

Experimental studies on fiber cement boards under compression loading

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Abstract

Fibre cement boards are widely used as external cladding in cold-formed steel (CFS) building systems, due to their superior durability and weather-resistant characteristics. These boards are made of cement and reinforced with short, randomly oriented, non-hazardous cellulose fibres. Characterizing the observed stress-strain behaviour of the board under compression loading is a challenging task due to: a) loading eccentricity which induces bending, b) global buckling caused by high slenderness of the specimen, and c) stress concentrations at the loading end resulting in bearing failure. The above failures are usually handled at the specimen preparation stage by gluing additional numbers of boards to reduce slenderness, and by the inclusion of end tabs to avoid bearing failure. However, the introduction of glue in the board specimen may alter the strength characteristics and modify the load transfer path. Preliminary studies on the board specimens following the standard testing procedure (ASTM D3501) for wood-based panels fail to simulate the real material behaviour of the boards under compression loading. It is clear that the existing test methods have several shortcomings and hence cannot be adopted for fibre cement boards. In this paper, the fibre cement boards were tested under compression loading using combined loading compression (CLC) test fixture. This paper presents the details of the experimental study and the results for board of thicknesses 8, 10, and 12 mm, respectively. The test matrix includes specimens tested in both longitudinal and transverse directions. Under compression loading, the board exhibited nonlinear behaviour up to failure. The structural parameters like ultimate stress, ultimate strain, Young's modulus, and Poisson ratio in both longitudinal and transverse directions were obtained. This study proposes a nonlinear constitutive model for the board material.

Keywords: Sheathing material, Fibre cement board, Compression loading, Experimental study, Constitutive model

1. Introduction

In recent years, the Cold-formed steel (CFS) wall panel-based building system is becoming an attracting alternative, and considered as one of the sustainable building solutions, particularly in the mid-rise building sector [1]. A typical CFS wall panel building system is an assembly CFS wall panels, floor panels, and roof [2]. The CFS wall panel consists of CFS framing members, clad on the both exterior and interior faces with single skin sheathing made of material like wood, gypsum, cement or steel. The CFS framing members mainly include CFS channel sections with and without lips. The joists (channel with lips) framing between the wall panels, with sheathing material attached on top of it, act as floor system in this building system. The connection between CFS framing members and the sheathing material are often made by self-drilling screws. A range of sheathing material available in the market for the use in CFS building system, namely gypsum plasterboard, Cement Particleboard (CP), Fibre Cement Board (FCB), Oriented Strand Board (OSB) and Calcium Silicate Boards (CSB). Among these, the cement-based boards are commonly preferred as exterior cladding to prevent moisture penetration in CFS wall panel building

systems [3]. Other sheathing material like gypsum/plasterboard and CSB are considered mainly as interior cladding.

The sheathing in the CFS wall panel serves primarily as cladding, also enhances the in-plane and out of plane buckling capacity of the stud under gravity loading [4, 5, 6] and offers lateral resistance under in-plane shear due to earthquake loading [7, 8]. The sheathed CFS joist in the floor system resists the floor loads by composite action under transverse bending [9, 10]. The current design trend in CFS building system is moving from "all-steel design" to "sheathing braced design" concepts, where the sheathing is considered as structural element contributing to strength and stiffness of the CFS walls and floors, to act as in shear and floor diaphragms [11]. Therefore, the mechanical properties of the sheathing material are essential to represent their behaviour in numerical models of the CFS subsystems particularly, CFS wall panels and floor system under combined gravity and lateral loading.

Despite their high use as structural and non-structural cladding in building system, limited studies on mechanical characterization of sheathing material are reported in the

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literature. Petrone et al. [12] and Chen and He [13] conducted experimental studies on plasterboard and Oriented Strand Board (OSB) made of different thicknesses under tension and compression loading. The objective of the study is to develop stress-strain constitutive relation under axial loading. Their tests were performed according to EN: 789 [14]. Experimental studies on plasterboard by Petrone et al [12], exhibited ductile nonlinear behavior in tension, and brittle failure with linear behaviour in compression loading. The studies on OSB board by Chen and He [13] exhibited linear behaviour up to failure under tensile loading, and nonlinear behaviour up to ultimate stress under compression loading. Stergiopoulos et al [15] performed compression tests on Gypsum boards as EN: 789 [14] and presented young's modulus and characteristic compressive strength along the longitudinal and transverse direction. In general, in the above studies the tensile tests were carried out with single board (thickness) dog bone specimen, and the compression tests were carried out by gluing four additional boards (of similar size) in the thickness direction to avoid global buckling failure [14]. The compression test was conducted in the UTM by applying compression load through compression platens, without any special test fixtures or anti-buckling device. Kumar [16] have conducted experimental studies on CSB under tensile, compression and shear loading to develop constitutive properties. In particular, the compression test was carried out on CSB following both ASTM D3501 [17] and EN: 789 [14] standards. In their study, the compression test specimen was prepared by gluing two boards to meet length to thickness ratio of 10 as per ASTM D3501 [17]. The specimen was mounted in the purposely designed test fixture, with guided lateral support to restrain the specimen undergoing buckling. at the both the longitudinal edges

In the above studies, it was observed that the test specimen in the compression tests was prepared by gluing more boards in the thickness direction to eliminate buckling failure [14, 17]. Despite the increased thickness and low L/t ratios, the existing compression test method suffers from the following drawbacks.

