ZNAČILNOSTI STABILIZACIJ TRIGONOMETRIČNIH TOČK NA PRIMORSKEM

CHARACTERISTICS OF TRIGONOMETRIC CONTROL NETWORK MARKS IN THE PRIMORSKA REGION

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IZVLEČEK

Na območju Slovenije, ki je bilo med letoma 1920 in 1947 v Kraljevini Italiji, smo izvedli analizo ohranjenosti različnih vrst stabilizacij trigonometričnih točk II. in III. reda. S pregledom topografij, fotografij na portalu hribi.net *ter vzorčnih terenskih pregledov smo med 52 trigonometričnimi točkami II. reda identificirali 16 takšnih, ki so bile verjetno stabilizirane v času Kraljevine Italije, ter 6 točk, ki so bile stabilizirane v obdobju avstro-ogrske monarhije. Med 407 trigonometričnimi točkami III. reda smo identificirali 68 točk, ki so bile verjetno stabilizirane v času Kraljevine Italije, ter 15 še starejših. Italijanski tip stabilizacije predstavljajo približno meter visoki betonski stebri štirikotne ali osmerokotne oblike s premerom od 40 do 70 centimetrov. Še starejši tipi stabilizacij geodetskih znamenj so izdelani iz klesanega naravnega kamna, ki velikokrat opravlja dvojno vlogo, tj. je točka različnih vrst geodetskih mrež in mejno znamenje, ki označuje meje katastrskih občin. V prispevku predstavljamo še kovinske signale iz leta 1996 ter v letih 1995–1997 izvedeno dodatno naknadno utrjevanje granitnih geodetskih znamenj, postavljenih po drugi svetovni vojni. Na koncu omenjamo še potencial takšnih v preteklosti vzpostavljenih geodetskih znamenj za uporabo v prihodnosti.*

ABSTRACT

An analysis of the present-day geodetic marks representing trigonometric points of the 2nd and 3rd order was carried out in the area of Slovenia that was part of the Kingdom of Italy between 1920 and 1947. By reviewing topographies, photographs on hribi.net and sample field surveys, we identified, among the 52 2nd order points, 16 points that had the Italian type of geodetic marks and 6 points with even older types of geodetic marks, dating back to the Austro-Hungarian Monarchy. Among the 407 3rd order points, we identified 68 Italian geodetic marks and 15 even older ones. The so-called Italian type of geodetic mark can be recognised as a concrete pillar with a square or octagonal shape, about 1 m high, with a diameter of 40 to 70 cm. The even older geodetic marks are carved from natural stone. These often have the dual function of being a trigonometric point mark and a land cadastral mark, indicating the boundary of cadastral municipalities. We also investigated the eccentric metal target signals erected in 1996, and those between 1995 and 1997, which were an additional post-consolidation of the existing granite trigonometric marks installed after the Second World War. Finally, we highlight the potential of these old geodetic marks in the design and planning of new measurements in the future.

KLJUČNE BESEDE

trigonometrične mreže, trigonometrične točke, stabilizacija, geodetska znamenja

KEY WORDS

national trigonometric networks, trigonometric point, stabilisation, trigonometric pillar, geodetic mark

1 INTRODUCTION

The different types of physical markers that represent the various geodetic and land-cadastre points used in the past are an important part of our geodetic technical heritage (Triglav Čekada et al., 2021b; Lisec et al., 2020). The trigonometric control network points from the period of the so-called classical geodetic surveying (in Slovenia this period ended with the establishment of the national active GNSS network SIGNAL in 2006) were indicated by different types of geodetic marks, sometimes also referred to as stations, signs (when made from concrete or natural stone), pillars or signals, which differ depending on the purpose and time period when the marks were introduced (Triglav Čekada and Jenko, 2020). Some of their common features are also defined by legislation and geodetic standards as well as the tradition of a former country in which the geodetic marks were erected. In this paper we will present the special features of geodetic marks erected in the Primorska region of the Republic of Slovenia and analyse their current state of preservation. Unlike the rest of the territory of the Republic of Slovenia, this part of the country was included in the Kingdom of Italy for more than 20 years in the previous century, officially between 1920 and 1947. We have examined the marking types of all the trigonometric network control points from the 2nd and 3rd orders and a smaller sample of trigonometric control points from the lower orders. We did not analyse trigonometric points from the 1st order (for more information on the 1st order trigonometric network, see Delčev, Timar and Kuhar, 2014; Stopar and Kuhar, 1997).

