

FLEXURAL BEHAVIOUR OF COLD FORMED CORRUGATED STEEL BEAM

Submitted in partial fulfillment of the requirements for the award of
Master of Engineering in Structural Engineering

By

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**DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A++" by NAAC
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APRIL – 2024



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **ESHWARAPRASATH.A.V** (42380001) who carried out the project entitled **"FLEXURAL BEHAVIOUR OF COLD FORMED CORRUGATED STEEL BEAM"** under our supervision from September 2023 to April 2024.

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DECLARATION

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DATE: 20.04.2024



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SIGNATURE OF THE CANDIDATES

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Abstract

Cold-formed corrugated steel and other channel sections were analyzed structurally and compared in this study. Beam with different corrugation patterns (Horizontal Corrugated beam with spacing, Horizontal corrugated beam without spacing, vertically corrugated beam) were designed in CATIA. The goal was to compare the designs' structural strengths and weaknesses, as well as their overall performance. ANSYS software is used to perform an in-depth examination of the structure. Because of this, the structural performance of each design option may be compared and contrasted. This research set out to shed light on the efficiency and structural differences between several types of corrugated steel beam. This study investigates the flexural behavior of cold-formed steel (CFS) corrugated beam through experimentation. Despite the increasing popularity of cold-formed steel in construction, its thin-walled nature makes it prone to buckling failures, prompting previous research on stiffener implementation. Three corrugated section configurations were tested: Horizontal corrugated with spacing, Horizontal corrugated without spacing, vertically corrugated. Corrugated sections exhibit unique behaviors, offering advantages such as increased ultimate strength and reduced deflection compared to straight sections. Vertically corrugated beam performs much better both in experimental and analytical analyses. The minimum deflection occurs in vertically corrugated 6.600mm. The study's findings can impact future design decisions and engineering applications, providing useful knowledge for enhancing the structural performance of cold-formed corrugated steel in a variety of design and building applications.

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CHAPTER – 1

INTRODUCTION

1.1 GENERAL

Cold-formed steel sections are developing at a rapid rate such that they are used as a common method of constructing light-weight floors and portal frame structures. In fact, it can be said that cold-formed steel (CFS) construction is now one of the highly competitive alternative to traditional structural system. Some of the widely acknowledged advantages of CFS framings are: lighter weight, reduces transport and handling costs, ease of prefabrication and mass production. The optimal design of CFS system is important in ensuring that they can produce a cost-effective solution which is somewhat lagging in other types of structural systems.

In steel construction, there are two main types of structural members one is hot rolled section and the other is cold-formed section. Cold-Formed Steel (CFS) is a type of steel fabricated by a cold forming process and Cold-formed steel goods are created by the working of sheet steel using stamping, rolling or presses to deform the sheet into a usable product. The thickness of the sheet used is generally between 1mm and 8mm Although cold-formed steel sections are used in car bodies, railway coaches, various types of equipment, storage racks, grain bins, transmission towers, transmission poles etc but in building construction it has limited advancement. The use of hot rolled steel sections becomes uneconomical for the steel structures subjected to light and moderate loads. The primary advantages of cold-formed steel are price stability, light weight, high strength and stiffness, uniform quality, ease of prefabrication and mass production, economy in transportation and handling, fast and easy erection and installation, non-combustibility, and the fact that it is termite-proof and rot-proof. The structural members like purlins, girts, roof trusses, complete framing of one and two storey residential, commercial and industrial structures subjected to moderate load, for which cold formed steel members may be sufficient. Cold formed sections like Channel, Zee sections, I-sections, angles, T-sections, hat sections, and tubular members are commonly used flexure members for purlins & girt in roof and wall system. These sections are extensively used in various engineering applications

because of their high strength to weight ratio. Studies on the flexural behaviour of cold-formed steel beams are increasingly popular in the last decades. Understanding and dealing with these phenomena has been the central focus of recent research efforts.

1.2 COLD FORMED STEEL SECTION

Cold-formed steel (CFS) section is the term used for products which are made by rolling or pressing thin gauges of steel sheets into goods. CFS goods are created by the working of thin steel sheets using stamping, rolling or presses to deform the steel sheets into a proper product which are usable. In the construction industry of steel, both the structural as well as the nonstructural parts are formed using the thin gauges of steel sheets. The building materials can be of columns, studs, beams, floor decking, built up sections and other any parts of the structure. CFS construction materials differ in many respects than other steel construction materials like hot rolled steel. The manufacturing of CFS products occurs at the room temperature with the use of rolling/pressing. The buckling property is used to analyze the strength of elements. The construction practices are just like the timber framing where the assembling stud frame using the screws.

The applications of CFS members includes the buildings, bridges, car bodies, storage tanks, highway products, railway coaches, transmission towers, drainage facilities, etc. The thin-walled steel members are of having the thicknesses usually having 0.4 mm to 7 mm. The steel plates and steel bars of thickness 25.4 mm can be made into the cold formed structural shapes. The yield strength of steel sheets used in the CFS construction process should be of at least 280 MPa as there is a trend to use the steel sheets of more yield strength.

There is a change in the mechanical properties of steel material due to the cold working material as it is formed using pressing. The yield strength and ultimate strength of the steel section which is formed from steel plates/sheets are increased. The coating of zinc or galvanizing is made to protect the cold-formed steel sections and this provides the protection against the corrosion in the environment. The thickness of 0.04 mm coating is usually made for internal

environment. If the moisture is present for a longer period of time then the thicker coat is provided for more protection.

In comparison to the hot rolled section with the cold rolled sections, CFS have more moment of inertia and section modulus in x-direction and y-direction, therefore the load carrying capacity and moment resisting capacity are higher.

1.3 ADVANTAGES OF COLD-FORMED STEEL MEMBERS

1. Members are light in weight.
2. Sections have High strength and stiffness.
3. The erection and installation procedure is very easy.
4. The conventional connection methods like riveting, bolting or welding can be used.
5. The construction process does not need any kind of formwork.
6. The desired shape and desired length are obtained by prefabrication process.
7. The transportation cost is lower as the lightweight sections are available.
8. The recycling of this type of material is possible easily.
9. The termite-proof and rot proof sections are prefabricated.
10. As compared to the hot rolled section the greater moment carrying capacity is possible due to the thinner wall sections

1.4 TYPES OF COLD-FORMED STEEL SECTIONS

Cold-formed steel elements are having types of stiffened or unstiffened. The stiffened elements obtained by an element supported by webs along both longitudinal edges. While the unstiffened element is obtained when the element supported along any one longitudinal edge only and the other edge can have the displacement.

The intermittently stiffened element is made by thin element divided into two or more narrow sub-elements and this is prefabricated by the introducing intermediate stiffeners in the rolling process. If the stiffener is adequate then, in that case, the edge stiffened element will be treated as the local buckling coefficient value of 4.0. While if the edge found to be inadequate or partially

adequate then, in that case, its effectiveness is disregarded and the element is regarded as unstiffened.

1.5 Local Buckling in cold-formed steel sections:

The local buckling is an important aspect in case of the cold-formed steel elements, the thin steel elements are used and it buckles before the yielding process occurs. As the plate becomes thinner than lower shall be the load for which element buckles.

When one edge of the steel plate is free to move while the other edge is supported then the plate buckles at considerably lower load and the value of 'K' reduces to 0.425. This property shows that the plates with the free edges could not perform properly under local buckling. To avoid the local buckling of CFS sections, the free edges are provided with a lip and that will be constrained to remain straight and shall not be able to free to move.

1.6 Behavior after post – critical analysis of CFS:

While considering the channel section when subjected to the uniform bending by the moment application at the end of cold-formed steel section. In this case, the thinner plate at the top layer will be under flexural compression and buckles. Such kinds of buckling will have the ripples on the top layer of the section and along the length of the section. The top portion of the plate is supported along the edges and its central portion and this is far from the support location, will deflect and distributes the load on the stiffer edges. The regions near edges are prevented to deflect up to the same extent. Therefore, the applied moment is largely resisted by the regions near edges. The region located near the centre is stressed a little bit and therefore less effective in resisting the applied moment. If the theoretical point of view is considered then the flat plates will buckle very soon at the elastic critical load.

The plate elements which are not flat perfectly will be deforming out of the plane under the incremental loading if applied. A nonuniform state of stress will exist all across the loading region of the cold-formed steel sections.

The effect of local buckling will be evaluated with the use of the concept of effective width. The least effective section in resisting the applied stresses is a very low stressed region at the center of the element. The regions near supports are very effective and considered to be fully effective. The effective width of the cold-formed section under compression is dependent on the width/thickness ratio, support conditions, and applied stress.

CHAPTER – 2

LITERATURE REVIEW

2.1 GENERAL

The review of experimentation and examination of Cold form corrugated beam and I-section. So numerous papers are available which depicts the impediments of utilizing I-section, advantages of corrugated beam.

2.2 REVIEW OF LITERATURE

Moussa Leblouba, and Sami W. Tabsh (2020) conducted the study on “Reliability-based shear design of corrugated web steel beams for AISC 360 specification and CSA-S16 standard” promote the adoption of corrugated web steel beams in building construction, this study focused on aligning design guidelines with prevailing North American steel design codes, namely the AISC 360 specification and CSA-S16 standard. Initial reliability analyses, employing the Monte Carlo Simulation method, were conducted to validate the desired reliability of welded plate girders designed according to these standards. Probabilistic resistance and load models, encompassing factors like dead, live, wind, and snow loads, were derived from existing literature. By combining these loads over a 50-year reference period for building structures using Turkstra's rule,

Feng Yue, et.al. (2020) experimented the study on “seismic performance of prefabricated corrugated steel utility tunnels Tunnelling and Underground Space Technology”. Shaking table tests were executed to evaluate the seismic performance of a prefabricated corrugated steel utility tunnel, encompassing models of the tunnel, two pipeline variations, and three bracket designs, simulating real-world scenarios. Comprehensive investigations encompassed dynamic aspects of the tunnel structure and adjacent soil, including dynamic earth pressure, acceleration, displacement, and strain. Displacement of the overlying soil on both sides of the tunnel exceeded that above its centre during earthquake simulations, as evidenced by Digital Image Correlation (DIC) results. Interaction between the

tunnel structure and surrounding soil was significant under dynamic loads. Notably, dynamic earth pressure on the lower tunnel sidewall surpassed that on the upper sidewall due to uneven mass distribution, potentially compromising seismic safety.

Vitaliy V. and Degtyarev (2020) experimented the study on Concentrated “load distribution in corrugated steel decks”. This study aimed to create nonlinear finite element (FE) models using ANSYS to analyze corrugated steel decks when subjected to concentrated loads. These models accounted for both physical and geometric nonlinearity, incorporating elastic-perfectly plastic material behavior. Convergence studies were conducted to determine the optimal mesh density. The investigation explored the influence of corner radii, geometric imperfections, and load magnitudes on elastic buckling loads and maximum concentrated loads. The results demonstrated strong agreement with experimental tests, highlighting the models' utility for parametric studies. An extensive parametric study was conducted, varying parameters like deck type, steel thickness, span conditions, load positions, and load applications. Maximum concentrated loads were converted into Equivalent Total Distributed Loads (ETDWs), governed by deck strength and deflection. The paper discussed the impact of various design parameters on deck strength, behavior, and ETDW, with a specific focus on load application to deck flanges or the web due to second-order effects.

En-Feng Deng, et.al. (2020) provided the study on “High efficiency analysis model for corrugated steel plate shear walls in modular steel construction” This study concentrated on the development of a High Efficiency Analysis Model (HEAM) for corrugated steel plate shear walls (CSPSWs) in modular steel construction. The HEAM introduced a skeleton curve and hysteresis regulation for CSPSWs and proposed equivalent cross braces to simulate their seismic performance. The HEAM developed in this study accurately predicts the seismic performance of CSPSWs, encompassing initial stiffness, unloading behavior, and pinching effects. The HEAM is versatile and applicable for simulating CSPSWs with or without openings. The HEAM significantly enhances the computational efficiency of CSPSW analysis. It can be used for dynamic structural analysis of CSPSWs and provides conservative predictions of their dynamic response in modular steel construction.

Tianli Chen, et.al. (2019) studied on “Investigates the Wanga Local buckling of corrugated steel plates in buried structures”. This paper investigates local buckling in the straight section of a corrugated steel pipe (CSP) within a pipe-arch structure. The study employs the Rayleigh-Ritz method, accounting for soil support, to derive theoretical formulas for elastic local buckling in the straight portion. Finite element models are used to assess actual rotational restraints imposed by the corrugated portion, resulting in modifications to the theoretical formulas. Furthermore, a finite element model of the entire pipe-arch structure is developed to validate the revised formulas. A simplified mechanical model is introduced for calculating the local buckling load of the straight portion of a CSP within a pipe-arch structure with soil support. This model is applicable for both even and odd numbers of half-buckling waves.

Man Zhou, et.al. (2019) provided “Shear performance analysis of a tapered beam with trapezoidal corrugated steel webs considering the Resal effect”. This study delved into the shear performance of a tapered beam featuring Tapered Corrugated Steel Webs (TCSWs), employing a combination of experimental and numerical analyses. The key findings of this investigation are summarized as follows: The Resal effect, a significant contributor to variations in shear performance between prismatic and tapered beams with TCSWs, was empirically and numerically validated for the first time. The Resal effect exhibits both positive and negative impacts on the effective shear force borne by the TCSW, contingent on different combinations of internal forces. The degree of influence exerted by the Resal effect on a tapered beam with TCSWs is primarily dependent on the magnitude of bending moments and the angles of taper

Xuhong Zhou, et.al. (2019) conducted the study on “evaluated the flexural capacity of lightweight cold formed steel floor system with oriented strand board subfloor”. This paper details an experimental study involving two full-scale specimens aimed at determining the composite action and ultimate load capacity of a lightweight floor system comprised of CFS C-shape joists and OSB subflooring. Subsequently, finite element models of the full-scale floor and simplified composite beams were developed and validated against experimental

tests. The research encompasses extensive parametric analyses utilizing these models to explore the influence of various parameters, including steel yield strength, OSB thickness, floor joist spacing, and subfloor-to-joist screw spacing, on the composite interaction between CFS floor joists and OSB subflooring. The paper also introduces equations for assessing the composite action coefficient for simplified beam models. Ultimately, a simplified method for evaluating the ultimate flexural capacity of the lightweight floor system employing CFS C-shape joists and OSB subflooring is proposed. The results from this method have been verified through both experimental tests and numerical investigations of two full-scale lightweight floors, displaying good agreement.

Wenying Zhang, et.al. (2018) conducted the study is based on “Lateral strength and deflection of cold-formed steel shear walls using corrugated sheathing”. The authors in this paper summarize and analyze their previous test results. They also conducted complementary tests and performed finite element analyses using ABAQUS. Based on the test and FEA results, they recommend shear resistance for corrugated steel sheathed shear walls under wind and seismic loads. Additionally, they propose a design method for determining the deflection of these shear walls under lateral loading. These recommended nominal strength and deflection calculation methods can serve as a guide for designing CFS framed shear walls with low-profile corrugated steel sheathings in mid- and low-rise buildings.

Alireza Farzampoura, et.al. (2018) analysed the study on “Analysis and design recommendations for corrugated steel plate shear walls with a reduced beam section”. This paper introduces a promising lateral-load-resisting system known as the Reduced Boundary Beam Section Corrugated Steel Shear Wall (RBS-CSSW). It also outlines a step-by-step procedure for designing CSSWs, taking into account the interaction between corrugated panels and frames (CPFI) with boundary elements. Furthermore, the paper proposes and computationally analyses a novel lateral-load-resisting system that incorporates corrugated plates with an RBS connection. The authors have developed strength equations to assess the strength of this new Lateral Resistance System (LRS) based on interactive shear buckling stresses and RBS frame strength. By employing the

CPFI method, two RBS-CSSWs were designed and subjected to finite element (FE) software analysis, with the FE modeling methodology verified. The paper concludes that the developed analytical equations exhibit a high degree of accuracy, with an error margin of less than 5%, when compared to the corresponding FE pushover analysis for all specimens.

Michał Gajdzicki, et.al. (2018) conducted the study based on “Stability analysis of bi-directionally corrugated steel plates with orthotropic plate”. This paper presents an orthotropic plate model that accurately determines critical force values for bi-directionally corrugated steel plates, particularly when experiencing global stability loss. The stiffness modules are dependent on the ratio l/L . However, these values stabilize for $l/L < 1/10$ – $1/20$. In practical cases with a ratio much smaller than $1/10$, orthotropic modules $D_{11} = D_{22}$, D_{12} , D_{66} can be derived from the tables.

The differences in critical force values between plate and shell models were as follows:

- Up to 6.5% for compression.
- Up to 4.0% for shear.

For thin wall plates with high corrugation amplitudes, different stability loss modes were observed apart from global forms. The paper highlights in green, within the geometrical dimensions of bi-directional corrugated plates that exceed the applicability of the orthotropic plate model. For all other plate dimensions, a simpler orthotropic plate model can replace the time-consuming advanced shell model to determine critical forces. The proposed procedure accounts only for the linear elastic behavior of the material.

John Papangelis, et.al. (2017) studied on “Direct strength method for shear capacity of beams with corrugated webs “. To avoid global shear buckling in beams with corrugated webs, it's essential to design them to withstand yielding or local shear buckling. The local shear buckling coefficient, k_L , was determined through prior finite element studies, revealing variability in its values for corrugated web beams. To ensure safety, it was chosen to assume that all edges of corrugated web panels are simply supported, using Eq. (2) for k_L in the proposed

shear design equations. The direct strength method (DSM) was employed to formulate design equations for the local shear buckling capacity of beams with corrugated webs. These DSM design equations were compared with previous DSM equations for cold-formed members and Eurocode design rules. In comparison to 74 previous test results, the proposed DSM design equations exhibited the best agreement, with an average ratio of ultimate test shear force to nominal design shear capacity of 1.032 and a coefficient of variation of 0.135.

Pengcheng Jiao, et.al. (2017) provided the study on “Lateral-torsional buckling analysis of wood composite I-beams with sinusoidal corrugated web”. This study aimed to develop a theoretical model for predicting the critical buckling loading capacity of wood composite I-beams with sinusoidal corrugated webs. The Rayleigh-Ritz method was employed to determine the critical load, and experimental and numerical simulations were conducted to validate the theoretical findings. Additionally, the model was simplified to a flat web, and the loading capacity of corrugated I-beams was validated against an existing study, resulting in satisfactory agreement. Parametric studies were carried out to explore how geometric factors, such as web thickness, length, and height, affect the buckling capacity of wood composite I-beams. Notably, a significant increase in buckling load (at least 17.17%) was observed when transitioning from flat to sinusoidal web I-beams. Optimal designs were conducted to investigate the impact of ratios, specifically the wavelength-to-beam length (a/L) and wave amplitude-to-flange width (A/T), on the critical buckling load and structure volume.