- Introduction of the glue between the adjacent boards significantly alters the characteristics of the material, failure plane and the measure of the actual compressive strength of the boards being investigated,
- Based on the choice of glue (either brittle or ductile adhesive), the glue layer become a weak plane, triggers premature failure by delamination between glued boards. Such occurrence of failure before reaching the compressive strength is another major concern [16].
- For the valid test, the failure should occur in the gauge section. Most often, the test specimen with fairly levelled edges when subjected to compression loading fail by bearing due to severe stress concentration [12, 13]. This makes the test invalid.
- Also, the specimen preparation is material and labor-intensive.

It is very clear from the literature that the compression test methods for single skin sheathing material needs further refinement to simulate the desired behaviour. In the

author's opinion, the test specimen consisting of single (virgin) board of finite thickness is more appropriate for evaluating stiffness and strength parameters under compression loading. The main objective of this paper is to propose compression test setup and test specimen (made of single thickness) for sheathing material, namely FCB to simulate realistic compression behaviour. The proposed setup should eliminate other unwanted failure modes like buckling, bending and bearing failure.

The organization of the paper is as follows. Following this introduction, preliminary experimental studies on FCB under compression loading with modified test specimen as per ASTM D3501 [17] is presented in section-2. In section-3, the compression test results on FCB specimens tested using Combined Loading Compression (CLC) test fixture, which realistically simulate the compression behaviour is discussed. The experimental results on FCB of different thickness 8mm, 10mm and 12mm thickness tested in longitudinal and transverse directions under compression loading is presented. Further, a nonlinear constitutive model based on experimentally derived parameters is proposed for the use in the FEA model of the sheathing material. The details of experimental studies and results are presented in the subsequent sections of this paper.

2. Compression Tests

Experimental studies on Fibre cement board (FCB) (marketed under brand name RAMCO HICEM) made of different thicknesses 8mm, 10, mm and 12mm under compression loading were carried out. FCB is made of siliceous material and reinforced with randomly oriented non-hazardous cellulose fibres. These boards are generally manufactured in two different board sizes, 8'×4' and 6'×4'. In this paper, the longer and shorter dimension of the sheathing is considered as the longitudinal (L) direction and transverse (T) direction respectively. The experimental studies on FCB under compression loading were conducted in 100kN MTS fatigue rated Universal Testing Machine (UTM) under displacement-controlled mode. The compression load was applied through compression platens with one spherical end at top and fixed end at the bottom. Strain reading from the strain gauges attached to the test specimens were acquired using HBM data acquisition (DAQ) system. The MTS controller output such as actuator displacement and load cell readings, were fed in to HBM DAQ system. All the sensor data related to experimental setup were simultaneously acquired in HBM DAQ at a data sampling rate of 10Hz. The Leica line laser was used to align the specimen in the center of the loading frame to avoid eccentric loading, and a camera was used to take pictures. The overall experimental setup is presented in Fig.1.

The overall objective of this paper is to propose compression test method, which includes test setup, appropriate dimensions of the test specimen with single thick board specimen, and necessary test fixtures to simulate actual compression behavior of FCB. Also, the test specimen should fail in acceptable failure modes like

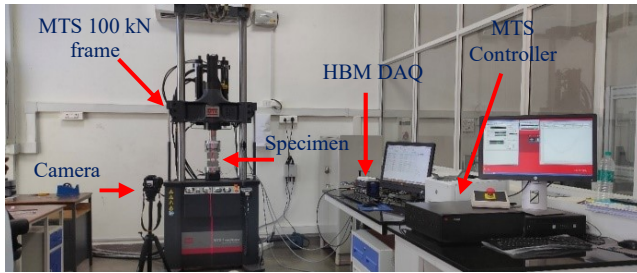


Fig. 1 Overall Experimental setup for compression test

axial splitting and shear failure, as per ASTM D3410[18] and ASTM D 6641[19]. Importantly, the proposed test setup should eliminate the unwanted failure induced by a) loading eccentricity and the associated bending, b) global buckling of the specimen due to high slenderness, and c) severe stress concentrations at the loaded edges resulting in an end bearing failure which is away from the gauge section. Preliminary experimental studies were carried out with single thick FCB specimen under compression loading, with different test methods like (a) ASTM D3501 [17] with modified test specimen, and (b) combine loading compression test fixtures. These studies were performed to arrive at a more reliable test method for establishing constitutive properties for FCB under compressive loading.