The area under consideration can be regarded as a coherent unit in the context of the subsequent densification of trigonometric control networks and the related types of new marks being introduced after the reconnection of the Primorska region to the territory of the former Yugoslavia, now the territory of the Republic of Slovenia, after the end of the Second World War. Between 1947 and 1948 the Geografski inštitut Jugoslovanske armade (abbreviated as GIJNA or GIJ, and later called the Vojnogeografski inštitut) developed and measured a trigonometric network of the 2nd order in the area of Primorska and the Slovenian part of the Istrian peninsula. In the surroundings of the city of Trieste, the 2nd order trigonometric network was re-surveyed in 1955 to meet the higher quality needs for the new demarcation line measurements with the Republic of Italy (Jenko, 1987). Between 1947 and 1948, GIJNA also carried out geodetic works on the 3rd and 4th order trigonometric networks in the Primorska region. In the areas surrounding the cities of Idrija and Cerkno, the Geodetski zavod Slovenije (GZS) participated with the GIJNA to complete the work in 1950 (Jenko, 1990). Therefore, in these areas, mostly the trigonometric points from 2nd to 4th order, are indicated by square-shaped marks that have upper dimensions of 20 cm × 20 cm or 15 cm × 15 cm, which protrude from the ground at most locations by at most a few decimetres, and are made from different types of granite (as erected by GIJNA, GZS) or concrete, known as the Idrija type of stabilisation (erected by GZS) (Triglav Čekada and Jenko, 2020). The trigonometric points marked with the Italian type of stabilisation can be identified as larger pillars made from concrete with a square or octagonal shape in the cross-section, about 1 m high, and with a diameter of 40 to 70 cm (Triglav Čekada and Jenko, 2020).

In this paper we will present in detail the different types of geodetic marks from the trigonometric networks in the Primorska region. These were provided by a co-author of this paper, Ivan Lojk, a land surveyor with many years of practical field experience who worked at the Regional Surveying and Mapping Authority in Koper from 1976 to 2016 (Triglav Čekada et al., 2021a). They include trigonometric points in the form of concrete pillars built during the Kingdom of Italy in the period 1920–1947, as well as even older types of geodetic marks from the period of the Austro-Hungarian Monarchy. Additionally, the details on the marks built or modified afterwards in the period of the Republic of Slovenia will be provided. These include the erection of the eccentric metal target sight signals from the post-1996 period, and the reinforcement of the classical granite geodetic marks with additional concrete in the period 1995–1997. Based on a subsequent detailed analysis of the various archive materials and field visits to the locations of the geodetic marks, we have also estimated the number of geodetic marks still preserved from the Italian or the Austro-Hungarian period. The paper concludes with a discussion on the potential that the geodetic marks preserved from the past can have today.

2 METHODOLOGY

The trigonometric control network points marking types were analysed for the area between the former Rapallo border and the present border between the Republic of Slovenia and the Republic of Italy. We focused on identifying the geodetic marks established during the Kingdom of Italy and the even older types of geodetic marks remaining from the time of the Austro-Hungarian Monarchy. The characteristics of the trigonometric mark type at each location were examined by inspecting the trigonometric point topographies in the archive trigonometric points database from the Surveying and Mapping Authority of Slovenia (hereafter, topographies). We examined 52 trigonometric points of the 2nd order, 407 points of the 3rd order and 18 points of the lower orders.