M. Wójcik, et.al (2017) experimented the study on “steel silo composed of corrugated walls and columns”. The primary findings from our experiments conducted in a full-scale steel cylindrical silo with corrugated walls and open-sectional thin-walled column profiles, containing cohesionless wheat (initial volumetric weight: 7.75 kN/m³), are summarized as follows: Pressure Distribution: Following the opening of the outlet, both horizontal and shear wall pressures consistently increased. Notably, the most substantial wall pressures were observed in the lower part of the silo during mass flow, exceeding those observed during filling by 70–120% for horizontal pressures and 45–80% for shear pressures. In the mid- and upper silo regions, the highest horizontal and shear wall

pressures occurred during eccentric flow, with values being 35–75% higher for horizontal pressures and 15–45% higher for shear pressures compared to filling.

W.C. Gao, and Y. Xiao (2017) studied on “Seismic behaviour of cold-formed steel frame shear walls sheathed with ply-bamboo panels”. A total of 16 cold-formed steel (CFS) stud shear walls, with and without ply-bamboo panel sheathing, underwent both monotonic and cyclic testing. These innovative CFS shear walls exhibited failure modes similar to those sheathed with conventional wood-based materials and demonstrated comparable nominal shear strength. Notably, even with changes in aspect ratio ranging from 2 to 1, the shear strengths per unit length remained consistent, suggesting that each ply-bamboo sheathing panel independently resisted shear forces. The test results indicated that either the CUREE or ISO cyclic loading protocol could be effectively applied to test ply-bamboo-sheathed CFS shear walls.

Maciej Obst, et.al. (2016) investigated the study on “experimental and analytical investigations of torsion phenomenon of thin-walled cold formed channel beams subjected to four-point bending”. This paper presents experimental and analytical investigations conducted on cold-formed thin-walled steel beams with open sections under pure bending conditions. The study involved testing two different beams with open cross-sections and measuring their rotation during bending. In addition to experimental findings, the authors provided an analytical solution for this problem and discussed the emergence of an additional torsional moment. It is important to emphasize that several factors, including the shape of the cross-section, the loading method, the materials used, and the test setup, were less than ideal. All these variables had an impact on the beams' strength. The analytical investigations of these two open thin-walled beams revealed that even a small 0.5% deviation from the total beam load was enough to lead to failure in poorly constructed and loaded beams. This highlights the substantial influence of real-world working conditions on the load-carrying capacity of thin-walled structures.

Jun Ye n, et.al (2016) provided the “Development of more efficient cold-formed steel channel sections in bending”. In this paper, a practical framework is

introduced for optimizing the cross-sections of cold-formed steel (CFS) beams, taking into consideration code-based design constraints, manufacturing considerations, and practical limitations. The framework was applied to optimize a commercially available CFS lipped channel section, specifically one with a folded-flange cross-section, while maintaining constant material usage. To address this, a modified European Standard EC3 design methodology was developed to accommodate various distortional buckling modes that could potentially occur within the folded-flange cross-section. To find solutions with maximum flexural strength, the particle swarm optimization algorithm was employed. The accuracy of the modified design model and the effectiveness of the optimization framework were rigorously assessed through detailed non-linear finite element analysis. As a result of these investigations.

Péter Hegyi n, and László Dunai (2016) conducted the “experimental study on ultra-lightweight-concrete encased cold formed steel structures Part I: Stability behaviour of elements subjected to bending”. Experimental program that investigates the behavior of cold-formed steel (CFS) elements encased in polystyrene aggregate concrete (PAC) under bending loads. A total of 48 member tests were conducted, encompassing two types of cross-sections. Both unbraced and braced members were tested to assess the increase in load-bearing capacity. The study also utilized three different lengths to explore various failure modes, including local, distortional, and global. Beneficial Effect of PAC-Bracing: The research demonstrated that PAC-bracing has a positive impact on the stability of CFS beams. It can increase the ultimate load level by a significant margin, ranging from 30% to 190%, depending on specific specimen parameters. PAC effectively restrains global and distortional buckling modes of steel elements, essentially providing "full bracing." Composite Effect: Interestingly, the contribution of the composite effect to the material's load-bearing capacity is found to be negligible. The primary driver for increased load-bearing capacity arises from the bracing effect of PAC.

Dan Dubina, et.al. (2015) provided the “experimental investigations of cold-formed steel beams of corrugated web and built-up section for flanges”. The paper discusses a comprehensive experimental program conducted at the CEMSIG

Research Centre, situated at the Politehnica University of Timisoara. This program primarily focused on examining the behavior of five beams featuring corrugated webs, each with different arrangements for self-drilling screws and shear panels.

Agreement Between Beams: Beams CWB-1 and CWB-3 displayed excellent agreement concerning both initial stiffness and ultimate force characteristics.

Stiffness Variation: Beam CWB-2 exhibited a slight increase in stiffness when compared to CWB-1 and CWB-3. This increase in stiffness can be attributed to the additional lipped channel sections that were locally added at the load application points.

Flexibility of CWB-4: Among the tested beams, CWB-4 emerged as the most flexible solution, demonstrating only half the initial stiffness when compared to CWB-2.

Optimal Solution: Beam CWB-5 was identified as the most optimal solution among the tested beams, based on the study's findings and conclusions.

Hui-Wen Tian, et.al (2015) experimented the study on “Testing of steel sheathed cold-formed steel trussed shear walls”. experimental investigation of a novel cold-formed steel shear wall system known as the steel-sheathed cold-formed steel trussed shear wall (SSCFSTSW), tested under both monotonic and reversed cyclic loading conditions. The study examined how the configuration of the skeleton, sheathing, and chord studs influenced the shear wall's performance,

Sheathing Type: Corrugated steel sheathing displayed less lateral deformation when subjected to the same load levels compared to plain steel sheathing. Notably, during testing, plain sheathing produced sharp sounds under tension, potentially affecting its practical use, while corrugated sheathing remained quieter.

Connection Failures: Failures in the connections between sheathing and framing, as well as between braces and tracks, allowed the shear walls to dissipate more energy along the lateral load path, aligning with seismic design principles. However, the buckling of chord studs resulted in an immediate reduction in wall resistance and the potential loss of vertical load-carrying capacity. This underscores the importance of avoiding this failure mode in actual design applications.

Guo-Qiang Li, et.al. (2015) conducted the study on “Local buckling of compression flanges of H-beams with corrugated webs” comprehensive investigation into the flexural strength of compression flanges in beams with

corrugated webs. The study takes into account various factors and proposes empirical formulas to calculate the critical buckling stress of these flanges, considering the influence of corrugated web geometry, initial geometric imperfections, and residual stresses. Effect of Corrugated Webs: Beams with corrugated webs exhibit distinct boundary conditions compared to those with plain webs. The presence of corrugated webs introduces an elastic rotational restraint effect on the local buckling behavior of compression flanges. This effect allows for a rational simplification of the flange plate, considering it as having two loading edge conditions: one simply supported and one rotationally restrained.

László Gergely Vigh, et.al. (2014) studied “Component model calibration for cyclic behaviour of a corrugated shear wall” development and calibration of a nonlinear analysis model aimed at capturing the monotonic and cyclic behavior of steel corrugated shear walls. The primary focus of the study is on the challenges encountered during the calibration process, which was particularly complex due to the absence of monotonic test data for the specific configurations under investigation and the relatively large number of model variables that required determination, resulting in a highly nonlinear optimization problem. The calibration process involved estimating the monotonic behavior, represented as a backbone curve, using nonlinear static analysis of a shell-element model of the experimentally tested shear walls. The response of the shear wall was found to be highly sensitive to the sheet-to-framing connection, as the predominant failure mode occurred in the connection zone. Consequently, a detailed sub-model analysis of the screwed connections was necessary. This multi-level analysis successfully estimated the elastic and post-yield monotonic behavior of the tested cases up to the capping point. Additionally, the finite element scale modelling approach allowed for the extension of results to wall configurations that were not included in the experiments.

B. Kövesdi, L. Dunai (2014) experimented the study on “Fatigue life of girders with trapezoidally corrugated webs: An experimental study” An experimental research study was conducted on the fatigue behavior of trapezoidally corrugated web girders. The study supported the design of the new Móra Ferenc bridge at the M43 highway over the Tisza River in Hungary. Six large-scale test specimens underwent static and repeated loading. The tests aimed to analyze the fatigue

behavior of the corrugated web girders and determine their fatigue detail category. The fatigue life of the analyzed girders was determined under pure bending and combined bending and shear. Additionally, the effect of weld size on fatigue behavior was investigated. The results of static measurements revealed typical structural behavior for the corrugated web girders, including the observed "accordion effect". Detailed analysis was conducted on normal stress distributions in the flange and web plates. The paper mainly focused on the fatigue behavior of the tested girders, including measurement of hot spot stresses at four locations along the girder length. The most sensitive point of the corrugated web girders from a fatigue perspective was identified based on hot-spot measurements, and stress concentrations were measured and evaluated during the tests, reaching up to 124.6% compared to nominal stress in the undisturbed zone of the flange in four-point bending and 116.4% in three-point bending.

Pankaj B. Pathare, Umezuruike Linus Opara (2014) Conducted the study on "Structural design of corrugated boxes for horticultural produce: A review" The importance of structural design in corrugated packaging for fresh produce transportation and storage has been emphasized. Corrugated boxes must possess adequate strength and stiffness to safeguard fresh produce during handling and transportation, with the box compression test (BCT) being the most commonly used measure of strength. Damage to products during transportation can be attributed to various vibration forces, necessitating understanding and management of these forces to optimize packaging. Horticultural packaging faces diverse loading conditions during filling, stacking, transportation, and storage, with bottom boxes on pallets experiencing the highest compression load. The final box design must strike a balance between strength and cost, considering that stronger boxes require more material and are costlier. Maintaining structural integrity and enhancing cooling performance are crucial aspects of box design, yet agreed-upon criteria for ventilation area remain absent. While empirical formulae are frequently employed to predict box strength, existing models often overlook the impact of vent openings. Future research should focus on developing robust simulation models integrating vent openings, package stacks, and storage conditions for designing ventilated corrugated boxes with enhanced strength.

László Gergely Vigh, Gregory G. Deierlein et.al (2013) studied the “Seismic performance assessment of steel corrugated shear wall system using non-linear analysis” The FEMA P-695 seismic performance evaluation method was demonstrated using a practical example of a steel shear wall system. Despite its comprehensiveness and relative objectivity, the methodology necessitates significant judgment in establishing design archetypes and performance groups, developing and calibrating nonlinear analysis models, and determining appropriate quality ratings. The study proposes seismic performance factors for the steel shear wall system, with $R = C_d = 4$ and $\Omega_o = 3$, based on available test data and established design requirements. These values assume clear design rules, such as ductile detailing requirements and uniform uplift force distribution along the height. If additional test data were available to further characterize the response or if quality ratings were higher, higher values for R might be justified. It's crucial to note that this study only addresses the analysis aspects of the FEMA P-695 procedures, not a full implementation. A complete implementation would entail an independent peer review panel evaluating design provisions and test data, along with a broader range of system archetypes. Similar analyses could establish values for Eurocode seismic performance parameters, necessitating redesigning and reanalyzing archetype structures to align with EC requirements and typical design practices.

A. Biegus, A. Kowal (2013) experimented the study on “Collapse of halls made from cold-formed steel sheets” An analysis of halls spanning over 24 m, constructed with steel cold-formed 'ABM-like' panels of 110 mm height, reveals failure to meet safety conditions due to insufficient resistance to predicted snow loads and inadequate shell stiffness. The Gdansk Hall disaster stemmed from lacking buckling strength, with errors in structural analysis. Documentation flaws include using lighter materials without reinforcing ABM panels and inadequate connections to concrete structures. Cold-formed steel panels are highly sensitive to imperfections. Immediate inspection of existing halls is crucial, as they may face disasters without reinforcement, indicating a need for spans under 20 m for safety compliance.

M.F. Hassanein, O.F. Kharoob (2013) provided the “Behavior of bridge girders with corrugated webs: (II) Shear strength and Design” This paper evaluates shear strength of bridge girders with corrugated webs (BGCWs) using realistic initial imperfection amplitudes. It compares existing design shear strengths with a new interactive shear buckling strength formula recommended by the authors, finding current designs overly conservative. Nonlinear FE analysis using ABAQUS software on full-scale failing BGCWs showed the proposed formula inadequacy across all behaviors. The Sause and Braxtan formula performed relatively well but requires further validation. Additionally, it was observed that stocky corrugated webs may not practically reach the yield shear strength as proposed by Moon et al. Finally, an illustrative example for calculating shear strength using the proposed formula was provided.

B. Kovesdi, L. Dunai, et.al (2012) experimented the “Interacting stability behaviour of steel I-girders with corrugated webs” The research analyzes the combined bending, shear, and patch loading of girders with corrugated steel webs. Previous experiments and numerical investigations are reviewed, and a finite element model is developed and verified using test results from Budapest University of Technology and Economics. Load carrying capacities are determined through geometric and material nonlinear analysis, with a parametric study conducted to investigate interaction behavior across a wide parameter range. New design interaction equations are proposed based on the calibrated numerical model, providing a more economic design approach. Results indicate that the interaction proposal of Elgaaly and Seshadri approximates the lower limit interaction curve well for girders with corrugated webs. Additionally, parameter-dependent interaction equations are introduced, taking into account girder geometry and loading conditions, leading to safer and more efficient designs. The developed design interaction curves are valid for corrugation angles of 20° to 60° , loading lengths between 0.2 and 0.8 times the web height, and specific web and fold ratios relevant for bridges.

V.B. Nguyen, C.J. Wang (2012) analysed the “Compression tests of cold-formed plain and dimpled steel columns” Compression tests were conducted on cold-formed plain and dimpled steel column specimens, alongside tensile tests for material properties. A total of 48 channel column specimens and 56 tensile

specimens were tested. An innovative approach for compressive testing of dimpled columns was proposed due to the absence of a standard protocol. Test details, including setup, instrumentation, and procedure, were described. Results showed that dimpled column specimens exhibited higher buckling and ultimate loads (9-33% and 8-26% higher, respectively) compared to plain columns, with corresponding increases in yield and tensile strength. Finite strip analysis predicted local buckling loads well, but theoretical buckling values were overestimated for inelastic behavior. Modes of failure and strength increases in dimpled specimens were attributed to plastic deformation during dimpling. Ongoing work aims to develop design methods using these results, including Finite Element analysis and further experimental validation, especially focusing on long columns.

E.C. Paredes, A. Bautista, et al (2012) investigated “Influence of the forming process of corrugated stainless steels on their corrosion behaviour in simulated pore solutions” The review of buckling and optimal design issues in cold-formed thin-walled beams covers extensive experimental tests revealing various buckling behaviors and interactions between modes. Studies on these problems have increased recently due to the ongoing importance of optimization for strong yet lightweight structures. Cross-sectional shape significantly impacts structural integrity, and optimization aims to improve shapes based on defined objectives. Advances in manufacturing technology allow for the production of various beam shapes, meeting diverse requirements. Mathematical models guide studies and propose quality measures for systematic beam comparison.

Alireza Bagheri Sabbagha, Mihail Petkovski (2011) experimented the study on “Ductile moment-resisting frames using cold-formed steel sections: An analytical investigation”

FEA conducted on proposed moment-resisting connections revealed that cold-formed sections, especially curved flange sections, can offer sufficient energy dissipation capacity for seismic design of moment-resisting frames. Through plate type connections between cold-formed beams and columns can also provide ample strength and ductility if appropriately detailed and stiffened to allow for plasticity development in the beams. Seismic behavior of these frames, and their seismic code classification, depends on the cyclic behavior of the beam-column

connections. Ongoing experimental investigation at the University of Sheffield will assess the cyclic (hysteretic) behavior of the suggested details of beam-column connections.

2.3 OBJECTIVE

- To study the flexural behavior of the corrugated beams under the finite element analysis.
- To study the flexural behavior of the corrugated beam under the two-point loading conditions.
- To compare the flexural behavior of the corrugated beam by both experimental & Analytical.

CHAPTER – 3

MATERIALS & METHODOLOGY

3.1 MATERIAL

The general size of CFS sheet is 8' X 5' (2438mmX1524mm). Model size is 1200mmX165mmX155mm. The thickness of steel sheet is 2mm. The Horizontal corrugated beam with spacing, Horizontal corrugated without spacing and the Vertically corrugated beam is fabricated. Total number of sheets required for experiment -2nos. Weight of each sheet is around 60kilograms. Each model is fabricated and tested under two-point load in L/3 ratio.

3.2 COLD ROLLED SHEET

Material required for model size is 165mmX155mmX1200mm. The horizontal corrugated beam with spacing, without spacing and the vertically corrugated beam is fabricated. Weight of each sheet is around 60kilograms. The cost of the cold rolled sheet is 70rs /kg. Each model is fabricated and tested under two-point load in L/3 ratio.



Fig: 3.1 Cold rolled sheet

Fig 3.1 shows Standard size of Cold rolled sheet 2438mmX1524mm is available in the market. The straight line is marked in the CR sheet.

3.3 MACHINE CUTTING & WELDING

The experimental dimensions for Corrugated steel beam are in 165mmX155mmX1200mm. The angle of corrugated beam web part is 25°. Material required for single model is 656mmX1200mm. The straight line is marked in CR sheet was cut into required size & it is shown in figure 3.2.

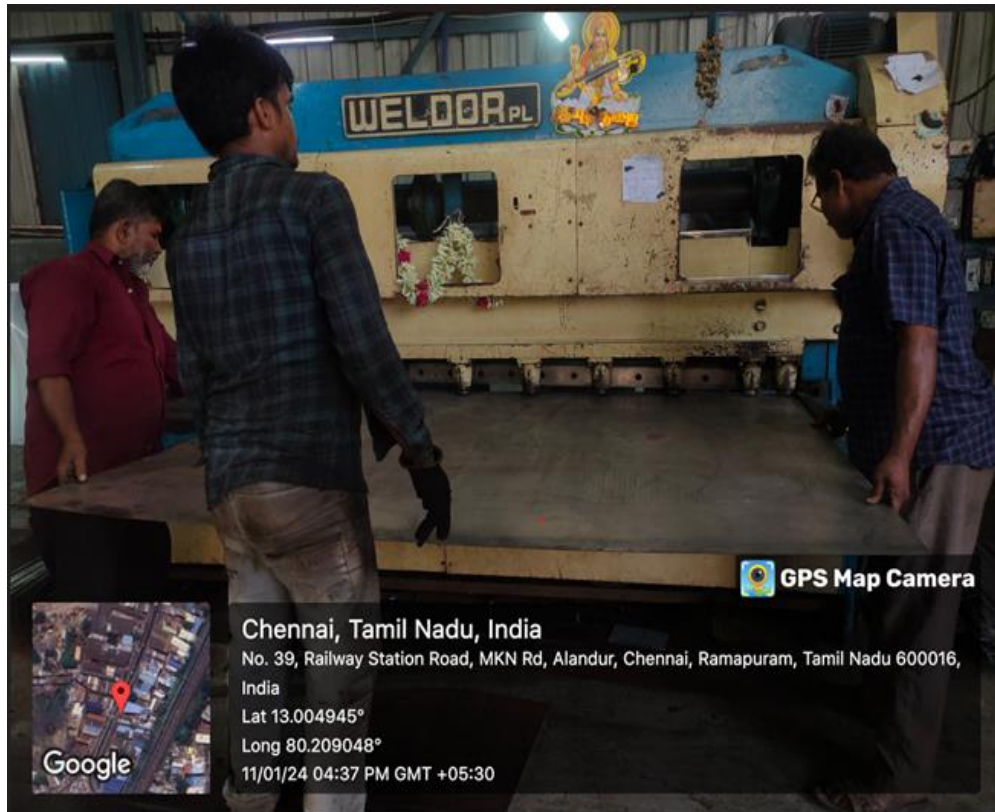


Fig: 3.2 Machine cutting

Fig 3.2 Shows the machine cutting. Material required for single specimen is 656mmX1200mm.

