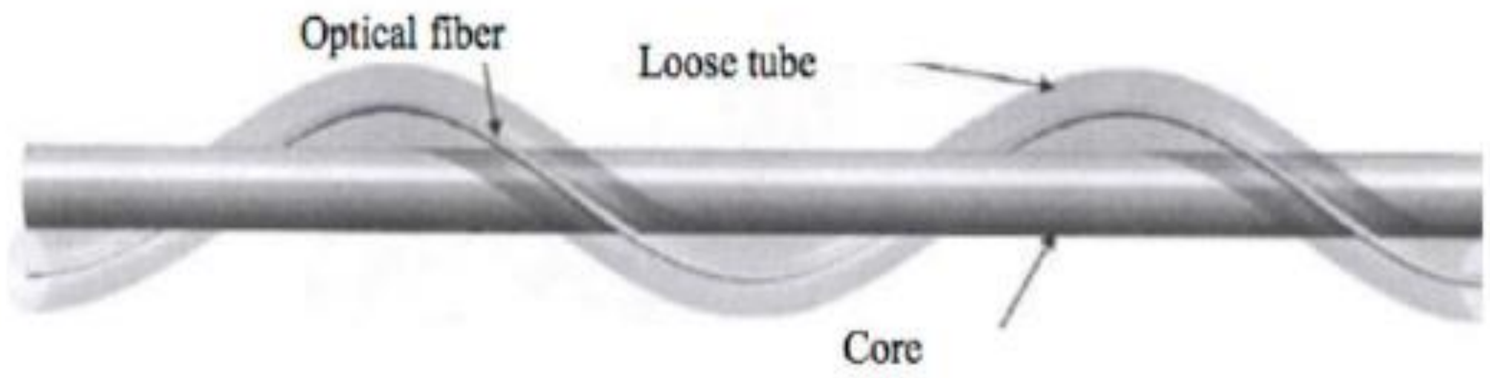
28 November 2019

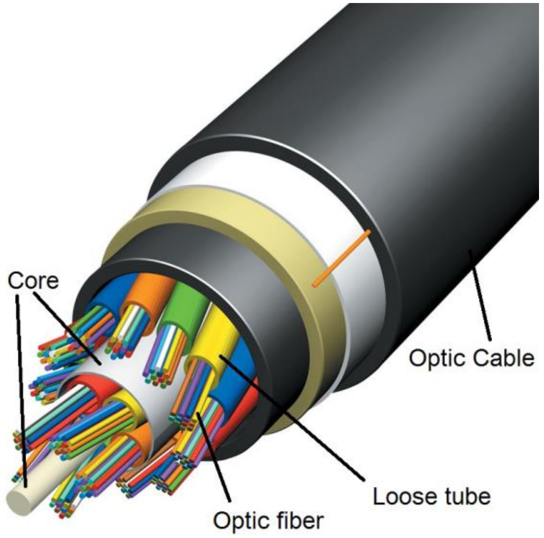
Various bend loss measurement in optical fiber cables

