Numerical Study on Cold-Formed Steel C-Section Under Shear By ABAQUS

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***Abstract*—This study presents the development and validation of a three-dimensional finite element model of a cold-formed steel lipped channel beam subjected to shear loading using ABAQUS. The numerical model was developed in accordance with the adopted experimental configuration.. The validation methodology was based on comparison with a published experimental investigation to assess the reliability of the developed numerical model. The validated modelling procedure provides a robust framework for accurately predicting the shear behaviour of cold-formed steel members and forms the basis for future numerical investigations involving different cross-sectional configurations and loading conditions. The proposed finite element modelling approach can be used as an efficient alternative to extensive experimental testing for the analysis and design of thin-walled steel structural members.**

***Index Terms*—Cold-Formed Steel, Finite Element Analysis, ABAQUS, Validation, Lipped Channel Beam, Shear Behaviour, Numerical Modelling.**

I. INTRODUCTION

Cold-formed steel (CFS) structural members have become an integral component of modern construction owing to their high strength-to-weight ratio, ease of fabrication, dimensional accuracy, and economic advantages. Manufactured by cold-forming thin steel sheets into various cross-sectional shapes, these members are extensively used in residential buildings, industrial structures, storage racks, roof systems, wall framing, and modular construction. Their lightweight nature reduces the dead load on structures while facilitating faster construction and improved material efficiency.

Among the various cold-formed steel sections, lipped channel beams are widely adopted because the presence of edge lips enhances local stability and improves the overall structural performance of the section. However, due to the slenderness of their web elements, these members remain susceptible to local buckling and shear instability when subjected to concentrated or transverse loading. The prediction of shear behaviour is therefore a critical aspect of the structural design and safety assessment of cold-formed steel members.

The primary objective of this validation study is to establish a reliable finite element modelling methodology for cold-formed steel lipped channel beams subjected to shear loading. A validated numerical model provides a dependable foundation for future studies involving different cross-sectional configurations, stiffening arrangements, and loading conditions while reducing the dependence on extensive experimental testing.

Fig 1:

II. NEED FOR THE STUDY

The increasing application of cold-formed steel (CFS) structural members in modern construction has created a growing demand for reliable analytical techniques capable of accurately predicting their structural behaviour. Owing to their thin-walled configuration, cold-formed steel members are more susceptible to local buckling and shear instability than conventional hot-rolled steel sections. Consequently, understanding their behaviour under shear loading is essential for safe and economical structural design.

Finite Element Analysis (FEA) has emerged as a powerful numerical tool for evaluating the structural performance of engineering components. Nevertheless, the reliability of finite element predictions depends entirely on the accuracy of the developed numerical model. Therefore, validation against published experimental investigations is an essential step before numerical models can be applied to structural analysis or parametric studies.

III. PROBLEM STATEMENT

Finite element software has become an indispensable tool for structural analysis because it enables engineers to predict stress distribution, deformation, and failure mechanisms efficiently. However, numerical predictions are strongly influenced by modelling assumptions, including geometry, material properties, element formulation, mesh density, boundary conditions, and loading arrangements. If these modelling parameters are not properly validated, the numerical results may not accurately represent the actual structural behaviour.

The present study addresses this requirement by developing a finite element model of a cold-formed steel lipped channel beam using ABAQUS and validating it against a published experimental investigation adopted in the uploaded project. The validation process establishes the reliability of the modelling approach and provides a dependable numerical framework for future analytical investigations.

IV. LITERATURE REVIEW

Finite element validation has become an essential part of structural engineering research, particularly for cold-formed steel (CFS) members, where complex buckling behaviour and material nonlinearity significantly influence structural performance. Several researchers have investigated the behaviour of cold-formed steel members using experimental and numerical approaches to develop reliable analytical models.

Hamdallah and Abdullah (2020) performed a nonlinear finite element investigation on stiffened and unstiffened cold-formed steel channel sections. Their study demonstrated that web stiffeners significantly improve structural stability, delay local buckling, and increase the load-carrying capacity of thin-walled steel members. The research highlighted the effectiveness of finite element modelling in accurately predicting the behaviour of cold-formed steel sections under structural loading.

Supriya P. and Dr. Santosh investigated the structural performance of light-gauge steel I-sections with flange stiffeners. Their study reported that suitable stiffener configurations improve the compression resistance and overall stability of thin-walled steel members. The research emphasized that the incorporation of stiffeners enhances the structural efficiency of cold-formed steel sections.