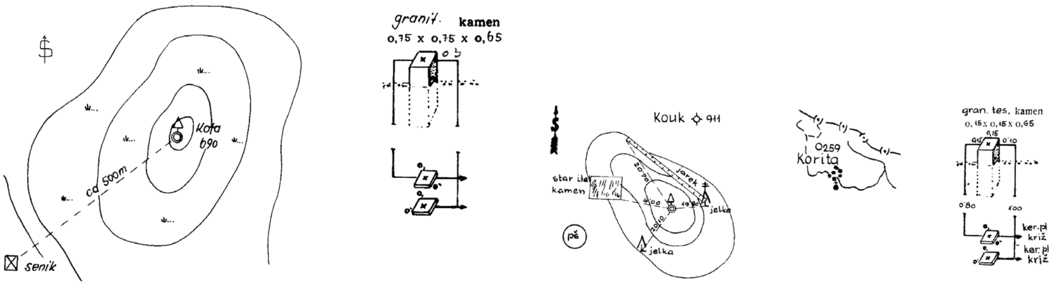
Additionally, for all these trigonometric points we checked whether some kind of information on the geodetic mark stabilisation type is available on the *hribi.net* website, as it contains a lot of photographs, including photographs of the mountain peaks, which occasionally reveal various geodetic marks. The most frequently photographed geodetic marks are the Italian types, with concrete pillars, mainly because of their greater dimensions and the fact that a mountaineering box is often attached to them, containing a mountaineering registration book and stamp. On the *hribi.net* website we were thus able to check 27 locations of 2nd order and 87 locations of 3rd order trigonometric points. If we concluded from the examination of the topographies that a geodetic mark with the Italian type of stabilisation was present at a certain location, but it could not be seen on *hribi.net*, we considered that at this location the original geodetic mark was not preserved any longer. If we could not conclude from the topographies that the geodetic point had the Italian type of stabilisation, but it was visible in the photographs on *hribi.net*, we still considered such a geodetic point as a location where the Italian type of stabilisation is preserved.

In lowland areas we inspected some locations using *Google Street View*. Several trigonometric point locations were also checked in the field. However, as we were not able to check all the geodetic points in the field, we mainly assumed that a specific type of geodetic mark indicated on the topographies was still present at a given location, as we considered the geodetic point topographies to be an appropriate source of information on the type of geodetic mark. They were primarily made before, during or immediately after the geodetic survey at the location of a particular geodetic point, usually in the first two decades after the Second World War.

On the trigonometric point topographies that have geodetic marks built during the Kingdom of Italy, this type of geodetic mark cannot be uniquely identified, while the description of this type of geodetic mark can vary: *old Italian stone, concrete* or described by incorrect material as *granite stone of larger dimensions* (Figure 1a), *concrete pillar*, and occasionally just *concrete stone without dimensions*. If on the topography, only *concrete stone* is indicated as a marking type, this may also mean that the geodetic mark is of a specific type, established for the geodetic and mining surveying needs for the Idrija Mercury Mine, where the smaller geodetic marks (blocks) made from concrete were used as well, with upper dimensions of 15 cm × 15 cm or 20 cm × 20 cm and an above-ground height of a few decimetres, at most. A special feature of these is the metal rod in the centre, which protrudes out of the concrete by a few centimetres. We also came across examples of topographies in which an old pillar made from concrete was used only as a physical marker in nature, similar to different bigger rocks or trees, used to generally place the geodetic point in the local area – meaning that it does not represent a trigonometric point any longer (Figure 1b). Still, it can be helpful when trying to reconstruct the position of a possibly ruined primal trigonometric mark. It should be noted here that when a geodetic point was physically established and measured within trigonometric network surveys immediately after the Second World War, there was no requirement to adopt the old geodetic marks that were already standing there, but rather to replace or substitute them with new ones (Triglav Čekada and Jenko, 2020). Some, admittedly only a few, geodetic points where the existing mark was adopted for new measurements and new needs, have in the attribute part of the topography a comment that reads *adopted old Italian stone*. However, as we discovered during the field visits, the mere mentioning of a *stone without dimensions* on topography did not prove to uniquely and unambiguously define the Italian types of geodetic marks (Figure 2). It turned out that such a reference only exceptionally refers to an Italian pillar of octagonal shape; mostly it describes an even older type of geodetic mark that represents at the same time a boundary and a trigonometric point, or sometimes it describes examples of different crosses carved in natural rock, but occasionally it can also describe newer types of classical geodetic markings, e.g., smaller granite stones, which were not properly included (updated) in the topographies.

