SIGNALING GEODETIC POINTS WITH THE USE OF FIBER OPTICS

Izabela Wilczyńska[1]

Abstract

In a typical geodetic work are measured two values: an angle and distance. Manufactures try to minimalize errors these variable. In engineered surveying the precision of measurement must be high. To achieve this goal the instrument must be set in the vertical axes line of the instrument and signal. In the arduous conditions where is not lot of space for surveying, where is lot of dust, vibration, inhomogeneous temperature field and insufficient lighting field observation. It is very difficult to center instrument with high precision. To improve the quality of leveling and centering in a simple way we can use uncomplicated fiber-optic attachment called reflective optical fiber adapter. In this paper the author described the construction and operation of the instrument. The conducted experiments have shown high accuracy.

Keywords

Geodetic points, fiber optic, plummet optical.

1 INTRODUCTION

In a typical geodetic work are measured two values: an angle and distance. Manufactures try to minimalize errors these variable. In engineered surveying the precision of measurement must be high. However, other factors also affect the measurement error, for example:

- errors thick, mistakes caused by poor observational techniques or carelessness,
- ignores the movement of the plate bubble during observation,
- unequal atmospheric refraction (choose cool days or night time),
- errors associated with temperature, refraction, lighting,
- limitations of the theodolite reading systems and human eyesight,
- errors associated with leveling and centering.

Some of them can be avoided if proper field procedure is adopted such as observing more than one round of observations. To improve the quality of leveling and centering in a simple way we can use uncomplicated fiber-optic attachment called reflective optical fiber adapter.

1.1 Centering method of surveying instruments

Measurement conditions must be appropriate. First of all instrument and target should be centered over point. Also, the circle and the transverse axis must be horizontal. It is necessary to have the center of the instrument, which is the point of intersection of the transverse axis and the vertical axis of the instrument, directly over a given point on the ground. Tools to achieve these conditions are:

- plummet tape,
- plummet stick,
- plummet optical,
- plummet laser,
- plummet mechanical,

and their characteristic of parameters are presented in Table 1.

If the plummet (laser or optical) rotates with the instrument, it is easy to see whether there is a plummet error by simply rotating the instrument. If the line of collimation makes a circle then there is an error, this can be removed by keeping the instrument still and adjusting the line of collimation of the plummet to point at the centre of the circle. If the plummet does not rotate, then errors are harder to detect. Correcting such an error generally requires a special instrument, or professional servicing [1].

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Type of centering device	Mean centering error [mm]
plummet tape	1.5
plummet stick	0.5 – 1.0
plummet optical	0.5 – 0.8
plummet laser	0.3
plummet mechanical	0.1 – 0.4

Tab. 1 *Centering accuracy of the different types of divisions*[4]

1.2 Optical fiber

An optical fiber is a flexible, transparent fiber made of a pure glass (silica) not much wider than a human hair. Its function is to transmit light between the two ends of the fiber. Optical fibers are widely used in fiber-optic communications, which permits transmission over longer distances and at higher bandwidths (data rates) than other forms of communication. Fibers are used instead of metal wires because signals travel along them with less loss. Specially designed fibers are used for a variety of other applications, including sensors and fiber lasers [5]. There are several types of fiber optic (see Fig. 1)