Roy and Chen (2022) investigated the shear capacity of cold-formed steel channels with edge-stiffened web holes, unstiffened web holes, and plain webs. Their numerical and analytical study demonstrated that web stiffening considerably improves shear resistance and influences the failure mechanism of cold-formed steel members. The authors also evaluated existing design provisions and proposed recommendations for predicting the shear capacity of different web configurations.

D. Amali and M. Anbarasu (2024) developed validated nonlinear finite element models to investigate the behaviour of cold-formed steel built-up I-beams composed of four channel sections. After validating the numerical models against available experimental results, they conducted an extensive parametric study considering section geometry, thickness, steel grade, and slenderness. Their research showed that validated finite element models can accurately predict structural behaviour and can be effectively used to assess the adequacy of existing design provisions and propose improved design methods.

M. Anbarasu (2020) investigated the behaviour of cold-formed steel built-up battened columns through experimental testing and numerical validation. A nonlinear ABAQUS finite element model incorporating material and geometric nonlinearities was developed and validated against experimental observations. The study demonstrated close agreement between numerical and experimental results, confirming that properly validated finite element models can reliably predict the buckling behaviour and ultimate strength of cold-formed steel structural members

V. RESEARCH GAP

Although numerous studies have investigated the structural behaviour of cold-formed steel members using both experimental and numerical approaches, relatively fewer studies have focused on establishing a standardized and reliable finite element validation procedure that can be directly applied for future analytical investigations. Previous researchers have primarily concentrated on evaluating the ultimate strength, buckling behaviour, and shear capacity of cold-formed steel sections under different loading conditions. While these investigations have significantly contributed to understanding the behaviour of thin-walled steel members, the development of validated numerical models remains an essential prerequisite before conducting detailed parametric studies.

Therefore, the present study aims to establish a systematic finite element validation procedure using ABAQUS that can accurately simulate the shear behaviour of a cold-formed steel lipped channel beam. The validated numerical model developed through this investigation can subsequently be used for future studies involving different cold-formed steel sections and structural configurations.

VI. OBJECTIVES

The primary objective of the present study is to develop and validate a finite element model of a cold-formed steel lipped channel beam subjected to shear loading using ABAQUS.

The specific objectives of the study are as follows:

1. To develop a three-dimensional finite element model of the selected cold-formed steel lipped channel beam using ABAQUS.
2. To define the appropriate material properties, shell section, interaction properties, and analysis parameters required for numerical modelling.
3. To apply suitable boundary conditions and loading arrangements that represent the adopted experimental configuration.
4. To perform both linear and nonlinear finite element analyses for predicting the structural behaviour of the beam.
5. To validate the developed ABAQUS model using a published experimental investigation adopted as the benchmark reference.
6. To establish a reliable numerical modelling methodology that can be used in future investigations involving cold-formed steel structural members.

VII. RESEARCH METHODOLOGY

The research methodology adopted in the present investigation consists of a systematic finite element validation procedure using ABAQUS software. The methodology was developed to ensure that the numerical model accurately represents the structural behaviour of the selected cold-formed steel lipped channel beam before it is used for further analytical studies.

Finally, the numerical response obtained from the ABAQUS model was compared with the published experimental investigation to evaluate the accuracy and reliability of the developed finite element model. The validated numerical modelling procedure established through this study provides a dependable framework for future investigations involving cold-formed steel structural members subjected to shear loading.

FLOW CHART 1

Selection of Published Experimental Study

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Validation Specimen Selection

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Geometry Creation in ABAQUS

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Material Property Definition

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Section Assignment

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Assembly of Model
↓
Interaction Definition
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Boundary Conditions
↓
Load Application
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Meshing
↓
Linear Analysis
↓
Nonlinear Analysis
↓
Comparison with Published Experimental Results
↓
Validation of ABAQUS Model

VIII. VALIDATION SPECIMEN

8.1 Selection of Validation Specimen

The finite element model developed in the present study was validated using a published experimental investigation adopted as the benchmark reference. According to the uploaded project, the validation was carried out using the experimental study by Poologanathan Keerthan and Mahen Mahendran, titled *Experimental Investigation and Design of Lipped Channel Beams in Shear*.

The purpose of selecting this benchmark specimen was to establish confidence in the finite element modelling procedure before applying it to further numerical investigations. Validation against a published experimental study ensures that the modelling assumptions, boundary conditions, material representation, and loading arrangements accurately reproduce the structural behaviour of the physical specimen.