2.1. Modified Large panel compression test as per ASTM D3501 [17]

ASTM D3501 [17] recommends slenderness limits (length to thickness ratio (L/t)) for the test specimen to be less than 20 and 10 to evaluate elastic stiffness and strength parameter respectively. The limiting L/t ratios are generally achieved by gluing two or more boards in the thickness direction to eliminate buckling. In this paper, the large panel compression test specimen made of single board (thick) specimen with end tabs on either the side near the loading edges is proposed as a modification to existing test specimen. The tabs were chamfered at non-bearing edges for a gradual transfer of loads from the loaded edge to the specimen. The tabs were attached by adhesive and fixed by C-clamps until the adhesive is cured. Preliminary experimental studies were carried out on a typical 10mm thick FCB tested in the longitudinal direction under compression loading. The test specimen consists of single 10mm thick FCB of size 400×210 mm. Instead of gluing more number of boards to meet the slenderness requirement, here end tabs made of same board thickness and of different length were attached on either sides of the test specimen as shown in Fig. 2. The width of end tab is 170mm pasted in the middle of the specimen, leaving a width of 20mm on either side of the test specimen both in the front and back to restrain the specimen laterally at the longitudinal edges. The dimensions of the specimen and end tabs for test specimen with both L/t ratio of 20 and 10 are presented in Table 1 and shown Fig.2 for clarity. In Table 1, the specimen type A refers to test specimen with $L/t = 20$, and the specimen type B refers to the test specimen with $L/t = 10$. The inclusion of end tabs in test specimen reduces the unsupported length of the board being tested. Also, the provisions of end tabs increase the bearing area, and thereby reduces the compressive stress at the loaded ends and avoids bearing failure.

Table-1. Dimensions of large panel compression test specimens

Specimen type	Length to thickness ratio	Tab length (mm)	Test length (mm)	No of Specimens
A	Less than 20	105	190	6
B	Less than 10	155	90	2

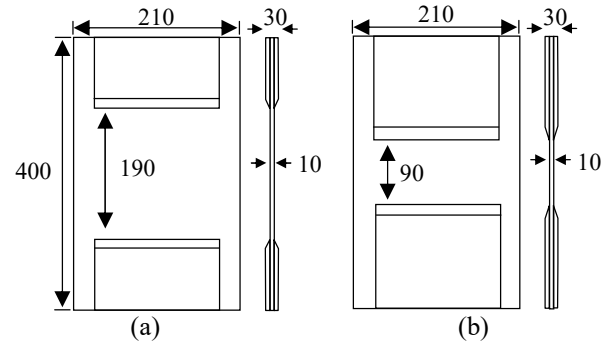


Fig.2 Large panel compression test specimen
(a) Type A, (b) Type B

The special fixture was designed and fabricated as per ASTM D3501 [17] for testing the boards under compression loading. The fixture is an assembly of a T-slotted base beam, sliding stiff vertical bracket with predrilled slotted holes, and a vertical plate with round-edge to laterally support the specimen in the longitudinal edges. The specimen was placed in the test fixture after loosening the lateral supports and aligned vertically. A loading plate of $300\text{mm} \times 300\text{mm} \times 50\text{mm}$ was placed on the top and a preload of 1kN was applied to the specimen. Then the lateral supports were installed at the ends maintaining a uniform gap of 1mm throughout the length to allow the axial deformation under compression loading. The large panel compression test specimen was instrumented with two 60 mm strain gauges in the longitudinal direction of loading in the front and back of the specimen to investigate the onset of buckling during testing. One additional, 10 mm strain gauge was installed in the transverse direction to measure lateral strain. Fig. 3 shows the view of large panel compression test fixture and the test the specimen in the UTM, along with instrumentation is shown in Fig.3. A total 8 Nos of large panel compression tests were carried with proposed test specimen. The specimens are labelled for example as FC10L-LPC-A1 referring to the specimen made of fibre

