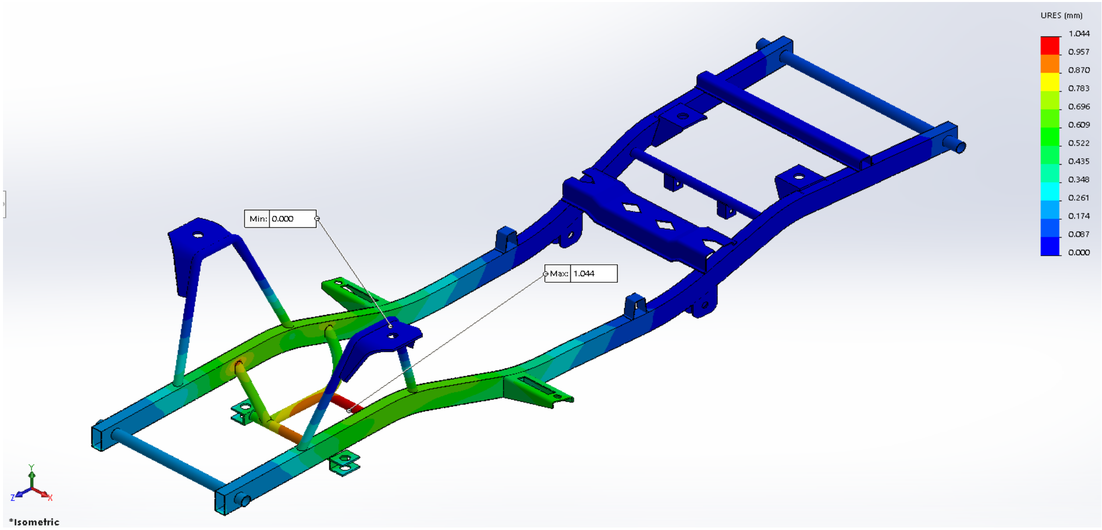

Figure 12.a Deflection of solid plate beam chassis at descend road

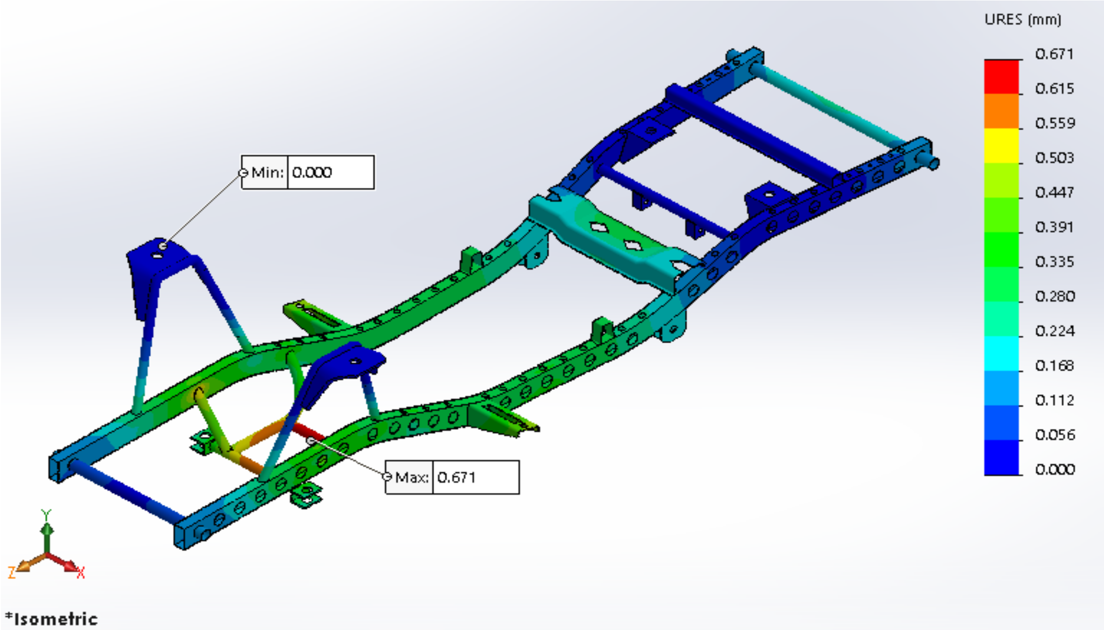

Figure 12.b Deflection of Porforated plate beam chassis at descend road

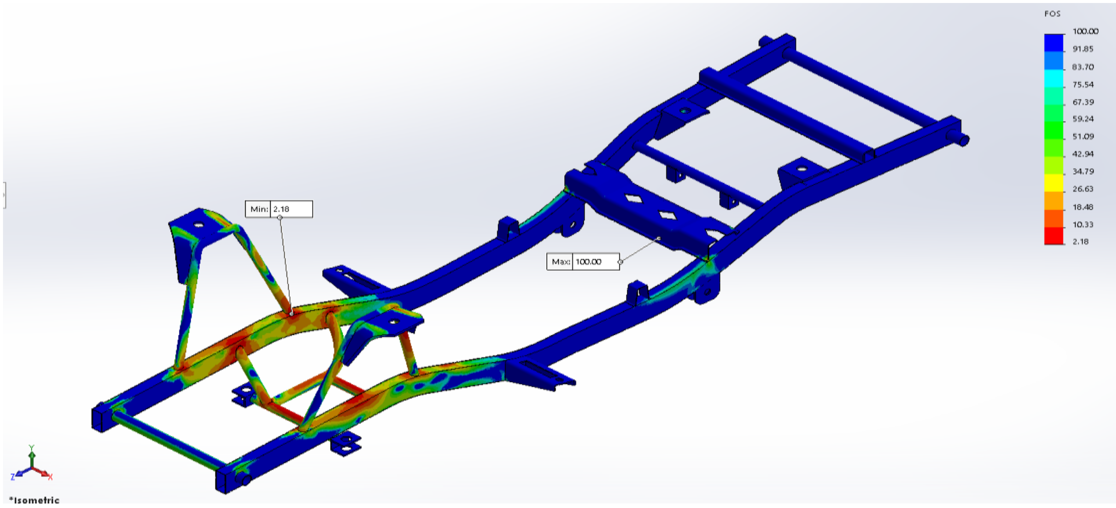

Figure 13.a Safety Factor of solid plate beam chassis at descend road

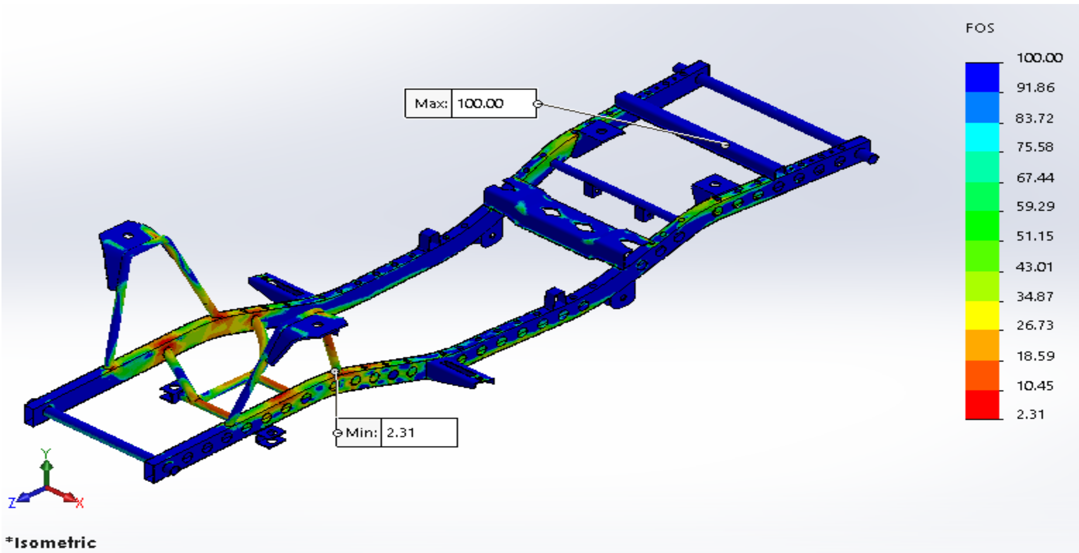

Figure 13.b Safety Factor of Porforated plate beam chassis at descend road

The fourth case is when the car is brake from 40 km/h until stop for 5 second. In this condition it is assumed that most of load is concentrated at front of chassis. In this case, the maximum stress of solid plate is 284.738 Mpa (Figure 14.a, while perforated plate stress is 374.682 Mpa (Figure 14.b). Maximum deflection of solid plate and porforated plate are 1.044 mm (Figure 15.a) and 1.055 mm (Figure 15.b) respectively. And minimum safety factor is 2.18 for solid plate (Figure 16.a) and 1.66 for perforated plate beam chassis (Figure 16.b).

