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High performance fibre reinforced cement concrete slender structural walls

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Abstract. In the design of reinforced concrete structural walls, in order to ensure adequate inelastic displacement behaviour and to sustain deformation demands imposed by strong ground motions, special reinforcement is considered while designing. However, these would lead to severe reinforcement congestion and difficulties during construction. Addition of randomly distributed discrete fibres in concrete improves the flexural behaviour of structural elements because of its enhanced tensile properties and this leads to reduction in congestion. This paper deals with effect of addition of steel fibres on the behavior of high performance fibre reinforced cement concrete (HPFRCC) slender structural walls with the different volume fractions of steel fibres. The specimens were subjected to quasi static lateral reverse cyclic loading until failure. The high performance concrete (HPC) used was obtained based on the guidelines given in ACI 211.1 which was further modified by prof.Aitcin (1998). The volume fraction of the fibres used in this study varied from 0 to 1% with an increment of 0.5%. The results were analysed critically and appraised. The study indicates that the addition of steel fibres in the HPC structural walls enhances the first crack load, strength, initial stiffness and energy dissipation capacity.

Keywords: fibres; high performance concrete; slender structural wall; stiffness

1. Introduction

Considerable researches, as well as lessons learned from previous earthquakes, have led to improved understanding of the seismic behaviour of structural walls. Fintel (1991) indicated that properly designed shear walls could be used effectively as the primary lateral-load resisting system for both wind and earthquake loading in multistory buildings as they are efficient to provide lateral strength, stiffness and lateral drift control. Structural walls can be classified based on their overall height-to-length ratio known as the aspect ratio. Walls with an aspect ratio greater than two are usually referred to as slender structural walls and which exhibit flexural behaviour. Slender structural walls are quite common in tall buildings (Rangan 2008).

Review of literature indicates that numerous investigations were conducted in the past to study

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the strength and behaviour of normal concrete structural walls (Sittipunt and Wood 1995, Lefas and Kotsovos 1990, Pilakoutas and Elanshai 1995, Tasnimi 2000, Massone and Wallace 2004, Su and Wong 2007, Dazio *et al*. 2009, Lowes *et al*. 2012, Gebreyohaness *et al*. 2014). The major aim of these studies is to investigate the influence of various parameters such as the aspect ratio of the wall, shape, axial load ratio, shear stress demand, horizontal and vertical reinforcement ratio, and compressive strength of concrete on the behaviour of structural walls. Even though several studies on reinforced concrete structural walls have been done in the past, only limited information is available on the strength and behaviour of High Performance Concrete (HPC) and High Performance Fibre Reinforced Cement Concrete (HPFRCC) slender structural walls.

High Performance Concrete (HPC) is not a new material but it is a further development of normal concrete. Main ingredients of HPC are the same as normal concrete and these ingredients when proportioned suitably along with mineral admixtures such as silica fume, fly ash etc. and chemical admixtures impart high performance characteristics to it. The major difference between HPC and normal concrete is the water cement ratio. The w/c ratio in normal concrete usually varies from 0.42 to 0.60 so that it contains more water than necessary to fully hydrate all its cement particles (Aitcin, 2011). In the case of HPC water cement ratio has no relevance, because of the presence of very fine materials such as mineral admixtures, which are finer than cement and in powder form. Hence instead of water cement ratio, w/b (water binder ratio) is more meaning full. The fine particles of mineral admixtures fill the entire voids and contribute the development of strength.

