AXIAL COMPRESSIVE PERFORMANCE OF BI-DIRECTIONAL INNOVATIVE CORRUGATED STAINLESS STEEL CORE PLATE WALL

Fidha Fathima P J[1], Dr. George K George[2], Muhammed Ajmal[3], Lakshmy E G[4]

[1]M.Tech Student, Structural Engineering, KMEA Engineering College, Kerala, India
[2]Assistant Professor, Dept. of Civil Engineering, KMEA Engineering College, Kerala, India
[3]Assistant Professor, Dept. of Civil Engineering, KMEA Engineering College, Kerala, India
[4]Assistant Professor, Dept. of Civil Engineering, KMEA Engineering College, Kerala, India

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Abstract - *Stainless Steel Corrugated Core Plate Walls (SSCPWs) represent a novel class of structural wall systems composed of thin stainless steel face plates interconnected by stainless steel core tubes arranged orthogonally. In this study, a novel bi-directional corrugated SSCPWs is analyzed under axial compression. A parametric investigation is conducted to evaluate the effects of variables such as core tube spacing, tube diameter, and face plate thickness across two distinct wall geometries: L-shaped and T-shaped. Additionally, the study examines how core tube connectors and geometric configurations influence the ultimate load-carrying capacity of the corrugated SSCPWs. Finite Element Analysis (FEA) is carried out using ANSYS Workbench 2024 R2 to simulate the structural behaviour under compressive loads.*

Key Words: Stainless Steel Core Plate Wall (SSCPW), bi-directional corrugated SSCPW, axial compression, core tubes, ultimate load carrying capacity, Ansys Workbench 2024 R2

1.INTRODUCTION

The bi-directional stainless steel core plate wall (SSCPW) is intended to offer superior performance in both seismic and non-seismic applications by enhancing lateral force resistance in two orthogonal directions. This multi-directional stability enables the system to efficiently distribute loads under varying conditions. Typically, an SSCPW consists of dual stainless steel plates connected by orthogonally placed core tubes, with copper brazing used to weld the components. These walls can be manufactured in various configurations, including T-shaped, L-shaped, or cross-shaped layouts, depending on architectural and structural needs. By modifying the arrangement, SSCPWs can serve multiple structural purposes such as beams, columns, floors, or wall components. [1,2]

1.1 Bi-directional (L And T-shaped) Stainless Steel Core Plate Walls

L-shaped core walls are particularly suited for buildings with irregular or asymmetric floor plans. They are often placed at corners, where enhanced torsional rigidity is required, or used to enclose service cores like stairwells or elevator shafts. T-shaped core walls, on the other hand, are deployed where structural resistance is needed in two perpendicular directions. These are commonly located along major axes or centrally within buildings, integrating with vertical circulation elements. Their unique shape enables efficient force transfer and reduces reliance on moment-resisting frames, which helps in achieving open and flexible interior layouts. Their configuration allows them to act as a central spine, providing stiffness and strength in two directions. [1,2]

1.2 Corrugated Stainless Steel Core Plate Walls

The corrugated profile of SSCPWs, especially when using trapezoidal patterns, contributes significantly to improved mechanical performance. Compared to flat plate systems of equivalent thickness, corrugated designs offer superior ductility, energy dissipation, and load-bearing capacity. These characteristics make them highly suitable for use in earthquake-prone zones, where absorption and dissipation of seismic energy are critical. Moreover, the corrugations enhance impact resistance by absorbing local stresses through deformation, effectively limiting damage. This increased stiffness also allows for thinner panels to be used without compromising strength, reducing the overall weight of the structure and potentially lowering foundation demands and installation time.

2. OBJECTIVES

The main objective of this research is to conduct a comprehensive comparative study on the axial load-carrying capacities of T-shaped and L-shaped corrugated stainless steel core plate walls, focusing on their structural behavior, load distribution mechanisms, and overall performance under axial loading conditions, in order to identify the most efficient configuration for structural applications.

3. FINITE ELEMENT MODELLING

3.1 General

To evaluate the axial compressive performance of the novel bi-directional corrugated SSCPWs, advanced finite element simulations were conducted using ANSYS Workbench 2024 R2. Non-linear analysis is employed to investigate the plastic behaviour of bi-directional corrugated stainless steel core plate walls, specifically in T-shaped and L-shaped configurations. The incorporation of corrugated core plates significantly improves vertical stiffness, enhances load-bearing capacity, and increases resistance to buckling.