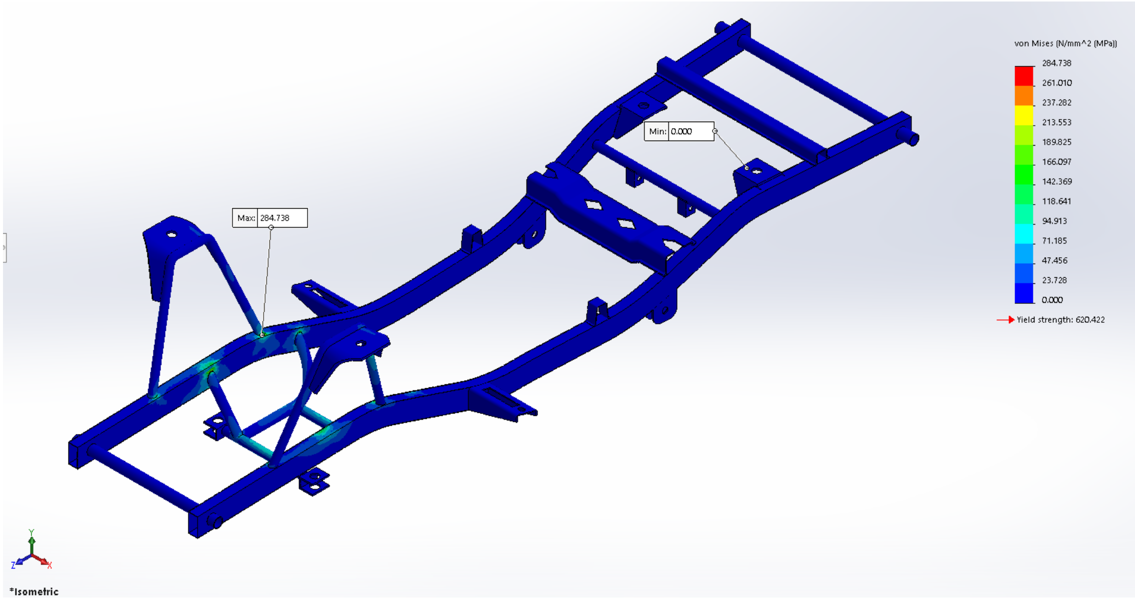

Figure 14.a. Solid plate beam stress at braking condition

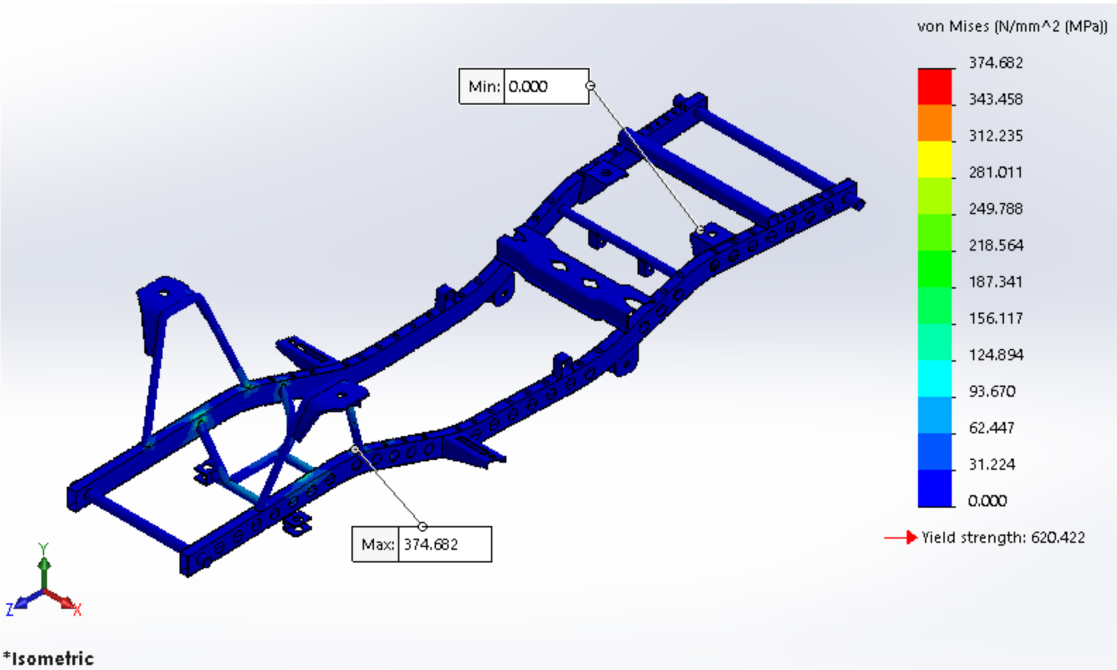

Figure 14.b Perforated plate beam stress at braking condition

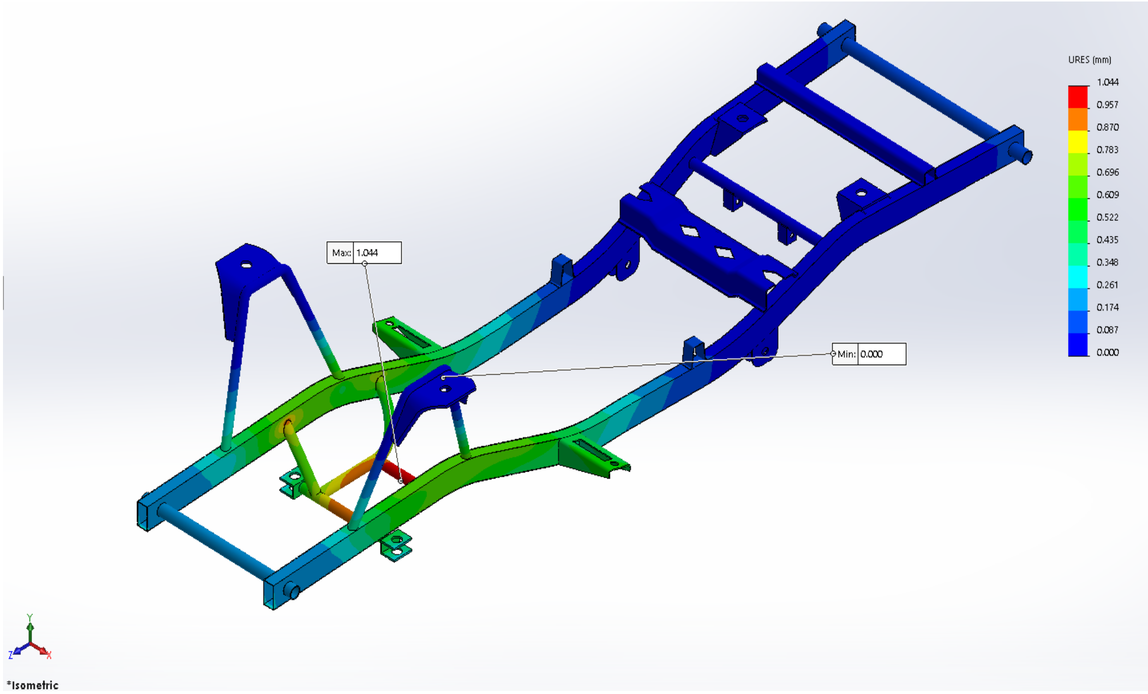

Figure 15.a Deflection of solid plate beam chassis at braking condition

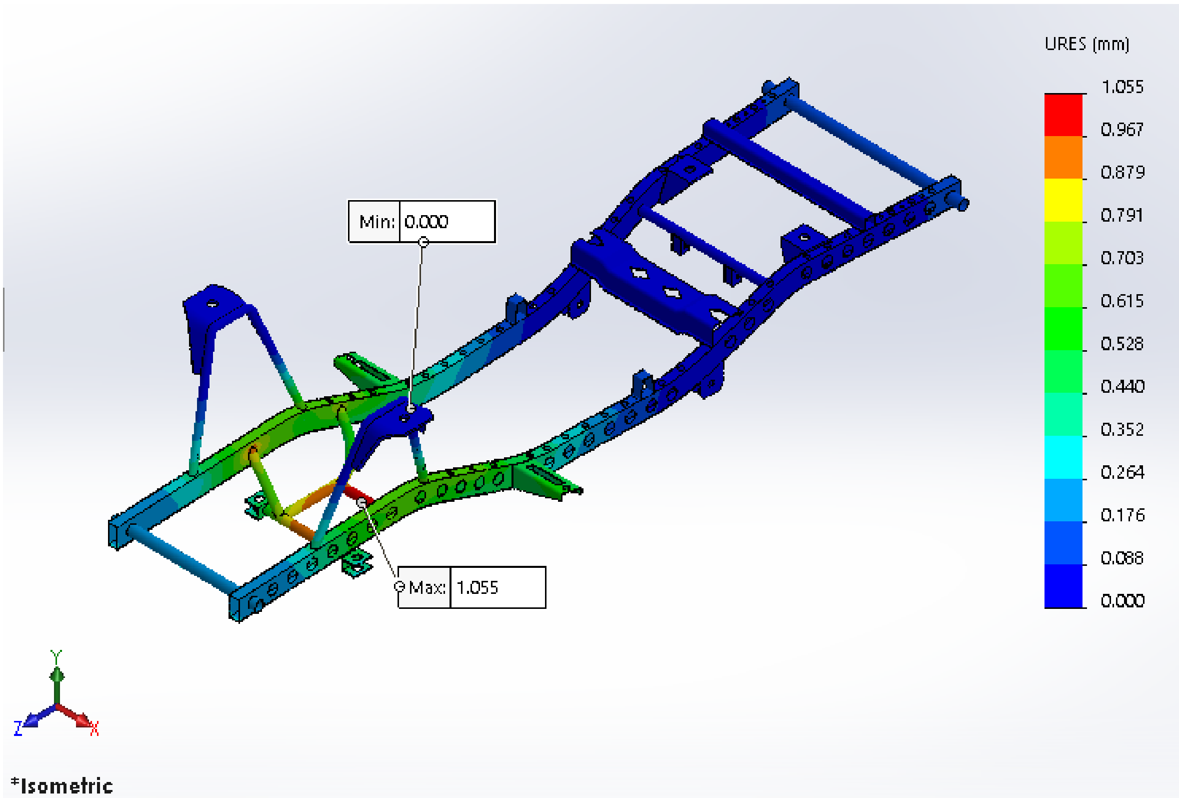

Figure 15.b Deflection of Porforated plate beam chassis at braking condition

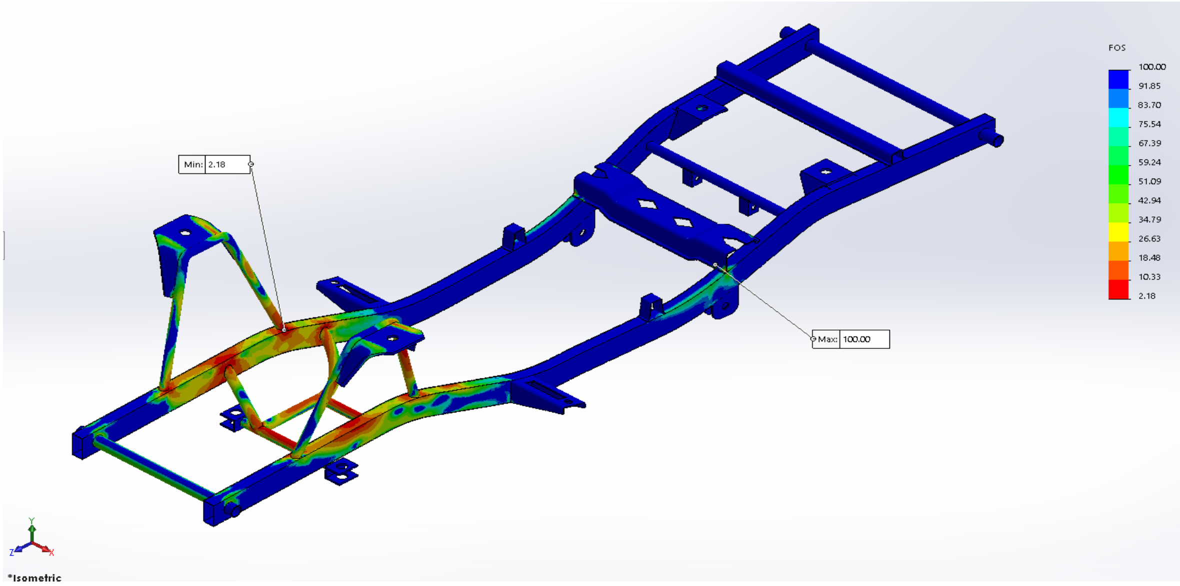

Figure 16.a Safety Factor of solid plate beam chassis at braking condition

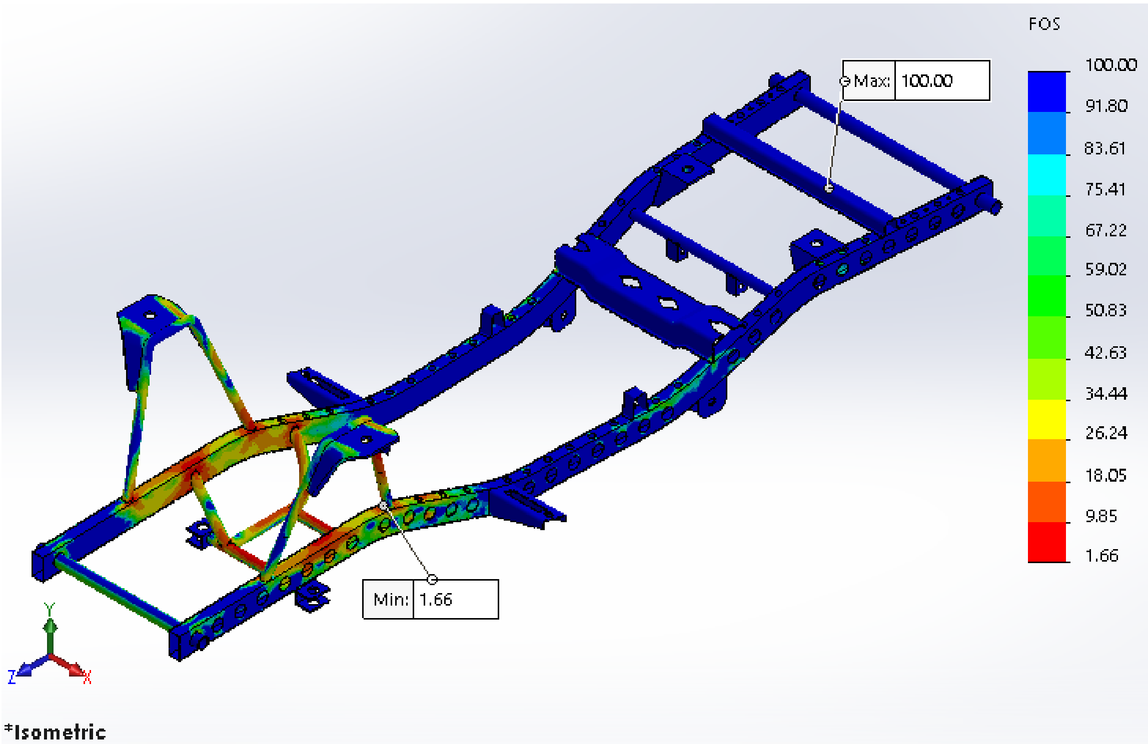

Figure 16.b Safety Factor of porforated plate beam chassis at braking condition

V. Conclusion

Two type of lader chassis was analysed by Finite Element Methode performed using SOLIDWORKS, solid plate beam and porforated plate beam chassis. Purpose of porforate the plate beam is reducing of chassis weight and finally incressing of battery live in electric car. The result of study performed in four case that are static condition, car climb, car pass through descend road and braking condition show that porforated plate beam chassis has lower performance. It can be seen that maximum stress of porforated plate is 25 % (everage) higher than solid plate, maximum deflection of porforated plate chassis is 20 % higher than solid plate and minimum safety factor of porforated plate is 20 % lower than solid plate. Safety factor as a critical parameter of both cases are above 1, and its can be say that all cases are recommended for electrical car chassis. Porforate the beam can reduce of about 22.5 % of chassis weight, hence it is conclude that porforated plate beam chassis is suitable for electrical car application.

Acknowledgements

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Stress Analysis of a Cross over Electric Car Chassis

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Stress Analysis of a Cross over Electric Car Chassis

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Abstract : *This paper presents, stress analysis of a ladder type cross over electric car chassis structure using FEM. The commercial finite element package SOLIDWORK was used for the solution of the problem. Two type of chassis was analysed, solid plate beam and porforated plate beam chassis. To reduce the weight of the chassis of the cross over electric car, the chassis structure design was modified by porforating the beam so that the main beam is not solid. The boundary conditions applied to this model of chassis can be classified into four general cases: static condition., the car climb 30^o. the car is passed through a descend road about 30^o and when the car is brake from 40 km/h until stop for 5 second. Output parameter analysed include stress, deflection and safety factor. It was concluded that porforate the plate beam reduce the chassis weight and did not have significant affect on the chassis safety factor, stress and deflection hence suitable for electric car.*

Keywords: *chassis, electric car, cross over, stress, porforate*

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I. Introduction

Now days, the increased demands on electric car have been increased not only on cost and weight, but also on improved complete vehicle features. Electric drive vehicles are becoming an attractive alternative to combustion engine cars with global gradual fossil fuel prices rise. In addition, increasing energy prices also have led to an increase interest in the development of electric vehicles. In addition, concerns over climate change and reduction of greenhouse gas emissions, and dependence of economies on foreign energy sources, have also become an initiative for extensive research on the use of electric cars as an alternative [1, 2, 3]. Cars with electrical drive systems represent a solution for the future, and will in a steadily increasing degree be seen on the roads. The history of electric cars is closely related to the history of batteries [4, 5, 6]. Electric cars appear to be the most suitable candidates to fulfill the environmental demands. In electric cars, efficiency of energy usage is very important. Indonesia is a large country. Roads in Indonesia generally have varied terrain. Cross over type vehicle is suitable for Indonesia. In order for an electric car cross over type to perform at its best it must have adequate structure, this means it must have a stiff frame. Since most of the car's weight is between the front and rear suspension, frame stiffness is absolutely the key between these points where it will not easily bend. For the electric car, stiffness is very important. Apart from safety requirements the chassis structure in itself should also provide torsional and bending stiffness as well as direct support for the front suspension and steering system mounting points. Some value of the safety factor for various condition of loading and material of structures was recommended by Vidosic [7]. Two aspects of frame stiffness should be considered which are beaming and torsional. Therefore the chassis is considered as the most important element of the vehicle as it holds all the parts and components together. In this study, an attempt is made to design an cross over electric car chassis that would reduce the weight and able to provide high specific strength and high specific stiffness, and easy to be manufactured. The main structure is ladder sturcture. Ladder chassis is thought to be one of the most established types of car chassis or vehicles chassis that is still utilized by the greater part of the SUVs till today. As its name indicates, ladder chassis takes after a state of a ladder having two longitudinal rails entomb connected by a few horizontal and cross supports. It should be noted that this 'ladder' type of frame construction is designed to offer good downward support for the body and payload and at the same time provide torsional flexibility, mainly in the region between the gearbox cross member and the cross member ahead of the rear suspension.

