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Advanced Mathematical Analysis of Chassis Integrated Platform Designed for Unconventional loading by using simple technique for static load

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Abstract— ***The present work deals with advanced mathematical stress analysis of a platform integrated structure mounted on vehicle chassis designed for unconventional type of loading pattern. The perceptible loading cases in the present analysis comprise static load and its effect on the platform/structure by usage of simple shear force & bending moment diagrams. Deflection analysis using conventional Macaulay's method invokes the structures suitability for the transportation. Present analysis accentuates on the design stage aspects of the platform as this research is a step in proposed doctoral study. A different type of combination of longitudinal and cross members in platform/frame design is formulated. Present design is anticipated after analysis of all possible combinations& orientations of longitudinal and cross members. Determination of section properties of longitudinal and cross members of the platform & deduction of elementary stress based on the unconventional load pattern are the fundamental steps in design and analysis of structure. Peculiarity of this analysis is the usage of combined section modulus of three members for computation of stress. Present research provides a tool that can be used prior to computer aided design and finite element analysis.***

Index Terms— **Concentrated load, chassis integrated structure, stress and deflection analysis, shear force and bending moments.**

I. INTRODUCTION

Chassis is a foremost cog in a vehicle system. Static analysis to determine key characteristics of a truck chassis and chassis mounted/integrated component needs to be carried prior to computer modeling and analysis.[1-4]The static characteristics include identifying location of high stress area and determining the torsion stiffness of the platform as well as vehicle chassis. For mathematical analysis the platform along with chassis is supposed to be a thin plate which is loaded by the forces applied at the boundary parallel to the plane of plate similar as in plane stress condition. [5] The load type to which the combination of chassis and platform is subjected is concentrated or point loading exactly opposite to the one that exists in all the present configurations. Such concentrated load is achieved by mounting shelters at the various corner locations on the platform termed as ISO corners for further reference.[6] The analysis of the combination i.e. chassis & platform for such load is realm of further analysis.

II. ANALYSIS OF STRESS IN VARIOUS PLATFORM MEMBERS

Outer longitudinal members engulf the cross members, which further integrate with vehicle chassis through main longitudinal members. Normal stress σ_z along z axis and the shearing stress along X-Z plane τ_{xz} and the shearing stress along Y-Z plane τ_{yz} becomes zero and the state of at all the ISO corner locations is presented the remaining components of normal and shear stresses given by σ_x, σ_y,τ_{xy} . Shear force diagram for outer longitudinal member provides distribution of shear force along outer to inner fibre of the longitudinal member. Section properties are also computed using simple mathematical techniques. [7]. Boundary conditions need to be specified aforementioned to precede stress analysis. The front and rear wheels provide necessary support reactions, so at these locations the vertical displacements are arrested.[11],[12] The displacement boundary conditions comprises of displacement function u defined as u = û, û being a displacement parameter of zero value as û = 0 for fixed boundary case. Stress and traction boundary conditions are specified using stress vector σ_n in normal direction& ŝ and these are related to each other as σ_n = ŝ . [13], [14] .Here ŝ is prescribed surface tractions specified as a force per unit area. The shear force diagram is constructed for half loading condition.

III. SHEAR MATHEMATICS FOR PLATFORM

For the shear discontinuity equation, the following units are demonstrated: Length units = m; Force units = kN; Moment units = kN-m Shear = $Ay\langle x-0.00\rangle^0 + By\langle x-5.80\rangle^0 - P1\langle x-0.70\rangle^0 - P2\langle x-3.60\rangle^0 - P3\langle x-7.40\rangle^0$ (1)

Ay, by are supports reactions in vertically upward direction, and P1, P2, P3 are the loads acting in vertically downward direction. Shear discontinuity equation showing actual numeric values Shear = $+21.13\langle x-0.00\rangle^0 + 42.22\langle x-5.80\rangle^0 - 15.50\langle x-0.70\rangle^0 - 31.60\langle x-3.60\rangle^0 - 16.25\langle x-7.40\rangle^0$ (2)