3.2 Geometry

The geometry of the bi-directional SSCPW was created using ANSYS Design Modeler. Both the face plates and core tubes were modeled from austenitic stainless steel grade S30408. The geometric details of the SSCPW specimen are illustrated in Fig -1, with corresponding parameters summarized in Table 1. The overall height, width and thickness of the wall are denoted by a, b and h, respectively, while b_1 and b_2 represents the width of two wall limbs. The plate thickness is indicated by t_f. For the core tubes, d represents the outer diameter, and t_w is the core tube thickness. The center-to-center distance between the tubes is defined as l_{mz} in the vertical direction and l_{ny} in the horizontal directions. Correspondingly, the clear spacing between adjacent core tubes is denoted as d_m and d_n for the vertical and horizontal orientations, respectively. Fig -2 displays the geometric parameters of the trapezoidal corrugated plate, while Fig -3 and Fig -4 represent the top and isometric views of the T-shaped and L-shaped SSCPW specimens, respectively. The material properties for the stainless steel used are provided in Table 2. To accurately capture the plastic behavior of the material, a multi-linear isotropic hardening model was employed [1,2]

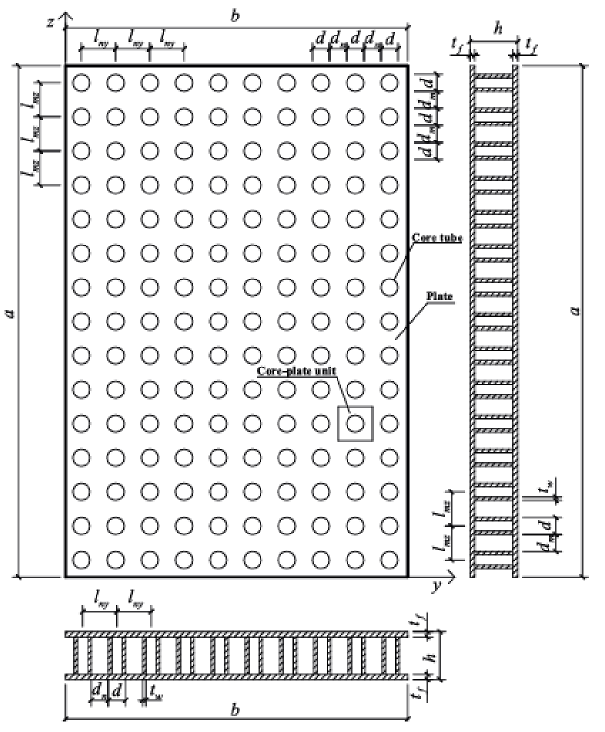

Fig -1: Schematic diagram of geometric parameters of SSCPW'

Table -1: Specification of design parameters of SSCPW

Geometric Parameters	Dimension (mm)
Length of wall (b)	1000 mm
Height of wall (a)	3000 mm
Width of wall (h)	152 mm
Thickness of steel plate (t_f)	2.5 mm
Diameter of core tube (d)	51 mm
Thickness of core tube (t_w)	0.5 mm
Spacing of core tubes in horizontal direction (l_{ny})	121 mm
Spacing of core tubes in vertical direction (l_{mz})	100 mm

Table -2: Material Properties of S30408 stainless steel

Material	Poisson's ratio	Young's modulus (MPa)	Yield strength (MPa)	Ultimate strength (MPa)
S30408 Stainless Steel	0.3	193,949	328	703