Tab 1 Geometry of the Validation Specimen

Parameter	Value
Section Type	Cold-Formed Steel Lipped Channel
Depth (D)	102 mm
Flange Width (B)	51 mm
Lip Length (L)	12.5 mm
Thickness (t)	1.5 mm

IX. FINITE ELEMENT MODELLING USING ABAQUS

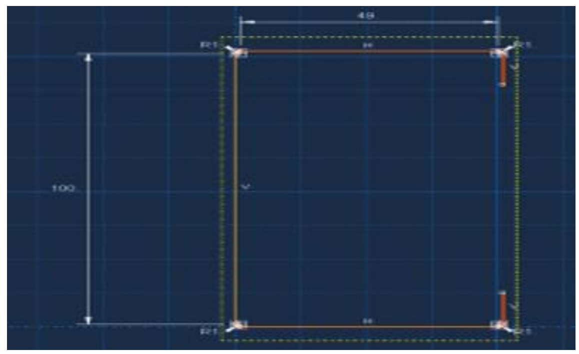


Fig 2 Part Creation

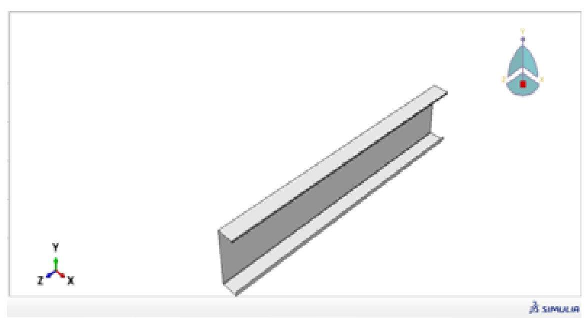


Fig 3 Geometry Creation

Tab 2 Material Property Definition

Property	Description
Young's Modulus	Elastic stiffness of steel
Poisson's Ratio	Ratio of lateral strain to longitudinal strain
Yield Strength	Stress at the onset of yielding
Plastic Stress–Strain Data	Material response beyond yielding