When using discontinuity functions, if the term in the <> brackets is negative for a particular value of x, the quantity in the <> brackets is defined to have a value of zero. For the moment discontinuity equation, the following units are demonstrated: Moment discontinuity equation using symbolic notations:

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$$Moment = Ay<x-0.00>^{1} + By<x-5.80>^{1} - P1<x-0.70>^{1} - P2<x-3.60>^{1} - P3<x-7.40>^{1} \quad (3)$$

Moment discontinuity equation showing actual numeric values:

$$Moment = +21.13<x-0.00>^{1} + 42.22<x-5.80>^{1} - 15.50<x-0.70>^{1} - 31.60<x-3.60>^{1} - 16.25<x-7.40>^{1} \quad (4)$$

When using discontinuity functions, if the term in the <> brackets is negative for a particular value of x, the quantity in the <> brackets is defined to have a value of zero. The shear force and bending moment diagram is for half loading case is constructed. The laden weight is presumed between 12 to 14 tons depending on the standard variant load case. The reactions are shown at locations A and B in shear force and bending moment diagram as shown in fig.1 below.

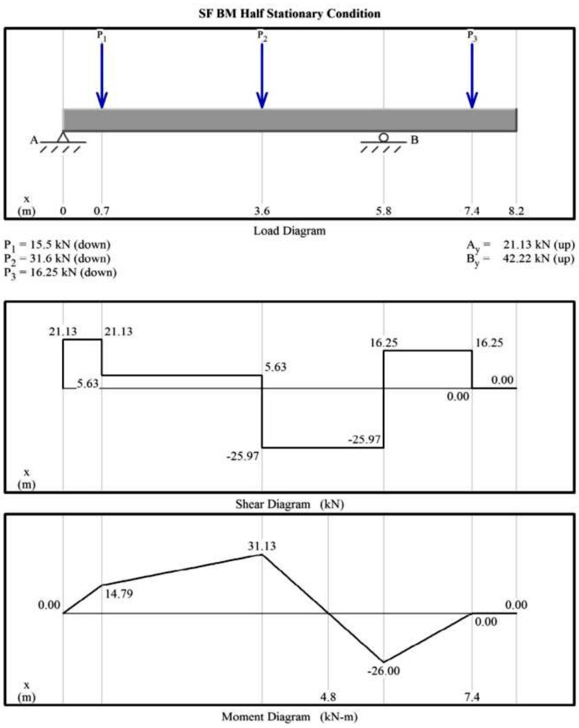


Fig. 1. Shear Force and Bending Moment diagram for outer longitudinal member in stationary condition

Thus the bending moment computed is 31.13kN-m, which is located at 3.6m from left support/front wheel. This revels that major component of load is acting at the central location of the platform and this part must be provided stiffener plate to improve the strength at this central location. [15]

IV. DEFLECTION MATHEMATICS FOR PLATFORM

For the slope discontinuity equation, the following units are displayed:

Length units = m; Force units = KN; Moment units = kN-m; EI = +4,921.01 kN-m²Slope discontinuity equation using symbolic notations:

$$EI \times Slope = Ay/2<x-0.00>^{2} + By/2<x-5.80>^{2} - (Slope\ at\ x{=}0) - P1/2<x-0.70>^{2} - P2/2<x-3.60>^{2} - P3/2<x-7.40>^{2} \quad (5)$$

Slope discontinuity equation showing actual numeric values:

$$EI \times Slope = +42.38/2<x-0.00>^{2} + 84.62/2<x-5.80>^{2} - 100.01 - 31.00/2<x-0.70>^{2} - 63.50/2<x-3.60>^{2} - 32.50/2<x-7.40>^{2} \quad (6)$$