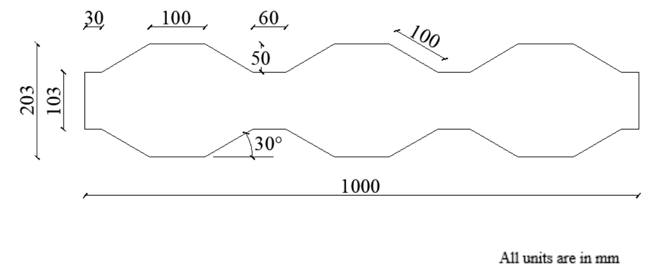

Fig -2: Geometry of trapezoidal corrugated plate

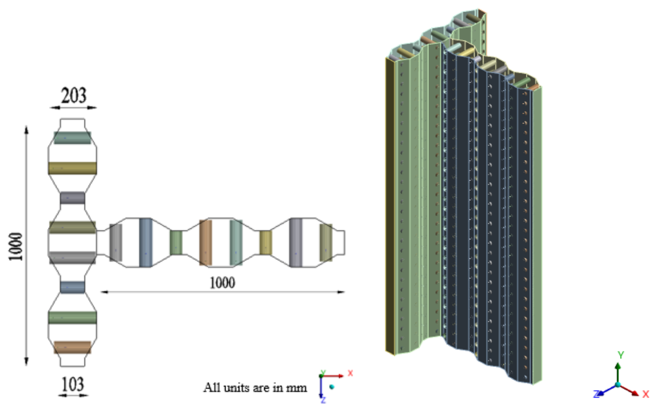

Fig -3: Top view and isometric view of T-shaped corrugated SSCPW

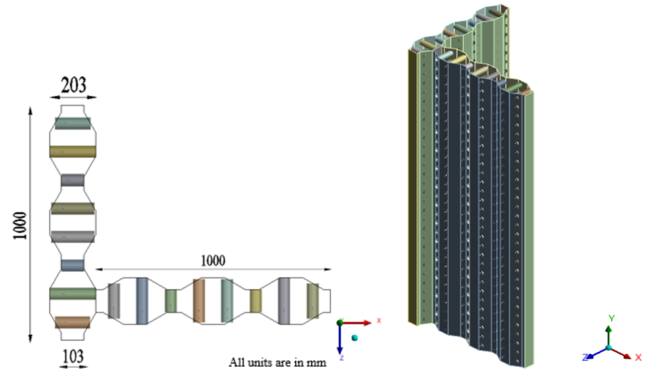

Fig -4: Top view and isometric view of L-shaped corrugated SSCPW

3.3 Meshing

Meshing divides the whole component into a finite number of small elements as per requirement. Adaptive size meshing of 50 mm size is used for the meshing of the specimen model. The element type used for connector is BEAM 188, and for the plates SHELL 181 is used. The element shape used is quadrilateral.

3.4 Loading and Boundary Conditions

The boundary conditions are set to simulate realistic constraints: the bottom of the SSCPW model is fully fixed, restraining all degrees of freedom, while the top is hinged, allowing rotation but restricting horizontal movements in the X and Y directions. A displacement-controlled compressive load is applied along the centroidal axis of the model to replicate axial compression. Fig -5 illustrates the meshing pattern and the application point of axial load on the T-shaped corrugated SSCPW.

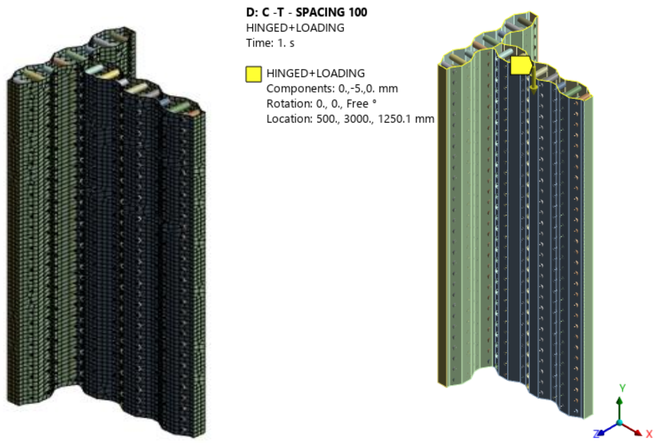

Fig -5: Total deformation of T-shaped and L-shaped corrugated SSCPW

4. RESULTS AND DISCUSSIONS

4.1 Comparative Study of the Axial Load Carrying Capacity of T And L-Shaped Corrugated SSCPW

A comparative study of T and L-shaped corrugated SSCPW under axial loading was done. In this study, models of 2.5 mm plate thickness, 51 mm core tube diameter and 100 mm vertical spacing of core tubes were considered. Thickness of the core tubes were taken as 0.5 mm for all the models. Chart -1 shows the load vs deflection graph of the T and L-shaped corrugated SSCPW. Table 3 shows the ultimate load and deformation values of the SSCPW. CT-SPACING 100 and CL-SPACING 100 represents corrugated T-shaped and corrugated L-shaped core walls with 100mm vertical spacing of core tubes respectively.