Welding is a Fabrication Process to Joint the Steel Materials, using high heat to Melt the parts joint together & allowing them to cool. In this the corrugated web portion is aligned and placed perpendicular to the flange portion. Mig welding is done to join the web to the flange as shown in below fig 3.3.



Fig 3.3 welding of corrugated beam

Fig 3.3 shows the welding process. The Mig weld is used to fabricate the member.

3.4 METHODOLOGY

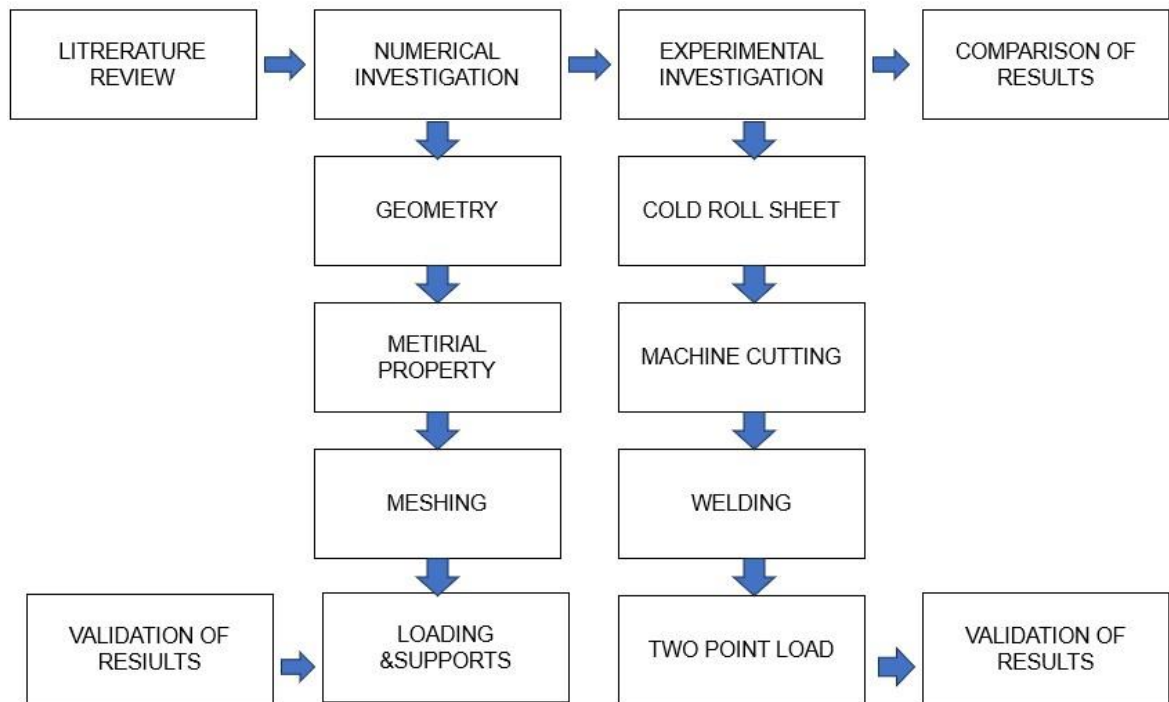


Fig 3.4 Methodology

3.7 ANALYTICAL MODEL

DESIGN OF CORRUGATED BEAM

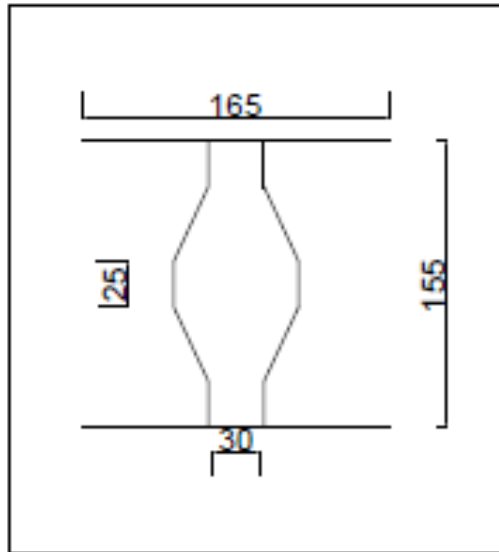


Fig 3.5 Horizontal corrugated beam with spacing (30mm)

The above fig 3.5 shows the dimensions of horizontal corrugated beam with spacing (30mm) for experimental data.

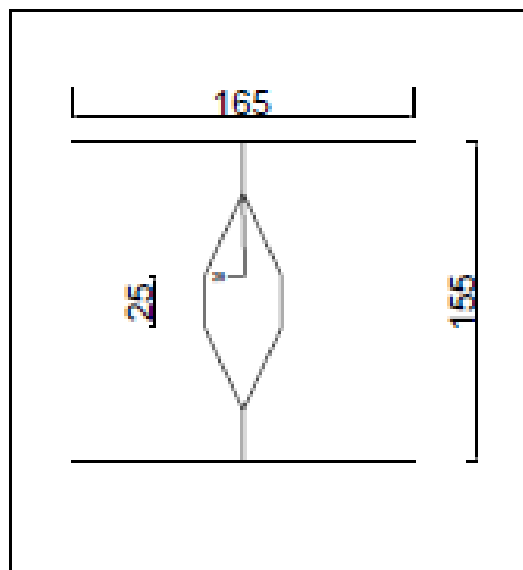


Fig 3.6 Horizontal corrugated beam without spacing (0mm)

The above fig 3.6 shows the dimensions of horizontal corrugated beam without spacing (0mm) for experimental data.

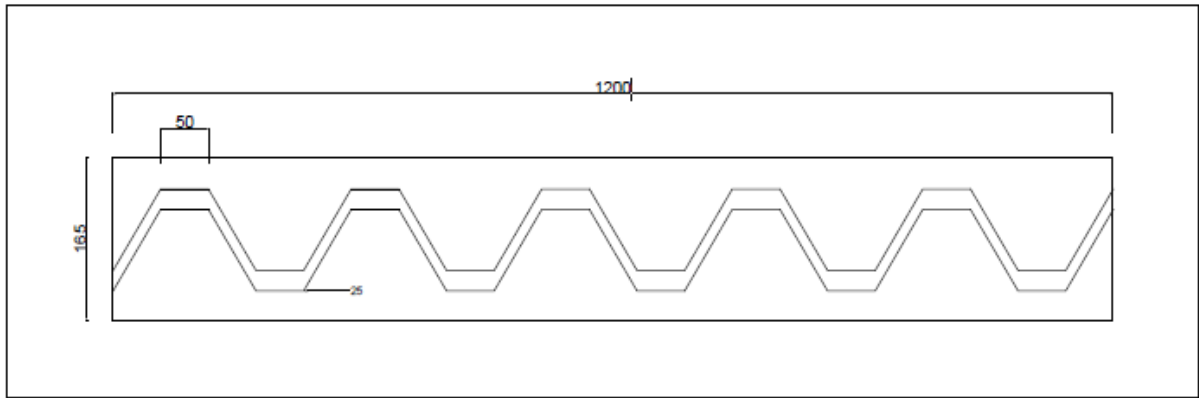


Fig 3.7 vertically corrugated beam

The above fig 3.7 shows the dimensions of vertically corrugated beam for experimental data.

3.8 CATIA MODEL

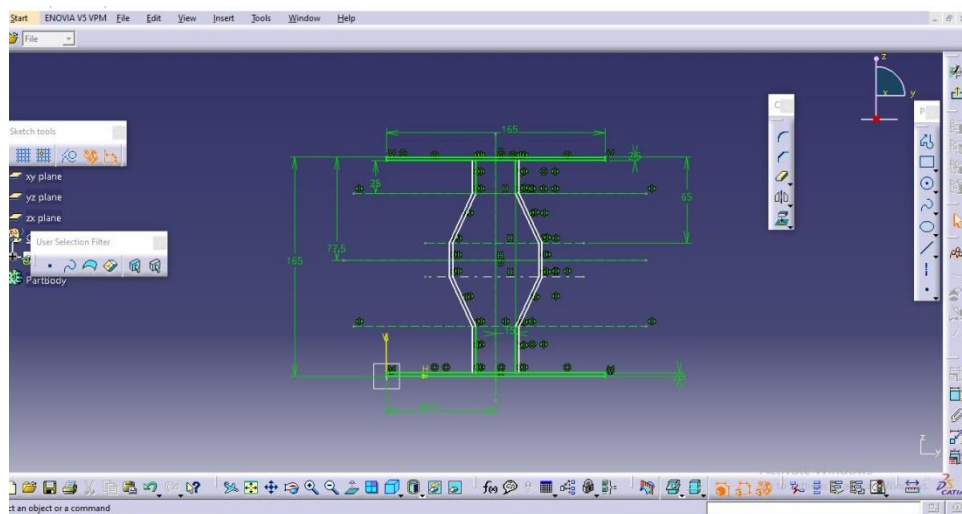


Fig: 3.8 Horizontal Corrugated beam with Spacing

The above Fig 3.8 shows the Horizontal corrugated beam with spacing(30mm). The general size of the beam is 165X155X1200mm and the corrugated angle 25° is designed in CATIA.

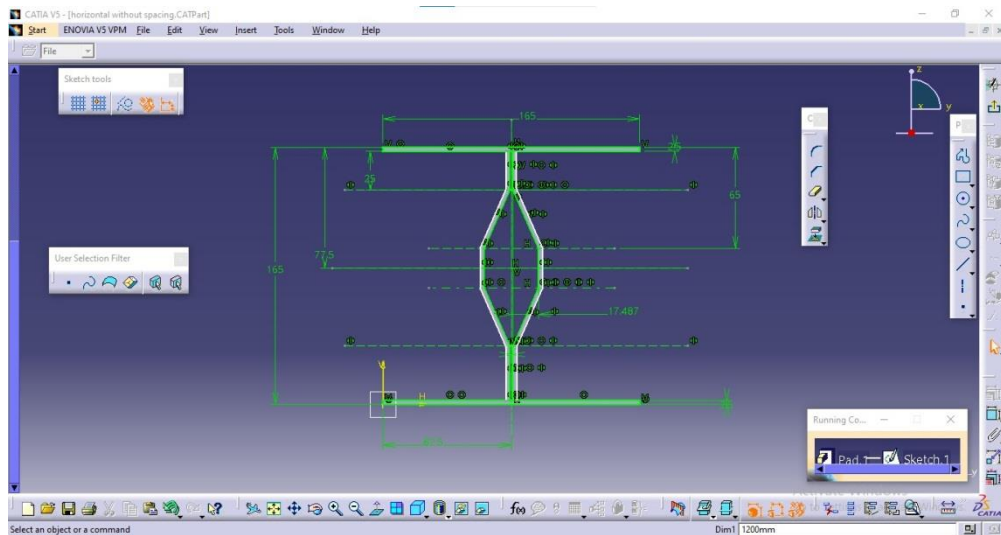


Fig:3.9 Horizontal Beam Corrugated without Spacing

The above Fig 3.9 shows the Horizontal corrugated beam without spacing(0mm). The general size of the beam is 165X155X1200mm and the corrugated angle 25° is designed in CATIA.

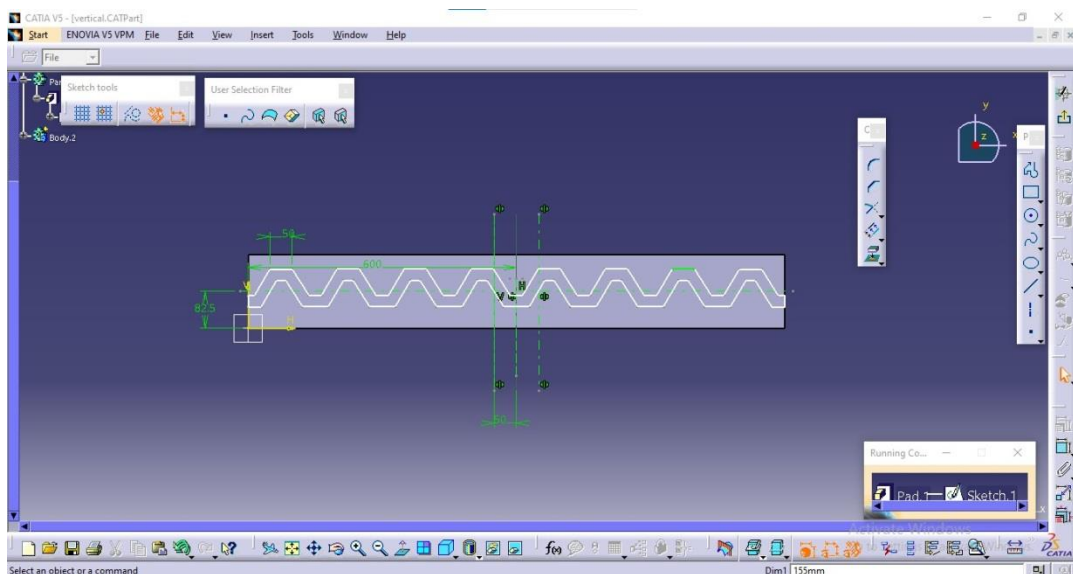


Fig:3.10 Vertical Corrugated Beam

The above Fig 3.10 shows the Vertically corrugated beam. The general size of the beam is 165X155X1200mm and the corrugated angle 25° is designed in CATIA.

3.9 GEOMETRY

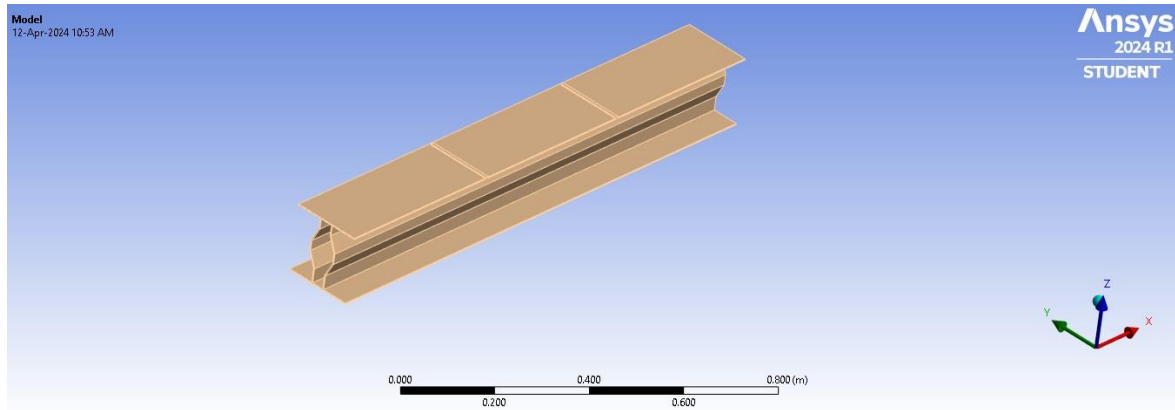


Fig 3.11 Horizontal corrugated beam with spacing

The above Fig 3.11 shows the geometry of Horizontal corrugated beam with spacing by using Ansys.

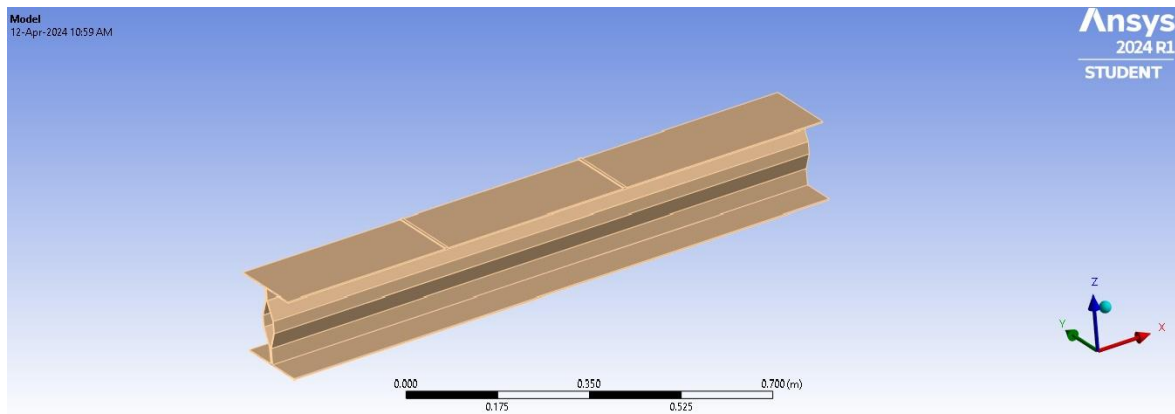


Fig 3.12 Horizontal corrugated beam without spacing

The above Fig 3.12 shows the geometry of Horizontal corrugated beam without spacing by using Ansys.

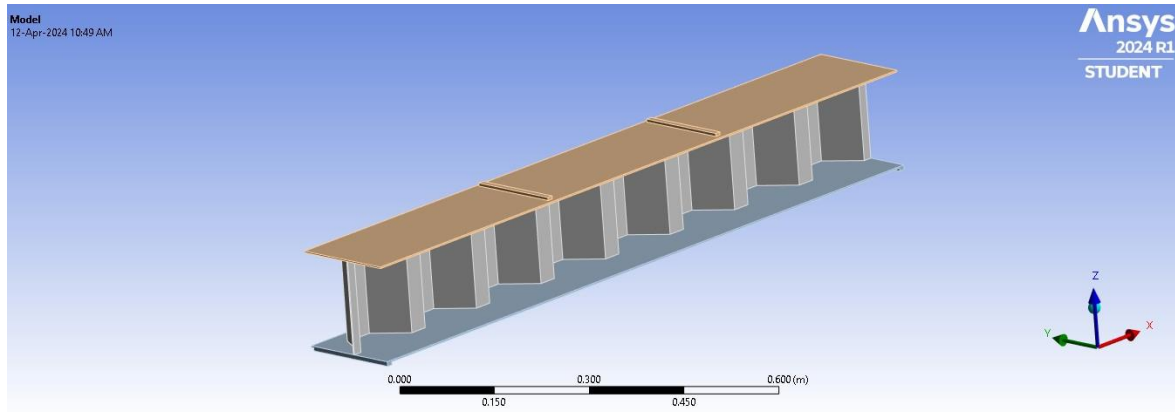


Fig 3.13 vertically corrugated

The above Fig 3.13 shows the geometry of Vertically corrugated by using Ansys.