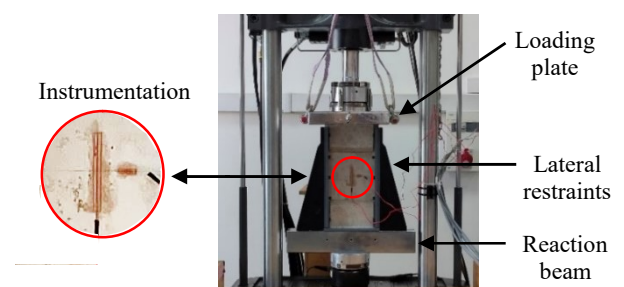
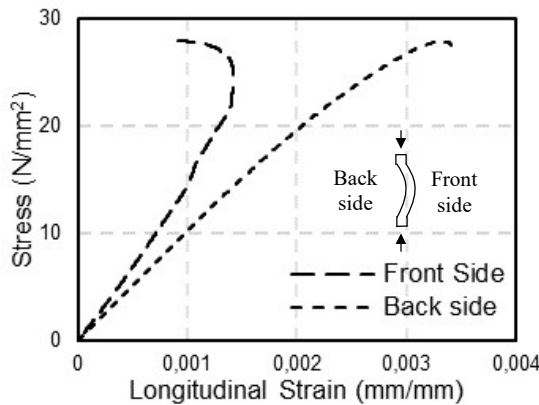


Fig. 3 Large panel compression test setup

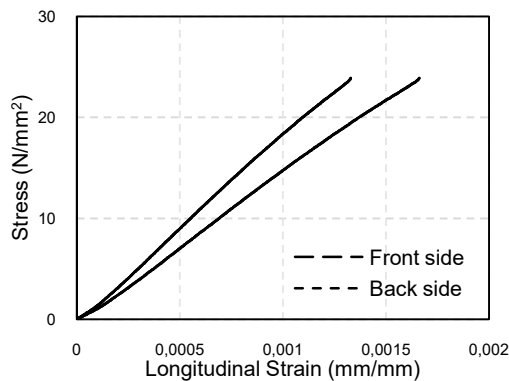
cement (FC) board of 10 mm, tested in the longitudinal (L) direction, with large panel compression test specimen of Type A (or Type B) and the first specimen of the same set. The test was conducted in displacement control mode with a loading rate of 0.2 mm/sec.

The stress-strain behaviour and observed failure modes of the typical test specimens, namely FC10L-LPC-A1& FC10L-LPC-B1 is shown in Fig.4 and Fig. 5. From Fig. 4(a), it is observed that the back to back strain gauge readings suddenly diverge and kinks in the opposite direction at a compressive stress of 25N/mm^2 . This is a clear indication of specimen buckling and the failed specimen is shown in Fig.5(a). Also, the divergence of these strain readings before this level is an indication of specimen bending. From Fig.4(b) and Fig.5, it is observed that the Type B specimen with L/t less than 10, the specimen undergoes pure compression and the failure was by bearing at one of the loaded edges. From Fig.5 (b) and 5(c), it was observed the failure is away from the gauge section, making the test invalid.

From the compression studies as per ASTM D3501 [17], it is evident that the test method even with modified test specimen meeting the stringent slenderness requirement, fail to simulate the true compression behaviour of the fibre cement board. The failure is always by buckling for the Type A specimen with $L/t=20$, and by bearing for the Type-B specimen with $L/t=10$. This study clearly concludes that the ATSM D3501 [17] test method for wood based structural panels under compression cannot be readily extended to fibre cement board.



(a) FC10L-LPC-A1



(b) FC10L-LPC-B1

Fig. 4 Stress-strain results for large panel compression test results

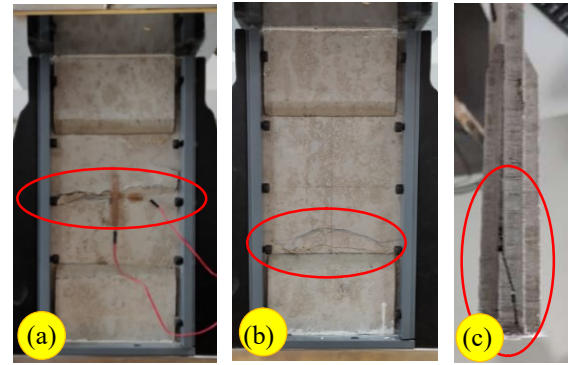


Fig.5 Typical failure patterns of large panel compression test specimen

2.2. Test with Combined Loading Compression (CLC) Test fixtures

To address the issue, the combined loading compression test fixture as per ASTM D6641 [20] used for characterizing the compression behaviour of polymer matrix composites is considered. The advantage of this test fixture is combines the best features of shear loading [18] and end loading test fixtures [19] used in characterizing composite material under compression loading. In this test setup, the test fixture subjects the test specimen to combined end and shear loading simultaneously, and also self-loaded between the compression platens of the UTM. A view of test specimen in CLC fixture and load transfer mechanism is shown in Fig.6. The shear-loading is introduced at the ends of the test specimen by clamping pairs of lateral support blocks, by tightening the allen screws with a torque in the range of 2.5 to 3 N-m. The clamping forces should be just sufficient to prevent end crushing. High clamping forces due to over tightening may