When short discrete fibres are distributed at random in conventional concrete, that composite is known as fibre reinforced concrete (FRC). When the same fibres are distributed in HPC, the composite is known as HPFRC. Structural walls should be capable of carrying large lateral forces and also should sustain the deformation demands imposed by strong ground motions. Therefore, it requires special reinforcement detailing in order to ensure adequate inelastic displacement capacity. However, these may lead to severe reinforcement congestion and difficulties during construction. Steel fibres are added to concrete to improve tensile properties, ductility, energy absorption capacity and also to control cracks (Balaguru *et al*. 1988, Ramakrishnan *et al*. 1981, Ganesan *et al*. 2013). Addition of short discrete steel fibres delays the initiation of micro cracks as the tensile strain carrying capacity of cementitious composites increases in the neighbourhood of fibres. After the formation of cracks, the fibres intercept the cracks and bridge across the same which leads to the deviation of cracks from the earlier plane of propagation. This leads to the finer width of cracks. Experimental research has shown that fibres can be used to partially replace confinement and shear reinforcement, without any compromise on strength and ductility (Kranti J and Bupinder S 2013, Ganesan *et al*. 2006, Uygunoglu 2008, Jones *et al*. 2008, Tadepalli *et al*. 2013, Narayan and Darwish 1987, Ganesan *et al*. 2007, Lim and Oh1999, Joaquim *et al*. 2013,Tuladhar and Benjamin 2014). Usage of HPC in the construction of earthquake-resistant structures, long-span bridges, offshore structures, nuclear power plants, and other mega-structures will result in lighter sections, leading to cost-effective structures. HPFRCC is a cement concrete composite in which short discrete fibres are randomly distributed throughout the HPC Matrix. The applications of high-performance fibre-reinforced cement composites (HPFRCCs) in earthquake-resistant structures are effective, since it increases shear strength, displacement capacity, and damage tolerance in members subjected to large inelastic deformations (Parra-Montesinos 2005). HPFRCCs are characterized by a stress-strain response that exhibits strain-hardening behaviour accompanied by multiple cracking, and have relatively large energy absorption capacity (Naaman and Reinhardt 2003). An alternative design was suggested by (Wight *et.al*.2009, Canbolat *et.al.*2005) consisting of precast HPFRCC coupling beams with different reinforcement configurations in order to simplify the reinforcement requirements in diagonally reinforced RC coupling beams. Parra-Montesinos and Chompreda (2007) have studied the deformation capacity and shear strength of fibre-reinforced cement composite (FRCC) flexural members subjected to displacement reversals and indicated that FRCC test specimens, with or without transverse steel reinforcement, exhibit a stable behaviour with drift capacities equal to or greater than 4.0%. It was reported that the confining effect of shear wall sections could be improved by the new strategy of transverse confining stirrups (Deng *et al*. 2008). A design alternative was also proposed, that consisted of the use of High-performance fibre-reinforced concrete (HPFRC) instead of regular concrete, combined with simplified wall reinforcement detailing, mainly focusing the transverse reinforcement in the wall boundary regions (Athanasopoulou and Parra- Montesinos 2013). Their studies also indicate that the use of an HPFRC material allows a significant relaxation in the spacing of confinement reinforcement in walls tested under high shear-stress reversals (four times the spacing and one-fourth the amount provided in companion RC specimens) without compromising wall seismic behaviour. Based on the encouraging results from these studies an experimental investigation was undertaken to evaluate the strength and behaviour of HPFRCC slender structural walls, with the different percentage of the volume fraction of fibres.

2. Experimental programme

The experimental programme consist of casting and testing of three slender structural walls under quasi static lateral reverse cyclic loading, out of these, two specimens were made of HPFRCC matrix and the other one with HPC matrix.

2.1 Materials

The materials consist of (i) Ordinary Portland Cement (OPC) of 53 Grade conforming to IS: 12269-1987 (reaffirmed 2004). Table 1 shows the properties of cement (ii) fine aggregate conforming to grading zone III of IS:383-1970 (reaffirmed 2002) and having a specific gravity of 2.52, and (iii) coarse aggregate of 12.5 mm maximum size and having specific gravity of 2.80. The properties of fine and coarse aggregates are shown in Tables 2-3. The supplementary cementitious materials used were fly ash and silica fume. Fly ash was obtained from Mettur Thermal Power Plant, Tamil Nadu which conforms to ASTM C 618-2003 and Silica fume from ELKEM India (P) Ltd., Navi Mumbai conforms to ASTM C 1240-2005. Tables 4 and Table 5 show the properties of fly ash and silica fume. Super plasticiser (Conplast430) was used as a chemical admixture. The reinforcing steel consisted of High Yield Strength Deformed bars (HYSD) of Fe 415 grade. Crimped steel fibres with a length of 30 mm and diameter 0.45 mm were used throughout the study. The properties of super plasticiser and crimped steel fibres are shown in Tables 6-7. The photograph of crimped steel fibres are shown in Fig. 1.