3.10 MESHING

Ansys meshing capabilities help reduce the amount of time and effort spent to get to accurate results. In Finite Element Analysis (FEA) is an analysis solved using a method called the Finite Element Method (FEM). With the help of discretization or meshing (nodes and elements) Finite Element Method reduces the degrees of freedom. Thus, meshing is done to break up larger parts into small pieces each piece representing an element to solve the model using finite element method. One of the purposes of meshing is to make the problem solvable using Finite Element. Hence, we create a mesh which splits the domain into a discrete number of elements for which the solution is be calculated.

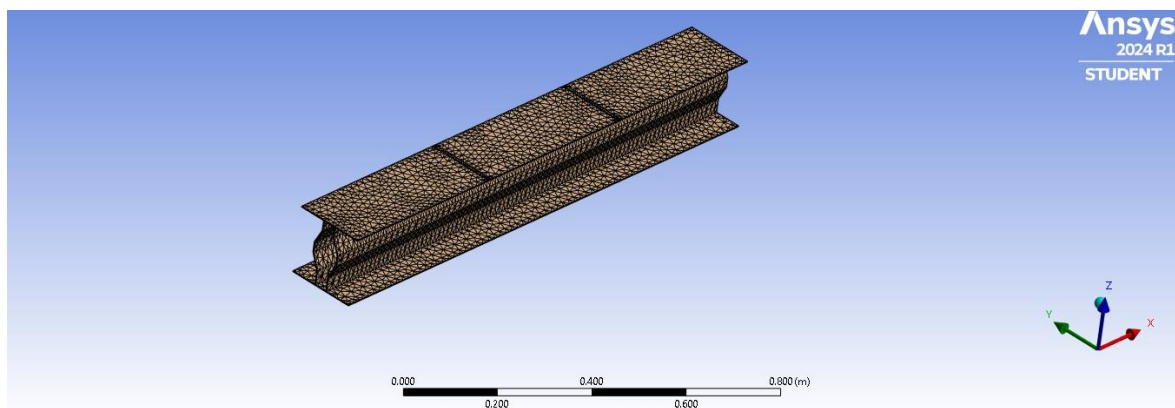


Fig 3.14 HORIZONTAL CORRUGATED BEAM WITH SPACING

The above Fig 3.14 shows the meshing of horizontal corrugated beam with spacing.

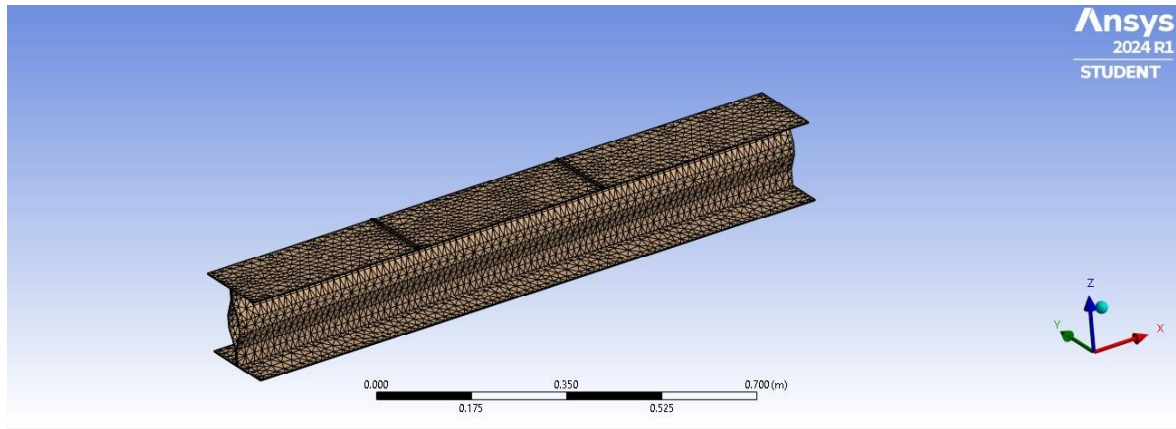


Fig 3.15 Horizontal corrugated beam without spacing

The above Fig 3.15 shows the meshing of horizontal corrugated beam without spacing.

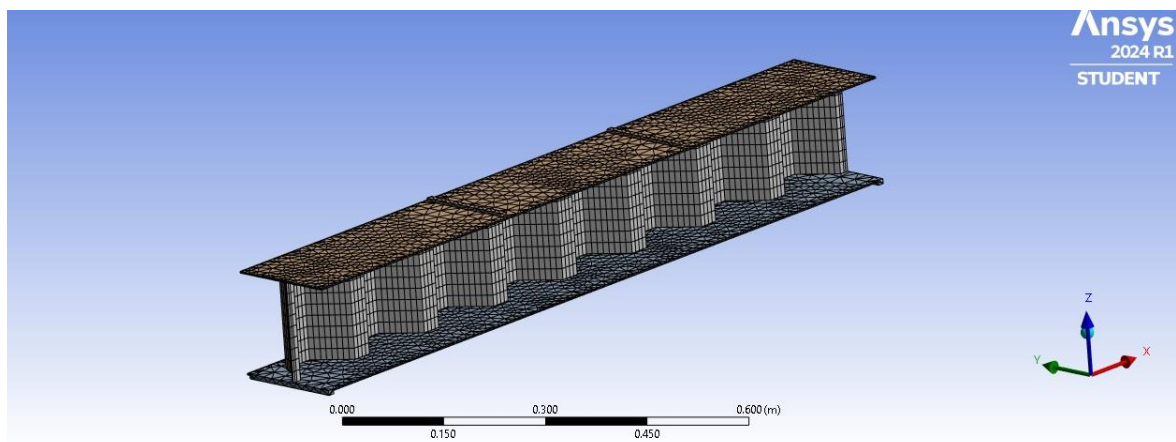


Fig 3.16 Vertically corrugated beam

The above Fig 3.16 shows the meshing of Vertically corrugated beam.

3.5 EXPERIMENTAL INVESTIGATION

SECTION OF MEMBER

The CR sheet is positioned and MIG welding is done. The flange and web are placed perpendicular to each other MIG weld is given at both the edges.



Fig: 3.17 Horizontal beam corrugated with spacing

Geometry of specimen the horizontal beam corrugated with Spacing model is fabricated. The Fig 3.17 shows the geometry of the horizontal beam corrugated with spacing respectively.



Fig: 3.18 Horizontal beam corrugated beam without spacing

Geometry of specimen the horizontal beam corrugated without Spacing model is fabricated. The Fig 3.18 shows the geometry of the horizontal beam corrugated without spacing respectively.



Fig: 3.19 Vertically corrugated beam

Geometry of specimen the vertically corrugated beam model is fabricated. The Fig 3.19 shows the geometry of the vertically corrugated beam respectively.



Fig 3.20 Different types of corrugated beam

3.6 EXPERIMENTAL SETUP

The testing was carried out in a loading frame of 100 Ton capacity. All the specimens were tested for flexural strength under two-point loading. The specimen was arranged with simply supported condition having an effective span of 1200mm. Loads were applied at one-third distance from the supports through a hydraulic jack of 25 KN to 30 KN capacity at a uniform rate till the ultimate failure of the specimens occurred. The deflection is measured at several location by using LVDT.

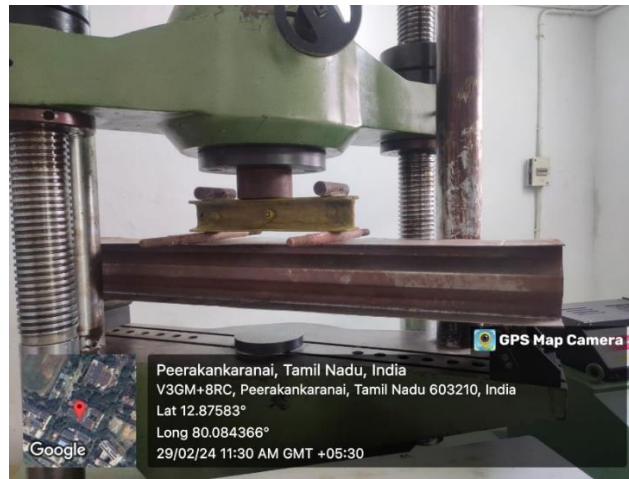


Fig: 3.21 CORRUGATED BEAM WITH SPACING

Fig 3.22 shows the experimental setup for corrugated beam under a two-point load condition.

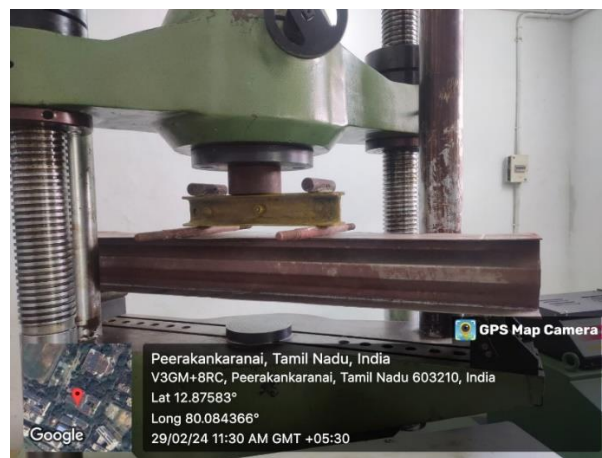


Fig: 3.23 CORRUGATED BEAM WITHOUT SPACING

Fig 3.23 shows the experimental setup for corrugated beam without spacing is under a two-point load condition.

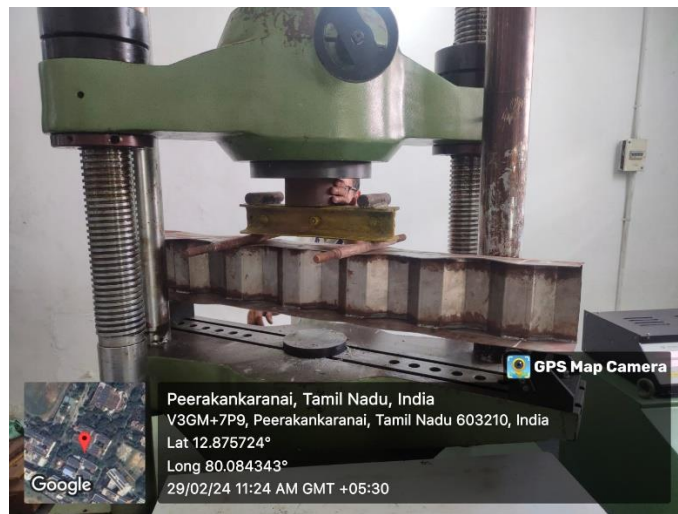


Fig: 3.24 VERTICALLY CORRUGATED BEAM

Fig 3.11 shows the experimental setup for vertically corrugated beam is under a two-point load condition.

CHAPTER – 4

RESULT & DISCUSSION

4.1 INTRODUCTION

Steel is Environmental Nature, this is used as recyclable, Steel is Mould to which shape we Want. The CR Steel is a Construction Material, Compare to Concert Steel Construction work is easy. Steel Load Bearing Capacity we be Changed by Used Gauge. To Analys the behavior of three different corrugated beam using Ansys software. To test the designed beam on loading frame under two-point load. Comparison of result both analysis & Experiment. The Corrugated beam with spacing, corrugated beam without spacing and Vertical corrugated beam is model and fabricated for testing.

4.2 EXPERIMENTAL RESULTS

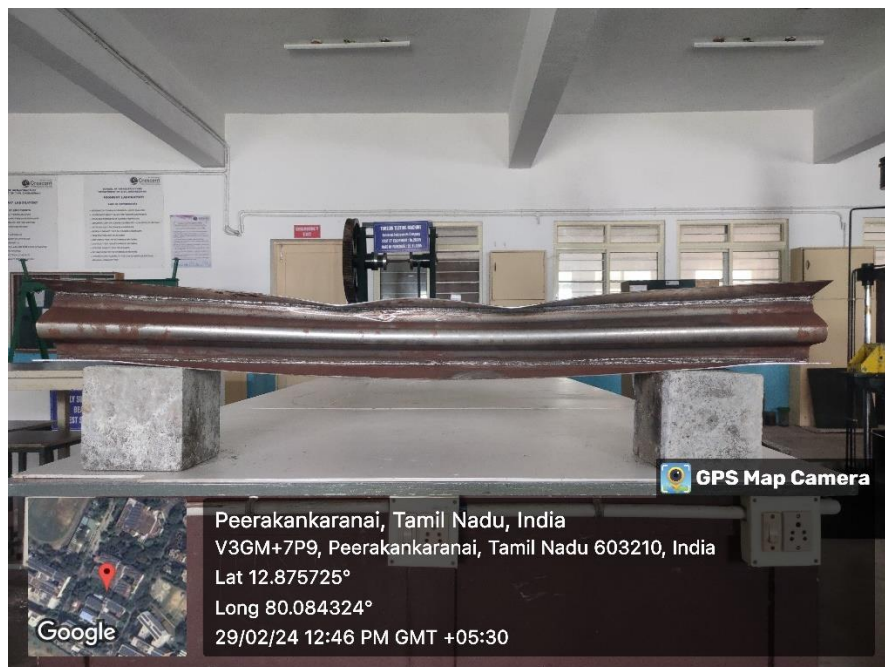


Fig 4.1 Horizontal corrugated beam with spacing

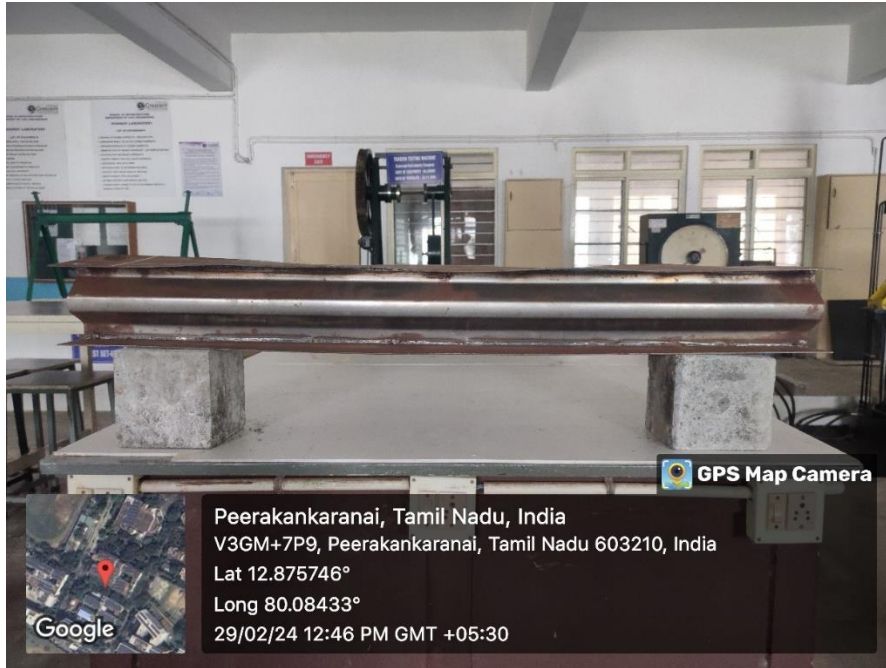


Fig 4.2 Horizontal corrugated without spacing

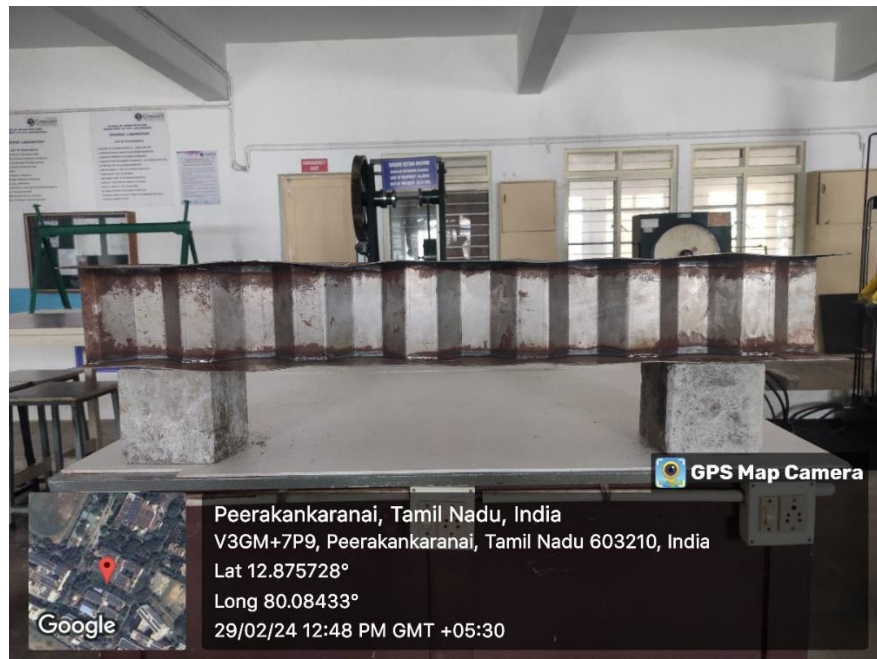


Fig 4.3 Vertically corrugated beam

4.3 ULTIMATE LOAD IN EXPERIMENTAL RESULTS

S.NO	SPECIMEN	ULTIMATE LOAD (KN)		AVERAGE ULTIMATELOAD
		SAMPLE 1	SAMPLE 2	
1.	Horizontal corrugated beam with spacing	25.80KN	22.30KN	24.05KN
2.	Horizontal corrugated without spacing	31.25KN	26.60KN	28.925KN
3.	Vertically corrugated beam	30.050KN	26.10KN	28.075KN

Table 4.1 Ultimate load for experimental results

4.4 YIELD POINT IN EXPERIMENTAL RESULTS

S.NO	SPECIMEN	YIELD POINT		AVERAGE YIELD POINT
		SAMPLE 1	SAMPLE 2	
1.	Horizontal corrugated beam with spacing	6.67	6.98	6.825
2.	Horizontal corrugated without spacing	7.71	7.58	7.645
3.	Vertically corrugated beam	4.39	4.81	4.6

Table 4.2 Yield Point

4.5 LOAD VS DEFLECTION

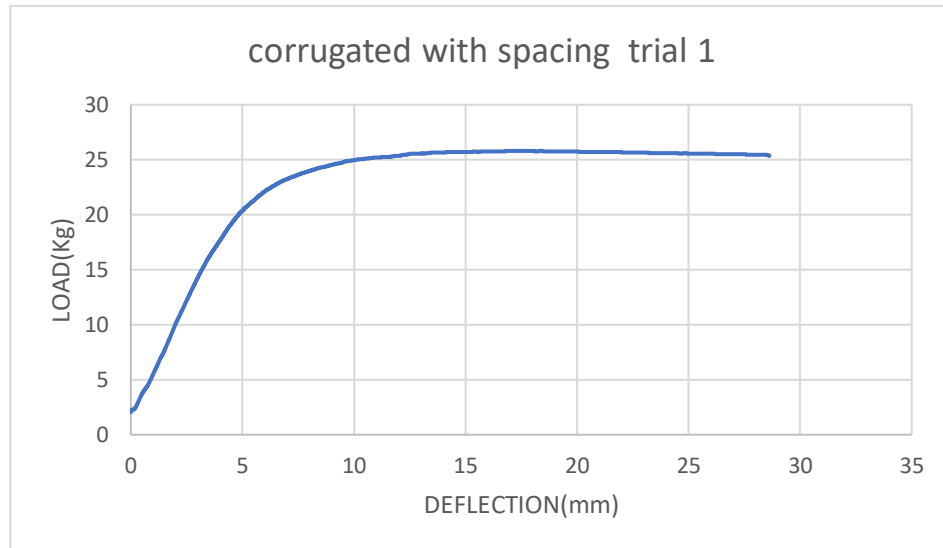


Fig 4.4 Horizontal corrugated beam with spacing trial 1

Fig 4.4 shows the load vs displacement curve for corrugated beam with spacing for trial 1. The above graph depicts the load deflection curve of the horizontal corrugated beam with 30mm spacing. It has reached the ultimate load of 25.8KN with deflection 16.790mm.