Even older types of geodetic marks were identified primarily based on field visits. At such geodetic points, in the attribute data of topographies, it is sometimes written as *old type of stabilisation*, but sometimes we also encountered larger cadastral boundary marks on the *hribi.net* website (Figure 2a). To determine whether this is a more important cadastral boundary mark of larger dimensions or a remnant of an Italian type of geodetic mark, we also consulted the data on the cadastral municipality boundaries. If a trigonometric point is on the border of a cadastral municipality, there is a high probability that it is not an Italian type of geodetic mark, but a cadastral municipality mark of larger dimensions, being at the same time a trigonometric and cadastral point.

Using various sources, from photographs on the *hribi.net* website to orthophotos from the Cyclic Aerial Surveying of Slovenia, we also determined the type of terrain on which the geodetic mark is currently located: forest, meadow, fields, rocks, open and built-up, and information on any trails and roads in the vicinity, for a possible later field visit. The first information will serve to assess the potential to identify geodetic points that enable immediate GNSS surveying. Such points are located in open areas without forest cover and can therefore be immediately included in new GNSS surveys.



a) b)

Figure 1: Two examples of topographies from which it can be indirectly concluded that an Italian type of geodetic mark could be found in nature: a) Rodne, trigonometric point of the 3rd order, No. 31, trigonometric district Idrija: the detailed sketch of the stabilisation on the topography (right) shows the larger dimensions of the erroneously described *granite stone*, being from concrete in nature, the pillar is also visible in photographs on the website https://www. hribi.net/gora/rodne/21/1964, b) Kovk, trigonometric point of 3rd order No. 259, trigonometric district Idrija: on the overview sketch in the topography (left) one distance, needed in the case of the reconstruction of the position of a potentially ruined primal trigonometric mark, is measured from the *old Italian stone* to the primal mark (source: SMA).

a) b)

Figure 2: Two examples of trigonometric points inspected in the field, marked in topographies as *stone without written dimensions*: a) Srnjak, trigonometric point of 3rd order, No. 1, trigonometric district Postojna and at the same time a tri-border of cadastral municipalities: on one side there is written 1878, on the other side the inscription MT (standing for German: Militärische Triangulation = military triangulation), which indicates that this is an old Austro-Hungarian geodetic mark, and on its base, there is also an inscription 1928 RA (standing for Italian: Rete Artiglieria = artillery network), which indicates that it was also used for surveying during the Kingdom of Italy (photo: M. Triglav Čekada, 2021); b) Kal over Kostanjevica, trigonometric point of the 3rd order, No. 76, trigonometric district Nova Gorica: stabilisation from the post – Second World War period – granite stone surrounded by a concrete slab (photo: R. Škafar, 2021).

3 RESULTS

3.1 The preservation rate of the Italian and even older geodetic marks in the trigonometric networks of the 2nd and 3rd order

In the trigonometric network of the 2nd order we found 30% of geodetic points on which the Italian type of geodetic mark is most probably still preserved and 12% of geodetic points marked with even older types of geodetic mark. In the trigonometric network of the 3rd order, there are 17% of Italian types of geodetic marks and 4% of even older geodetic marks. We cannot estimate those shares for trigonometric networks of lower orders, as we examined only a smaller sample of points from those networks, and for the ones examined in the field we already knew in advance from topographies that they are probably marked with an Italian type of geodetic mark.