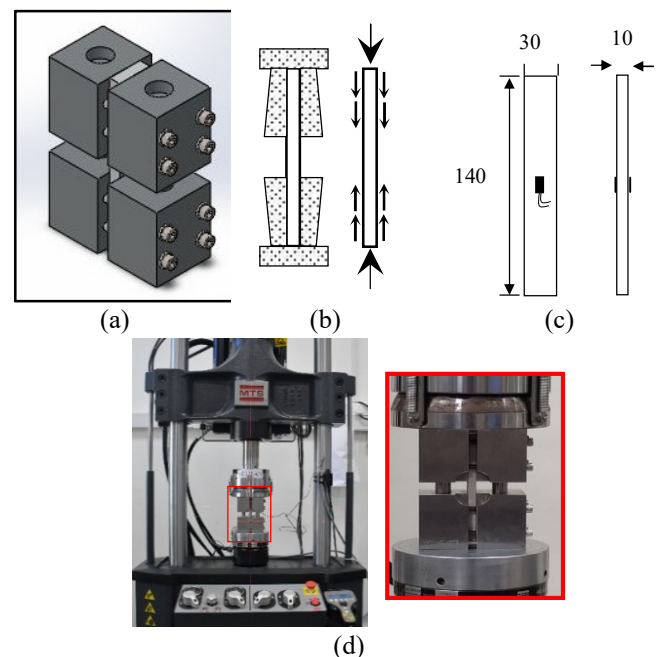


Fig. 6 CLC test experimental setup; (a) CLC test fixture, (b) Load transfer mechanism, (c) Test specimen with Instrumentation, (d) Specimen under loading

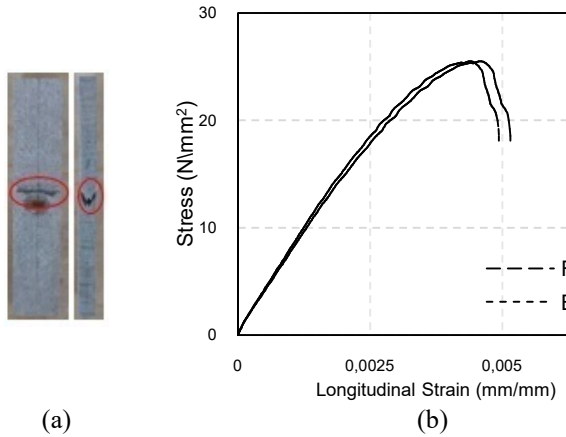


Fig. 7 CLC test results; (a) Observed failure mode, (b) Stress-strain plot

induce significant stress concentrations at the ends of the gauge section which may further degrade the measured compressive strength.

The test specimen considered here is made of 10mm thick FCB (single board thick) tested in the longitudinal direction under compression loading in the UTM. The standard dimension of the test specimen is 140 mm length and 30 mm width. Two No's of strain gauges with 5 mm gauge length and 120 ohms' resistance were pasted in the longitudinal directions on both sides of the test specimen to capture buckling. The specimen dimensions and the overall test setup is shown in Fig.6. The experiment was conducted on the displacement control mode at a loading rate of 0.01 mm/sec.

Fig. 7 shows the observed failure mode and the typical stress strain behaviour of the specimen studied. From the Fig. 7, it is observed that the stress-strain plot does not indicate the onset of buckling during the entire test. Also, the failure occurred due to axial splitting at the gauge section, which is also the desired failure mode. This study shows that the compression testing with CLC fixtures is a reliable method to simulate the real compression behaviour of the fibre cement boards. Hence, all the remaining studies on mechanical characterization of FCB boards under compression loading was carried out using CLC test fixtures only.

3. Experimental program

This sections presents the details of the test matrix, experimental setup with CLC test fixtures, results and discussion on the range of boards tested.

3.1. Test Specimen Matrix and test setup

The variations in the test included the specimens made of different thickness of the board (8, 10 and 12 mm) and tested along the longitudinal and transverse direction under monotonic loading. A minimum of two identical specimens were tested corresponding to each set of parameters, to ensure the repeatability of the behavior.

The mean values of the two tests were used if the strength of the two specimens were within 15% of each other. Otherwise, the mean values were based on the results of all the three identical specimens. Total 18 test specimens, 9 numbers each in longitudinal and transverse direction were studied. The specimen are labelled for example as FC12L-C2, referring to the fibre cement (FC) board specimen made of 12mm thick tested in longitudinal (L) or transverse (T) direction under compression loading (C), and the second specimen of the same set (or 'AVG' refers average value of particular group of tested specimens). The dimension of the test specimen considered was 145 mm long and 30 mm wide. The proposed dimension in the longitudinal directions was 5mm more compared to that of standard test specimen as per ASTM D6641 [20]. This was simply to facilitate convenient mounting of strain gauges. The actual dimensions were recorded by Vernier caliper with an accuracy of 0.01 mm. The specimens were instrumented with strain gauges using 5 mm gauge length and 120 ohms' resistance in the longitudinal and transverse direction. The test specimen was mounted in CLC fixtures and placed between compression platens of the UTM, as shown in Fig. 6. The specimen was tested in displacement control mode with loading rate of 0.02 mm/sec.