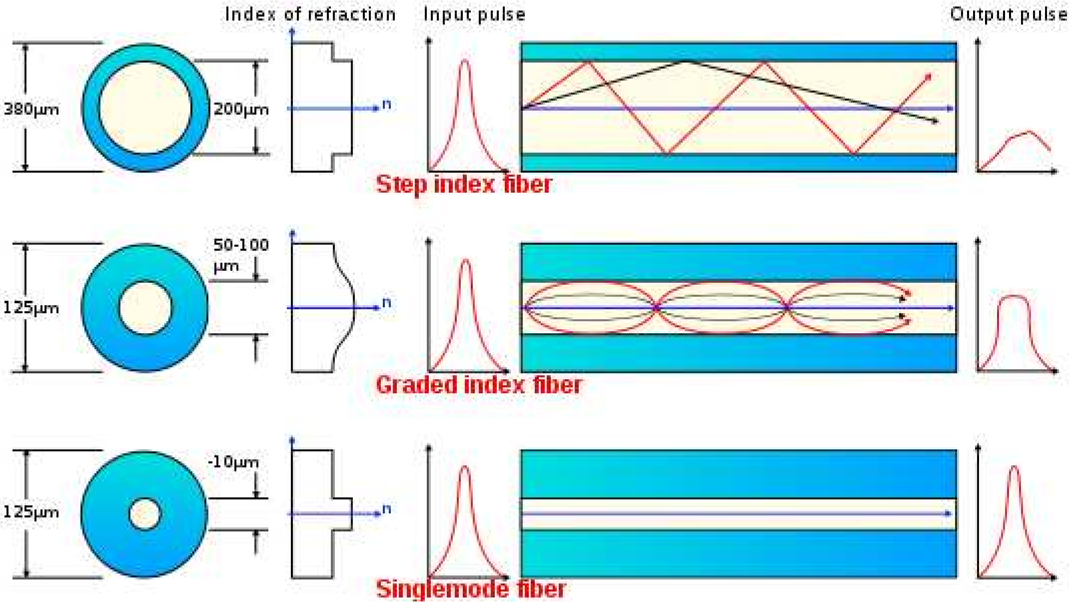

Fig. 1 *Types of optical fiber [6]*

2 REFLEKTIVE OPTICAL FIBER ADAPTER

In the arduous conditions where is not lot of space for surveying, where is lot of dust, vibration, inhomogeneous temperature field and insufficient lighting field observation. It is very difficult to center instrument with high precision. Centering task can improve reflective optical fiber adapter. Principle of operation based on the method of reflexive [3]. The project of construction is shown in Figure 2 and finished product is shown in Figure 3.

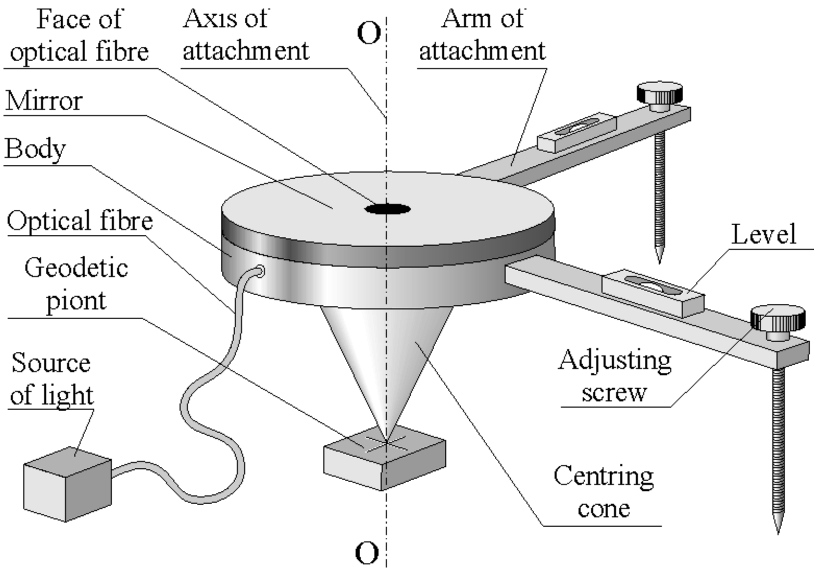

***Fig. 2** Constructional scheme of reflective optical fiber adapter [2]*

Attachment device consists of a body. The body is placed in the axis O – O in the bottom of the cone other removable support for example: rod, semicircular. The upper part of the mirror have a centrally embedded end of the fiber. To the body are attached two arms which are perpendicular to each other. The arms consists level gauge and set screws.

***Fig. 3** Reflective optical fiber adapter*

Reflective optical fiber adapter centering over the geodetic point with the use of an adjusting screw and level. Next move is connection with source of light. Instrument and target can be centered over geodetic. The next phase is set at the center point is shown in Figure 4.

