Comparison of Chosen Geodetic Method for Measuring of Swimming Pool Length

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Abstract. Lengths are one of the basic geometrical quantities measured in geodetic works. The most important precondition for proper measurement is an accurate knowledge of length measures, calibrated standards, comparative devices and length measuring instruments. Nowadays, there is some kind of technological boom in all technological spheres. The measured length can be partial result of another kind of measurement like the 3D scanning. The aim of article is to compare measuring methods for measuring of swimming pool length.

1. Introduction
Indoor swimming pool in Žilina city is the oldest long course pool in former Czechoslovakia. This swimming pool was open in July 1963. The original length of the pool was round 49.99 m. After many changes in time measurement and all International Swimming Federation regulations, the pool was no longer satisfying and the times and records were no more considered as regular. In 2017, there was massive reconstruction of the pool to upgrade the pool in total length of 50.03 m. During the official competitions, there are used special touchpads. In Slovakia, there are used touchpads OMEGA OCP5. The OCP5 touchpad consists of a high-grade stainless steel frame, supporting interlinked individual PVC slats. These are hard-wearing, non-abrasive and provide an excellent non-split surface [1]. The admissible tolerance in 50.00 m swimming pools will be +0.010, -0.000 m. Tolerances will be measured from wall to wall with minimum length 50.020 till maximum length 50.030 or from used touchpad to touchpad from minimum 50.000 to maximum 50.010. Tolerances have to be consistent 0.300 m above to 0,800 m bellow the water surface. These measurements should be certified by a surveyor or other qualified official, appointed or approved by the Member in the country in which the pool is situated [2].

The reconstruction of the pool was great way to test possibilities of 3D scanner to give relevant results in measuring of distance. Similar geodetic works were done [3-6] on the solving different cases of civil engineering practice by laser scanning technology, which was also inspired for our problem-solving.

2. Measurement criteria
There are number of criteria defined by Fédération Internationale de Natation (FINA) for measuring of swimming pool distance. First of all, the measurement shall be done by a certified surveyor. This person shall be appointed or approved by the Member in the country in which the pool is situated [2].

The surveying equipment shall be Total Station. The minimum requirements of the Total Station are angle measurement accuracy 0.3 mgon and distance measurement accuracy 1mm± 1.5 ppm. There are measured distances between points that have to be marked. All the points to be measured shall be marked
with self-adhesive reflective targets [2]. The width of the pool shall be measured in both ends of the pool. The depth of the pool shall be measured at least in 5 point per lane: 1 m and 6 m from each end wall and in the centre of the pool [2]. The length of the pool shall be measured in the centre of each line. Measuring of the length, width and depth shall be measured with the pool full of water. Only measurement of walls verticality and parallelism shall be measured with the pool empty [2].

From the other parameters there is also needed pool to be orthogonal and vertical. The verticality of the end walls shall be measured in the centre of each line. The wall shall form 90 degrees right angles, not less than 0.8 m below and 0.3 m above the surface of the water. The tolerance is ± 0.20°. The sides of the pool shall be orthogonal and form 90 degrees right angle. The tolerance of the angle is ± 0.05°. The 2 diagonals shall be the same length with tolerance 10mm [2].

3. Measurement of the pool length

There were chosen two independent methods for defining of pool length. First can be considered as precise and correct standard method. The lengths were calculated from the coordinates of the points in local coordinate system. The points were measured by forward intersection from angles. The station points were given perpendicular to the measured lengths in the middle of the pool. The measurement was realised by Total Station Trimble VX with angle accuracy 0.3 mgon and distance accuracy 1mm +2ppm. The measurement was done during the cleaning of the pool so the pool was empty and the measurement was done from the inside of the pool with passive reflection. The points have been marked in the same level, regularly in the middle of the lanes, marked by targets in total size 1.5x1.5cm. In table 1, there are possible results of the measurements of each lane numbered same as in the swimming pool with the accuracy of calculated length.

| Lane   | calculated length | accuracy   |
|--------|-------------------|------------|
| Lane 1 | 50.0320 m         | ±1.4 mm    |
| Lane 2 | 50.0314 m         | ±1.4 mm    |
| Lane 3 | 50.0322 m         | ±1.4 mm    |
| Lane 4 | 50.0331 m         | ±1.3 mm    |
| Lane 5 | 50.0313 m         | ±1.3 mm    |
| Lane 6 | 50.0313 m         | ±1.2 mm    |
| Lane 7 | 50.0322 m         | ±1.3 mm    |
| Lane 8 | 50.0318 m         | ±1.4 mm    |

Figure 1. The placing of the stations in the pool
The second step was to measure the same location in the same time by other barely similar method. The sparing method to be chosen was 3D scanning. The idea was to calculate distance from the relative coordinates given by the final 3D model. The only question was the problem of measurement. If it is better to measure whole pool from one position, to prevent the mistakes resulting from the creation of two and more scan final model. The other option was to measure the pool with higher density of points from a number of positions, which can have a consequence as less precision of final model. The final measurement was done from one position in the middle of the pool. After all was this scan supplemented by other two scans on both sides. The scans were given together by visual registration. The final precision of the model was 4mm. The final scans, the scan from single position and the 3D model created from four scans were compared. The criteria was the length of the pool lane.

![Figure 2. Final point cloud created from four scans (left) and the final model of the long course pool (right)](image)

In the table 2, there is possible to see the different values of lanes lengths compared with the length measured by forward intersection from the angles.

**Table 2.** The values of lane length measure by forward intersection by the angles (first column), measured as partial result from simple scan (second column) and measured from the 3D visual registered model (third column)

| Lane | Forward intersection from angles | Simple scan | 3D visual registered model |
|------|---------------------------------|------------|---------------------------|
| Lane 1 | 50.0320 m | 50.0343 m | 50.0226 m |
| Lane 2 | 50.0314 m | 50.0303 m | 50.0198 m |
| Lane 3 | 50.0322 m | 50.0347 m | 50.0207 m |
| Lane 4 | 50.0331 m | 50.0327 m | 50.0187 m |
| Lane 5 | 50.0313 m | 50.0327 m | 50.0181 m |
| Lane 6 | 50.0313 m | 50.0347 m | 50.0216 m |
| Lane 7 | 50.0322 m | 50.0327 m | 50.0117 m |
| Lane 8 | 50.0318 m | 50.0343 m | 50.0208 m |

4. **Conclusions and remarks**

The paper is focused on problematic of distance measurement especially the problem of defining of length of the swimming pool. The first part is focused on the requirements of length measurements. These requirements are given from the FINA, to make the competing in a number of pools as fair as it just can be. The measurement of indoor swimming pool was done by various methods. As is it possible to see at Table 1, the forward intersection with using of Total Station seems as method that is good
enough. At the Table 2, there is possible to see the comparison of lengths measured on scan/3D model. There is strong difference between the results. The simple scan measurement may with some correction replace the Total Station measurement.

On the other hand, the lengths measured from the 3D visual registered model have differences that can change the final interpretation of whole job. This mistake can be caused by incorrect registration, so there is possibility to increase the accuracy by using of other kind of registration. The visual registration seems as a source of big irregularities.

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