3.2. Test Results

Fig.8 presents the typical experimental results of the typical FCB test specimens with 12mm thick specimen tested in the longitudinal direction. Figure 8 shows (a) the load (P) vs. displacement (Δ) plot, (b) compressive stress (f) vs. longitudinal strain (ϵ_l), and (c) lateral strain (ϵ_t) vs.

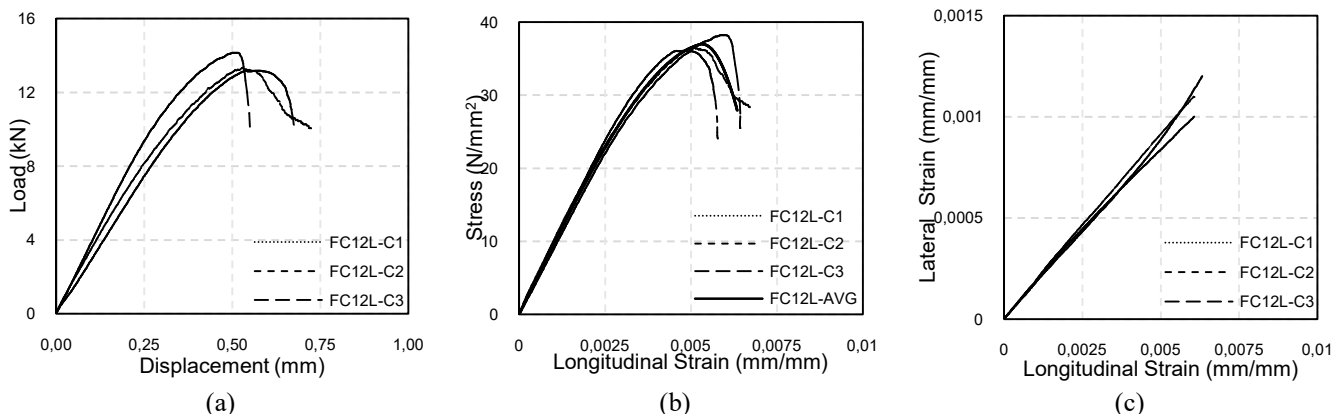


Fig. 8: 12 mm data in longitudinal direction; (a) load-displacement, (b) Compressive stress-longitudinal strain, (c) Lateral-longitudinal strain

longitudinal strain (ϵ_l) for the set of test specimens. In the Fig. 8a, it is observed that the load deformation behaviour was linear up to 60 % of the ultimate load, thereafter the load deformation curve becomes nonlinear. After the ultimate load, there was a drop in the load capacity with increase in the displacement, exhibiting low ductility, before the failure. Similar response was observed in the compression stress-strain behaviour as shown in Fig.8b. The nonlinear behaviour under compressive loading is mainly due to micro buckling of cellulose fibres present the board material. Average stress-strain curve for each group of test specimens was developed following Equal Arc Segment (EAS) method [21]. The average curve, FC12L-AVG was shown along with individual stress-strain data for 12mm test specimens in Fig.8b. Fig. 8c shows the lateral vs. longitudinal strain plot. The commonly observed failure modes under compression loading are axial splitting (A), shear (S) and combination of shear and axial splitting (A+S) as shown in Fig. 9.

The combined stress-strain plot of all FCB specimens made of 8mm, 10mm and 12mm tested along the longitudinal and lateral directions are presented in Fig.10. From the individual stress-strain plot, the modulus of elasticity (E_c) is calculated as a slope of the line fitted between $0.1f_{max}$ to $0.4f_{max}$ by linear regression analysis. The failure strain (ϵ_f) is evaluated as a strain corresponding to the 20% stress drop from the ultimate stress. The other useful structural parameters like ultimate load, ultimate displacement, modulus of elasticity (E_c), ultimate compressive strength (f_c), ultimate compression strain (ϵ_u), failure strain (ϵ_f) and the poisson's ratio (ν) extracted from the individual and average stress-strain curve are summarized in Table 2. The observed failure mode for the individual test specimen are also presented in Table 2.

From the Fig. 10 and Table 2, the following general observations are made

- The stress-strain behaviour of FCB specimen exhibits linear behaviour up to 50% of maximum stress, thereafter the nonlinear behaviour was observed up to ultimate compressive stress. Thereafter, the stress

degrades instantaneously exhibiting low ductile behaviour.