Sample text here

Optical fiber cables and various losses

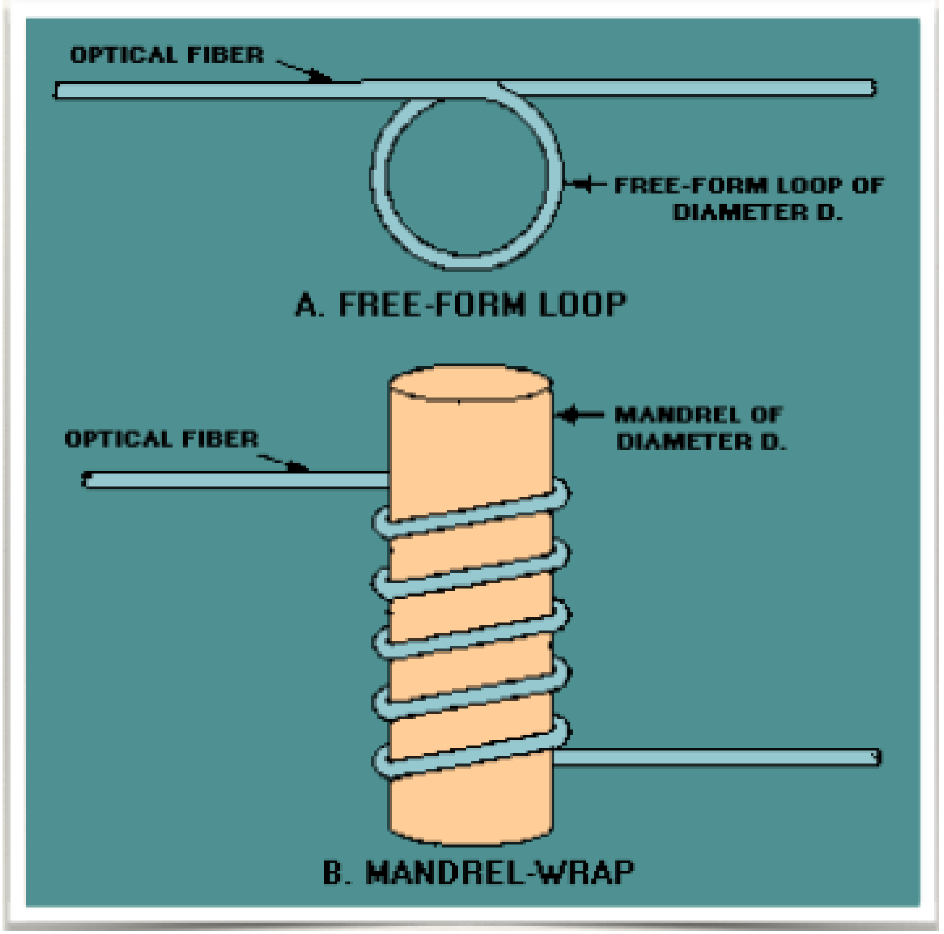
The design of the optical fifer cable (OFC) assembly requires consideration of several factors, e.g. manufacturing procedure dead and transient loads during cable-laying and in operation.
For optimum design of cables it is necessary to predict the signal attenuation and the degradation of optical fiber (OF). One of the major factors influencing this is macro bending losses. Hence it is important we analytically and with help of numerical methods investigate various losses optical fiber cable. Primarily this paper discuss numerical methodology for calculation of power losses because of macro bend. We will also touch upon losses because of micro bend losses but not to greater details.





Introduction

- In FTTH or OFC installations, transmission fibre needs to be bent around tight corners of walls, with bend diameter ranging from 5 to 20 mm. Such tight bending causes severe power loss
- While the agreement between theory and experiment is excellent at larger bend diameter, the results differ significantly for bend diameters less than 10 mm.
- This Cosserat theory of rods is also termed as geometrically exact beam theory (GEBT). to obtain stress tensor of a single-mode fibre that is bent and twisted.
- The computational results are compared with experimentally measured bend loss at different bend diameters (5.5 to 19.5 mm).



Geometric Effect :

When a fibre is bent, the optical path of the light changes as we move away from the centre of the bend. This change implies to the change of refractive index of the fibre. This change can be estimated using a technique known as conformal mapping [6]. The modified refractive index obtained from conformal mapping is given by below equation.

$$n_{geometric} = n\left(1 + \frac{x}{R}\right)$$

Stress effects

When a fibre is bent,it is subjected to bending stress and ultimately it will change the refractive index profile. Geometrically exact beam theory is employed instead of rudimentary Euler-Bernoulli beam theory in this work to compute the stress tensor in the case of planar loop of fibre, which is then employed in to Stress - Optics law to get modified refractive index [4], [5]. The equation which governs the change in RI profile under stress effect is given by below equation.

$$n_{stress} = n\{1 - \frac{n^2}{2}[P_{11}\epsilon_1 + P_{12}(\epsilon_2 + \epsilon_3)]\}$$