To reduce of weight of the chassis structure design was modified by perforating the beam so that the main beam is not solid. The characteristic of the chassis was checked by stress analysis. This paper presents, stress analysis of a ladder type cross over electric car chassis structure using FEM. The commercial finite element package SOLIDWORK was used for the solution of the problem. Two type of chassis was analysed, solid plate beam and porforated plate beam chassis. The porforated plate beam chassis that form a ladder chassis is the new contribution in electric car thechnology. This paper is divided to (5) five parts, and starting with introduction. Literature review is the second part that discuss of previous study followed by stress analysis procedure in the third part. In the fourth part is presented the result and discussion and conslussion will be presented in the last section.

II. Literatur Review

Many researchers had conducted analysis on chassis of various vehicles. Abd Rahman et. al. investigated stress analysis on a truck chassis using finite element method [8]. Finite element result had shown that the critical point of stress occurs at opening of chassis which is in contact to the bolt. Thus it is important to reduce stress magnitude at the specific location. Previous FEA agrees well with the maximum deflection of simple beam loaded by uniformly distributed force. Ebrahimi et. al. constructed a car model and its components analysis were carried out [9]. Sane et. al. performed stress analysis on a light commercial vehicle chassis using iterative procedure for reduction of stress level at critical locations[10].Koszalka et. al. accomplished stress analysis on a frame of semi low loader using FEM[11]. Two versions of frame design were analyzed, focusing on the part of beam where the highest stresses were located.

Rane et.al [12] did their work in the use of optimization techniques for redesign of the forklift chassis by the use of finite element analysis. Author focused their work on the study of the optimum material distribution to get an idea of the load flow path based on which new design with higher strength to weight ratio as compared with original design could be obtained. Assembly fitment parameters/functional requirements were to be kept as it is. Methodology used by the author for structural optimization was in three phases. In first phase chassis was subjected to topology optimization to obtain optimum density plots to reduce its weight. In second phase after topology optimization, size optimization is performed to obtain the optimal thickness of all the structural members. The output model is run for remaining load cases in the third phase. Author concludes how optimization techniques can be used as a tool in finite element analysis for achieving weight reduction. Through optimization techniques weight of the chassis was reduced by around 14.5 %.

Marco et al. [13] focused their study on weight reduction of the automotive chassis by using structural optimization method linked with finite element analysis. Various optimization techniques were explained. The methods were briefly introduced, and some applications were presented and discussed with the aim of showing their potential. A particular focus was given to weight reduction in automotive chassis design applications. The author provided a quick overview on structural optimization methods. Author explained how topology and topometry optimizations were more suitable for an early development stage, whose outcome could be further refined through size and shape optimizations.

Prabhakaran et al. [14] focused their work towards weight reduction of chassis by performing structural analysis. Basic calculations for the chassis frame were done analytically based on the bending theory and values of stress and deflection were obtained. Finite element analysis for the existing chassis was performed for overload condition and stress and deflection values were obtained. For weight reduction design modifications were made by doing a sensitivity analysis. In sensitivity analysis section modulus and flange width were kept constant. Three cases were considered for weight reduction in which thickness and height of the flange were varied. Comparison of the results showed that out of three cases third case resulted in about 6.7% of weight reduction

III. Methodology

The main objective of the study is to obtain a preferable design safety factor, maximum stress and deflection for a cross over electric car chassis using finite element method. Two model of ladder chassis was analysed, there are solid plate beam and porforated palte beam chassis. The analysis was conducted using Commercial version of SOLIDWORK.. There are three main steps, namely: preprocessing, solution and postprocessing. The preprocessing (model definition) step is critical. A perfectly computed finite element solution is of absolutely no value if it corresponds to the wrong problem. This step includes: define the geometric domain of the problem, the element type(s) to be used, the material properties of the elements, the geometric properties of the elements (length, area, and the like), the element connectivity (mesh the model), the physical constraints (boundary conditions) and the loadings [15].

The next step is solution, in this step the governing algebraic equations in matrix form and computes the unknown values of the primary field variable(s) are assembled. The computed results are then used by back substitution to determine additional, derived variables, such as reaction forces, element stresses and heat flow. Actually the features in this step such as matrix manipulation, numerical integration and equation solving are carried out automatically by commercial software [16].

The final step is postprocessing, the analysis and evaluation of the result is conducted in this step.