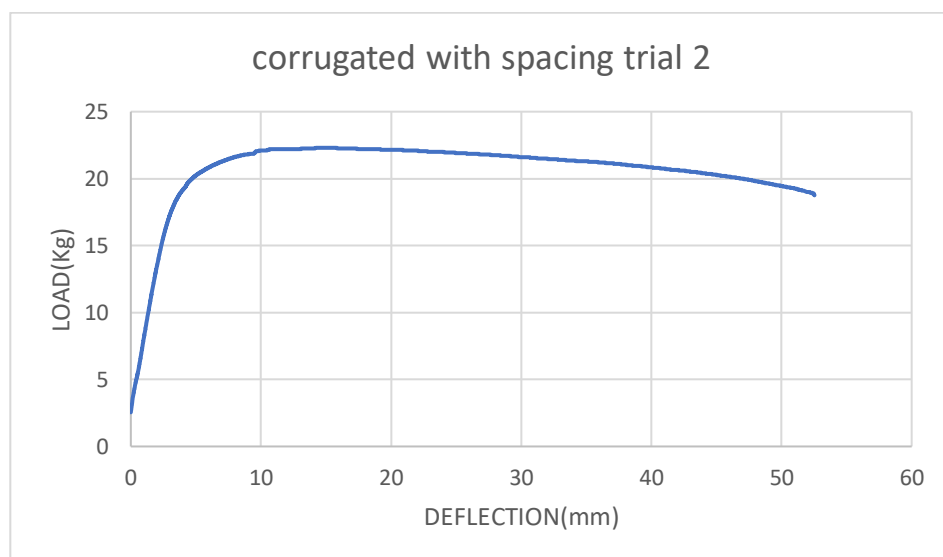


Fig 4.5 Horizontal corrugated beam with spacing trial 2

Fig 4.5 shows the load vs displacement curve for corrugated beam with spacing for trial 2. The above graph depicts the load deflection curve of the horizontal corrugated beam with 30mm spacing. It has reached the ultimate load of 25.8KN with deflection 16.790mm.

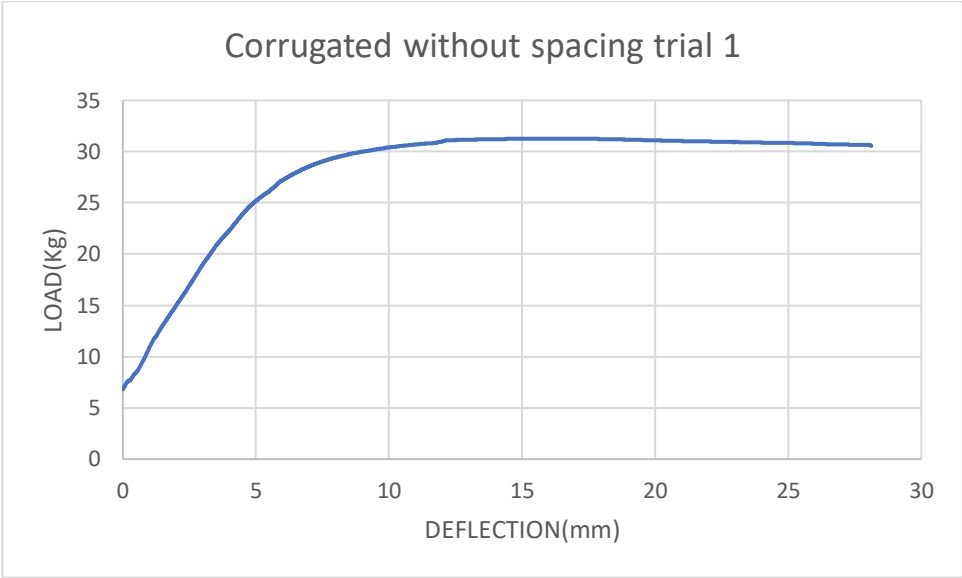


Fig 4.6 Horizontal corrugated beam without spacing trial 1

Fig 4.6 shows the load vs displacement curve for corrugated beam without spacing for trial 1. The above graph depicts the load deflection curve of the horizontal corrugated beam with 0mm spacing. It has reached the ultimate load of 31.25KN with deflection 14.390mm.

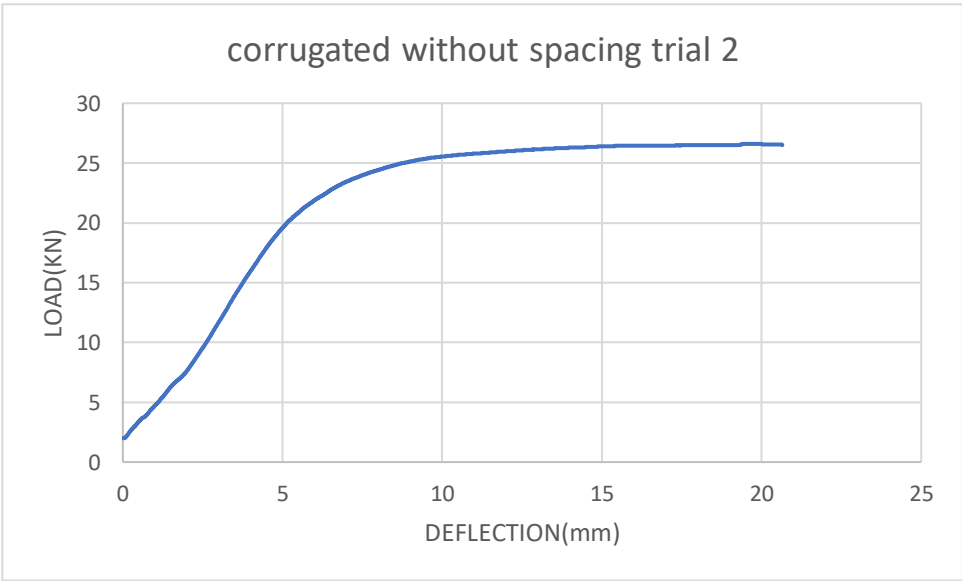


Fig 4.7 Horizontal corrugated beam without spacing trial 1

Fig 4.7 shows the load vs displacement curve for corrugated beam without spacing for trial 2. The above graph depicts the load deflection curve of the horizontal corrugated beam with 0mm spacing. It has reached the ultimate load of 26.60KN with deflection 19.390mm.

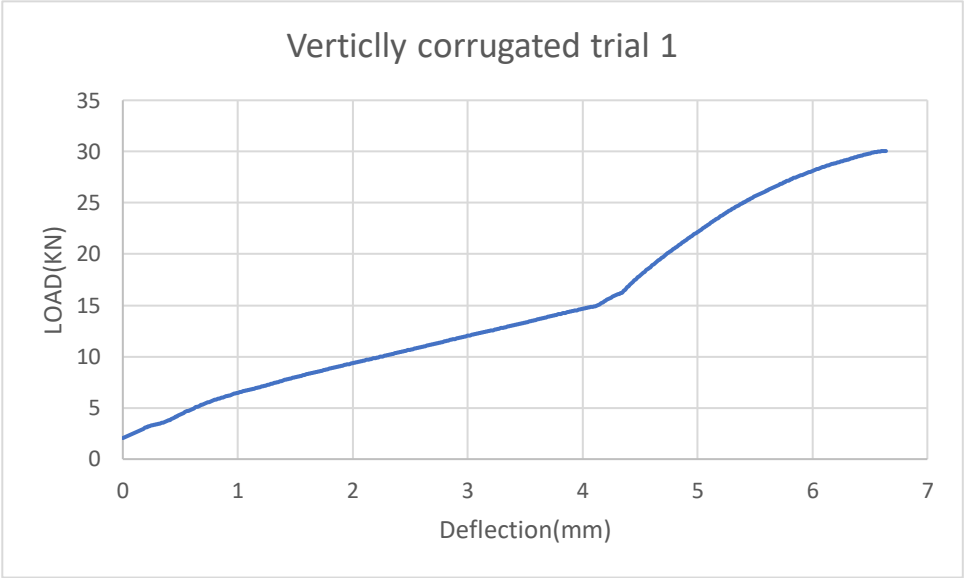


Fig 4.8 Vertically corrugated beam trial 1

Fig 4.8 shows the load vs displacement curve for Vertically corrugated beam for trial 1. The above graph depicts the load deflection curve of the vertically corrugated beam. It has reached the ultimate load of 30.050KN with deflection 6.600mm.

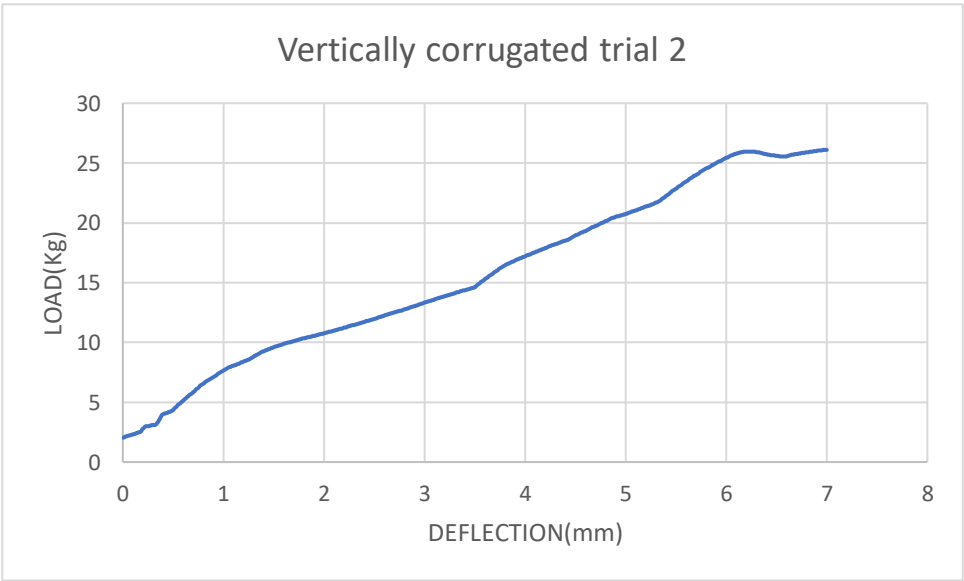


Fig 4.9 Vertically corrugated beam trial 2

Fig 4.9 shows the load vs displacement curve for Vertically corrugated beam for trial 2. The above graph depicts the load deflection curve of the vertically corrugated beam. It has reached the ultimate load of 26.10KN with deflection 6.960mm.

4.6 COMPARISON OF EXPERIMENTAL RESULTS

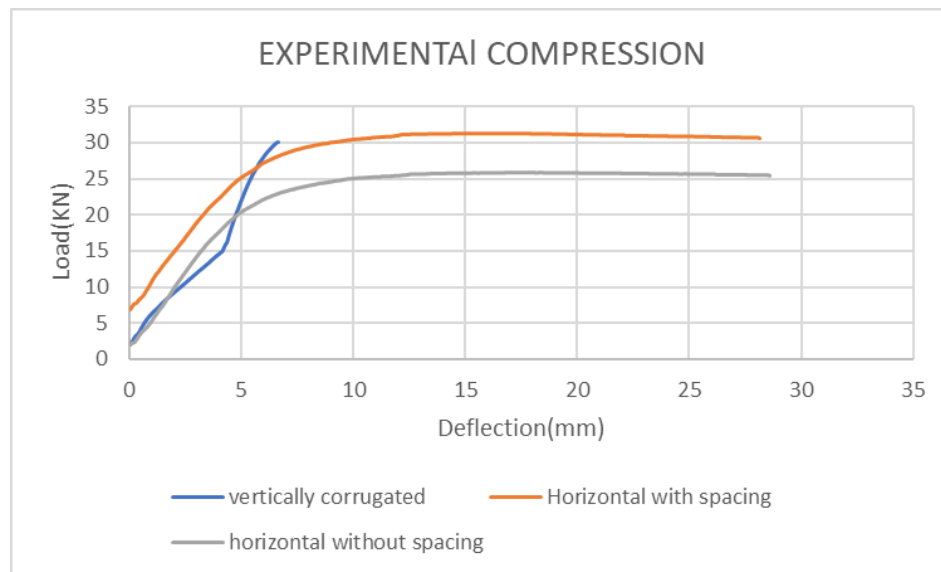


Fig 4.10 Experimental comparison

Fig 4.10 shows the experimental comparison result of horizontal corrugated with spacing, horizontal corrugated without spacing & vertically corrugated. The specimen follows the path in experimental.

4.7 DUCTILITY FOR COLD ROLLED BEAM

Ductility measures a material's ability to stretch without breaking under tensile stress. It's vital for applications like metalworking and construction.

S.NO	SPECIMEN	ULTIMATE LOAD	YIELD POINT	DUCTILITY
1.	Horizontal corrugated beam with spacing	24.05	6.825	3.523

2.	Horizontal corrugated without spacing	28.925	7.645	3.783
3.	Vertically corrugated beam	28.075	4.6	6.103

Table 4.3 Ductility

4.8 NUMERICAL RESULTS

The Deformation of horizontal corrugated beam with spacing model using ANSYS was shown in fig 4.11 to 4.16

HORIZONTAL CORRUGATED WITH SPACING

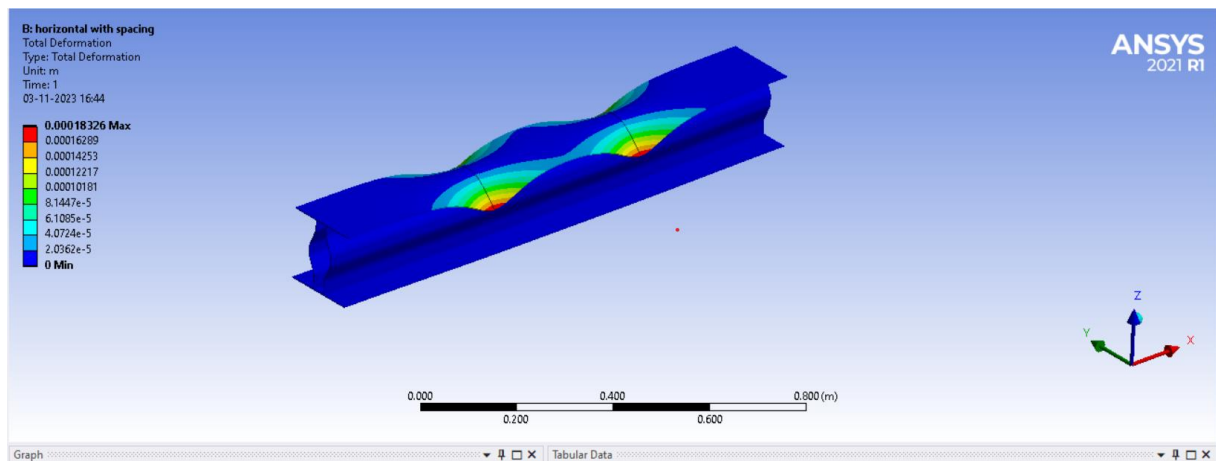


Fig 4.11 Total Deformation 30mm spacing

The above Fig 4.11 shows the Total Deformation in the horizontal corrugated beam with spacing.

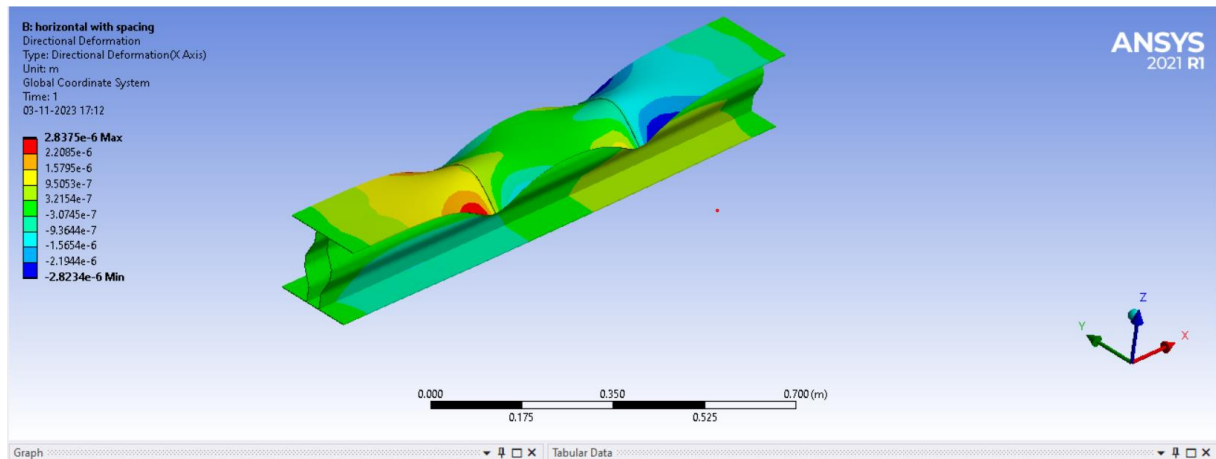


Fig 4.12 Directional Deformation 30mm spacing

The above Fig 4.12 shows the Directional Deformation in the horizontal corrugated beam with spacing.