The longitudinal and transverse reinforcement consists of 8 mm diameter HYSD bars in the form of rectangular grid that was placed in double layer. Because of the large overturning effect caused by horizontal earthquake forces, the edges of the structural wall experience high, compressive and tensile stresses. To avoid this, special boundary elements were provided at the edges (Rangan 1997). The main longitudinal reinforcement, provided in the boundary region

Table 1 Properties of cement

Sl.no	Properties		Test Results	Requirements as per IS:12269-1987 (reaffirmed 2004)
1	Specific Gravity		3.15	-
2	Normal Consistency		30%	-
3	Initial Setting Time		120 min	Not less than 30 min
4	Final Setting Time		310 min	Not more than 600 min
5	Compressive Strength	3 days	30.4 MPa	Not less than 27 MPa
		7 days	40.2 MPa	Not less than 37 MPa
		28 days	54.7 MPa	Not less than 53 MPa

Table 2 Properties of fine aggregate

Sl.no	Properties	Test Results
1	Fineness Modulus	2.28
2	Specific Gravity	2.52
3	Bulk density	1596 kg/ m^3
4	Loose density	1480 kg/ m^3
5	Zone	III
6	Water absorption	0.90 %

Table 3 Properties of coarse aggregate

Sl.no	Properties	Test Results
1	Fineness Modulus	6.68
2	Specific Gravity	2.80
3	Bulk density	1518 kg/ m^3
4	Loose density	1433 kg/ m^3
5	Maximum size of aggregate	12.5 mm
6	Water absorption	0.82 %

Table 4 Properties of fly ash

Specific gravity	2.40
Silica, SiO_2	55.39%
Iron oxide, Fe_2O_3	9.80%
Alumina, Al_2O_3	23.20%
Calcium oxide, CaO	5.58%
Magnesium oxide, MgO	1.31%
Sulphate, SO_3	1.80%
Potassium oxide, K_2O	2.92%

Table 5 Properties of silica fume

Specific gravity	2.10
SiO_2	90.36%
Moisture content	0.60%
Retained on 45 microns sieve	0.40%
Bulk Density	640 kg/ m^3

Table 6 Properties of super plasticizer

Product Name	Conplast SP 430
Specific gravity	1.22 at 30° C
Chloride content	Nil
Air entrainment	1 to 2% additional air is entrained

Table 7 Properties of steel fibre

Type of fibre	Crimped steel fibre
Length of fibre	30 mm
Diameter of fibre	0.45 mm
Aspect ratio	66
Ultimate tensile strength	800 MPa

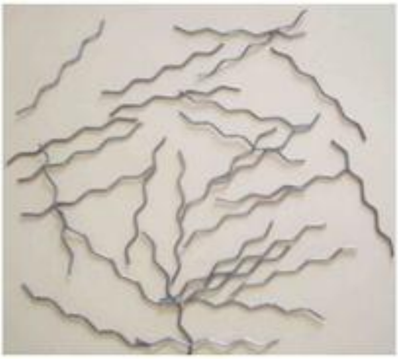


Fig. 1 Crimped steel fibres

consists of 2% of the area of cross section of the boundary element and provided over a width of 100 mm at the boundary of the element on each side. The longitudinal and transverse reinforcement provided in the wall web were 0.67% and 0.54% respectively. The nominal dimension of the specimens, together with the details of reinforcement is shown in Fig. 2.

2.2 Details of mix proportioning

The HPC used in this study was proportioned to attain a compressive strength of 60 MPa. Mix design was done based on the guidelines given in ACI 211.1-91 modified by Aitcin (1998). Themixes were obtained by replacing 20 percent of cement mass by fly ash and 8 percent cement mass by silica fume. The water binder ratio considered was 0.29. The same mix proportions were maintained for all the mixes. In the case of steel fibre reinforced concrete, when steel fibres are used in the mix proportion, the cement paste content is to be increased by adjusting the fine to coarse aggregate as per the Guide for Specifying, Proportioning, and Production of Fiber-Reinforced Concrete ACI 544.3R -08. Also the addition of mineral and chemical admixture increases the workability. In the present study when fibres vary from 0 to 1%, it was noted that a simple increase in superplasticiser was adequate to improve workability of the mix. Hence the chemical admixture was adjusted for different volume fractions of fibres. In the mix proportions

Table 8 HPC mix proportions (kg/m^3)

Cement	Fly ash	Silica fume	Sand	Coarse aggregate	Water	Super plasticizer
405	110	45	600	1041	156	11.6

obtained for HPC when fibres were added to the mix, workability got reduced and in order to increase the workability and maintain a uniform compacting factor of 0.9 for all the mixes, dosage of superplasiciser was adjusted in each mix. The dosage of super plasticiser for each mix was decided after carrying out sequential trials between dosage of superplasticiser and volume fraction of fibres. It is observed that up to 0.5% there is no need to adjust the dosage of superplasiciser and for mixes with higher than 0.5% fibres, the workability decreases. The super plasticiser dosage for 0.5% fibres was 2.07% by mass of cementitious materials, and for 1% fibres it was 2.28%. The HPC mix prportion for M60 grade concrete is given in Table 8.