Figure 3 shows the spatial distribution of the 2nd and 3rd order trigonometric network points where the Italian types of geodetic marks are most likely preserved. It is noticeable that they have been preserved mainly in the less populated hilly areas of a wider area around the cities of Idrija and Cerkno, the Brkini hills and in the Pivka basin, including the mountain Vremščica. However, fewer are preserved in the more populated hilly parts of the upper Posočje, Kambreško, Brda, Kras and the Koprska brda.

Table 1 shows a higher proportion of Italian and even older types of geodetic marks on open, grassy or even bare mountain or hill peaks in the trigonometric network of the 2nd order, where new GNSS surveys would be immediately possible. In the trigonometric network of the 3rd order about a half of the trigonometric points stabilized by both types of geodetic marks are located in the forested areas today, which means that they are not placed in favourable locations for immediate, new GNSS surveys. This was expected, as the trigonometric network points of the 2nd order are located at higher mountain peaks than the trigonometric points of the 3rd order.

Table 1: Probable Italian or even older types of geodetic marks at trigonometric network points of the 2nd and 3rd order in the area between the former Rapallo border and today's border between the Republic of Slovenia and the Republic of Italy. Both trigonometric network orders have an additional column where the number of points not located in forested areas is given, meaning that they would potentially be useful for any new GNSS surveys.

Trigonometric network	Number of points examined	Number of probable geodetic marks of Italian types	Number of geodetic marks of Italian types that are not located in a forest	Number of probably even older geodetic marks	Number of even older geodetic marks that are not located in a forest
2nd order	52	**16**	12 (75 %)	**6**	4 (67 %)
3rd order	407	**68**	35 (51 %)	**15**	7 (47 %)

In this review we have only summarised the still-active trigonometric points that are marked with the Italian or even older types of geodetic marks and can be still found in the nature. However, even more, wrecked Italian concrete pillars can be found in the field. These do not have the function of trigonometric points anymore, and many times they lie in the vicinity of the more recent granite marks set up after the Second World War (Figure 4), but their remains have not been plotted in the topographies. For example, on the Lačna hill, above the village of Gračišče, there is a demolished Italian concrete pillar beside the new granite mark, representing a present-day trigonometric point of the 2nd order, No. 366. As this location is also on the boundary of cadastral municipalities, the hribi.net website (https://www.hribi.net/gora/lacna/26/1705) shows nearby another older cadastral municipality boundary stone of larger dimensions in a dry-stone fence, which may also have been used for trigonometric surveys in the past[1]. Additionally, the co-author of this paper, Ivan Lojk, told us about the former Italian concrete pillar in the village of Črnotiče, representing the former trigonometric control point of the 2nd order,

[1] *On the map of the 3rd Military topographic survey of the Austro-Hungarian Monarchy from the period 1880–1885 this location is already marked as a point where numerical triangulation was carried out.*

No. 345, that was demolished during the expansion of the nearby Črni kal quarry. Similarly, on the Karlovica hill above the village of Pregarje, there was a 2nd order trigonometric point, No. 350, which was probably marked by an octagonal pillar, but was later destroyed and a new trigonometric mark was erected eccentrically in its original location.