Where,

P_{11} & P_{12} are Stress Optic Coefficients

ϵ_1, ϵ_2, ϵ_3 are stress tensors obtained from GEBT

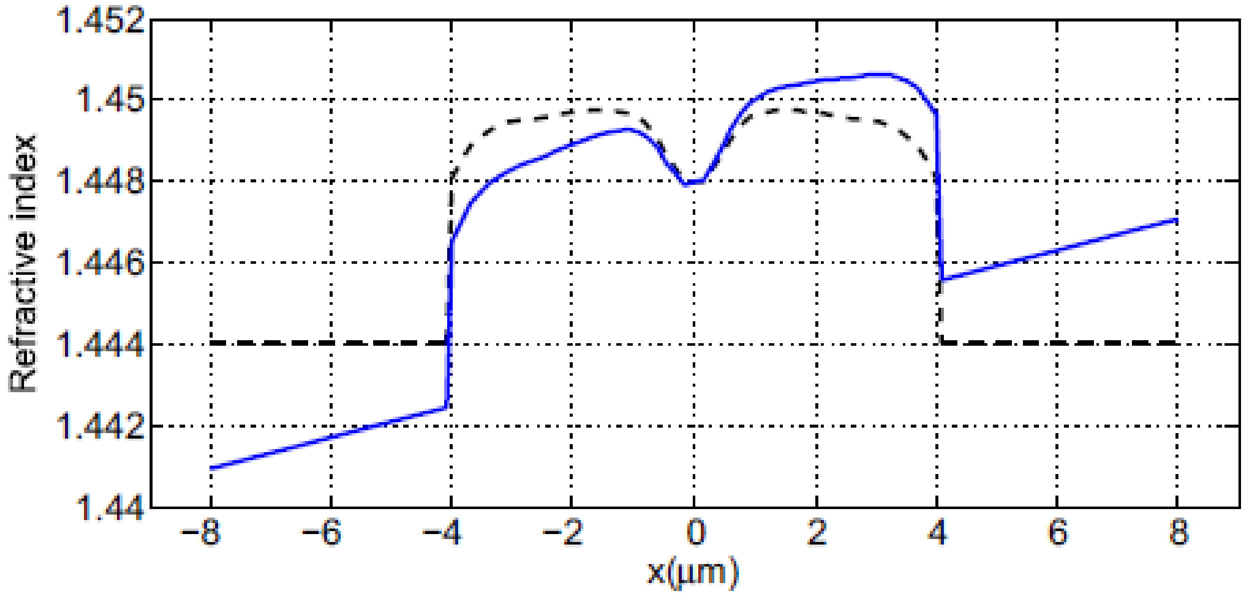
Combining the geometric and stress effects

Now the overall effect of geometry and stress effects on the optical fiber refractive index can be found using Eqn.

$$n'(x,y) = n[1 - \frac{n^2}{2}\{P_{11}\epsilon_2 + P_{12}(\epsilon_1 + \epsilon_3)\}]\left(1 + \frac{x}{R}\right)$$