2.3 Hardened properties of high performance fibre reinforced cement concrete (HPFRCC)

The mechanical properties like compressive strength (f_c), split tensile strength (f_{ct}), flexural strength(f_{cr}), modulus of elasticity(E_c) and poisson's ratio (μ) of hardened HPC and HPFRCC specimens were determined using cubes, cylinders and prisms. In each series, three specimens were cast and tested, and their average value is reported. The test results are given in Table 9. It may be noted that addition of fibres to HPC did not result in a significant increase of compressive strength. However as the fibre content increases, values of $f_{ct}$and f_{cr} gradually increase and when the value of V_f reaches 1%, there is significant enhancement in the values of $f_{ct}$and f_{cr} The reason may be due to better interface between the cement paste, fine aggregate and coarse aggregate due to the addition of silica fume and improved cracking performance due to the addition of steel fibres. Addition of fibres significantly improved the value of E_c and μ.

2.4 Test specimen

The experimental work consists of casting and testing of three slender structural walls with an aspect ratio of 3. Two different volume fractions of fibres, viz., 0.5%, and 1%, were used for the HPFRCC mix. The height (H), length (L) and thickness (t) of the specimens were, 1500 mm, 500 mm and 100 mm respectively. To provide fixity at the bottom, a base block of 100 mm wide 450 mm deep and 1100 mm long was constructed monolithically with the walls. The specimens were designed and detailed according to the seismic provisions of ACI 318-08. The details of the specimens are summarized in Table 10.

Table 9 Hardened properties of concrete

Mix Designation	V_f %	f_c (N/mm^2)	f_{ct} (N/mm^2)	f_{cr} (N/mm^2)	E_c(*10^{-4}) (N/mm^2)	μ
HPC	0.00	60.34	4.25	6.56	3.8	0.201
HPFRCC1	0.25	62.52	4.92	8.25	4.03	0.260
HPFRCC2	0.50	62.96	5.60	9.10	4.53	0.270

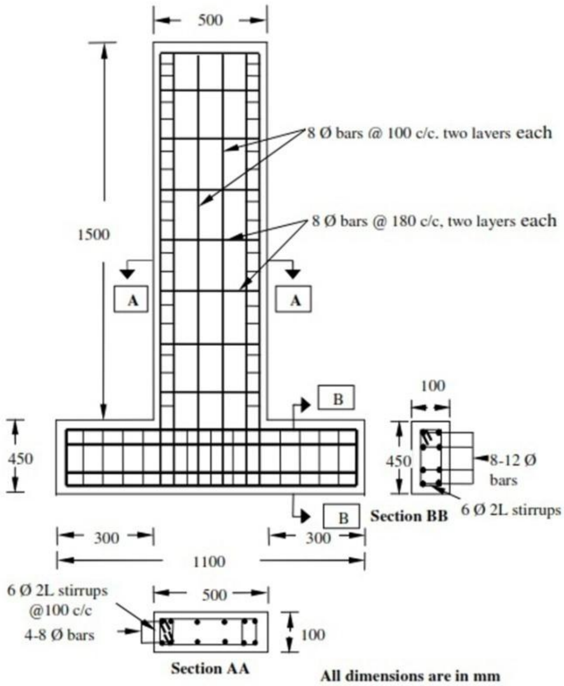


Fig. 2 Geometry and reinforcement details of structural wall specimens

2.4.1 Casting of specimens

For casting of wall specimens, a specially designed steel mould made up of 100 mm wide and 8 mm thick mild steel flats was used. The steel mould was fabricated in such a way that it could be easily dismantled and assembled for repetitive use and also the wall and its base block can be cast monolithically. The specimens were cast horizontally on a level floor in the Structural Engineering Laboratory. Required numbers of bolt holes of 50 mm diameter were also provided in the base block of the wall corresponding to the position of holes in foundation block. Figs. 3 (a)- (b) show the reinforcement cage placed in steel mould and specimens after casting. The form work was removed after 24 hours of casting and cured for 28 days.