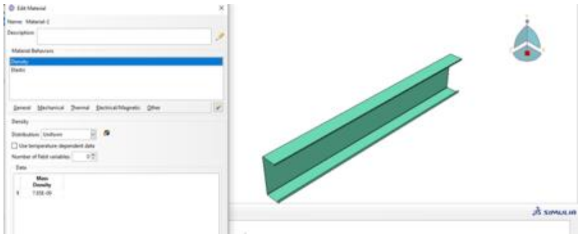


Fig 4 Section Assignment

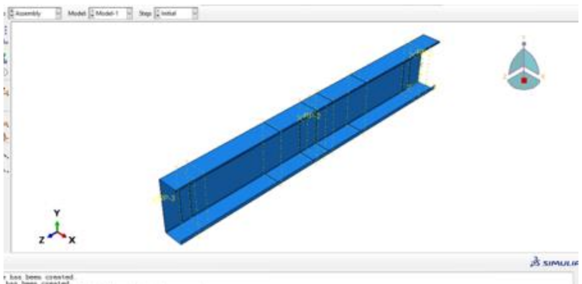


Fig 5 Assembly of the Model

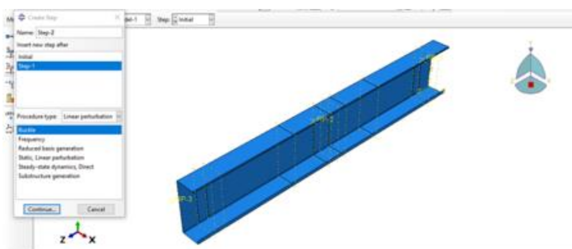


Fig 6 Step Definition

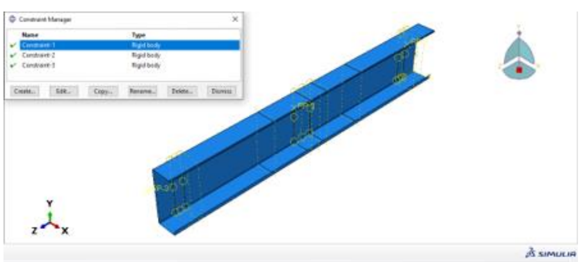


Fig 7 Interaction Properties

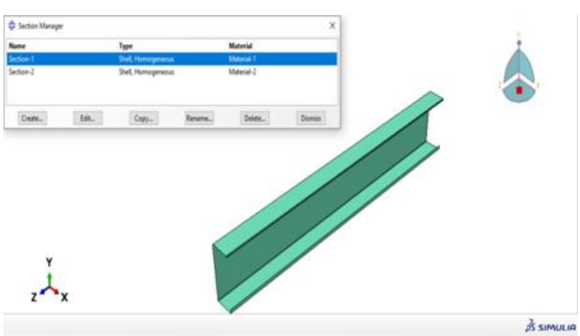


Fig 8 Section Geometry

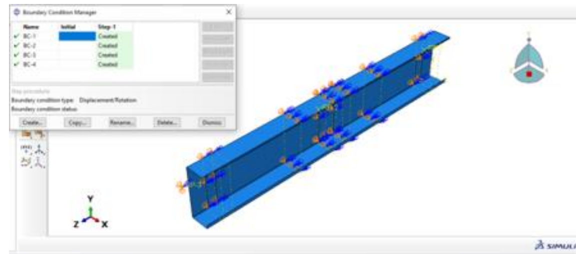


Fig 9 Boundary Conditions

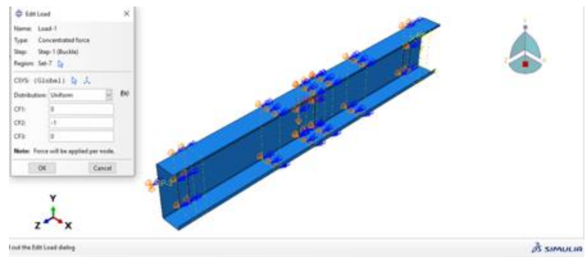


Fig 10. Load Application

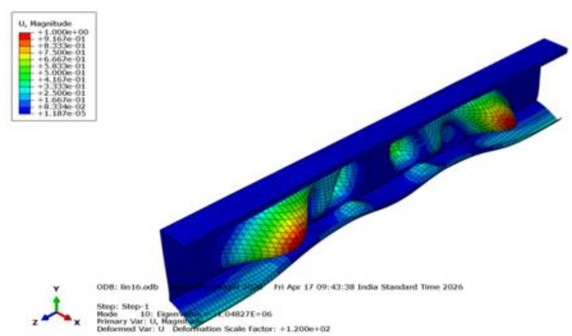
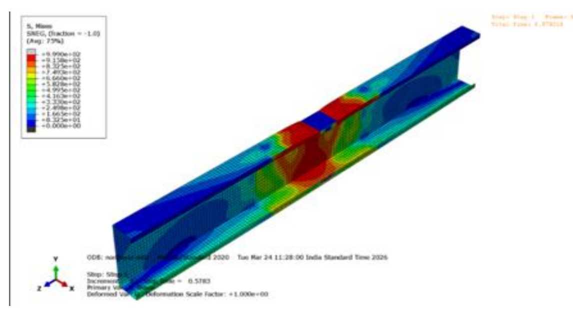


Fig 11. Linear and Nonlinear Analysis



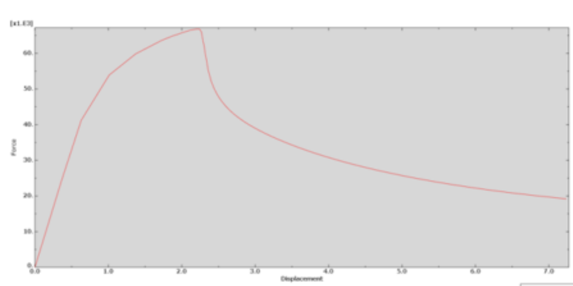


Fig 12 Resulted Graph

X. RESULTS

The finite element model developed in ABAQUS was successfully analysed under the prescribed boundary conditions and loading configuration to evaluate the structural response of the cold-formed steel lipped channel beam. The numerical model converged satisfactorily the analyses, indicating that the adopted modelling procedure, was appropriate for simulating the structural behaviour of the validation specimen.

The validation procedure adopted in this study provides a systematic framework for comparing the numerical predictions with the published experimental investigation .The developed finite element model establishes a reliable numerical platform for future investigations on the shear behaviour of cold-formed steel structural members and demonstrates the applicability of ABAQUS as an effective tool for structural validation.

The developed finite element model provides a systematic framework for simulating the behaviour of cold-formed steel members subjected to shear loading.

The validation methodology established in this study confirms that finite element analysis using ABAQUS is an effective tool for representing the behaviour of cold-formed steel members. A validated numerical model provides greater confidence in predicting structural behaviour and serves as a reliable alternative to repeated experimental investigations, particularly during preliminary design and analytical studies.

The modelling framework developed through this work can be extended to future investigations on stiffened and unstiffened cold-formed steel sections, different loading conditions, and advanced numerical studies. Consequently, this validation study establishes a dependable foundation for subsequent analytical and parametric research involving cold-formed steel structural systems.

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