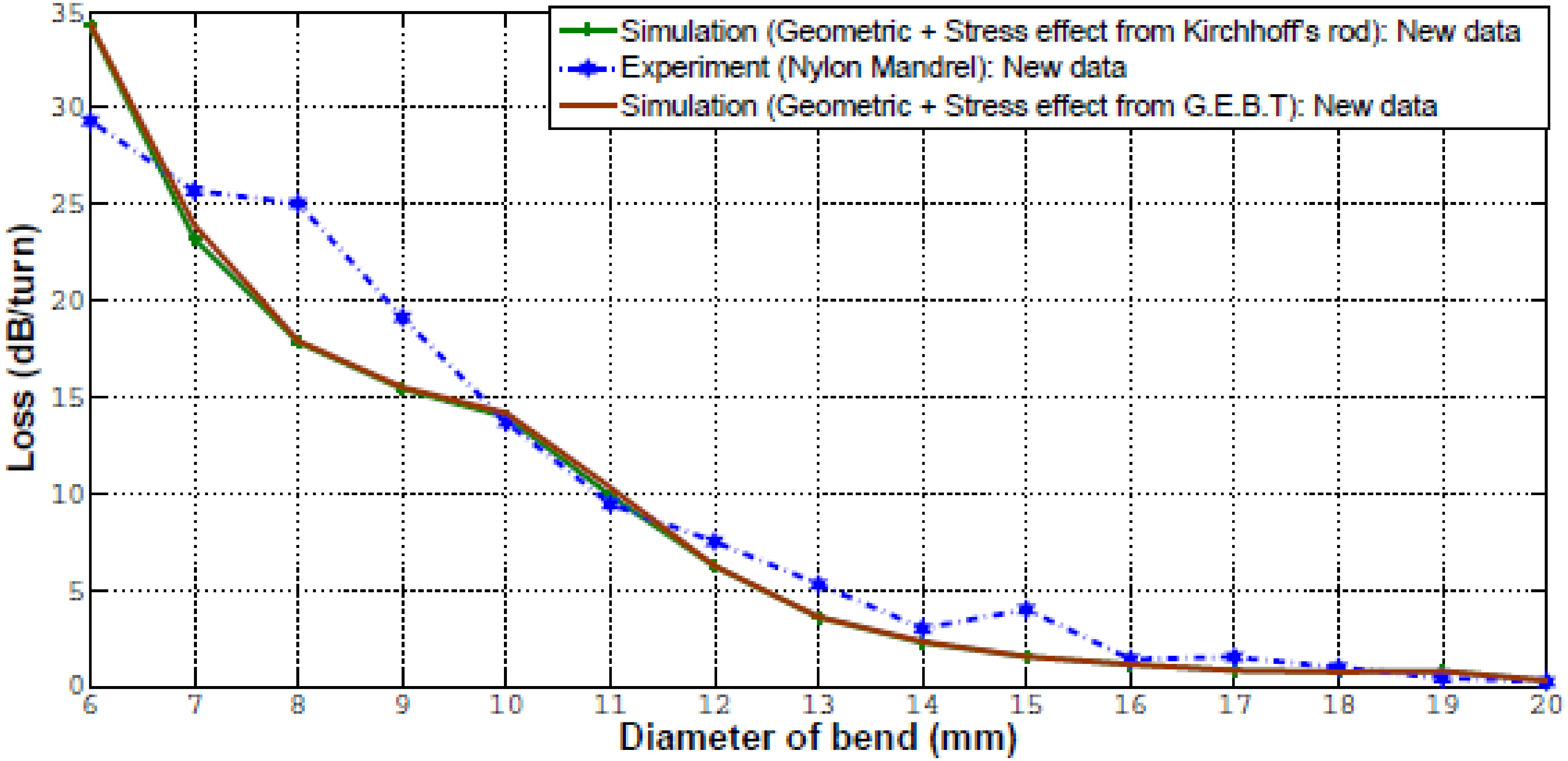
Modified refractive index

First the refractive index profile for a straight fibre (unbent case) is considered, then geometric and stress effects that has been discussed are considered. The comparison of the modified refractive index with the straight fibre index and with geometric and stress effects has been shown in along side figure. In the same way, the modified refractive index profile for all the bend diameters from 5 to 20 mm are generated and then fed in to COMSOL.