3. Test setup and instrumentation

Double acting hydraulic jack of capacity 100 kN was used for applying lateral reverse cyclic loads. Linear variable displacement transducer (LVDT) having 300 mm travel and a least count of 0.01 mm was used for monitoring the in plane horizontal displacement at the top of the wall. Figs. 4 (a) - (b) show the schematic diagram and photograph of the test setup. A load cell of 100 kN capacity was used to measure the applied load accurately. The load control procedure adopted for testing, was quasi static reverse cyclic load test, in which equivalent static forces are imposed on the structural elements to induce an inelastic response. The test specimens were loaded quasi statically according to a standard, incrementally increasing, fully-reversed cyclic loading pattern.

Table 10 Details of specimens

Specimen Designation	Aspect ratio of structural wall (H /L)	Volume fraction of fibre %	Aspect ratio of fibre	Ultimate strength of fibre MPa
HPCW1	3	0	-	-
HPFRCCW2	3	0.50	66	800
HPFRCCW3	3	1.00	66	800

The application of push and pull cyclic loading on the specimen was done using an arrangement consisting of mild steel rods with 25 mm diameter, threaded on both ends and connected to mild steel channels and fixed to the hydraulic jacks through load cells for the forward and reverse application of loads. The specimen was inserted into the foundation block and connected through the holes on the web portion of the foundation using 50 mm diameter mild steel rods. In view of the fact that the application of axial load improves the performance of the structural wall under reverse cyclic loading, no axial load was applied to structural wall during the testing. This is adopted to create the worst condition.

3.1 Testing of wall specimens

The walls were subjected to quasi static lateral reversed cyclic loading until failure. The walls were incrementally loaded with a hydraulic jack having capacity100kN. One cycle of loading consisted of both forward and reverse cycles and after each cycle, the amplitude of loading was increased. This process was continued till lateral failure occurred. The loading history of the specimens consists of a series of stepwise increasing loading cycles as shown in Fig. 5. Loading history consists of peak loads of 5kN, 10kN, 20kN, 30kN, 40kN, and 50kN in each cycle of the forward and reverse direction. The test was carried out in the above loading frame, which adopts load control procedure and behaviour under the peak load was studied. However, the post peak behaviour is essential for demonstrating the ductility performance and failure mode of specimens under extreme loading in the case of simulated seismic load tests.