Model

Components of cross over electric car chaissis is shown in Fig. 1 (a,b,c). The beam is porforated at vertical (Fig. 1.a. and horisontal beam plate (Fig. 1.b).

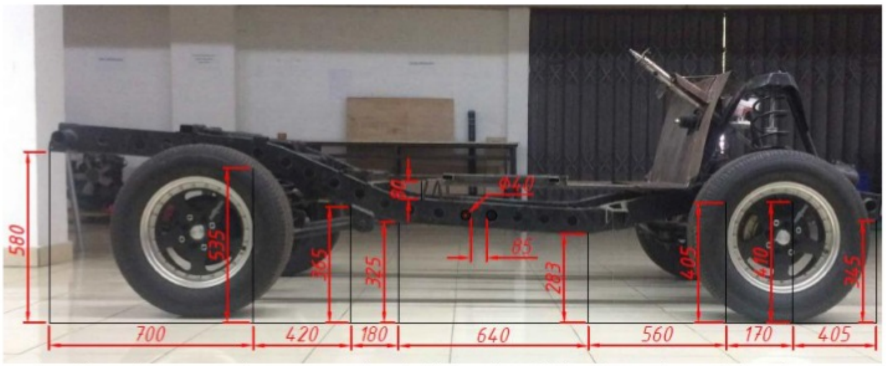

Figure 1 a. General structure of cross over electrical chassis and showing perforated plate beam at vertical

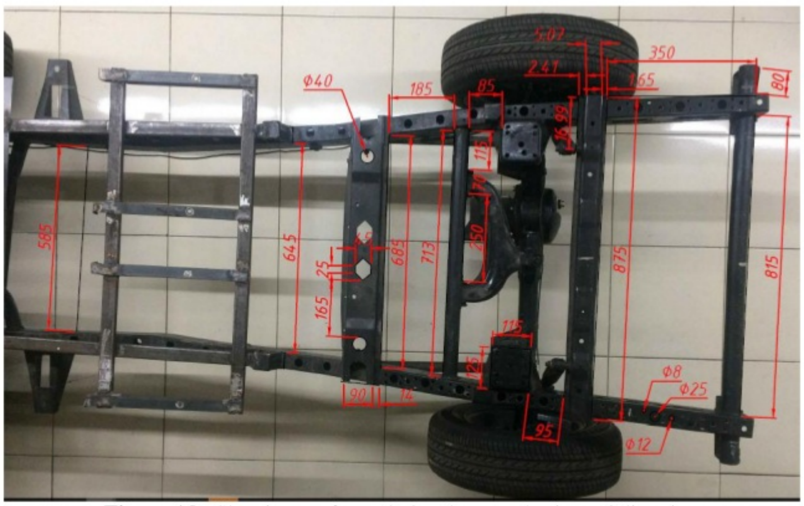

Figure 1.b. Showing porforated plate beam at horisontal direction

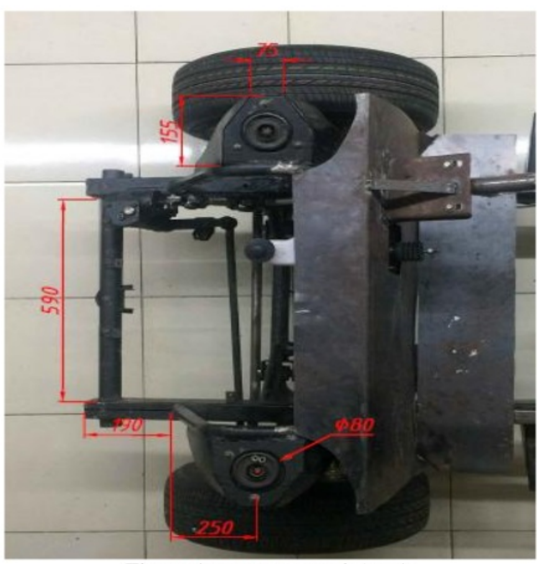

Figure 1.c. Front part of chassis

Due to uncertainty in estimating the vehicle loads and the dynamic and oscillating nature of it, the quasi-static method is used to conceptual design of ladder frame (chassis). In order to design a chassis at the first step, the force exerted on the chassis and its location is determined. Then, note to the boundary condition, bending moments and shear forces diagrams along the chassis are extracted. Finally, appropriate profile section which reduces the weight and endures loads is selected from handbook [17] and Maximum allowable stress and strain theories are used to design a chassis. In this analysis, following basic equation were used:
Bending moment $M_b(x)$ and shear force $V(x)$ along the chassis are [17]:

$$V(x) = -\int w(x)\,dx \quad (1)$$
$$M_b(x) = \int V(x)\,dx \quad (2)$$

Where w(x) is expanded load on chassis

Regarding the bending moment and shear stress diagrams maximum normal stress along the chassis can be evaluated from [17]:

$$\sigma_{max} = N(M_{b\,max}/S_{min}) \quad (3)$$

where σmax is maximum normal stress, N is dynamic factor load (includes safety factor) and Smin is minimum section module. Therefore, according to maximum allowable stress, the section module is determined by considering the dynamic load factor. Optimal section module should be larger than Smin and have minimum density to reduce chassis weight. Maximum strain theory, which is based on the maximum allowable chassis deflection, is more conservative than maximum stress theory. The relation between chassis strain and bending moment is described as follows [17]:

$$E.I.y(x) = \int dx \int M_b(x)\,dx + C_1x + C_2 \quad (4)$$

where E and I are modulus of elasticity and inertia moment of chassis respectively. $y(x)$ is function of deflection along chassis deflection, and $C1$, $C2$ are constant coefficients.
In elasto-static problem, each element forms a stiffness matrix [K], relating force [F] and displacements [u] at nodes. The size of stiffness matrix is equal to the number of nodes per element multi;plies by the number of freedom per nodes, as the following [17]:

$$[F]=[K][u]. \quad (5)$$

In eigenvalue problem te characteristic matrix is formed as

$$\{[K]-\omega^2[M]\}[U]=0 \quad (6)$$

Where M is the mass matrix, ω^2 is eigenvalues and u is eigen vector.

In this study two model of electrical chassis are developed, there are solid plate beam model and porforated plate beam model. Figure 2 show the solid plate beam model of cross over electric car chassis and firgure 3 show the porforated plate beam.

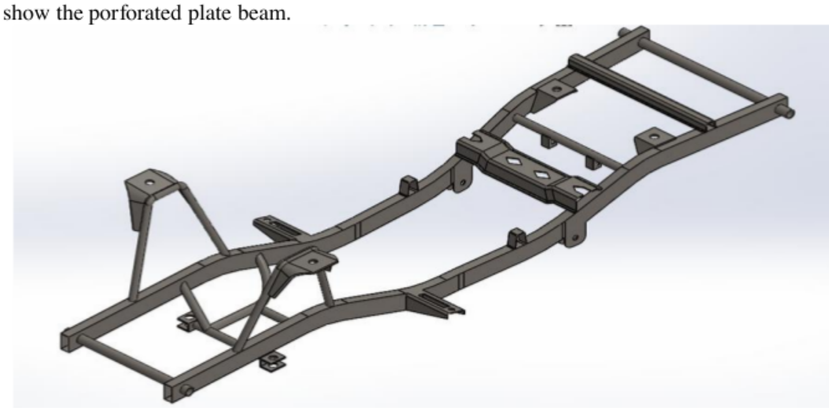

Figure 2. Solid plate beam model

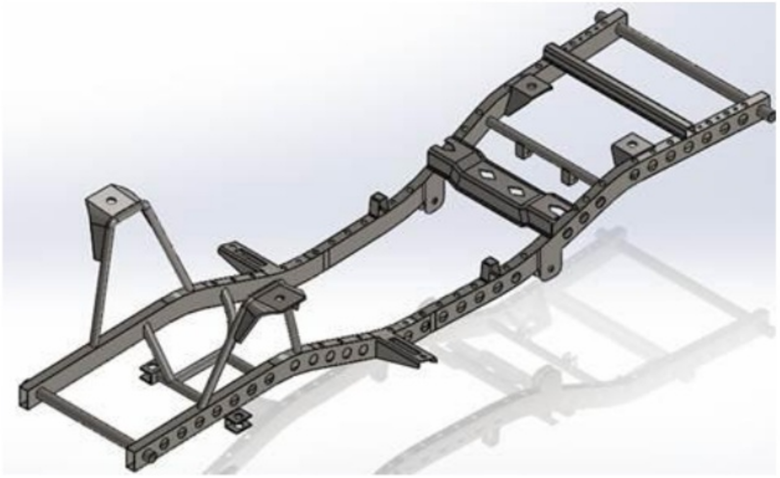

Figure 3 Porforated plate beam model

Load

The cross over electric car chassis model is loaded by static forces from battere, motor and passenger. For this model, batere load is 27 batere with 25 kg each, motor load is 45 kg and 2 passenger with 70 kg each. Position of each load is described in Figure 4 below. In this situation the peperties of material is described in the following Table 1.

Table 1. The properties of chassis material

Name	Alloy Steel
Model type	Linear Elastic Isotropic
Default failure criterion	Max von Mises Stress
Yield **strength**	6.20422e+008 N/m^2
Tensile strength	7.23826e+008 N/m^2
Elastic modulus	2.1e+011 N/m^2
Poisson's ratio	0.28
Mass density	7700 kg/m^3
Shear modulus	7.9e+010 N/m^2
Thermal expansion coefficient	1.3e-005 /Kelvin

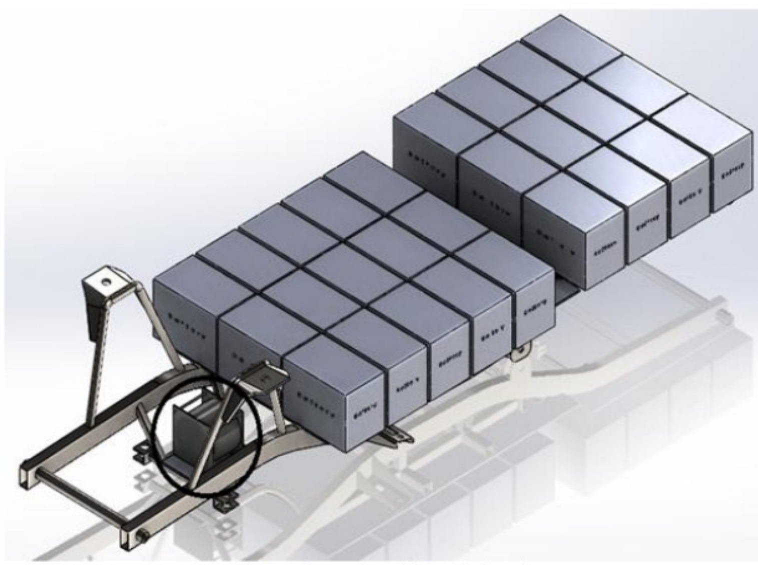

Figure 4 Load position of chassis

Boundary Condition

The boundary conditions applied to this model of chassis can be classified into four general cases: the first boundary condition case applied in static condition. The second case of boundary condition is applied when the car climb 30°. in this condition the load concentration will move on rear part. The third case of boundary condition is applied when the car is passed through a descend road about 30°. In this situation the load concentration move at front part of chassis. And the fourth case of boundary condition when the car is brake from 40 km/h until stop for 5 second. All condition represent the actual condition for electric car operation in Indonesia street. Parameter analysed for above boundary condition include stress, deflection and safety factor where all parameter are applied at solid plate beam chassis and perforated plate beam chassis.