- The commonly observed failure modes are axial splitting (A), shear (S) and combination of shear and axial splitting (A+S).

The difference in the modulus of elasticity for 8mm and 12mm board is always less than 1.1% in both longitudinal and transverse direction. But the modulus of

- elasticity of the 10mm board is always less around 5-7 % and 15-18% when compared to modulus of elasticity of 8mm and 12mm board in the longitudinal and transverse directions respectively.
- The modulus of elasticity for the boards of thicknesses 8mm, 10mm and 12mm in the longitudinal direction is always higher when compared to the transverse direction, which clearly shows the orthotropic properties of FCB material.
- In general, the compressive strength was higher for large thickness board. Also the compressive strength of any particular board thickness along the longitudinal direction is always higher compared to that of transverse direction.

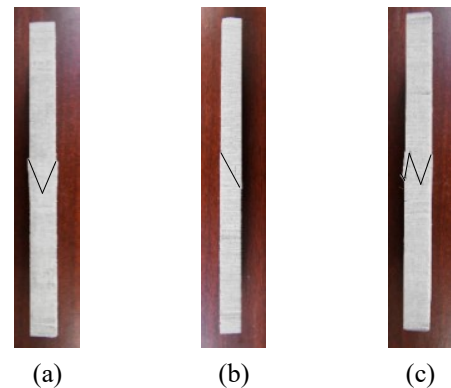


Fig. 9 Failure pattern of compression test specimen (a)axial splitting, (b) shear, (c) combined axial splitting and shear

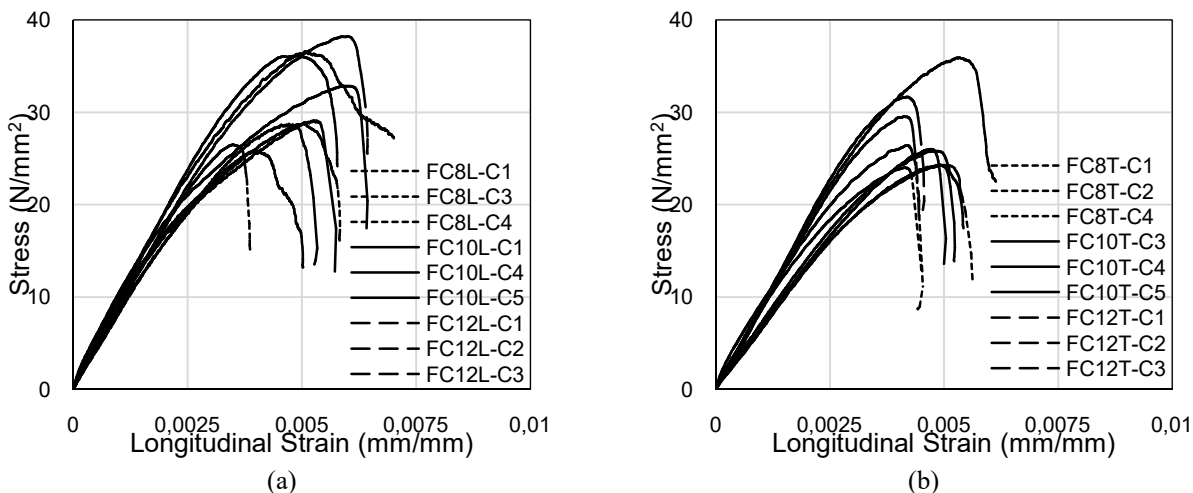


Fig. 10 Combined plots of stress-strain; (a) longitudinal direction, (b) transverse direction.