Fig. 3a Reinforcement cage in steel mould

Fig. 3b Specimen after casting

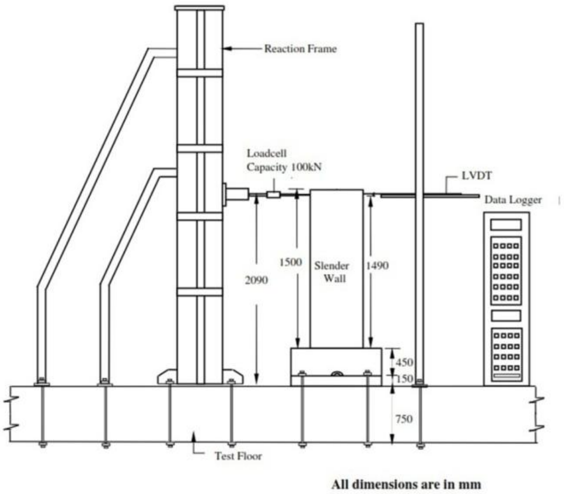


Fig. 4a Schematic diagram of the test set up

Fig.4b Photograph of the test set up

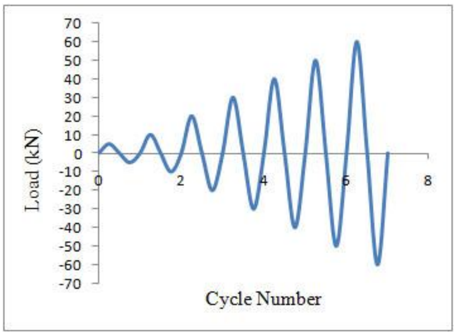


Fig.5 Loading history

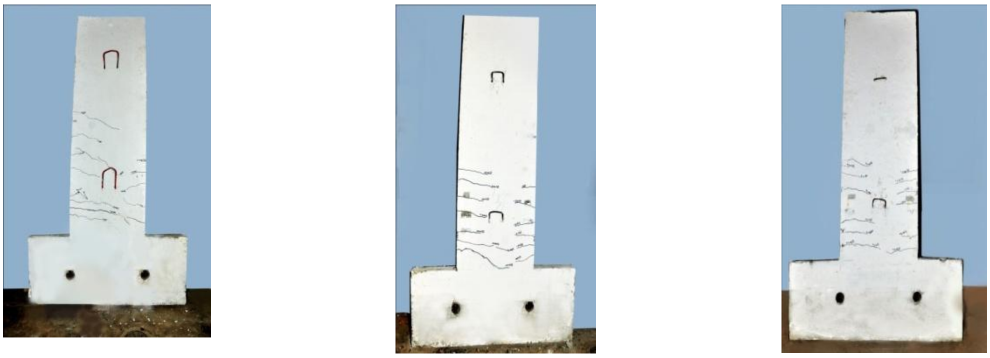
4. Results and discussions

4.1 Overall behaviour

All the walls designed according to the seismic provisions of ACI 318-2008 exhibited a hysteretic behaviour with flexural failure. Details of test results are given in Table 11. In HPC structural wall flexural- shear cracks were observed. These flexural-shear cracks continued to form as the load increases. However, in HPFRCC structural wall specimens, cracks were horizontal and it indicates development of flexure cracks. First crack load, ultimate load and corresponding deflection of specimens improved with the increase in fibre content, which may be due to the enhancement in tensile strain carrying capacity of concrete in the neighbourhood of fibres. Compared to HPC wall specimen, crack spacing of HPFRCC wall specimens were less and the cracks were non uniformly distributed. The fibres arrest the cracks by bridging across the cracks and preventing further propagation of cracks in the same direction and thus leading to a mixed mode of crack propagation. Hence, there is a demand for more energy for further propagation of cracks. This leads to improvement in load carrying capacity. It may be noted from the table that the first crack load of HPFRCC slender structural wall with 0.5% and 1% steel fibres are 1.84 and 1.76 times higher than the HPC slender structural wall. In HPFRCC composites the fibres play a vital role, only after the formation of first crack and the fibres will be effective in the post cracking zone. At this stage, the fibres bridge across the crack and delay the propagation of the cracks. However, at 1% steel fibres, the balling action took place and the overall distribution of fibres were highly non uniform compared to 0.5% volume fraction of fibres, where balling action did not occur. The concept of fibre technology indicates that the tensile strain carrying capacity of matrix is in general higher in the neighbourhood of fibres when the fibres are distributed properly. However, it may be noted that once the crack occurs, the matrix will be relieved of the tensile load carrying capacity and entire load have to be shared by the fibres bridging across the cracks. Hence as far the first crack load is considered, the enhancement of tensile strain carrying capacity of matrix due to the proper presence of steel fibres is vital. In this study, hence specimens with 0.5% steel fibres gave a better first crack load than specimen with 1.0% steel fibres. When the quantity of fibres is higher, the stiffness of the composite enhances as these fibres contribute to the overall structural behavior of the composite, after the first cracking. Hence at higher percentage of fibres the stiffness was found to be higher. Cracks were mainly horizontal for HPFRCC specimens; however, in the case of HPC specimens, cracks started deviating gradually from the horizontal position as the loading increases. In HPC wall specimen the first visible crack observed had a width of 0.05 mm. While in HPFRCC specimens, it is lower than 0.05 mm. The maximum width of crack observed in HPC specimens was 0.45mm. In HPFRCC specimens with 0.5% and 1% steel fibres, the maximum width of crack observed were 0.35 mm and 0.40 mm respectively. The vertical reinforcement in the wall shows post yield deformation (strains). From the monitoring of strains in the longitudinal steel bars of HPCW1, a strain value of 0.007 was noted in the tension side at left and 0.0068 in tension side at right of the wall in the 6^{th} cycle of loading. In HPFRCCW2 a strain value of 0.008 was noted in the tension side at left and 0.0077 in tension side at right of the wall in the 6^{th}cycle of loading. In HPFRCCW3 a strain value of 0.0075 was noted in the tension side at left and 0.0073 in tension side at right of the wall in the 6^{th}cycle of loading. Fig.6 shows the photograph of tested specimens.