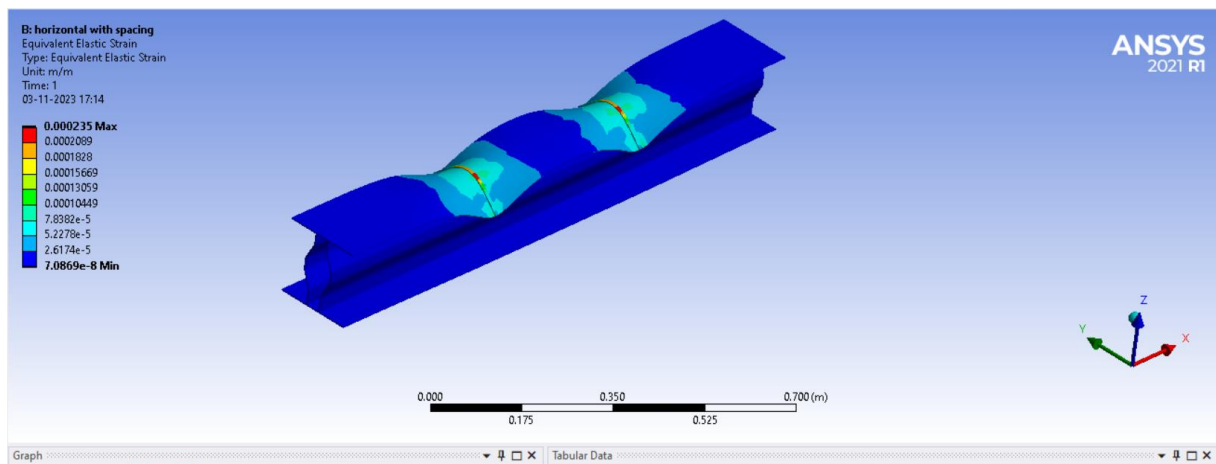


Fig 4.13 Equivalent Elastic Strain 30mm spacing

The above Fig 4.13 shows the Equivalent Elastic Strain in the horizontal corrugated beam with spacing.

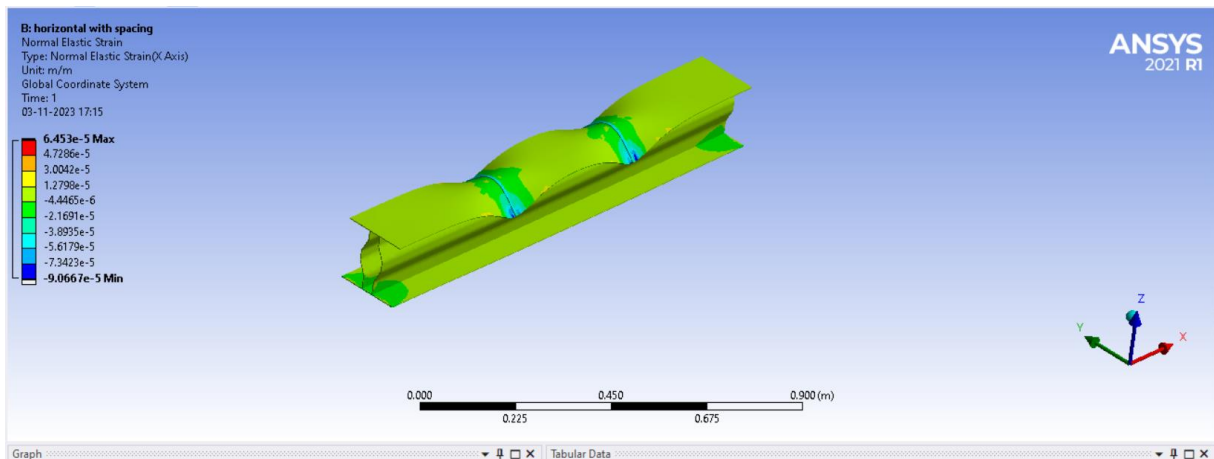


Fig 4.14 Normal Elastic Strain 30mm spacing

The above Fig 4,14 shows the Normal Elastic Strain in the horizontal corrugated beam with spacing.

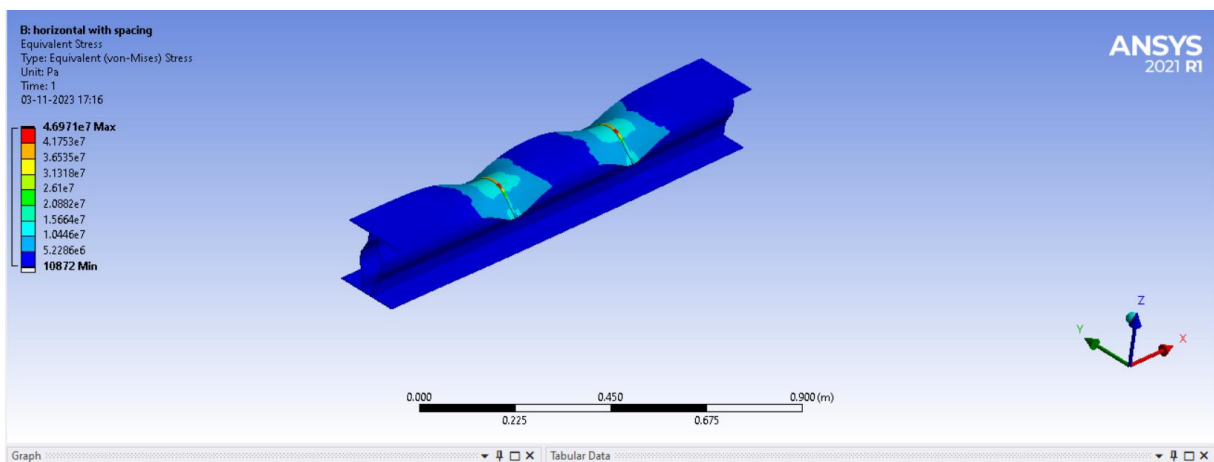


Fig 4,15 Equivalent Stress (Pa) 30mm spacing

The above Fig 4.15 shows the Equivalent Stress in the horizontal corrugated beam with spacing.

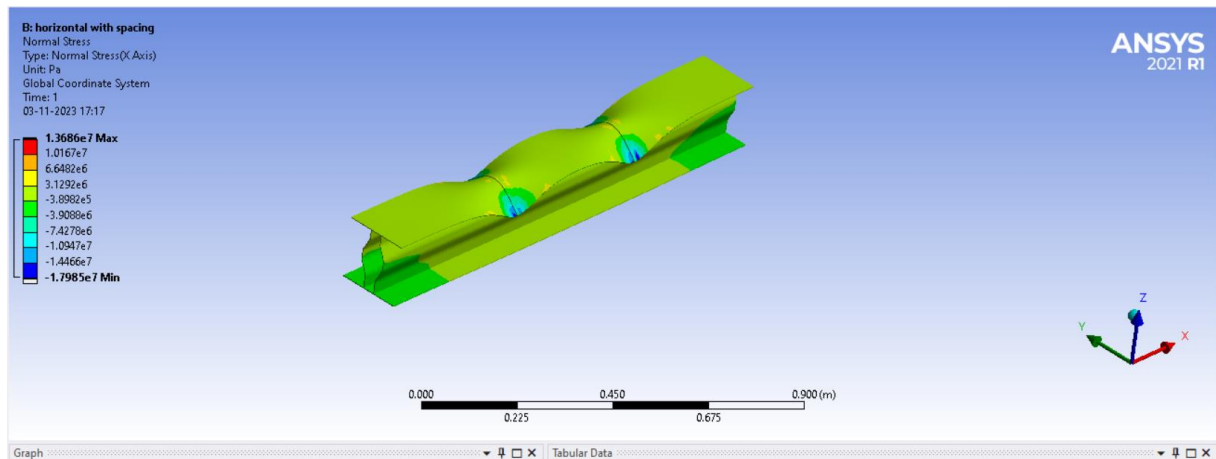


Fig 4.16 Normal Stress (Pa) 30mm spacing

The above Fig 4.16 shows the Normal stress (Pa) in the horizontal corrugated beam with spacing.

4.8 RESULT OF CORRUGATED WITHOUT SPACING

The Deformation of horizontal corrugated beam without spacing model using ANSYS was shown in fig 4.17 to 4.22

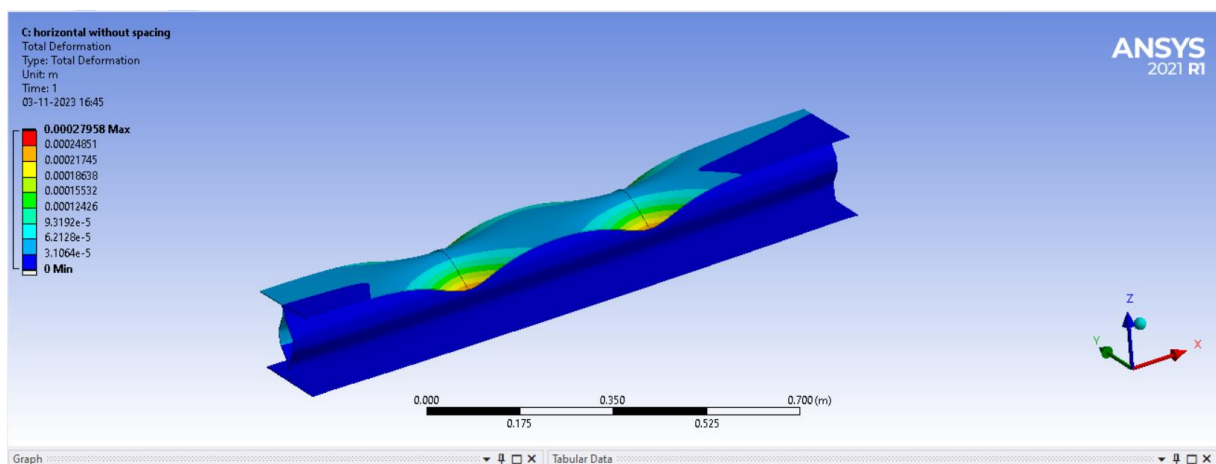


Fig 4.17 Total Deformation 0mm spacing

The above Fig 4.17 shows the Total deformation in the horizontal corrugated beam without spacing.

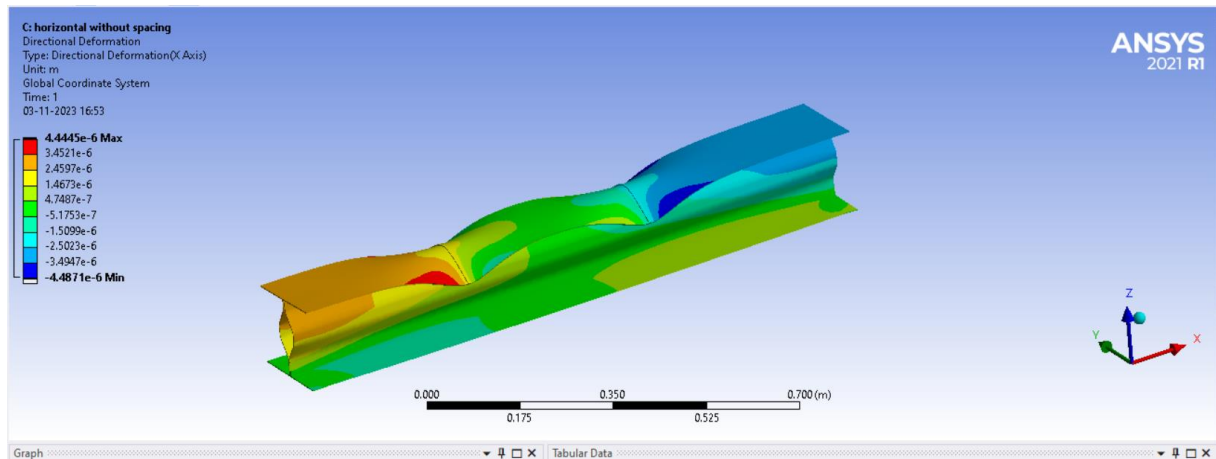


Fig 4.18 Directional Deformation 0mm spacing

The above Fig 4.18 shows the Directional Deformation in the horizontal corrugated beam without spacing.

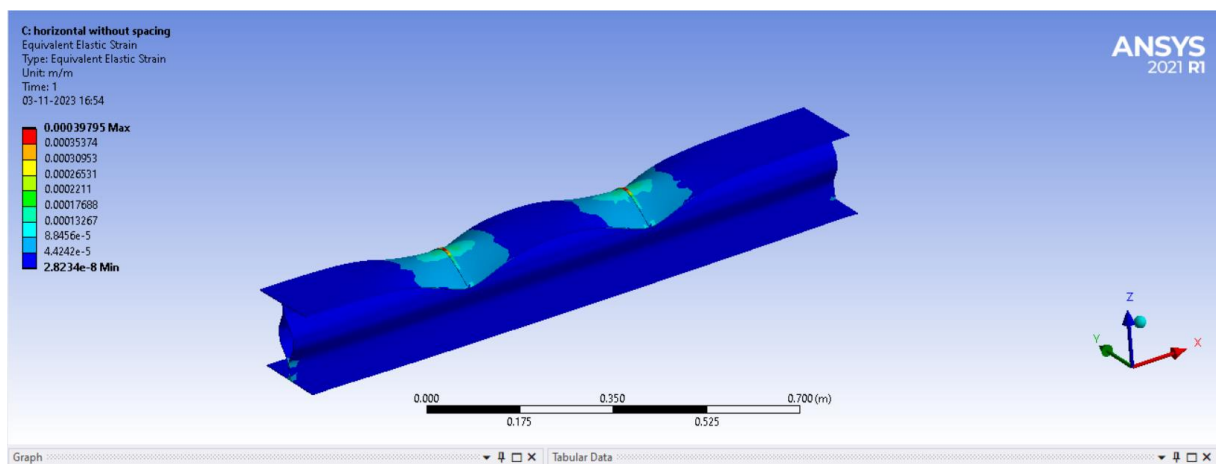


Fig 4.19 Equivalent Elastic Strain 0mm spacing

The above Fig 4.19 shows the Equivalent Elastic Strain in the horizontal corrugated beam without spacing.

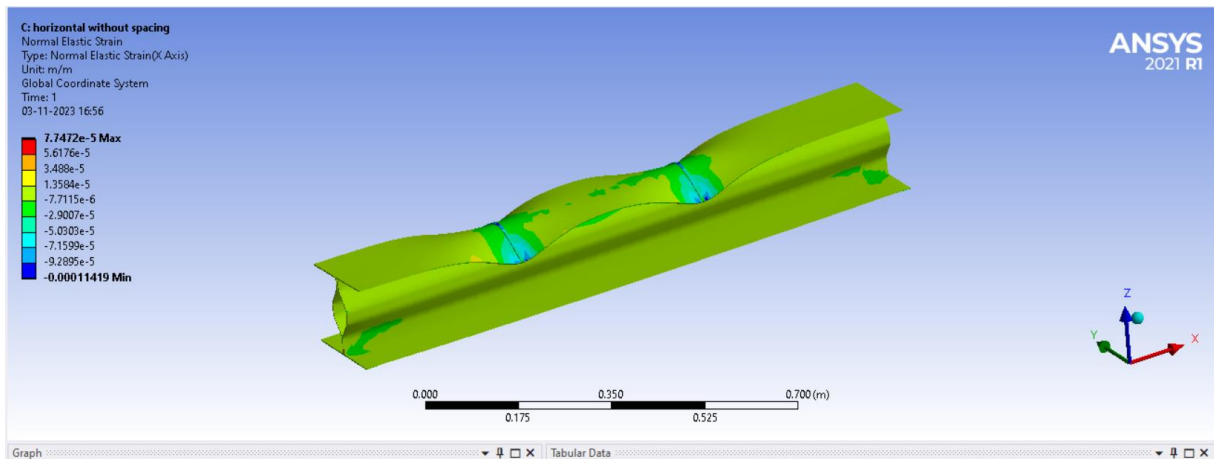


Fig 4.20 Normal Elastic Strain 0mm spacing

The above Fig 4.20 shows the Normal Elastic Strain in the horizontal corrugated beam without spacing.

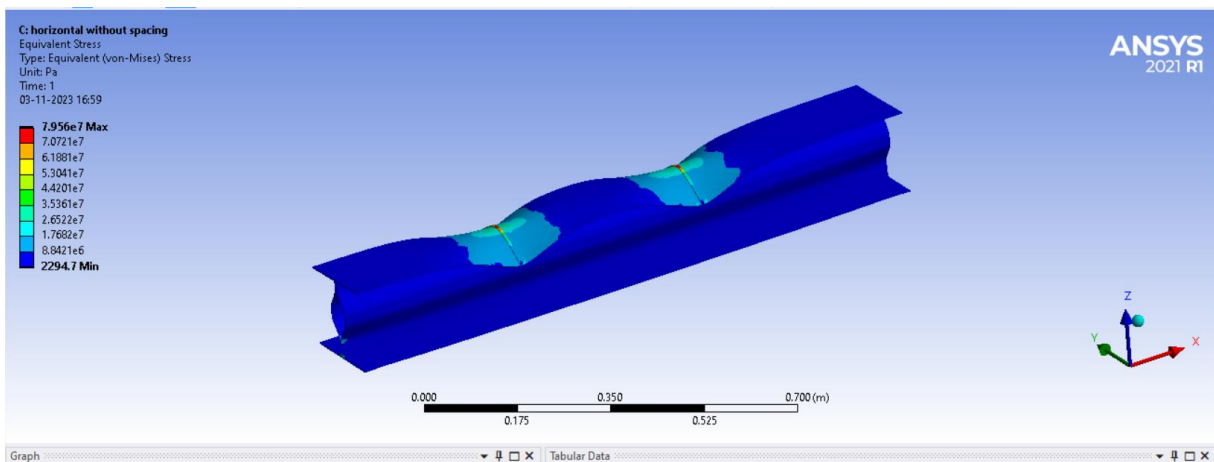


Fig 4.21 Equivalent Stress (Pa) 0mm spacing

The above Fig 4.21 shows the Equivalent Stress (Pa) in the horizontal corrugated beam without spacing.

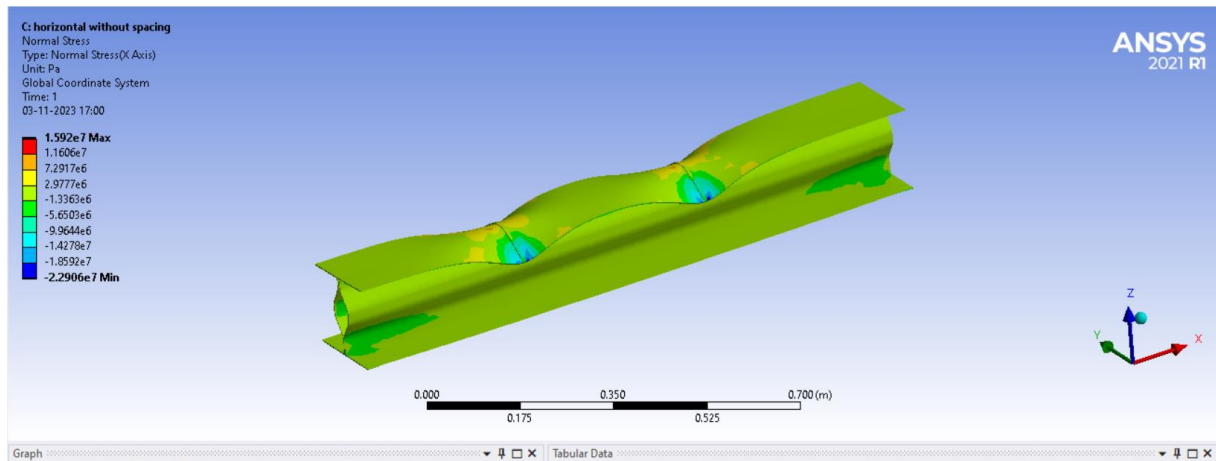


Fig 4.22 Normal Stress (Pa) 0mm spacing

The above Fig 4.22 shows the Normal Stress (Pa) in the horizontal corrugated beam without spacing.