IV. Result And Discussion

Figure-5 (a and b) shows a comparison between the stresses among the solid plate and perforated plate beam chassis at static condition. For the solid plate beam, maximum tress is about while maximum stress for perforated plate chassis is about . This figure clearly that porporate the beam plate does not have significant effect of stress at static condition..

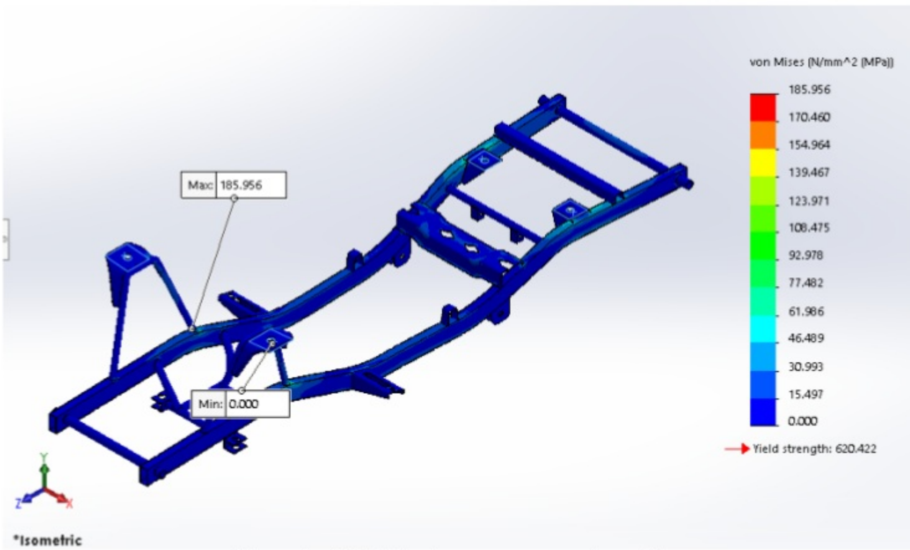

Figure 5.a. Solid plate beam stress at static condition

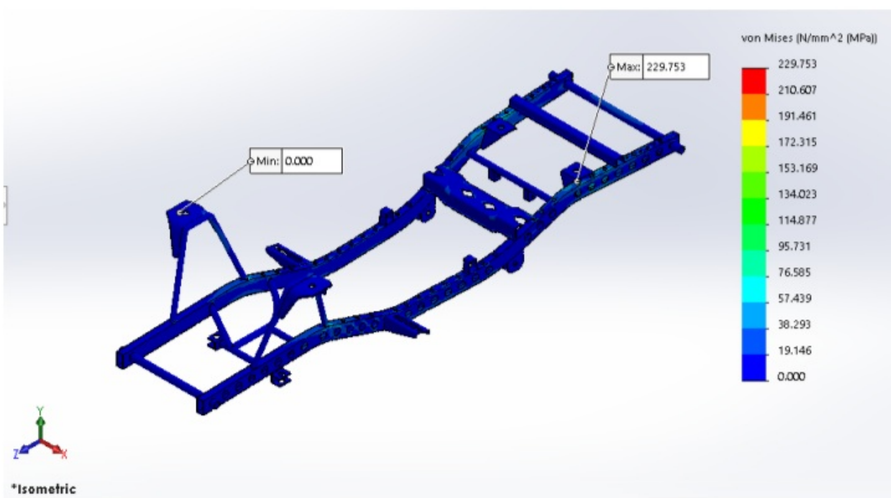

Figure 5.b. Porforate plate beam stress at static condition

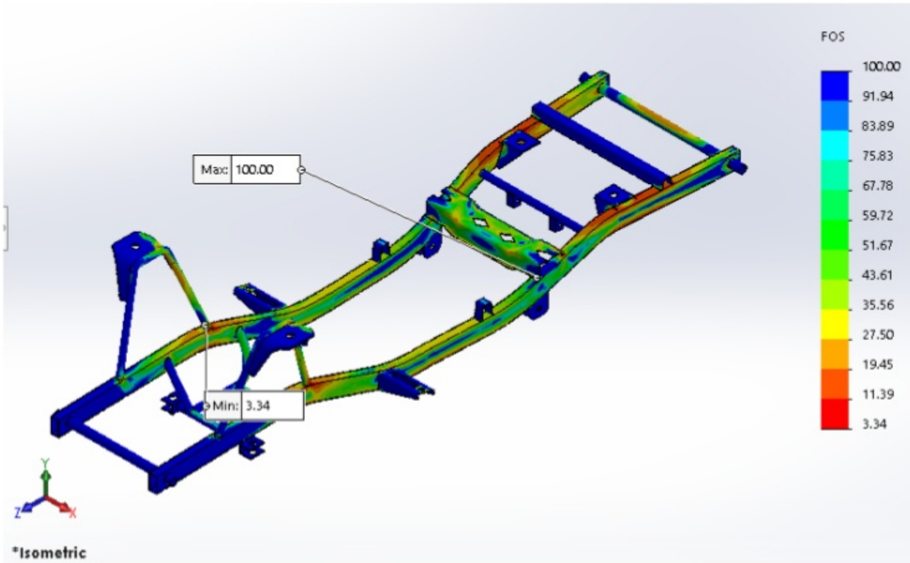

Figure 6.a Safety Factor of solid plate beam chassis at static condition

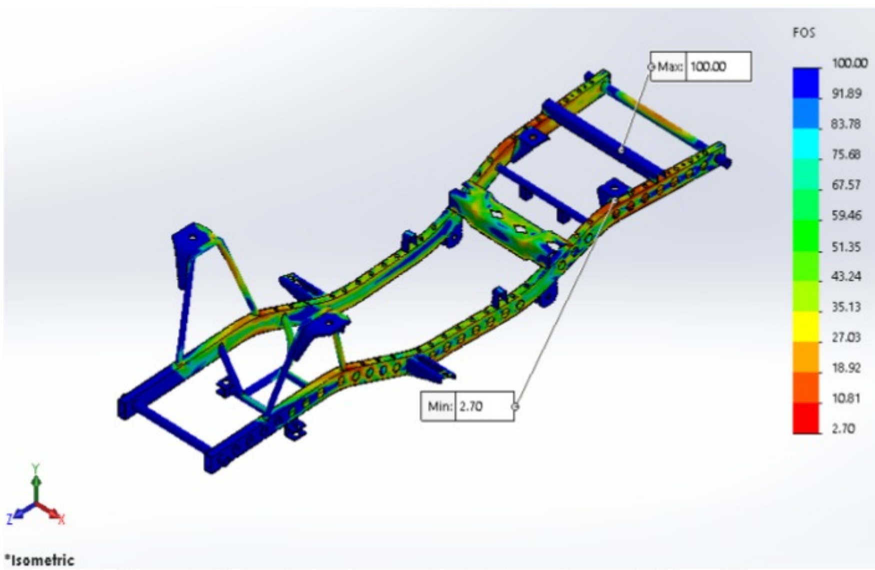

Figure 6.b. Safety Factor of porforated plate beam chassis at static condition

Safety factor analysis of both solid and porforated beam at static condition is described at Figure 6.a and Figure 6.b. It can be seen that minimum safety factor of solid plate beam chassis is 3.34 while porforated plate beam have 2.7 or lower than solid plate. Although the safety factor is lower than solid plate, the porforated plate beam still satisfy for electric car chassis where still more than 1. Similar result is shown at Figure 7.a and 7.b for deflection of both solid and porforated plate beam at static condition. Maximum deflection of solid plate beam is 1.141 mm and deflection of porforated plate beam is 1.312 at the same location.

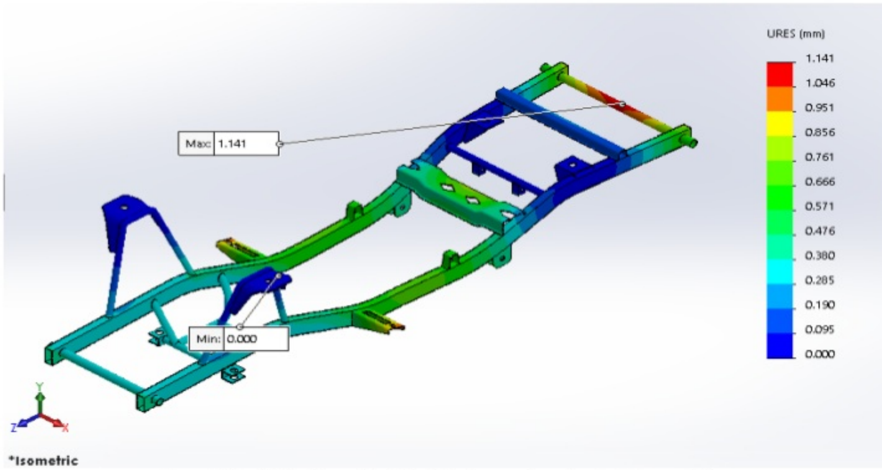

Figure 7.a Deflection of solid plate beam chassis at static condition

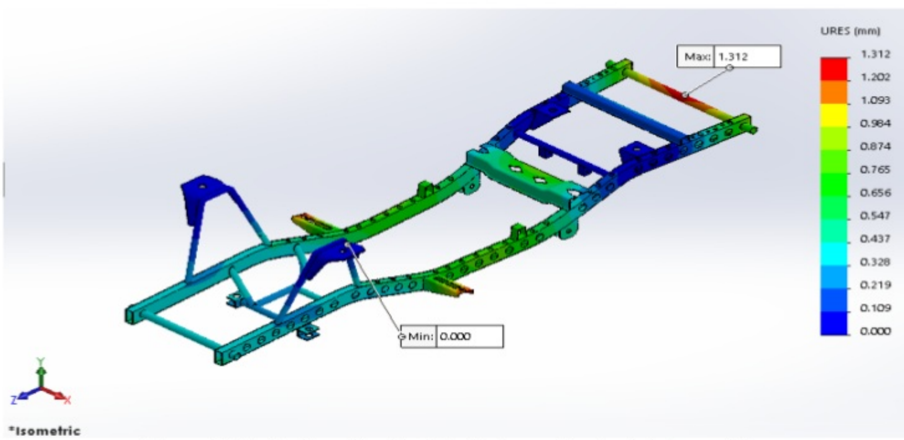

Figure 7.b Deflection of porforated plate beam chassis at static condition

The second case of boundary condition is applied when the car climb 30°. In this condition the load concentration will move on rear part. In this case, result of stress computation are shown at Figure 8.a for solid plate beam chassis and Figure 8.b for porforated plate beam chassis. From these figure it can be seen that maximum stress of solid plate beam 205.84 Mpa and lower than porforated plate beam of 324.599 Mpa stress.