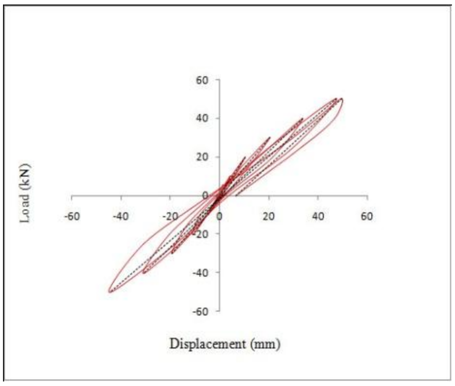
Table 11 Experimental results

Specimen	First Crack Load (kN)	Ultimate Load (kN)	Displacement corresponding to Ultimate Load(mm)
HPCW1	10.6	50.05	49.65
HPFRCCW2	19.5	53.60	56.20
HPFRCCW3	18.5	52.12	55.31

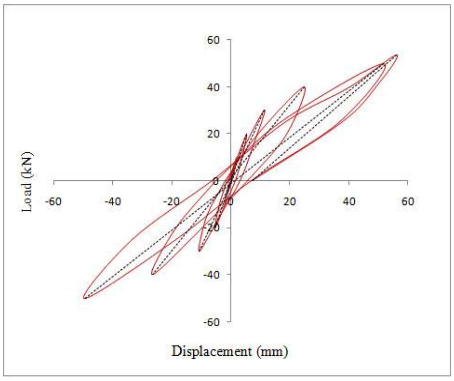


HPCW1 HPFRCCW2 HPFRCCW3

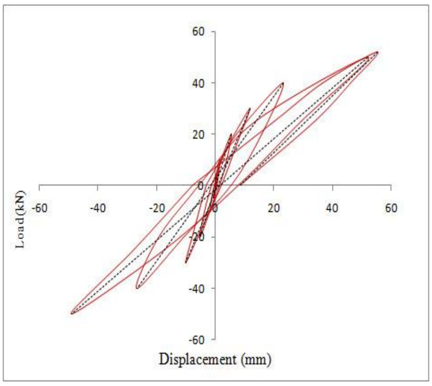
Fig. 6 Crack patterns of HPC and HPFRCC structural walls



HPCW1



HPFRCCW2



HPFRCCW3

Fig. 7 Load-displacement hysteresis of HPC and HPFRCC structural walls

4.2 Load deformation behaviour

Structures are expected to enter into elasto-plastic range during strong earthquakes, and the hysteresis loops can provide a good understanding for the analysis of seismic elastoplastic response. The load-displacement hysteresis curves for the specimens are shown in Fig. 7. It may be seen from these figures that load-displacement curves are linear up to the formation of first crack. After cracking, slope of the hysteresis curves (secant stiffness) degrades with an increase of displacement (Ganesan *et al*. 2010). The HPFRCC specimens exhibited less amount of deflection than HPC specimen for the same level of loading in the initial cycles, which indicates the increase in stiffness. This indicates the effect of fibres on the stiffness of the wall during the early cycles of loading.

4.3 Stiffness degradation

The lateral stiffness of the structural wall specimens was calculated from the base shear required for causing unit deflection at the top of the wall (Ganesan *et al*. 2010, Devi *et al*. 2011) The stiffness in a particular cycle was calculated from the slope of the line joining peak values of the base shear in each half cycle. The stiffness values were normalised by the gross stiffness. Fig.8 shows the comparison of stiffness degradation for HPC and HPFRCC structural wall specimens. It can be noted that as the number of cycles increases, the stiffness decreases, but the HPFRCC specimens under reverse cyclic loads exhibited less degradation of stiffness. This may be due to the effectiveness of steel fibres in bridging the cracks and the mixed mode of propagation of cracks as mentioned earlier in section 4.1. From the figure it may be noted that the initial stiffness of the HPFRCC structural wall with 0.5% and 1% steel fibres are 16.67% and 37.5% higher than that of HPC structural wall.