Table-2. Elastic and strength parameters under compression

Specimen number	P	Δ	E_c	f_c	ε_u	ε_f	ν	Failure mode
	kN	mm	N/mm ²	N/mm ²	$\mu\text{m/m}$	$\mu\text{m/m}$		
Longitudinal Direction								
FC8L-C1	6.22	0.70	9298.2	25.86	3996	4691	0.181	A+S
FC8L-C3	6.99	0.69	9396.1	28.75	4791	5445	0.196	A
FC8L-C4	6.42	0.44	8765.2	26.49	3498	3799	0.179	S
FC8L-AVG			9368.1	26.89	4042	4605		
FC10L-C1	11.05	0.75	9930.9	32.83	5978	6342	0.229	A
FC10L-C4	9.56	0.42	8141.8	29.09	5286	5463	0.147	S
FC10L-C5	9.53	0.50	8401.5	28.72	4715	5183	0.181	A+S
FC10L-AVG			8844.7	30.12	5262	5722		
FC12L-C1	13.33	0.53	9747.6	36.60	5072	6385	0.194	A
FC12L-C2	13.17	0.58	9594.1	36.09	4916	5717	0.183	A+S
FC12L-C3	14.15	0.51	8934.1	38.20	5989	6343	0.171	S
FC12L-AVG			9471.3	37.01	5326	6246		
Transverse Direction								
FC8T-C1	5.97	0.41	8659.0	23.97	4121	4315	0.180	A+S
FC8T-C2	6.75	0.55	9344.1	26.39	4201	4381	0.174	S
FC8T-C4	6.03	0.31	7191.5	24.27	4975	5404	0.147	A+S
FC8T-AVG			9001.5*	24.71	4406	4765		
FC10T-C3	8.76	0.54	7793.8	26	4671	4859	0.123	S
FC10T-C4	8.68	0.44	7072.8	25.78	4833	5346	0.175	S
FC10T-C5	8.15	0.44	6567.4	24.28	4868	5144	0.107	S
FC10T-AVG			7316.3*	25.50	4579	5133		
FC12T-C1	12.01	0.51	9018.7	31.64	4210	4458	0.177	A+S
FC12T-C2	11.53	0.52	8758.6	29.53	4128	4393	0.165	S
FC12T-C3	12.83	0.51	8957.4	35.91	5297	5854	0.162	A+S
FC12T-AVG			8858.3	32.43	4545	4936		

*refers to average of two specimens

3.3. Nonlinear constitutive model

In order to develop a finite element model of the sheathing material, a constitutive relationship that determines the actual compression behaviour of the material is essential. In this study, the non-linear behaviour stress-strain behaviour of FCB compression data is idealized with Ramberg-Osgood curve [22] up to the ultimate stress, and with a linear curve for the representing the post peak response. The proposed constitutive model is given in Eqn. 1, where E_c , f_c , ε_u and ε_f are experimentally derived model parameters from the average stress-strain curve, as summarized in the Table 2, and the hardening exponent 'n' is obtained from the nonlinear regression analysis to fit the experimental response up to ultimate stress. The constitutive law of the descending curve was approximated with a linear regression fit using degradation factor, D. Table 3 summarizes the parameter, n and D obtained for the range of boards tested in this study.

$$\varepsilon = \frac{f}{E_c} + \left(\varepsilon_u - \frac{f_u}{E_c} \right) \left(\frac{f}{f_u} \right)^n \quad 0 < \varepsilon \leq \varepsilon_u \quad (1.a)$$

$$\varepsilon = \varepsilon_u + \frac{(f - f_u)}{(1 - D)E_c} \quad \varepsilon_u \leq \varepsilon < \varepsilon_f \quad (1.b)$$

Table-3. Fibre cement board constitutive model

Parameter	8L	8T	10L	10T	12L	12T
n	4.5	5.5	5.5	8.5	8	10
D	1.7	1.9	1.8	1.5	1.6	2.1

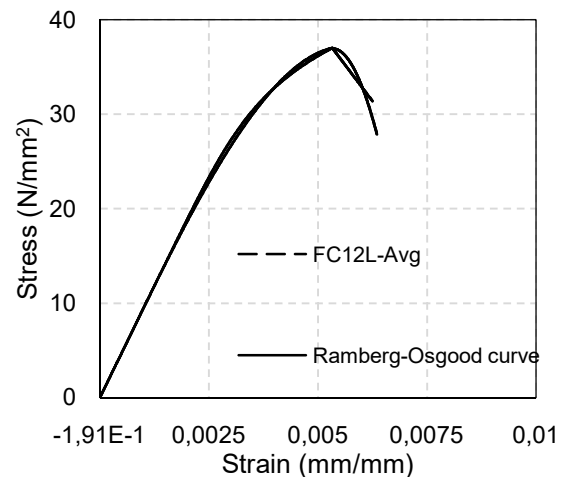


Fig. 11: Comparison between Ramberg-Osgood curve and measured FCB stress-strain curve

4. Conclusion

In this paper, a new compression test with CLC fixtures was proposed as an alternative to simulate the realistic compression behaviour of FCB specimens. The gross buckling or stress concentration induced bearing failure was not observed during tests. Detailed experimental studies on FCB with 8mm, 10mm and 12mm thicknesses under compression loading in longitudinal and transverse directions were carried out. From the experimental response, it was observed that the FCB under compression exhibits nonlinear behaviour due to micro buckling of cellulose fibres present in the board material. The commonly observed failure modes are axial splitting (A), shear (S) and combination of shear and axial splitting (A+S). The useful structural parameters like ultimate load, ultimate displacement, modulus of elasticity, ultimate compressive strength, ultimate compression strain, failure strain and the poisson's ratio are extracted from the test specimen and summarized. Finally, a constitutive model using Ramberg-Osgood equation was proposed to represent the nonlinear compression behaviour of the range of FCB specimens studied here.

Disclosures

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