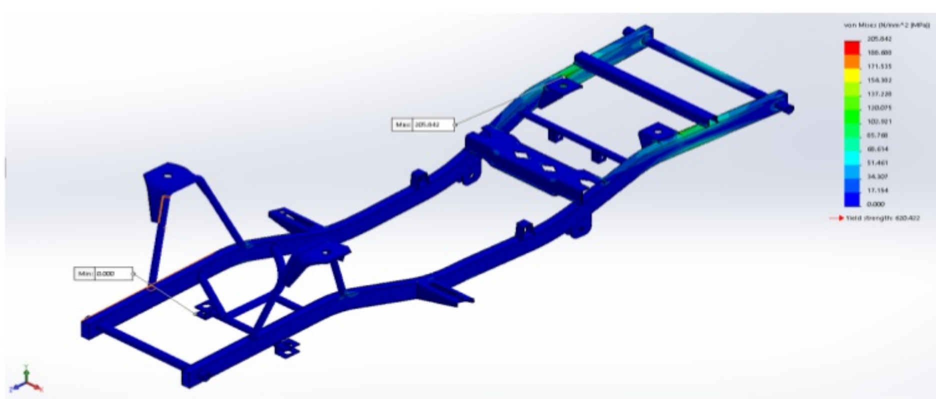

Figure 8.a. Solid plate beam stress at climb condition

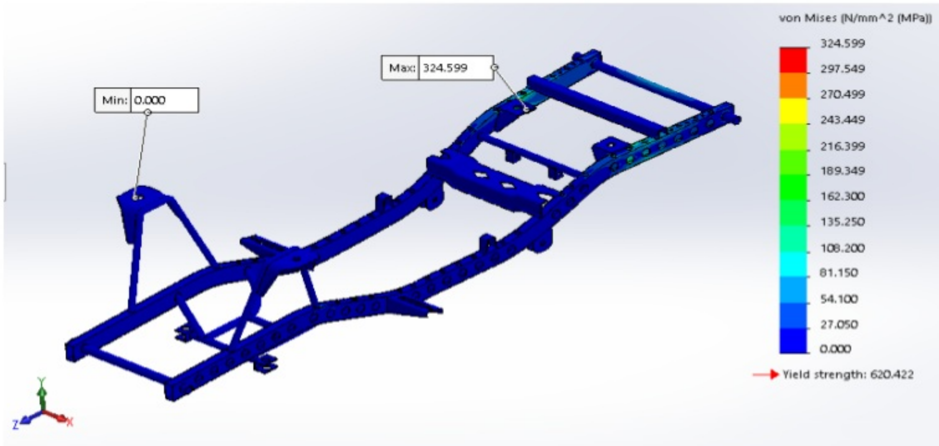

Figure 8.b Porforated plate beam stress at climb condition

Similarly at climb condition, the maximum deflection of solid plate beam is 2.433 mm and for porforated plate is 2.765 mm. The result of computation are shown at Figure 9.a for solid plate beam and Figure 9.b for porforated plate beam.

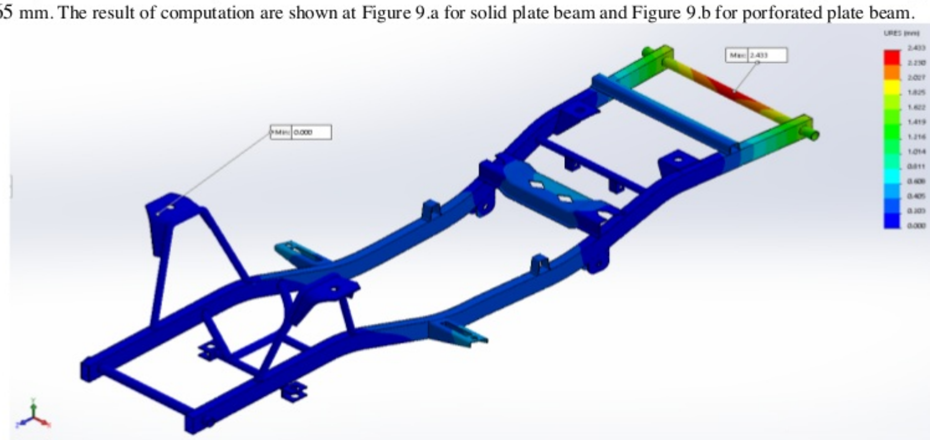

Figure 9.a Deflection of solid plate beam at climb condition

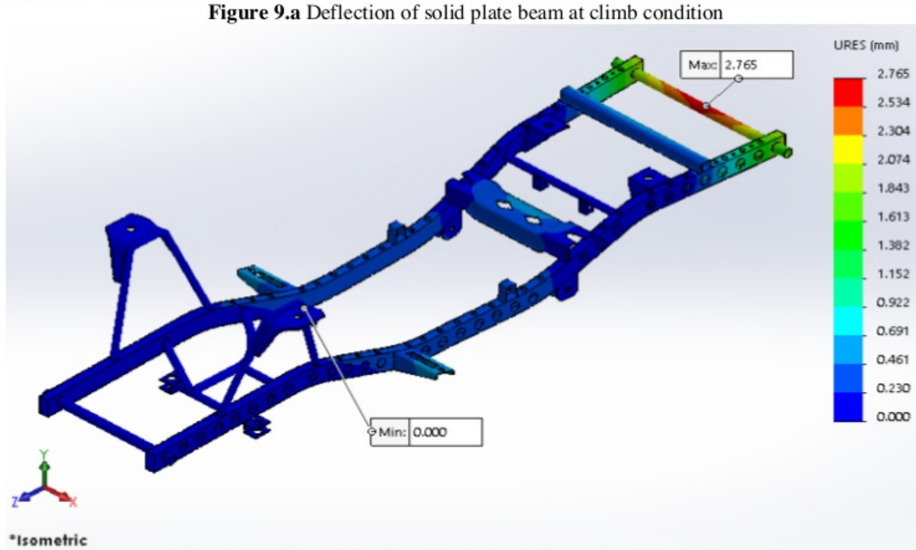

Figure 9.b Deflection of porforated plate beam at climb condition

Figure 10.a and 10.b show safety factor of solid plate beam chassis and perforated plate beam respectively at climb condition based on computation result. The safety factor of both chassis type are above 1 although safety factor of perforated plate chassis lower than solid plate.

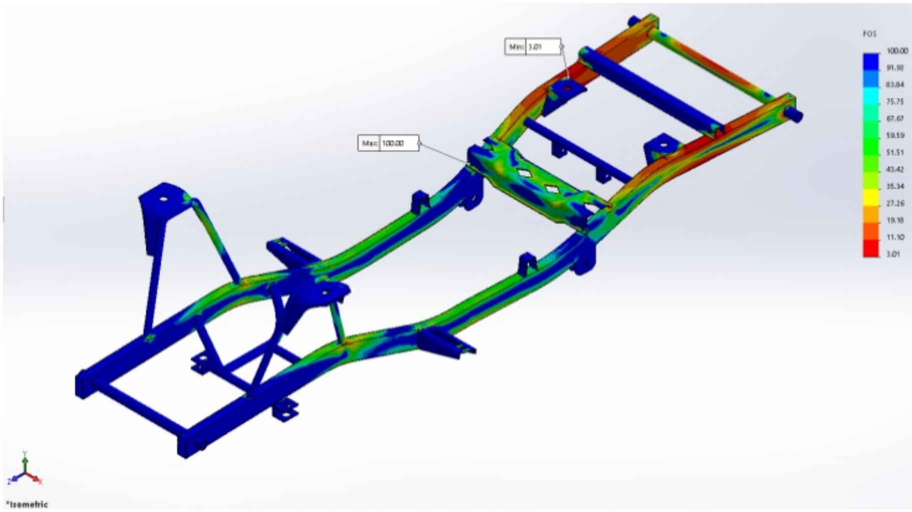

Figure 10.a Safety factor of solid plate beam at climb condition

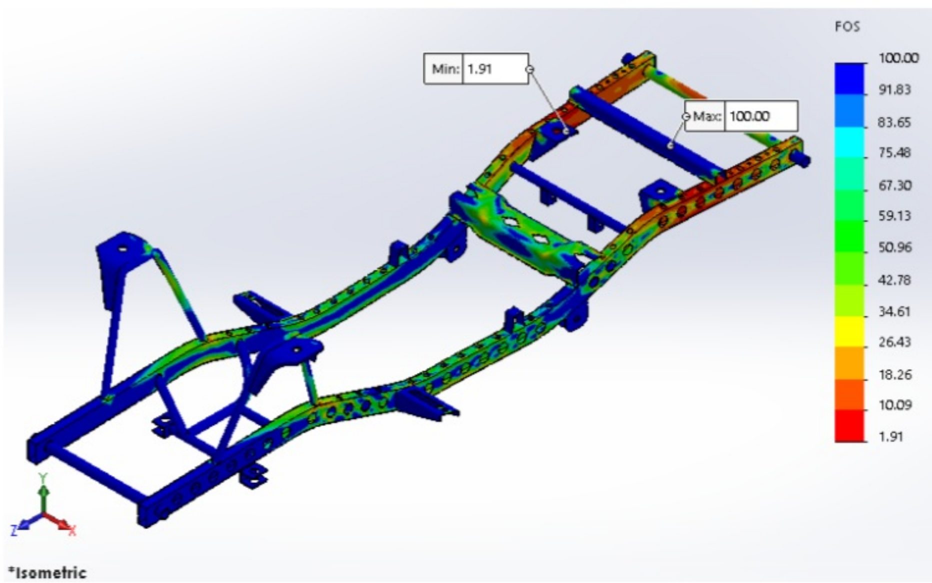

Figure 10.b Safety factor of perforated plate beam at climb condition

Computation result of chassis at descend road for both chassis are shown at Figure 11, 12, and 13. In this situation the load concentration move at front part of chassis. The result of computation have the same tendency as the previous case unless the position of maximum deflection, maximum stress and minimu safety factor Where it is concentrated on the front of chassis. Detail of value of these parameter can be seen at following figure.