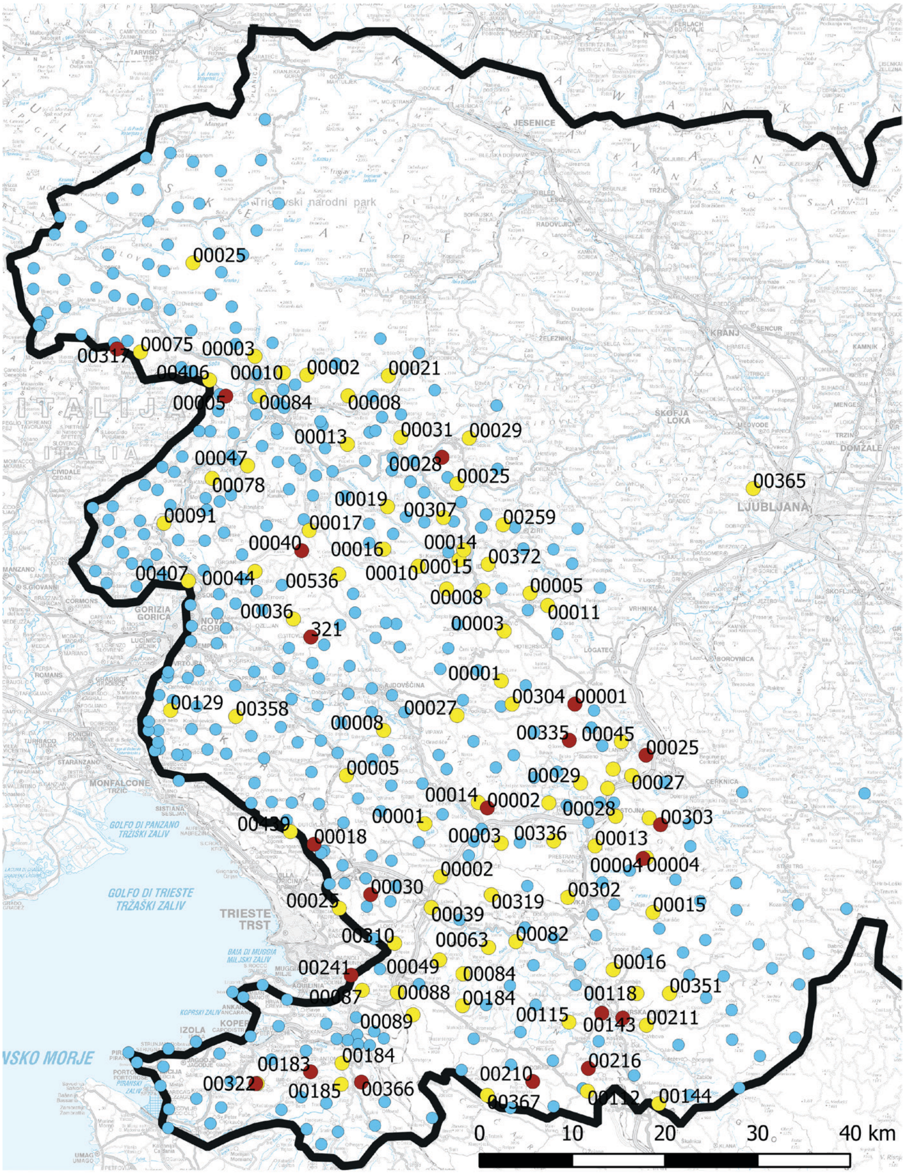


Figure 3: Examined locations of trigonometric control points of the 2nd and 3rd order between the former Rapallo border and today's border between the Republic of Slovenia and the Republic of Italy: blue – examined, yellow – probably still existing Italian type of marking, red – an even older type of marking from the time of the Austro-Hungarian Monarchy (source of the map: SMA).

Figure 4: Example of a ruined Italian pillar at Črna griža next to the new trigonometric point of the 4th order, No. 47, trigonometric district Sežana (photo: R. Škafar, 2021).

3.2 Interesting examples of Italian or even older types of geodetic marks

Although the Italian pillars were made from concrete around 100 years ago, most of them are still well preserved. They often bear the year of construction and the inscription RA (for Italian: Rete Artiglieria = artillery network). The inscription RA is sometimes also found in combination with even older geodetic marks, such as on the trigonometric point examples of the 3rd order at the Postojna trigonometric district of No. 1 Srnjak from Figure 2a, No. 4 C0 Sveta Trojica from Figure 6 and the 2nd order, No. 322, in the village of Pomjan from Figure 9.