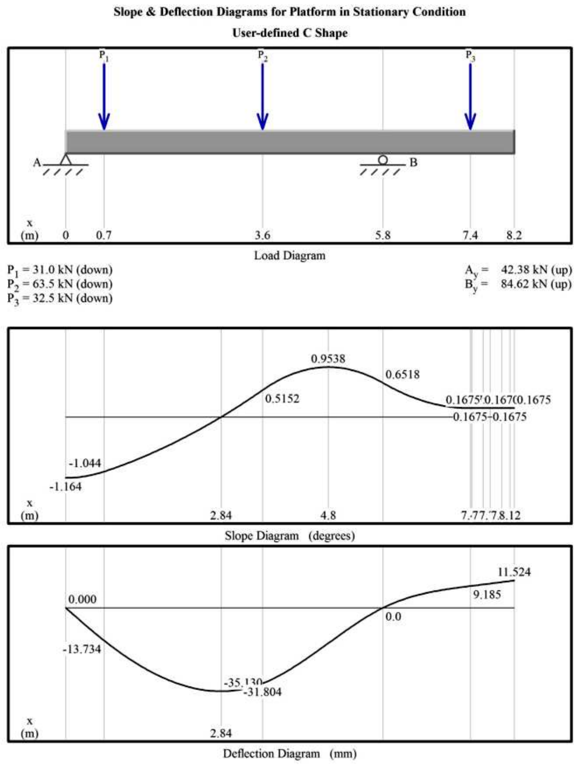
Slope computed from this equation is in units of radians. When using discontinuity functions, if the term in the <> brackets is negative for a particular value of x, the quantity in the <> brackets is defined to have a value of zero. For the deflection discontinuity equation, the following units are displayed: Length units = m; Force units = KN; Moment units = kN-m; EI = +4,921.01 kN-m² Deflection discontinuity equation using symbolic notations:

$$EI \times Deflection = Ay/6<x-0.00>^{3} + By/6<x-5.80>^{3} - (Slope\ at\ x{=}0)\ x - P1/6<x-0.70>^{3} - P2/6<x-3.60>^{3} - P3/6<x-7.40>^{3} \quad (7)$$

Deflection discontinuity equation showing actual numeric values:

$$EI \times Deflection = +42.38/6<x-0.00>^{3} + 84.62/6<x-5.80>^{3} - 100.01x - 31.00/6<x-0.70>^{3} - 63.50/6<x-3.60>^{3} - 32.50/6<x-7.40>^{3} \quad (8)$$

Deflection computed from this equation is in units of mm. When using discontinuity functions, if the term in the <> brackets is negative for a particular value of x, the quantity in the <> brackets is defined to have a value of zero. The slope and deflection analysis carried out below helps us to predict the theoretical values of slope deflection parameters. [16]. The slope and deflection plots are shown in fig 2 below.



Fig; 2 Slope and Deflection analysis diagram for outer longitudinal member in stationary condition

The slope, deflection and shear force & bending moment analysis is performed by considering the design constraints on length of the platform. The parameters such as overall

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height of the vehicle, shelter/container height and chassis height from ground pose restriction on the height of the platform and determine the space for the platform[17],[18],[19]. Overall length for accommodation of longer shelters/containers increases the rear overhung.

V. CONCLUSION

Advanced design and analysis of platform for unconventional loading pattern using elementary concepts of strength of materials as shear force, bending moment diagrams and slope & deflection analysis through numerical method is accomplished. Elementary concepts as shear force and bending moment along with advanced three dimensional concepts as plane stress are combined to formulate the mathematics behind the platform behavior under concentrated loading. Applying the identical modus operandi the behavior of the individual members of the platform can be mathematically devised. Though these theoretical values are of least significance in design for strength of the platform, as they are determined only for the geometry subjected to concentrated load, they provide a competent contrivance to handle the advanced computer aided design and finite element analysis. Discrete analysis of variant load cases will be attempted in further research and mathematical. Experimentations to verify these elementary calculations will be attempted in further process. Present analysis is elementary step in mathematical design and formulation of the platform and its behavior under proposed loading pattern. The values devised in this analysis are theoretical and experimental verification needs to be carried out. Prior to experimentation computer aided design and finite element analysis needs to be performed which are already stated in proposed research. Mathematical calculations for variant load case will be attempted in further analysis. Behavior of platform under braking load and when vehicle travels on gradient are the cases which will be attempted in further mathematical process.

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