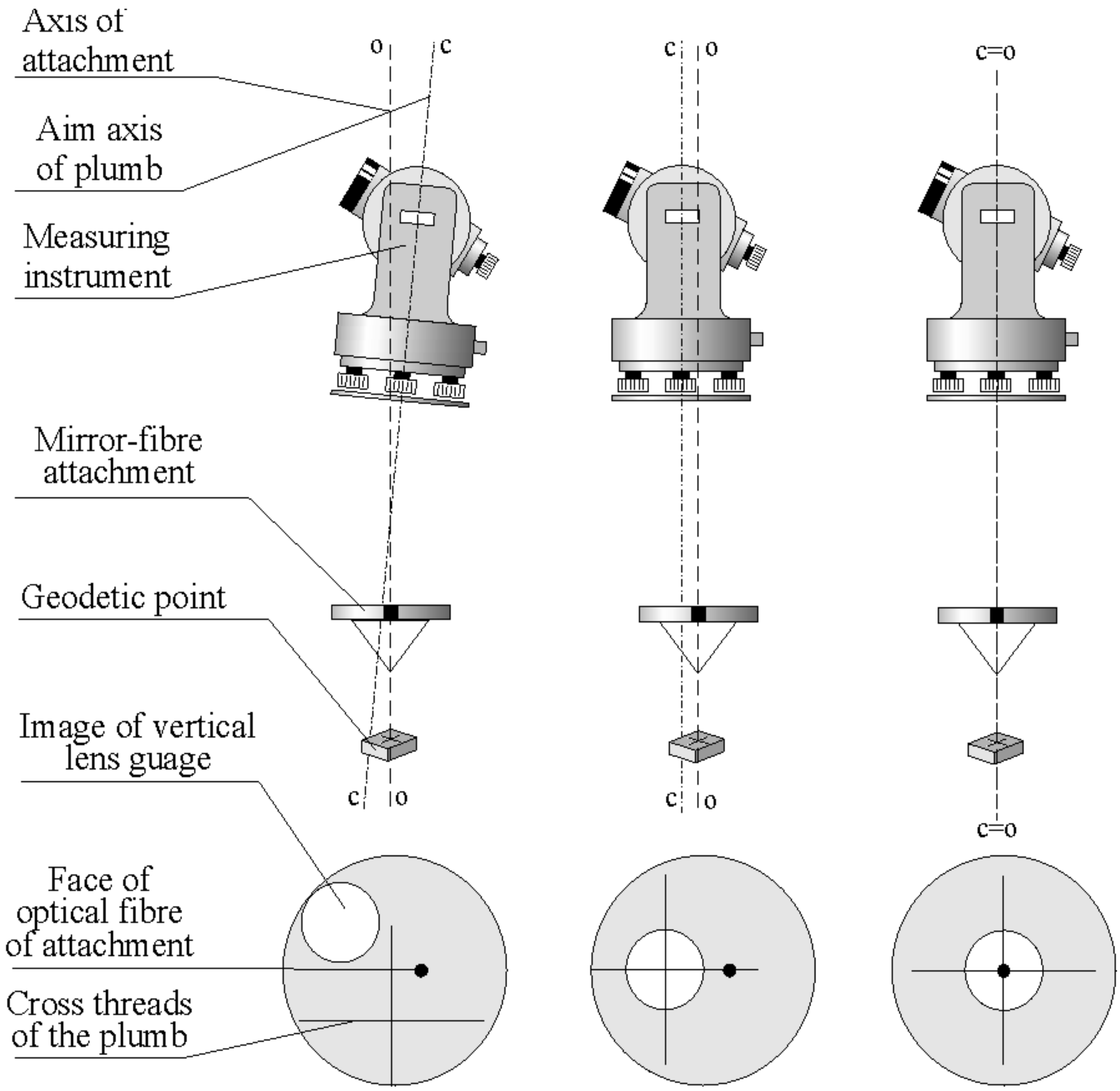

Fig. 4 *Successive phases of plumbing and centering the instrument over geodetic point [2]*

To assess the accuracy of the instrument author conducted a series of observations consisting of an electronic tachymeter TC1800 Leica centering over reflective optical fiber adapter (see Fig. 4). Measurement activities consisted of repeated deviation of the optical axis. Measurements were carried out for at a distance of 1.00 m, 1.25 and 1.50 between the adapter and the instrument. Results of measurements and calculations are summarized in Tables 2 – 4.