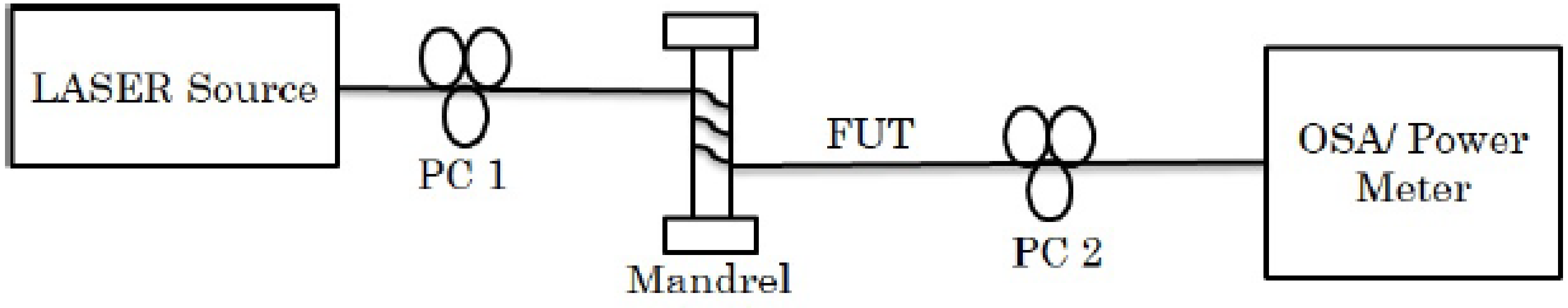
M-shaped refractive index profile of unstressed and unbent fiber along the centroidal plane of fiber(dotted black); Modified Refractive index of the optical fiber (incorporating both *geometry* and *stress* effects) for a bend radius of 3mm(solid blue)