Here we present in more detail some Italian pillars in southern Primorska, for which Ivan Lojk has given us more details or which other authors of this paper inspected in the field for their current status:

- **Velika Milanja**, trigonometric point of 2nd order, No. 351, Z0: Italian octagonal pillar of higher-order trigonometric point, first renovated in 1976, secondary renovation in 1996, and also included in one of the EUREF GNSS measurement campaigns in Slovenia[2] (point abbreviation: MILO).
- **Razsušica or Glavičorka near Slovenian-Croatian border**, 2nd order, No. 367: Italian octagonal pillar. It is 1 m high, with upper dimensions of about 50 cm × 50 cm.
- **Veliko Gradišče above the village of Vrhpolje nad Krvavim Potokom**, 2nd order, No. 310: Italian square pillar of upper dimensions 30 cm × 30 cm, with original square opening for placement of the sighting signal mark. During the EUREF GNSS measurement campaigns in Slovenia[2] in 1996 (abbreviation of the point: VGRA), a bolt for the forced centring of the GNSS antenna was installed in the centre of the filled aperture for the placement of the sighting signal mark.

[2] *Between 1994 and 1996, three EUREF GNSS survey campaigns were carried out in Slovenia. The GNSS measurements at Velika Milanja and Veliko Gradišče were a part of the so-called third campaign, which aimed to densify points in the territory of Croatia, and 6 points were additionally measured in the territory of Slovenia (Berk et al., 2003).*

Hribček above the village of Dvori, 4th order, No. 96 Z2, triangulation district Koper, embedded 1931 RA (Figure 5a): Italian concrete pillar of square cross-section with opening for the installation of the sighting signal mark's placement. During the construction of the road bypass around the village of Dvori, the geodetic mark representing Z0 was destroyed. Only the Italian pillar representing Z2 was then preserved. While Z0 was still in existence, in Z2 an aluminium bolt was installed in the hole for the placement of the sighting signal mark and this was resurveyed at the same time as Z0.

Kubeljska varda, 3rd order, No. 184, triangulation district Koper (Figure 5b): Italian square pillar with upper dimensions of 70 cm × 70 cm and a filled hole for the placement of the sighting signal mark, where a bolt is installed on which a cross is carved. Around 2000, this point was renumbered from 2B to 184. Today, it is a part of the 3rd-main-order national trigonometric network. It was erected in the 1930s to serve as a local triangulation basis for the planned construction of a water pipeline or reservoir intending to supply water to the city of Koper and its surrounding area. However, the waterworks were not completed because the Second World War started. After the war, it was proposed to continue with the construction of the water pipeline, but this was later not carried out.

Hrib above the village of Popetre, 3rd order, No. 185, Z0, triangulation district Koper: Italian square pillar with upper dimensions of 50 cm × 50 cm and 70 cm high. Around 2000, the point was renumbered from 3B to 185.

Velika Čebulovica, 3rd order, No. 2, triangulation district Sežana: Italian square pillar, 1 m high, with upper dimensions of 40 cm × 40 cm.

Jelovica above the city of Postojna, 3rd order, No. 28, triangulation district Postojna (Figure 5c): a square Italian pillar with its Italianised Slovenian place name inscribed as Jellovicca, RA, 1926. It is 1.15 m high with upper dimensions of 43 cm × 43 cm. Half of the top of this pillar is chipped off.

Počivalnik, 3rd order, No. 27, triangulation district Postojna (Figure 5d): a square Italian pillar with its Italianised Slovenian place name inscribed as Pocivalni, RA, 1926. The original square opening at the top for the placement of the sighting signal mark is still being preserved, unfilled today, being 12 cm × 15 cm in diameter and with a depth of 33 cm. The pillar is 105 cm high, with upper dimensions of 39 cm × 39 cm.

Goli vrh on the Slovenian-Italian border, 3rd order, No. 25, Z0, triangulation district Sežana: Italian square pillar to which they later added additional standpoint to facilitate GNSS surveys. The Italian pillar is 1 m high and has upper dimensions of 40 cm × 40 cm.