Height	1,50		x		y	
Coordinate	x	y	v	v^2	v	v^2
1	13,68	8,27	-0,0497	0,0025	0,0853	0,0073
2	13,72	8,24	-0,0097	0,0001	0,0553	0,0031
3	13,78	8,22	0,0503	0,0025	0,0353	0,0012
4	13,82	8,26	0,0903	0,0082	0,0753	0,0057
5	13,69	8,17	-0,0397	0,0016	-0,0147	0,0002
6	13,61	8,19	-0,1197	0,0143	0,0053	0,0000
7	13,65	8,18	-0,0797	0,0063	-0,0047	0,0000
8	13,73	8,20	0,0003	0,0000	0,0153	0,0002
9	13,76	8,14	0,0303	0,0009	-0,0447	0,0020
10	13,80	8,15	0,0703	0,0049	-0,0347	0,0012
11	13,78	8,14	0,0503	0,0025	-0,0447	0,0020
12	13,77	8,22	0,0403	0,0016	0,0353	0,0012
13	13,73	8,12	0,0003	0,0000	-0,0647	0,0042
14	13,67	8,29	-0,0597	0,0036	0,1053	0,0111
15	13,66	8,15	-0,0697	0,0049	-0,0347	0,0012
16	13,66	8,14	-0,0697	0,0049	-0,0447	0,0020
17	13,81	8,16	0,0803	0,0065	-0,0247	0,0006
18	13,71	8,15	-0,0197	0,0004	-0,0347	0,0012
19	13,79	8,16	0,0603	0,0036	-0,0247	0,0006
20	13,74	8,16	0,0103	0,0001	-0,0247	0,0006
21	13,75	8,24	0,0203	0,0004	0,0553	0,0031
22	13,68	8,18	-0,0497	0,0025	-0,0047	0,0000
23	13,69	8,21	-0,0497	0,0025	0,0253	0,0006
24	13,74	8,12	0,0603	0,0036	-0,0347	0,0012
25	13,68	8,13	-0,0597	0,0036	-0,0247	0,0006
26	13,69	8,22	-0,0397	0,0016	0,0053	0,0000
27	13,71	8,13	0,0603	0,0036	-0,0147	0,0002
28	13,73	8,25	0,0303	0,0009	0,0353	0,0012
29	13,75	8,12	0,0503	0,0025	-0,0347	0,0012
30	13,74	8,16	0,0103	0,0001	-0,0247	0,0006
Average[mm]	13,73	8,18	Sum [mm^2]	0,0779	Sum [mm^2]	0,0697
Errors [mm]	mo	0,050	mx	0,051	my	0,048

***Tab. 2** Results of measurements at a height 1,50m*

Height	1,25		x		y	
Coordinate	x	y	v	v^2	v	v^2
1	13,12	7,00	0,1043	0,0109	-0,0147	0,0002
2	13,11	7,03	0,0943	0,0089	0,0153	0,0002
3	12,94	6,97	-0,0757	0,0057	-0,0447	0,0020
4	12,99	7,12	-0,0257	0,0007	0,1053	0,0111
5	12,98	6,99	-0,0357	0,0013	-0,0247	0,0006
6	13,03	7,01	0,0143	0,0002	-0,0047	0,0000
7	13,05	7,02	0,0343	0,0012	0,0053	0,0000
8	13,03	6,99	0,0143	0,0002	-0,0247	0,0006
9	13,06	7,00	0,0443	0,0020	-0,0147	0,0002
10	12,97	6,89	-0,0457	0,0021	-0,1247	0,0155
11	13,07	7,01	0,0543	0,0030	-0,0047	0,0000
12	13,06	7,00	0,0443	0,0020	-0,0147	0,0002
13	13,03	6,98	0,0143	0,0002	-0,0347	0,0012
14	13,01	7,02	-0,0057	0,0000	0,0053	0,0000
15	12,95	7,08	-0,0657	0,0043	0,0653	0,0043
16	13,00	6,98	-0,0157	0,0002	-0,0347	0,0012
17	13,02	7,06	0,0043	0,0000	0,0453	0,0021
18	13,04	7,02	0,0243	0,0006	0,0053	0,0000
19	12,98	6,96	-0,0357	0,0013	-0,0547	0,0030
20	13,01	7,06	-0,0057	0,0000	0,0453	0,0021
21	13,08	7,11	0,0643	0,0041	0,0953	0,0091
22	12,99	6,98	-0,0257	0,0007	-0,0347	0,0012
23	13,02	7,00	0,0043	0,0000	-0,0147	0,0002
24	12,95	7,03	-0,0657	0,0043	0,1153	0,0133
25	13,00	6,95	-0,0157	0,0002	-0,0647	0,0042
26	12,98	6,99	-0,0357	0,0013	-0,0247	0,0006
27	13,02	7,01	0,0043	0,0000	-0,0047	0,0000
28	13,01	7,02	-0,0057	0,0000	0,0053	0,0000
29	12,98	7,04	-0,0357	0,0013	0,0253	0,0006
30	12,99	7,02	-0,0257	0,0007	0,0053	0,0000
Average [mm]	13,02	7,01	Sum [mm^2]	0,0573	Sum [mm^2]	0,0605
Errors [mm]	mo	0,044	mx	0,044	my	0,045