Comparing experiment and simulation results

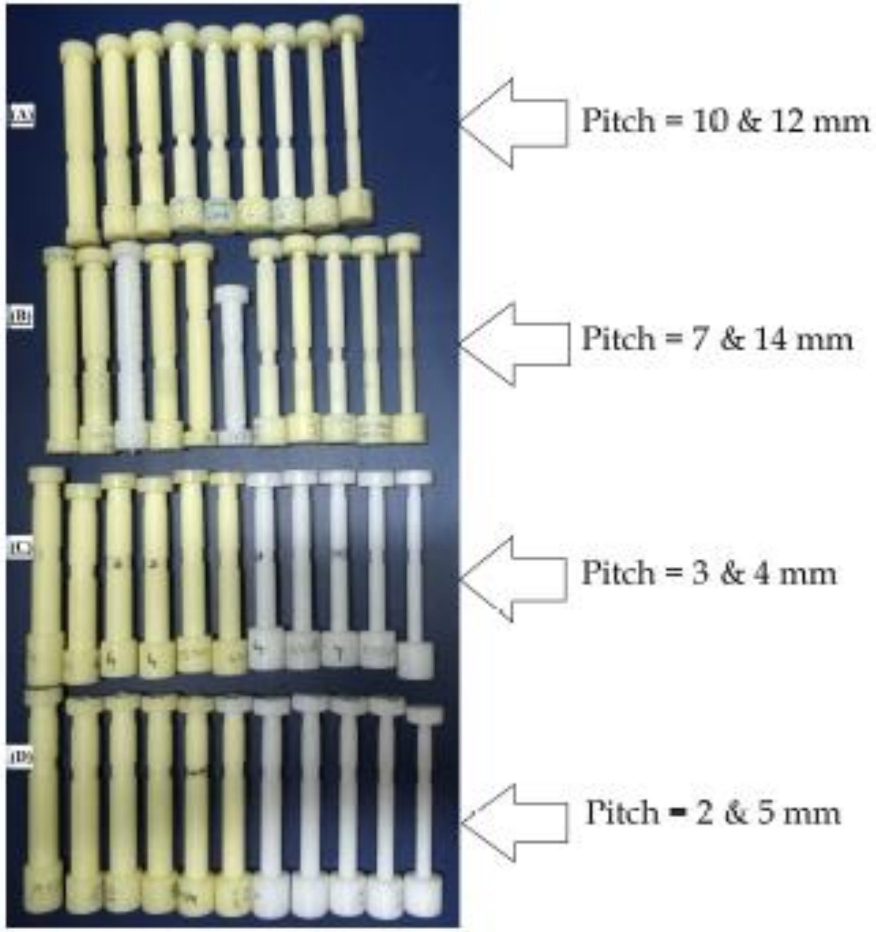


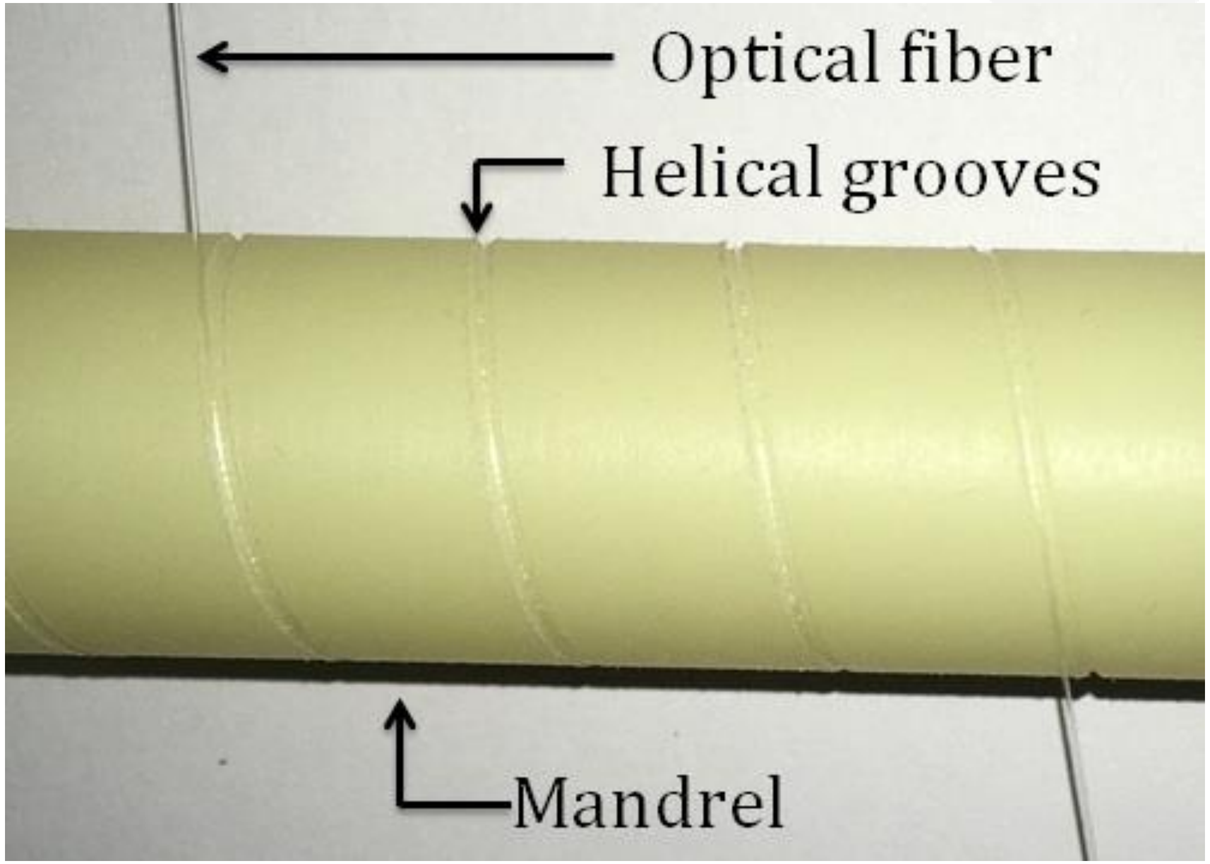
Experimental Set-up

The schematic of the experimental set-up that was used for calculating the loss for both In-Plane and Helical bends is shown in below figure with its wavelength 1550 nm was used as the LASER Source. Two Polarisation Controllers before and after the FUT, are adjusted to give out maximum light intensity at the output. A reference loss, that was present without any bending was noted and was subtracted from the loss obtained after bending the fibre, leaving out the loss due to bending. Loss at every bend diameter presented in this report is the average of the three experimental results.

