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DESIGN AND OPTIMIZATION OF STAINLESS-STEEL BERTH USING NX-CAD AND ANSYS

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ABSTRACT

Indian Railways uses stainless-steel berths in passenger coaches to ensure safety, durability, and passenger comfort. These berths are subjected to static passenger loads and must comply with strength and deformation limits specified by railway standards. The present work focuses on the design and structural analysis of a stainless-steel berth using computer-aided design and finite element techniques.

The berth model is developed using NX-CAD as per standard dimensions and mounting conditions. Static structural analysis is carried out in ANSYS to evaluate stresses, deformation under prescribed loading conditions. Based on the analysis results, design modifications are performed to improve structural performance and reduce weight without violating allowable stress limits. The results obtained show that the optimized berth design is structurally safe and meets the required performance criteria. This study demonstrates the effectiveness of CAD and FEA tools in the design and optimization of railway coach components.

Keywords: Stainless-Steel Berth, NX-CAD, ANSYS, Finite Element Analysis, Structural Optimization

I. INTRODUCTION

Indian Railways continuously focuses on improving passenger safety, comfort, and durability of coach interiors. The berth system is a load-bearing structural component that must safely support passenger loads during static and dynamic conditions. Traditionally used materials and designs often result in higher weight and sub-optimal stress distribution, which affects overall coach efficiency.

With advancements in computer-aided design (CAD) and computer-aided engineering (CAE), it has become possible to design and validate railway components virtually before physical manufacturing. NX-CAD enables precise geometric modelling, while ANSYS provides a powerful platform for structural analysis and optimization. This research aims to utilize these tools to design and optimize a stainless-steel berth, ensuring compliance with strength and deformation limits specified in railway standards.

II. LITERATURE REVIEW

Several researchers have investigated the structural behaviour and optimization of railway coach components using finite element methods. Studies indicate that stainless steel offers superior corrosion resistance, strength-to-weight ratio, and durability compared to conventional materials. Finite element analysis has been widely used to predict stress concentration, deformation patterns, and failure zones in railway structures.

Previous research highlights that optimization through thickness variation and geometric refinement can significantly reduce component weight without compromising safety. The literature reviewed in the thesis establishes that CAD-FEA

integration is an effective approach for improving structural performance of railway berths and similar load-bearing components.

III. DESIGN OF STAINLESS-STEEL BERTH USING NX-CAD

The stainless-steel berth is modelled in NX-CAD as per the dimensions and configuration specified in the Indian railway standerds. The design includes primary load-bearing members, supporting brackets, and welded joints. Material properties corresponding to stainless steel are assigned during the modelling stage.

The CAD model accurately represents the actual berth geometry used in railway coaches. Proper constraints and reference planes are defined to ensure dimensional accuracy and manufacturability. The finalized NX-CAD model is then imported into ANSYS for structural analysis.

IV. FINITE ELEMENT ANALYSIS IN ANSYS

A. Material Properties

The material properties of stainless steel, including Young's modulus, Poisson's ratio, density, and yield strength, are defined as per standard values used in the thesis.

B. Meshing

A suitable mesh is generated using solid elements to capture stress variations accurately. Mesh refinement is applied in critical regions such as joints and load-application areas to improve result accuracy.

C. Boundary Conditions and Loading

Boundary conditions are applied to simulate actual mounting conditions of the berth inside the coach. Static loads representing passenger weight are applied as per railway design standards.

D. Solution and Evaluation

Static structural analysis is carried out to determine equivalent (von-Mises) stress, total deformation, and factor of safety.

V. RESULTS AND DISCUSSION

The analysis results obtained from ANSYS show that the initial berth design satisfies allowable stress and deformation limits. Stress concentration is observed near support regions, which is consistent with expected structural behaviour under static loading conditions.

Design optimization is performed by changing material to aluminium, modifying sectional dimensions and thickness of selected members. The optimized design demonstrates reduced weight while maintaining stresses below permissible limits. The results confirm that the optimized stainless-steel berth achieves improved structural efficiency without compromising safety.

A. Numerical Results Summary

Table 1 presents a comparison of key structural parameters obtained from static structural analysis for the initial and optimized berth designs.

Table 1: Comparison of Structural Results for Stainless-Steel Berth

Parameter	Initial Design	Optimized Design
Maximum von-Mises Stress (MPa)	171.62	70.78
Maximum Deformation (mm)	10.38	2.9
Weight of Berth	37.2	31.4

B. Graphical Representation of Results

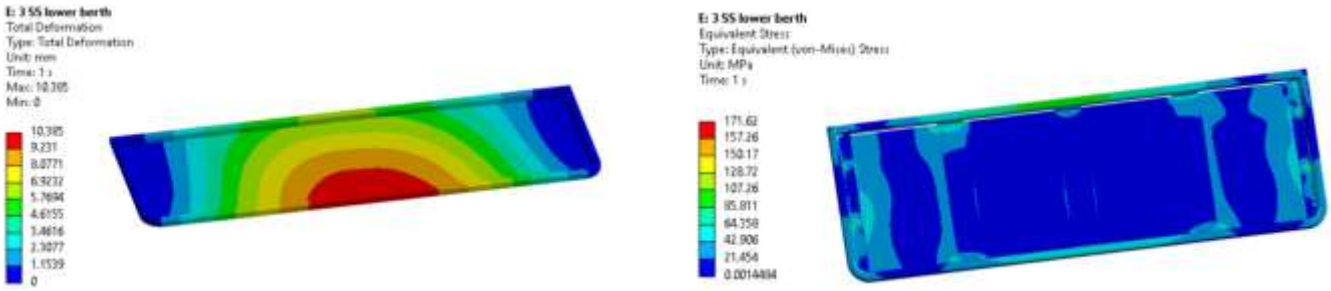

Figure 1

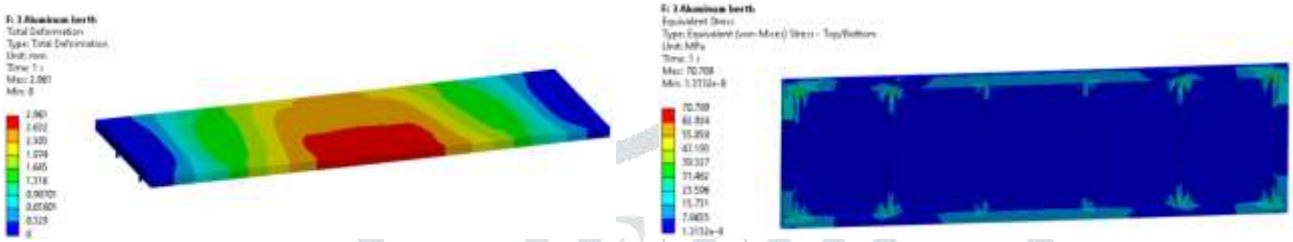

Figure 2

These graphical results clearly indicate that the optimized design achieves better stress distribution and lower deformation while ensuring structural safety.

VI. CONCLUSION

This research paper presents the design and optimization of a stainless-steel berth using NX-CAD and ANSYS. Finite element analysis confirms that the optimized design satisfies structural strength and deformation requirements specified by railway standards. The study demonstrates that CAD-FEA-based optimization is an effective approach for improving railway coach components.

VII. FUTURE SCOPE

Future work may include dynamic and fatigue analysis of the berth under real service conditions, experimental validation of the optimized design, and investigation of alternative lightweight materials for further weight reduction.

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