Tab. 3 *Results of measurements at a height 1,25m*

Height	1,00		x		y	
Coordinate	x	y	v	v²	v	v²
1	12,16	7,52	0,0037	0,0000	-0,0627	0,0039
2	12,14	7,54	-0,0163	0,0003	-0,0427	0,0018
3	12,09	7,59	-0,0663	0,0044	0,0073	0,0001
4	12,19	7,61	0,0337	0,0011	0,0273	0,0007
5	12,20	7,57	0,0437	0,0019	-0,0127	0,0002
6	12,18	7,62	0,0237	0,0006	0,0373	0,0014
7	12,16	7,56	0,0037	0,0000	-0,0227	0,0005
8	12,14	7,58	-0,0163	0,0003	-0,0027	0,0000
9	12,15	7,55	-0,0063	0,0000	-0,0327	0,0011
10	12,12	7,69	-0,0363	0,0013	0,1073	0,0115
11	12,17	7,54	0,0137	0,0002	-0,0427	0,0018
12	12,18	7,59	0,0237	0,0006	0,0073	0,0001
13	12,13	7,64	-0,0263	0,0007	0,0573	0,0033
14	12,16	7,55	0,0037	0,0000	-0,0327	0,0011
15	12,14	7,69	-0,0163	0,0003	0,1073	0,0115
16	12,17	7,60	0,0137	0,0002	0,0173	0,0003
17	12,10	7,58	-0,0563	0,0032	-0,0027	0,0000
18	12,14	7,59	-0,0163	0,0003	0,0073	0,0001
19	12,16	7,58	0,0037	0,0000	-0,0027	0,0000
20	12,15	7,55	-0,0063	0,0000	-0,0327	0,0011
21	12,18	7,55	0,0237	0,0006	-0,0327	0,0011
22	12,15	7,53	-0,0063	0,0000	-0,0527	0,0028
23	12,18	7,55	0,0237	0,0006	-0,0327	0,0011
24	12,13	7,54	-0,0263	0,0007	-0,0427	0,0018
25	12,19	7,54	0,0337	0,0011	-0,0427	0,0018
26	12,15	7,60	-0,0063	0,0000	0,0173	0,0003
27	12,13	7,59	-0,0263	0,0007	0,0073	0,0001
28	12,18	7,61	0,0237	0,0006	0,0273	0,0007
29	12,21	7,65	0,0537	0,0029	0,0673	0,0045
30	12,16	7,58	0,0037	0,0000	-0,0027	0,0000
Average [mm]	12,16	7,58	Sum [mm^2]	0,0225	Sum [mm^2]	0,0546
Errors [mm]	mo	0,036	mx	0,027	my	0,043

Tab. 4 *Results of measurements at a height 1,00m*

 

Fig. 5 *Electronic tachymeter TC1800 centering over reflective optical fiber adapter*

Tachymeter positioning accuracy of the optical axis over the point using the reflective optical fiber adapter was conducted from thirty series of observations:

- in the transverse direction at a height 1,50 m 0,050mm,
- in the longitudinal direction at a height 1,50 m 0,048mm,
- in the transverse direction at a height 1,25 m 0,044mm,
- in the longitudinal direction at a height 1,25 m 0,045mm,
- in the transverse direction at a height 1,00 m 0,027mm,
- in the longitudinal direction at a height 1,00 m 0,043mm.

Graph of the average error of height is shown in Figure 6. It can be seen that the error value increases with increasing altitude between the instrument TC1800 and adapter. This phenomenon occurs both in the transverse and longitudinal direction (see Fig. 7).