4.10 RESULT FOR VERTICALLY CORRUGATED

The Deformation of vertical corrugated beam without spacing model using ANSY was shown in fig 4.23 to 4.28.

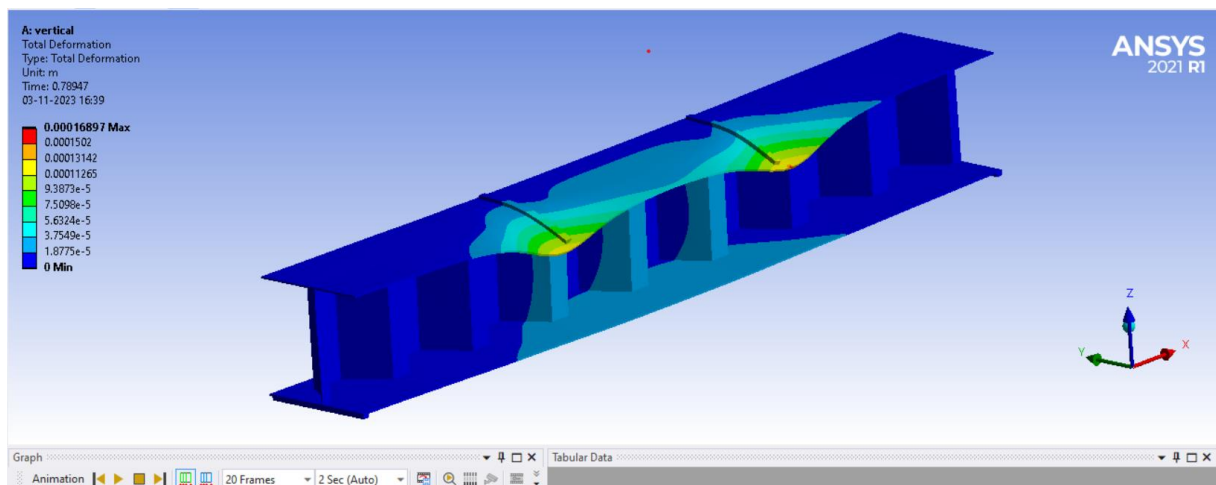


Fig 4.23 Total Deformation vertically corrugated

The above Fig 4.23 shows the Total deformation in the vertically corrugated beam.

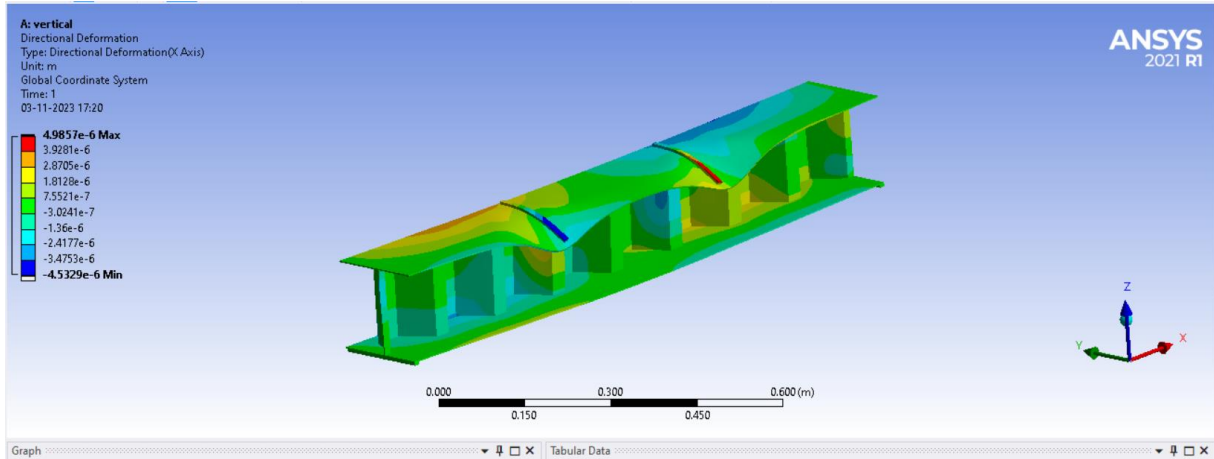


Fig 4.24 Directional Deformation vertically corrugated

The above Fig 4.24 shows the Directional Deformation in the vertically corrugated beam.

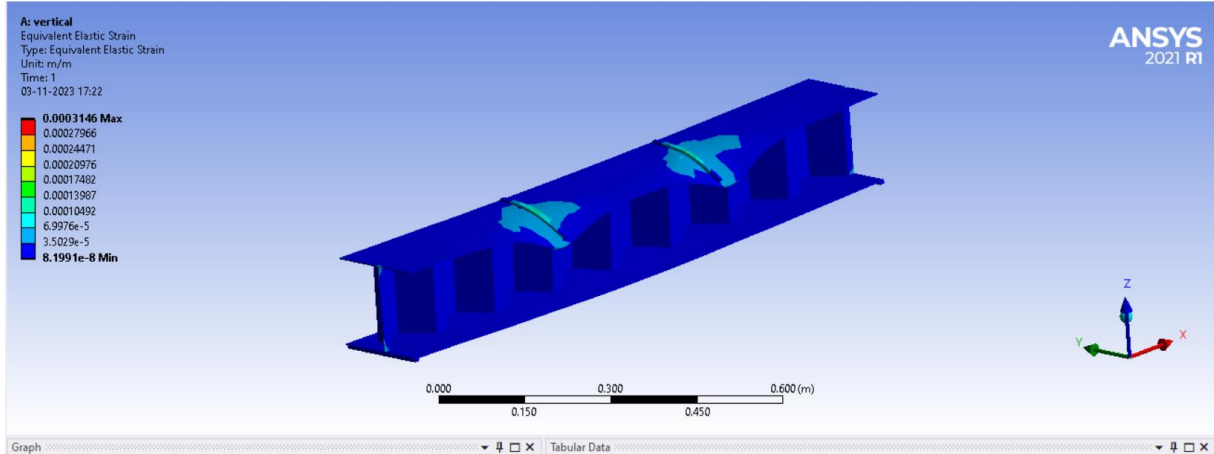


Fig 4.25 Equivalent Elastic Strain vertically corrugated

The above Fig 4.25 shows the Equivalent Elastic Strain in the vertically corrugated beam.

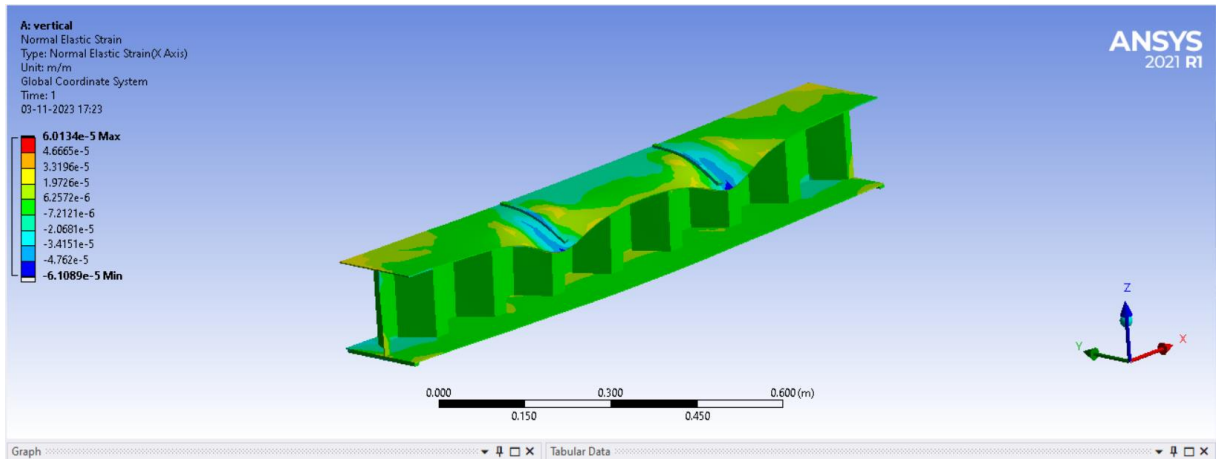


Fig 4.26 Normal Elastic Strain vertically corrugated

The above Fig 4.26 shows the Normal Elastic Strain in the vertically corrugated beam.

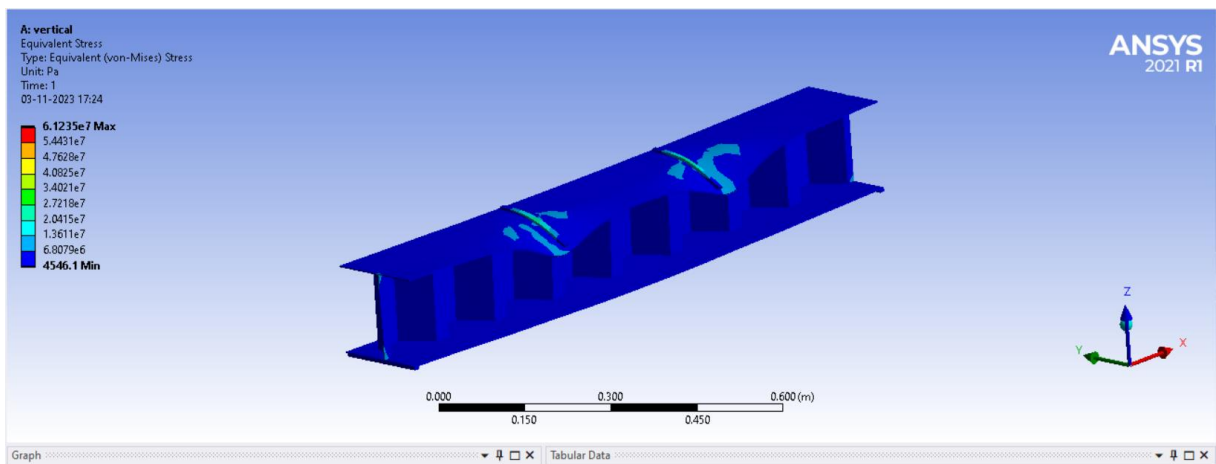


Fig 4.27 Equivalent Stress (Pa) vertically corrugated

The above Fig 4.27 shows the Equivalent Stress (Pa) in the vertically corrugated beam.

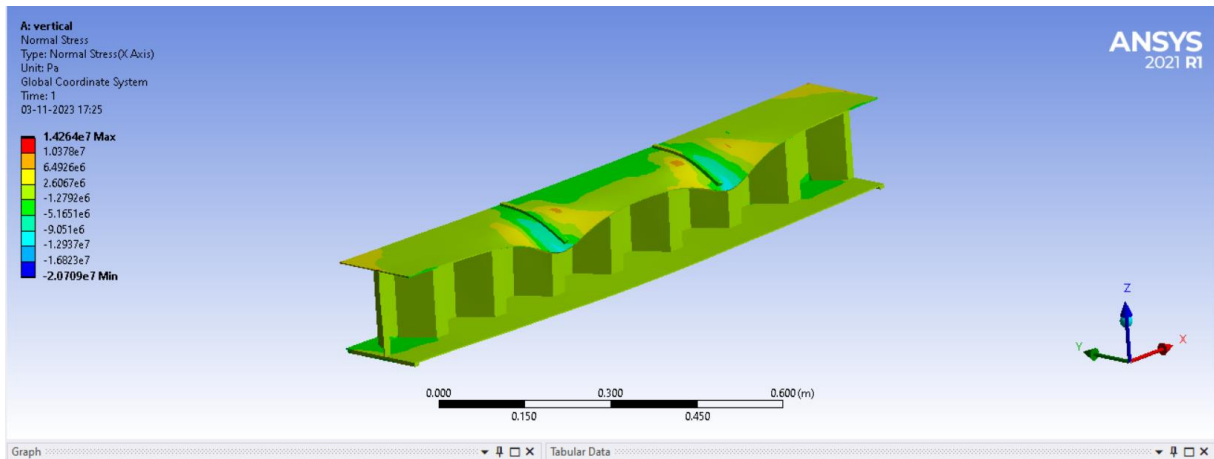


Fig 4.28 Normal Stress (Pa) vertically corrugated

The above Fig 4.28 shows the Normal Stress in the vertically corrugated beam.

4.11 ULTIMATE LOAD IN NUMERICAL RESULTS

S.NO	SPECIMEN	ULTIMATE LOAD (KN)		AVERAGE ULTIMATELOAD
		SAMPLE 1	SAMPLE 2	
1.	Horizontal corrugated beam with spacing	24.70KN	24.30KN	24.5KN
2.	Horizontal corrugated without spacing	30.25KN	29.80KN	30.025KN
3.	Vertically corrugated beam	31.50KN	30.10KN	30.8KN

Table 4.4 Ultimate Load for numerical results

4.12 LOAD VS DEFORMATION

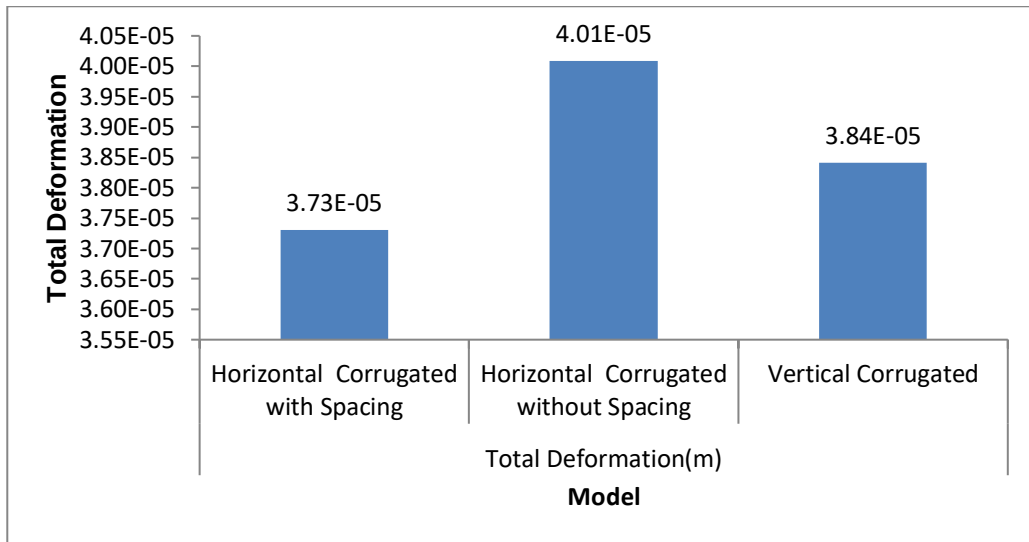


Fig 4.29 Comparison Total Deformation

The above fig 4.29 Shows the maximum & minimum values of total deformation of CFS corrugated steel beam after applying the two-point load.

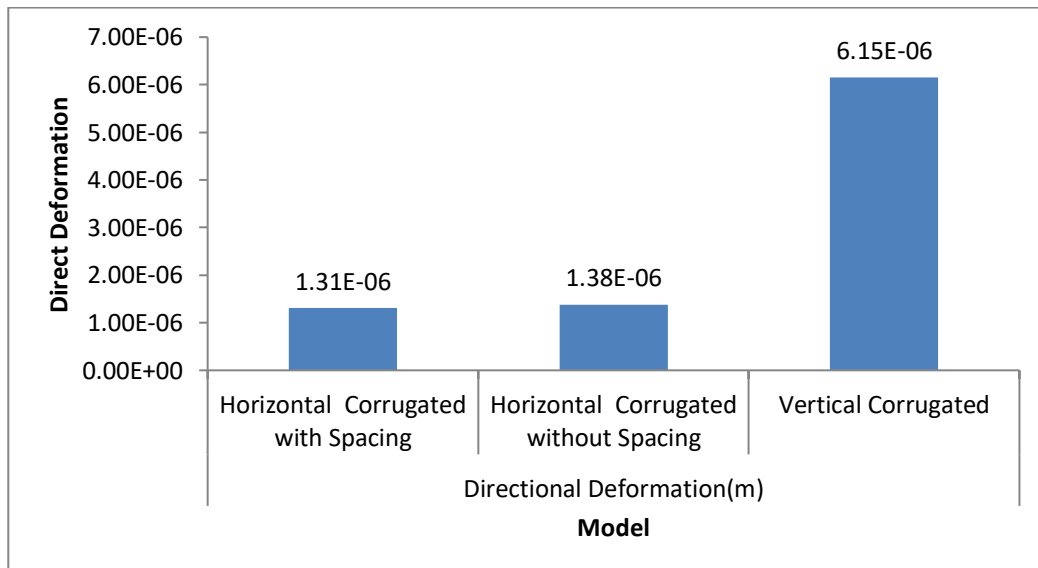


Fig 4.30 Comparison Directional Deformation

The above fig 4.30 Shows the maximum & minimum values of directional deformation of CFS corrugated steel beam after applying the two-point load.

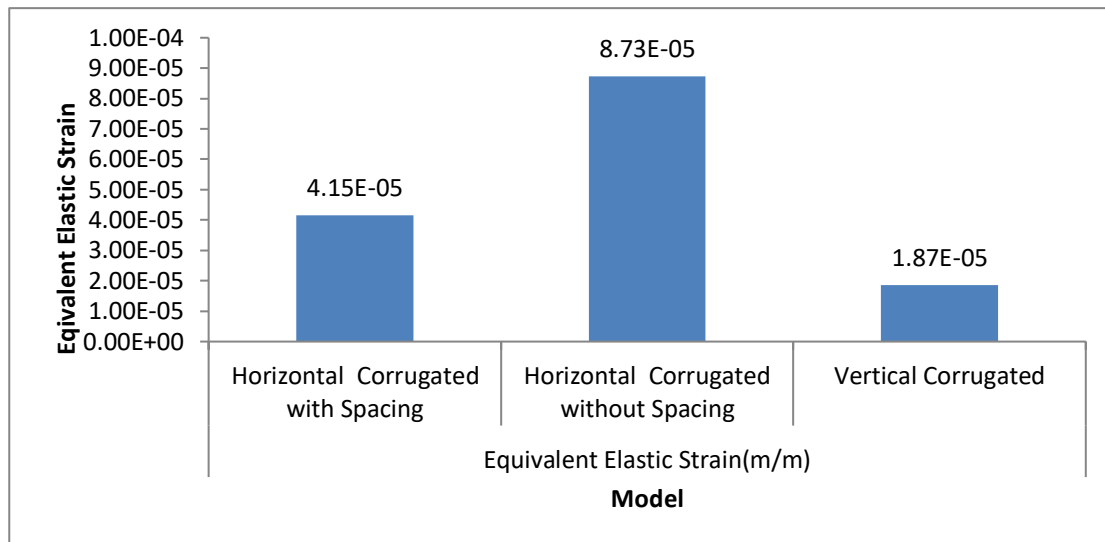


Fig 4.31 Comparison Equivalent Elastic Strain

The above fig 4.31 Shows the maximum & minimum values of equivalent elastic strain of CFS corrugated steel beam after applying the two-point load.