4.4 Energy dissipation capacity

In seismic design, inelastic ductile behaviour is associated with energy dissipation upon load reversal, which is an essential mechanism to survive strong earthquakes. The energy dissipation capacity of a member under the load is equal to the work done in straining or deforming the structure up to the limit of useful deflection, that is, numerically equivalent to the area under the

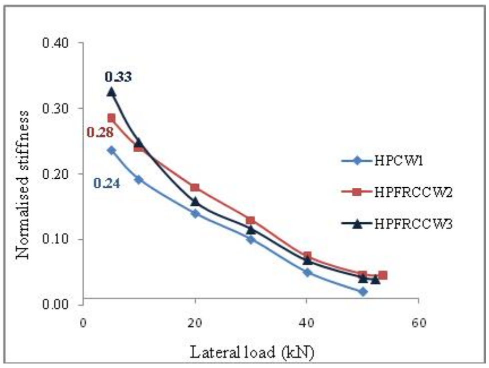


Fig. 8 Comparison of stiffness degradation of HPC and HPFRCC slender structural walls

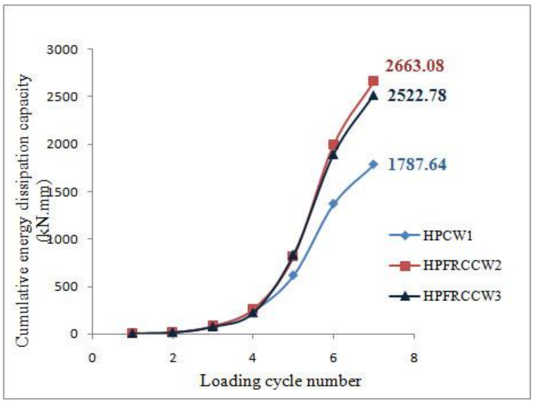


Fig. 9 Comparison of cumulative energy dissipation capacity of HPC and HPFRCC slender structural walls

load-deflection curve (Daniel *et al*. 2002Yun-do *et al.* 2004, Kuang and Ho 2008). The energy dissipation capacity during various load cycles was calculated from the sum of the area under the hysteretic loops. Fig.9 shows the cumulative energy dissipation capacity with loading cycle number of the specimens. The cumulative energy dissipation capacity of the HPFRCC slender structural wall with 0.5% steel fibres and HPFRCC structural wall with 1% steel fibres are 48.97% and 41.12% higher than that of HPC slender structural wall. The reason is that as the number of cycles increases, micro cracks develop and fibres, which are distributed at random, intercept cracks and bridge these cracks. This action will control further propagation of cracks and result in the demand of higher energy for debonding and pull out of fibres in the vicinity of cracks.

5. Summary and conclusions

The application of high-performance concrete in the construction of high-rise buildings leads to cost effectiveness, high strength, improved durability and lighter sections. However there are some disadvantages in using the high performance concrete, owing to its low tensile strength. This shortcoming can be rectified by adding short discrete steel fibres into the HPC matrix. The load-deflection characteristics, stiffness degradation trend, energy dissipation capacity; first crack load; ultimate load and crack pattern of HPC and HPFRCC structural walls were investigated. Based on the experimental results the following observations were made:

- The First crack load of HPFRCC slender structural wall with 0.5 % and 1 % steel fibres are 1.84 and 1.76 times higher than the HPC slender structural wall. However, the inclusion of fibres in the HPC improved ultimate load carrying capacity marginally.
- HPFRCC structural walls exhibit less stiffness degradation compared to HPC shear walls. The initial stiffness of HPFRCC slender structural wall with 0.5% and 1% steel fibres are 16.67% and 37.5% times higher than the HPC slender structural wall.
- The inclusion of fibres enhances the cumulative energy dissipation capacity. The cumulative energy dissipation capacity of the HPFRCC slender structural wall with 0.5% and 1% steel fibres are 48.97% and 41.12% times higher than the HPC slender structural wall.

- The study reveals the superior behaviour of HPFRCC over HPC and indicates that the construction difficulties associated with congestion of reinforcement may be partially solved by employing HPFRCC in the critical regions of the structural wall.
- In HPC wall specimen the first visible crack observed had a width of 0.05 mm. While in HPFRCC specimens, it is lower than 0.05 mm. The maximum width of crack observed in HPC specimens was 0.45mm. In HPFRCC specimens with 0.5% and 1% steel fibres, the maximum width of crack observed were 0.35 mm and 0.40 mm respectively.

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