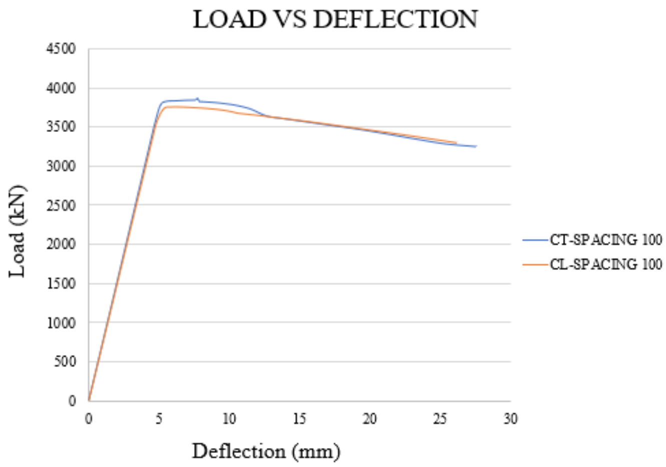

Chart -1: Load vs deflection curve of T and L-shaped corrugated SSCPW

Table -3: FEA results of T and L-shaped corrugated SSCPW under axial load

Case	Model Name	Ultimate Deformation (mm)	Ultimate Load (kN)
T-Shaped Corrugated SSCPW	CT-SPACING 100	7.72	3865.80
L-Shaped Corrugated SSCPW	CL-SPACING 100	6.33	3749.30

From the journals, the axial load capacity of T and L-shaped flat type SSCPW were 1400 kN and 1180 kN. Axial load capacity of T-shaped corrugated SSCPW increased by 2.76 times and for the L-shaped wall the axial load capacity increased by 2.18 times, when compared with the flat type SSCPW of T and L-shapes. [1,2]

Under axial loading, T-shaped walls exhibited consistently higher load-bearing capacity than L-shaped walls under similar configurations. There was an approximately 3.1% increase in the load carrying capacity in T-shaped walls than in L-shaped walls. This is attributed to the geometric efficiency of the T-shaped cross-section, which has a greater moment of inertia and sectional depth, leading to enhanced buckling resistance and better axial force distribution. The T-shaped walls tend to have more symmetrical lateral stiffness, minimizing stress concentrations at re-entrant corners and promoting a more uniform stress flow under compression. Fig -6 shows the total deformation diagrams of the T and L-shaped corrugated SSCPWs.

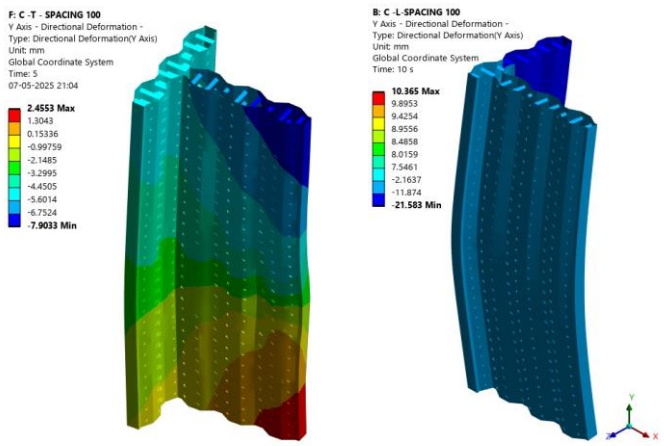

Fig -6: Deformation shapes of T-shaped and L-shaped corrugated SSCPW

5. CONCLUSION

The load carrying capacity of the SSCPWs were increased by introducing corrugations to the plates of the core wall. These bi-directional corrugated walls were tested under axial loading conditions by varying different parameters such as plate thickness, core tube diameter and vertical spacing of the core tubes. Also, the influence of the core tubes and the efficiency of the geometric shape of the core walls were also studied.

The main conclusions obtained from the analysis are:

- Axial load capacity of T-shaped corrugated SSCPW increased by 2.76 times and for the L-shaped wall the axial load capacity increased by 2.18 times, when compared with the flat type SSCPW of T and L-shapes.
- Axial load capacity of T-shaped corrugated SSCPW is 3.1% more than the L-shaped wall. This increase is attributed to the geometric efficiency of the T-shaped cross-section, leading to enhanced buckling resistance and better axial force distribution.
- The T-shaped corrugated SSCPW with 2.5mm plate thickness, 51mm outer diameter of core tubes and 100mm vertical spacing of cores provided the maximum load carrying capacity under axial loading.

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