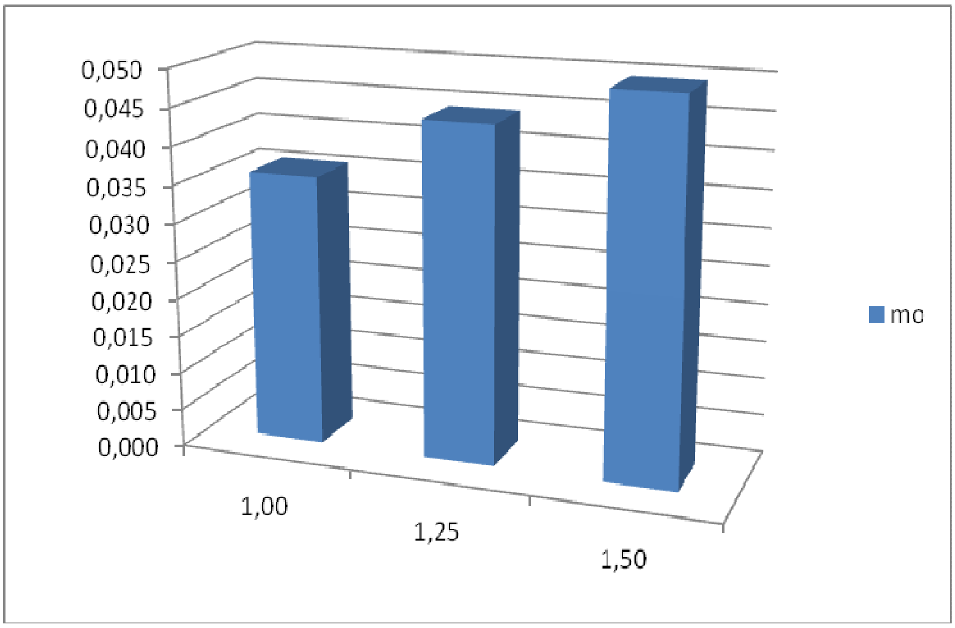

Fig. 6 *Graph of the average error depending on the height*

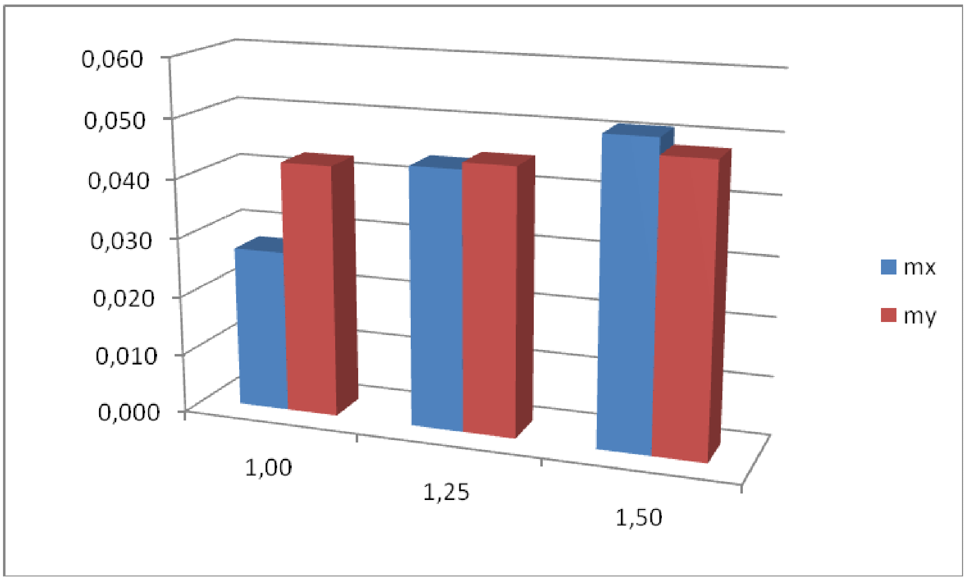

Fig. 7 *Graph of the error in the transverse and longitudinal direction, depending on the height*

Comparing with table 1 it can be concluded that the measurements performed using adapter imply a smaller centering errors than without it. Reflective optical fiber adapter is helpful in increasing the accuracy of measurements.

Features reflective optical fiber adapter:

- the measurement higher accuracy at low cost,
- small size for easy transport,
- user-friendliness,
- simple design using basic geometric dependence.

Reflective optical fiber adapter allows measurements in a dusty and shaded space. It can be used during accurate measurements on objects, when may be poor lighting conditions occur. The attachment device also can be used in tunnels and other structures requiring height accuracy measurements. Reflective optical fiber adapter is so small and compact that can be used in daily measurements.

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