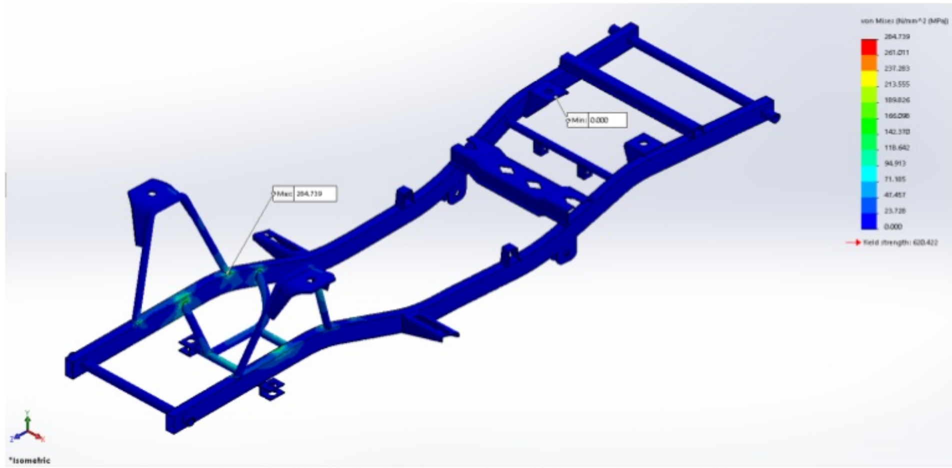

Figure 11.a Solid plate beam stress at descend road condition

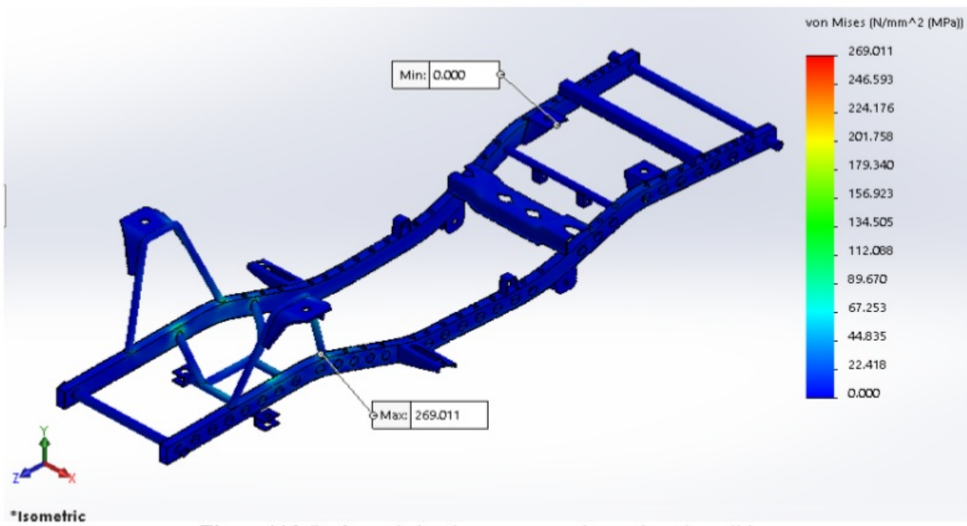

Figure 11.b Porforated plate beam stress at descend road condition

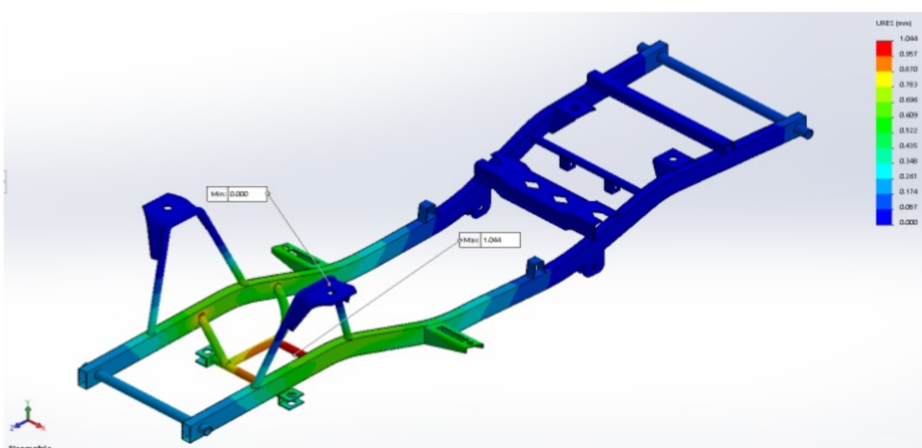

Figure 12.a Deflection of solid plate beam chassis at descend road

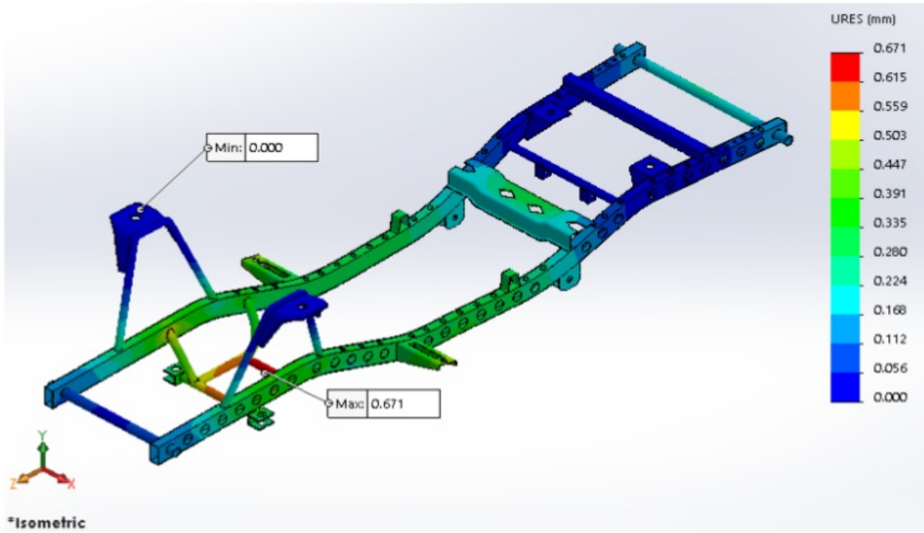

Figure 12.b Deflection of Porforated plate beam chassis at descend road

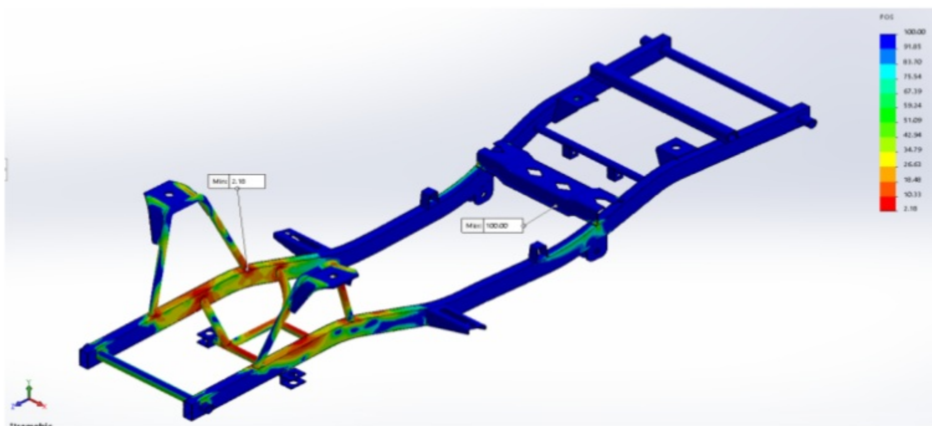

Figure 13.a Safety Factor of solid plate beam chassis at descend road

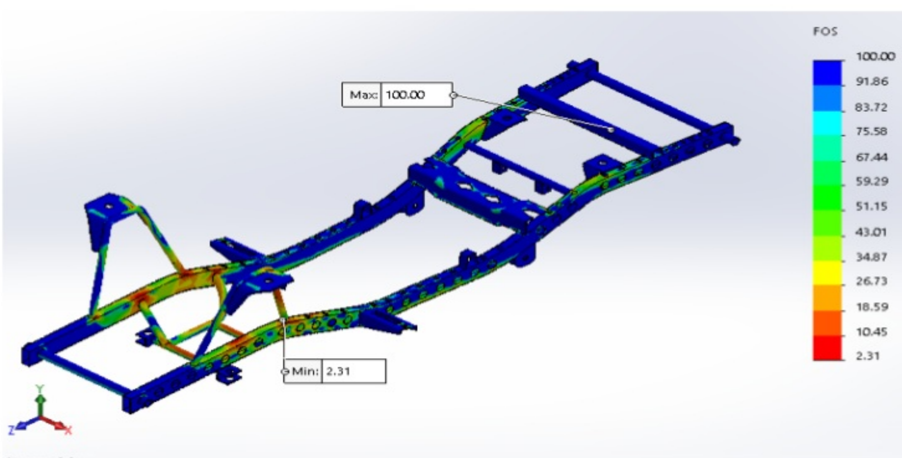

Figure 13.b Safety Factor of Porforated plate beam chassis at descend road

The fourth case is when the car is brake from 40 km/h until stop for 5 second. In this condition it is assumed that most of load is concentrated at front of chassis. In this case, the maximum stress of solid plate is 284.738 Mpa (Figure 14.a, while porforated plate stress is 374.682 Mpa (Figure 14.b). Maximum deflection of solid plate and porforated plate are 1.044 mm (Figure 15.a) and 1.055 mm (Figure 15.b) respectively. And minimum safety factor is 2.18 for solid plate (Figure 16.a) and 1.66 for porforated plate beam chassis (Figure 16.b).