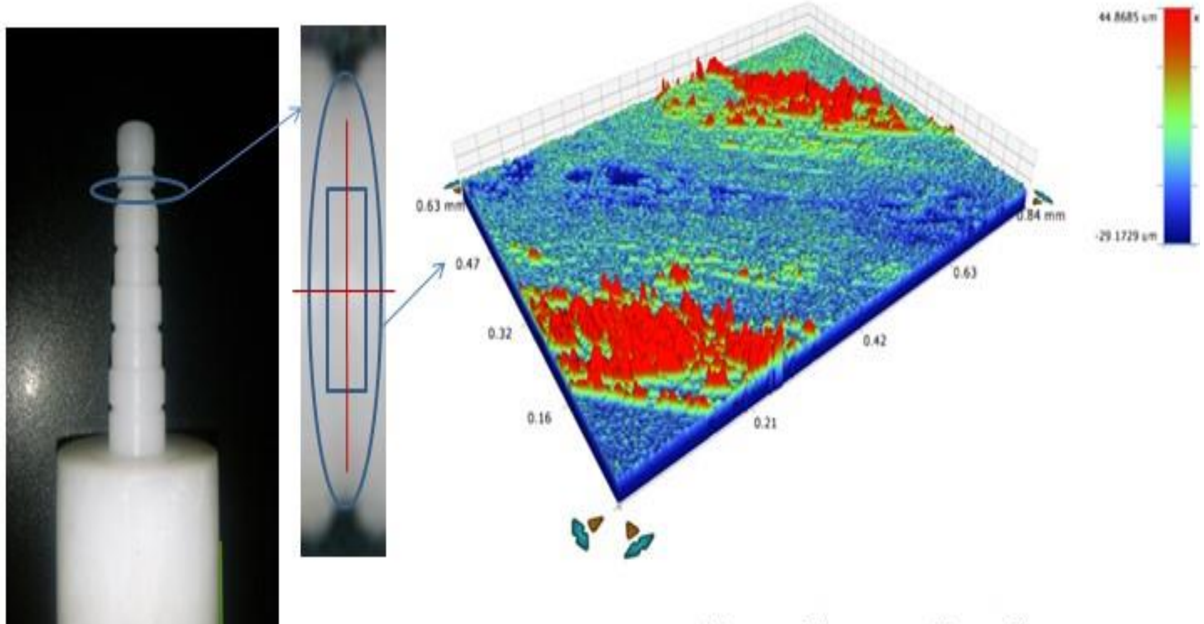


Mandrel -Experimental setup

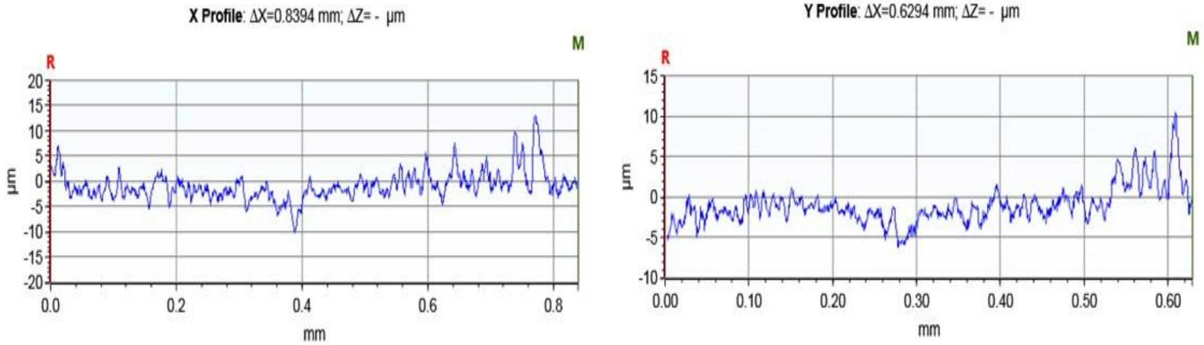




Surface roughness of the mandrel



(a) Nylon Mandrel (b) Spot for Measurement (c) 3D profile generated by profilometer



Bend diameter	Roughness:Ra(µm)
5.5mm bend diameter	4.4135
6.5mm bend diameter	4.5315
7.5mm bend diameter	4.774
9.5mm bend diameter	2.881
11.5mm bend diameter	2.899
13.5mm bend diameter	2.985
15.5mm bend diameter	1.594
17.5mm bend diameter	3.02
19.5mm bend diameter	3.092

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