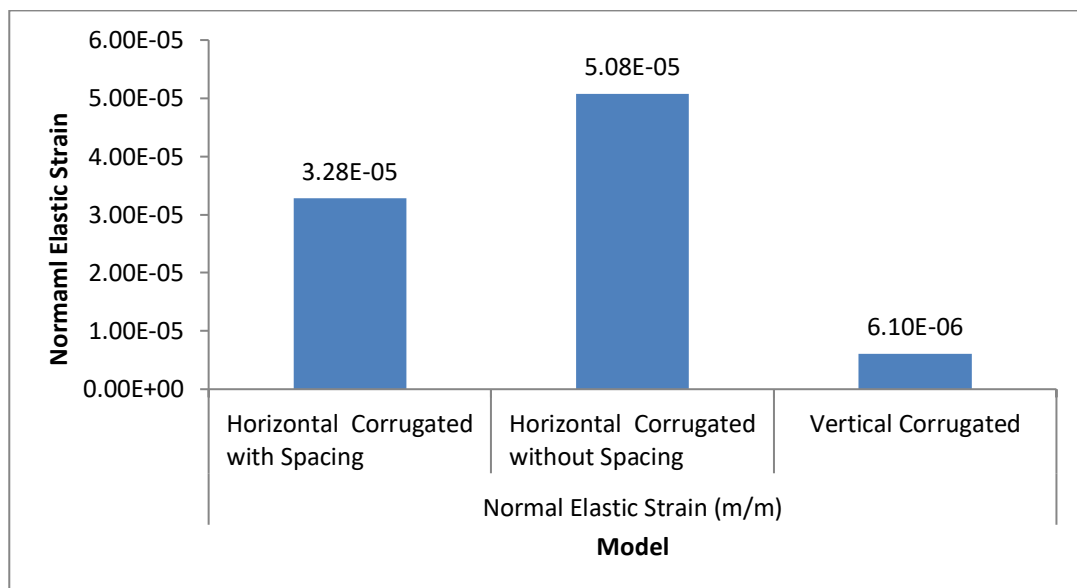


Fig 4.32 Comparison Normal Elastic Strain

The above fig 4.32 Shows the maximum & minimum vales of normal elastic strain of CFS corrugated steel beam after applying the two-point load.

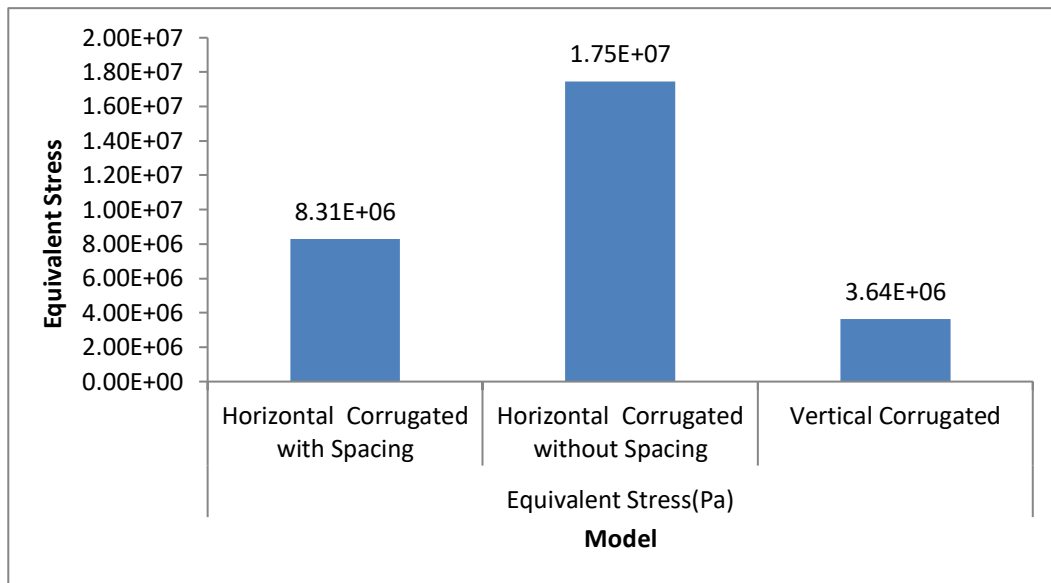


Fig 4.33 Comparison Equivalent Stress (Pa)

The above fig 4.33 Shows the maximum & minimum vales of equivalent stress (Pa) of CFS corrugated steel beam after applying the two-point load.

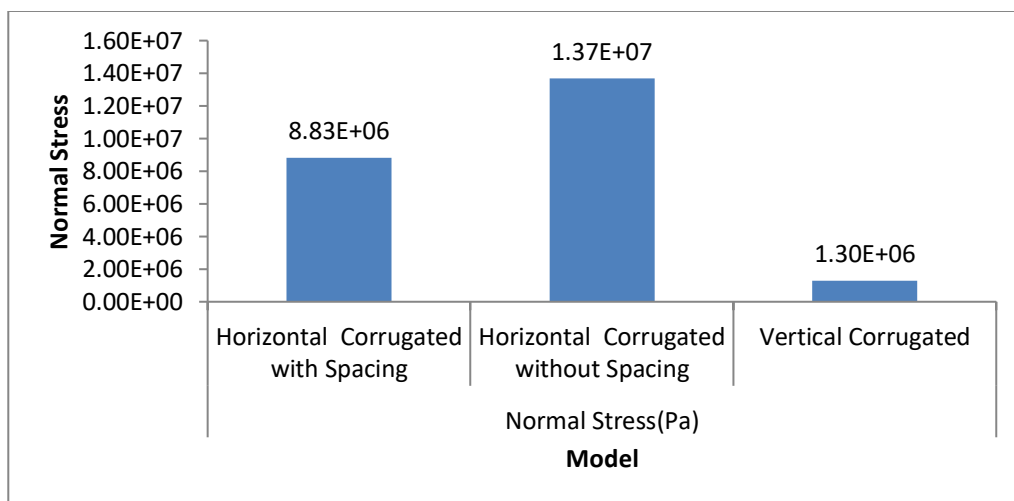


Fig 4.34 Comparison Normal Stress (Pa)

The above fig 4.34 Shows the maximum & minimum vales of normal stress (Pa) of CFS corrugated steel beam after applying the two-point load.

4.13 COMPARISON OF NUMERICAL RESULTS

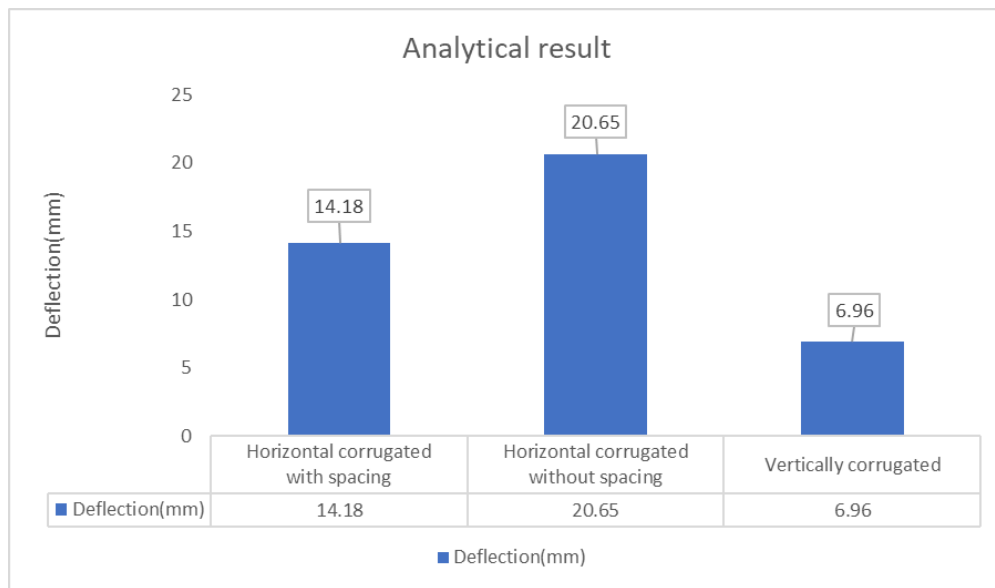


Fig 4.35 Analytical comparison

The above fig 4.35 shown the analytical comparison of deflection when load applied on the corrugated beam. In this analytical data the Vertically corrugated beam is good when compare to horizontal corrugated beam with spacing & horizontal corrugated without spacing. The vertically corrugated beam reaches the minimum deflection of 6.69mm.

4.14 COMPARISON OF EXPERIMENTAL & NUMERICAL RESULTS

ULTIMATE LOAD

S.NO	SPECIMEN	ULTIMATE LOAD (KN)		% LOAD(KN)
		EXPERIMENTAL RESULTS	NUMERICAL RESULTS	
1.	Horizontal corrugated beam with spacing	25.80KN	24.70KN	4.26KN% decrease in load
2.	Horizontal corrugated without spacing	31.25KN	30.25KN	3.2KN% decrease in load
3.	Vertically corrugated beam	30.050KN	31.50KN	4.48KN% increase in

				load
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Table 4.3 Percentage of load

4.15 COMPARISON OF RESULTS

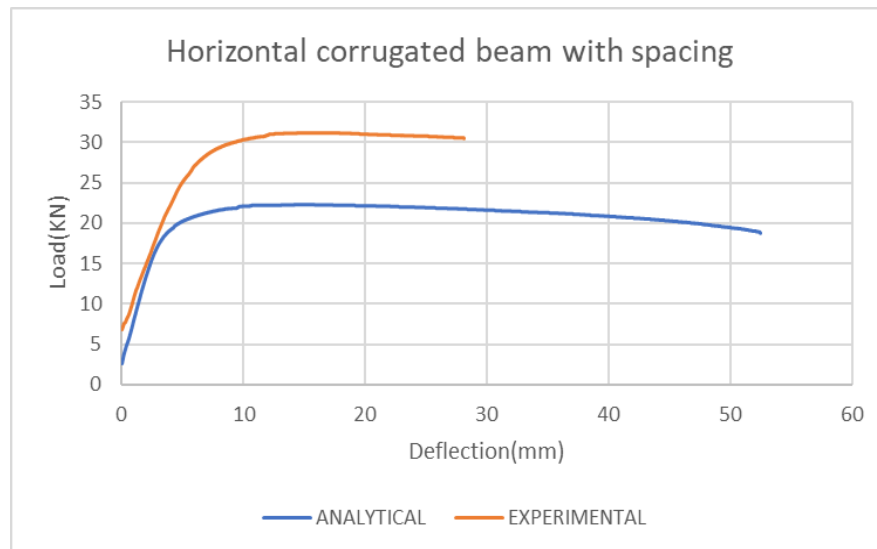


Fig 4.36 Comparison of corrugated beam with spacing

Fig 4.36 shows the load vs deflection curve for Horizontal corrugated beam with spacing. The above graph depicts that the load & deflection curve for Horizontal corrugated beam with 30mm spacing. The specimen follows the similar path both in analytical & experimental.

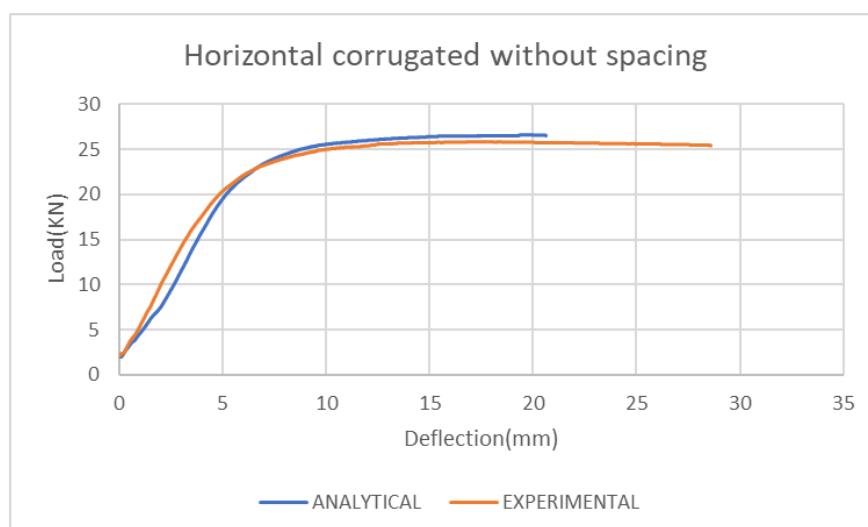


Fig 4.37 Comparison of corrugated beam without spacing

Fig 4.37 shows the load vs deflection curve for Horizontal corrugated beam without spacing. The above graph depicts that the load & deflection curve for Horizontal corrugated beam with 0mm spacing. The specimen follows the similar path both in analytical & experimental.

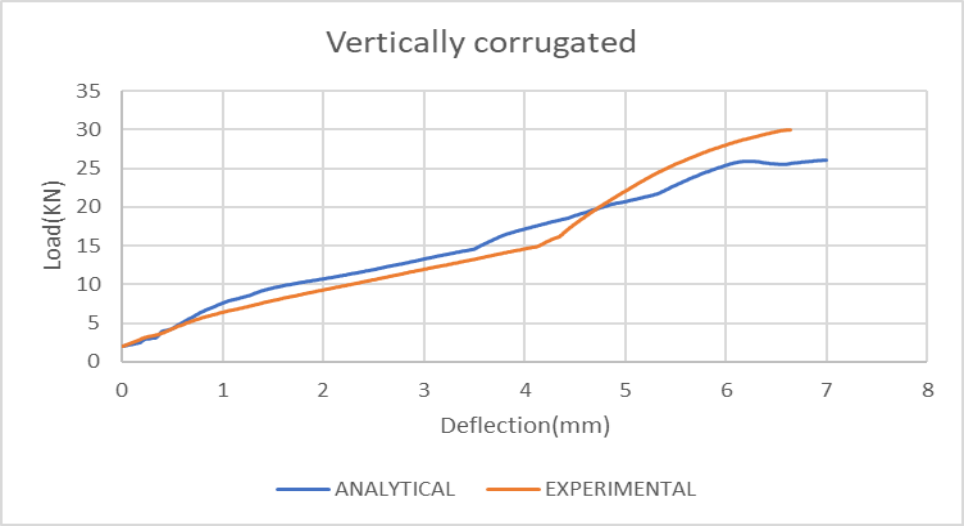


Fig 4.38 comparison Vertically corrugated beam

Fig 4.38 shows the load and deflection curve for vertically corrugated beam. The above graph depicts that the load & deflection curve for vertically corrugated beam. The specimen follows the similar path both in analytical & experimental.

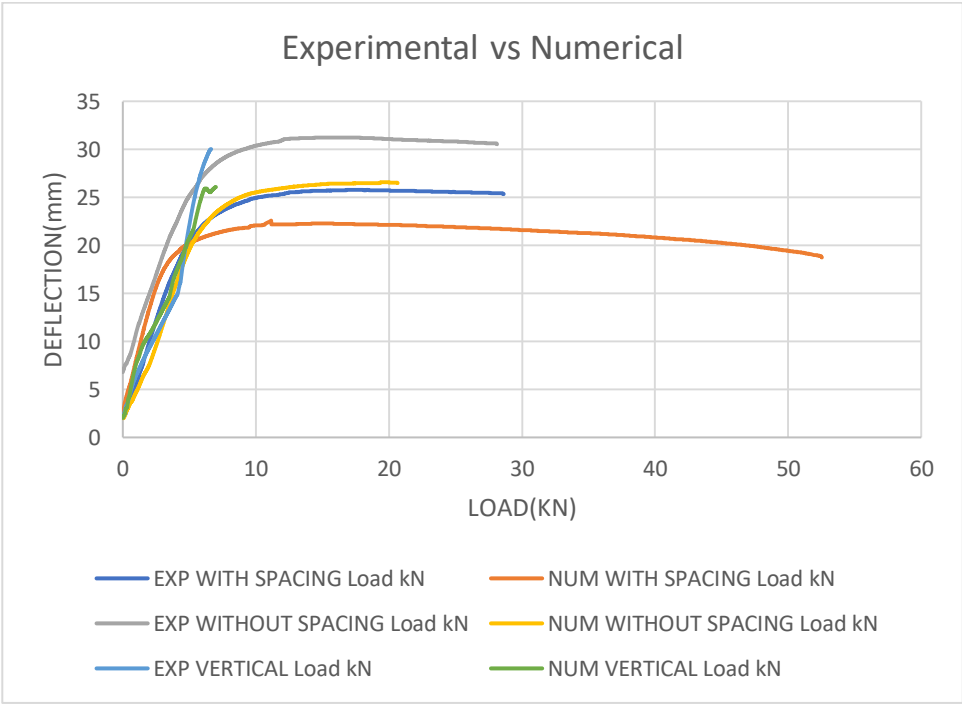


Fig 4.39 Experimental vs Numerical

Fig 4.39 shows the load vs deflection curve for both experimental & numerical.

CHAPTER – 5

5.1 SUMMARY OF THE WORK

This study examines and compares the structural properties of cold-formed corrugated steel and other channel sections. Beams with different corrugation patterns were designed using CATIA software, including horizontal corrugated beams with and without spacing, as well as vertically corrugated beams. The aim was to assess the structural strengths and weaknesses of these designs, using ANSYS software for detailed examination. The research seeks to uncover the efficiency and structural variances among several types of corrugated steel beams. It investigates the flexural behavior of cold-formed steel corrugated beams, which are susceptible to buckling due to their thin-walled nature. Three corrugated section configurations were tested, revealing unique behaviors that offer advantages such as increased ultimate strength and reduced deflection compared to straight sections. Vertically corrugated beams performed significantly better in both experimental and analytical analyses, exhibiting the minimum deflection of 6.600mm. The study's findings hold potential implications for future design decisions and engineering applications, providing valuable insights for

enhancing the structural performance of cold-formed corrugated steel across various design and building contexts.

5.2 CONCLUSION

The Flexural behaviour of cold formed corrugated steel beam is studied by Analytical & Experimental. In this study consider vertically corrugated beam obtains a high resistance to the applied two-point loading condition and corrugated acts as a web stiffener for the beam. The maximum load obtained were 26.10KN from the ANSYS result and 30.050KN from experimental test for vertically corrugated section for which corresponding deflection were recorded as 6.960mm and 6.6mm. Other specimens namely Horizontal corrugated with 30mm spacing and Horizontal corrugated with 0mm spacing were resisting the load nearly equal to half the value of load resisted by vertically corrugated beam both analytically and experimentally.

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