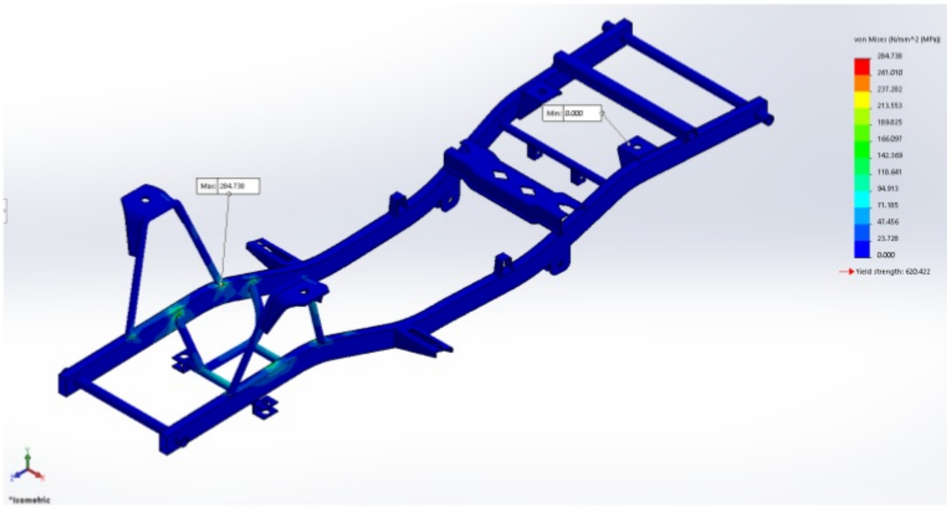

Figure 14.a. Solid plate beam stress at braking condition

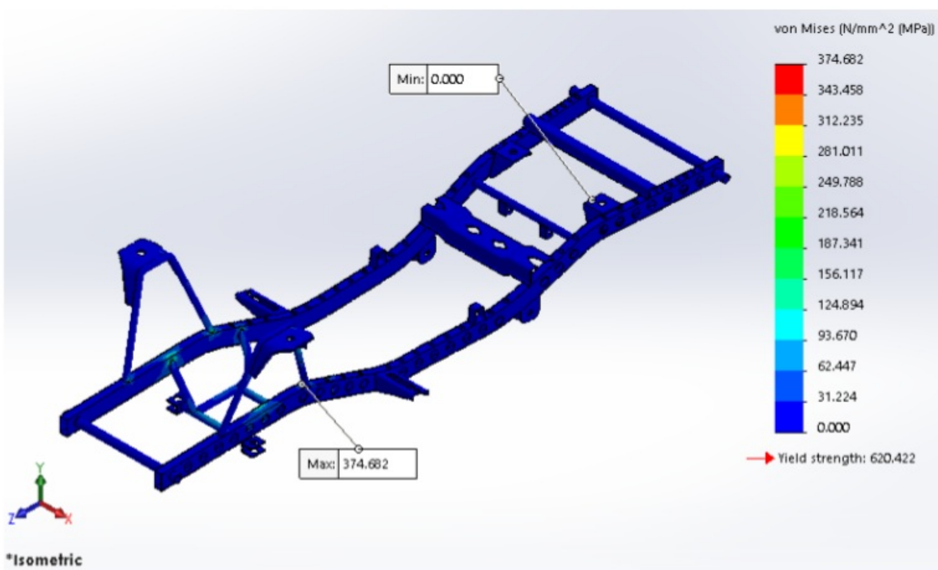

Figure 14.b Porforated plate beam stress at braking condition

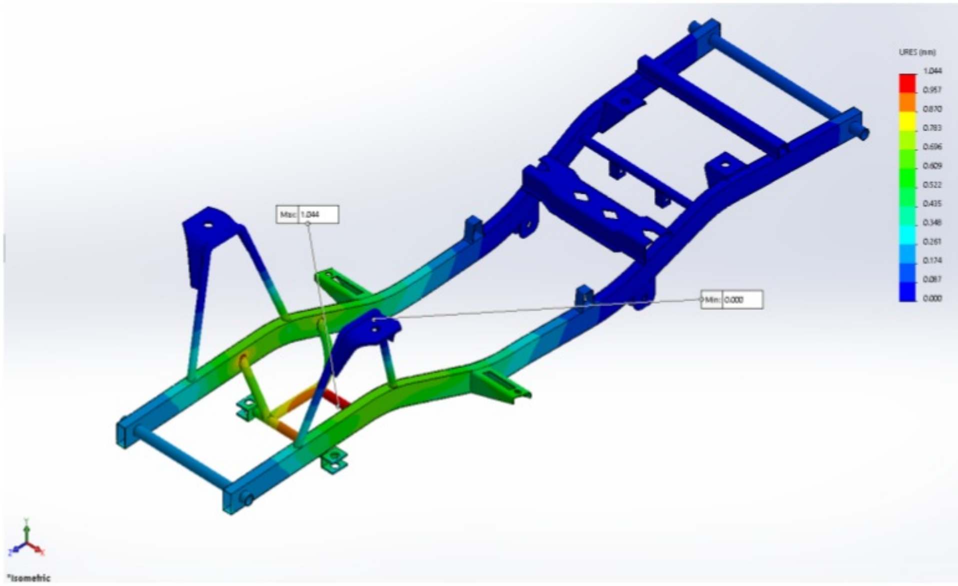

Figure 15.a Deflection of solid plate beam chassis at braking condition

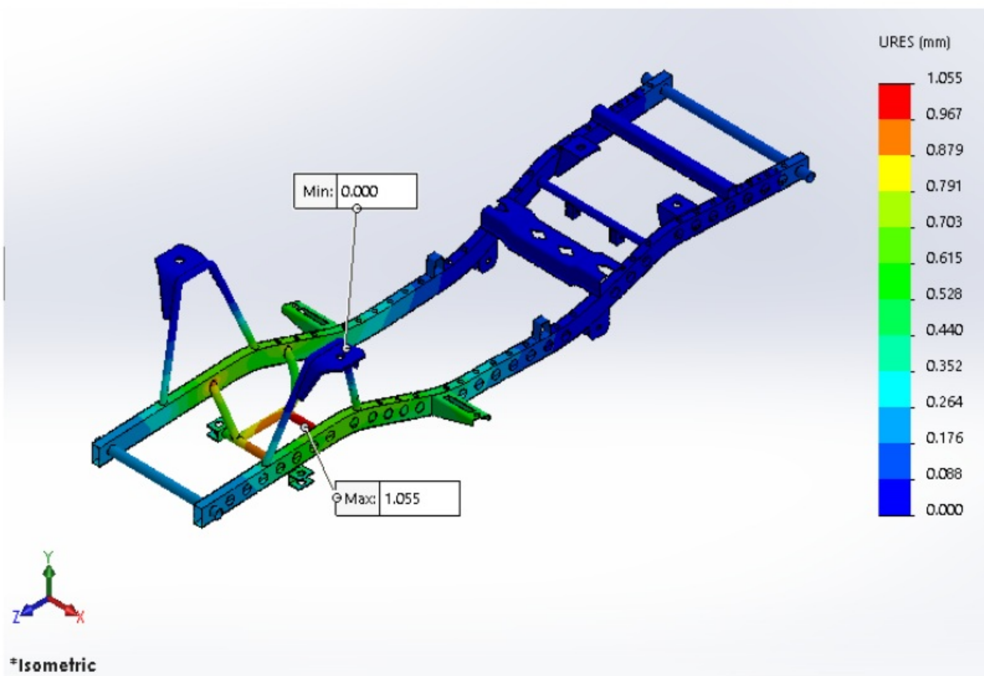

Figure 15.b Deflection of Porforated plate beam chassis at braking condition

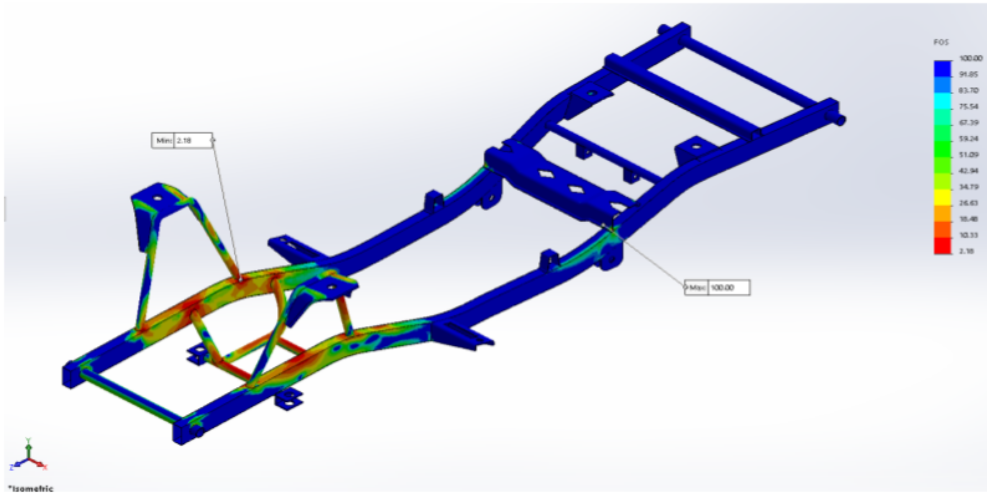

Figure 16.a Safety Factor of solid plate beam chassis at braking condition

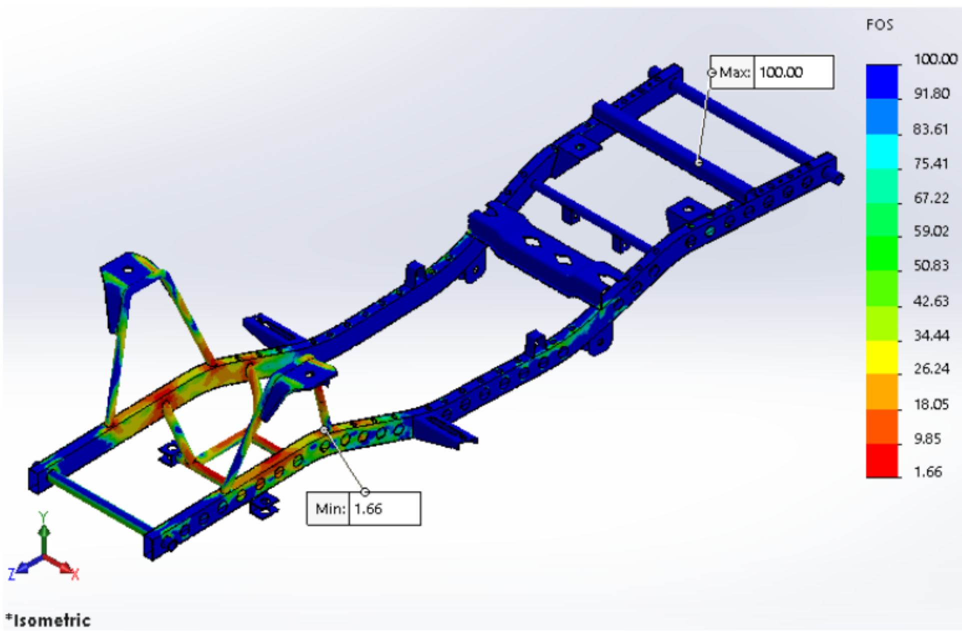

Figure 16.b Safety Factor of porforated plate beam chassis at braking condition

V. Conclusion

Two type of lader chassis was analysed by Finite Element Methode performed using SOLIDWORKS, solid plate beam and porforated plate beam chassis. Purpose of porforate the plate beam is reducing of chassis weight and finally incressing of battery live in electric car. The result of study performed in four case that are static condition, car climb, car pass through descend road and braking condition show that porforated plate beam chassis has lower performance. It can be seen that maximum stress of porforated plate is 25 % (everage) higher than solid plate, maximum deflection of porforated plate chassis is 20 % higher than solid plate and minimum safety factor of porforated plate is 20 % lower than solid plate. Safety factor as a critical parameter of both cases are above 1, and its can be say that all cases are recommended for electrical car chassis. Porforate the beam can reduce of about 22.5 % of chassis weight, hence it is conclude that porforated plate beam chassis is suitable for electrical car application.

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