The simpler types of trigonometric marks with even older dates having upper dimensions of 15 cm × 15 cm or 20 cm × 20 cm, i.e., dating from the period of the Austro-Hungarian Monarchy or possibly even earlier, can be identified by the fact that they are made of carved natural stones, which often have a cross inscribed, the arms of which are perpendicular to the direction of the sides of the top face of the stone (Figures 7a, 7b, 7d). Some have the letters MT carved on one of their side faces (standing for German: Militärische Triangulation = military triangulation), for example, the one on the Stari Grad hill above Planina, the trigonometric point of the 3rd order, No. 25, trigonometric district Postojna (Figure 7b). From that period we can find two additional types of geodetic marks, being of larger size, which can again be called pillars: the first type is carved out of natural stone in a square shape, and the second is a pillar of cylindrical cross-section built out of stones. A sketch of the latter can be found in the Instructions for Astronomical and Trigonometrical Surveys of 1844 (Instruction … 1844, 233).

Pillars carved out of the natural stone, can be found on the mountain Nanos, on its part named Pleša, which today represents a trigonometric point of the 3rd order, No. 2, and has upper dimensions of 55 cm × 55 cm (Figure 7c) and on the Matajur mountain, 2nd order, No. 317 (https://www.hribi.net/gora/matajur/1/747). Both locations were already marked on the maps of the 3rd Military Topographic Survey of the Austro-Hungarian Monarchy of 1880–1885 as triangulation control points: the first was used for the graphical trigonometric survey and the second for the numerical trigonometric survey. A huge pillar, with at least the lower carved stone base being preserved from the same period, can be found at the Sveta Trojica mountain (1106 m) above the village of Slovenska vas near the city Pivka, representing the trigonometric point of the 3rd order, No. 4, in the trigonometric district Postojna (Figure 6).

a

b

c

d

Figure 5: Geodetic mark examples of Italian type: a) Hribček above the village Dvori, 4th order, No. 96, trigonometric district Koper (photo: R. Škafar, 2021), b) Kubeljska varda, 3rd order, No. 184, trigonometric district Koper (photo: R. Škafar, 2021), c) Jelovica, 3rd order, No. 28, trigonometric district Postojna (photo: R. Škafar, 2021), d) Počivalnik, 3rd order, No. 27, trigonometric district Postojna (photo: M. Triglav Čekada, 2021).

a b c d

Figure 6: Mountain tops of Sveta Trojica (1106 m) denoted No. 4, C0 and Lonica (1124 m) denoted No. 4, Z0 of the 3rd order, triangulation district Postojna, above the village of Slovenska vas near the city of Pivka, changing through time: first row in 2005 performing GNSS surveys (photo: archive of I. Lojk) and second row soon after the Second World War (photo: archive of V. Bric): a) in c) No. 4, C0 Sveta Trojica probably the Austrian type of geodetic mark, b) in d) 4 Z0 Lonica the Italian type of geodetic mark.

A pillar of cylindrical cross-sections built out of stones, representing a trigonometric point of the 2nd order, No. 335, has been decaying for a long time on the top of the St. Lovrenec hill on Hrušica. In the trigonometric point database, it has been described as an old Austrian geodetic mark. Between 2005 and 2007 it was restored by the local tourist organisation. Similar pillars built out of stones are also located on the Veliki vrh hill (Lajše), 3rd order, No. 28, trigonometric district Idrija (https://www.hribi.net/slika_gora/veliki_vrh_lajse/7575) and the Deveti konfin hill (its name in English: Ninth boundary mark) above the village of Volče, 3rd order, No. 5, trigonometric district Tolmin (https://www.hribi.net/slika_pot/solarji_deveti_konfin_cez_jezo/150458). Unfortunately, we cannot be certain about the latter geodetic mark, as it appears as if it has been recently renovated or completely rebuilt. This location is in fact indicated on the map of the 3rd Military Topographic Survey of Austria-Hungary of 1880–1885 as the point where a so-called numerical triangulation was carried out, which meant that geodetic measurements were made at the mark and the coordinates of the point were subsequently computed. This geodetic mark also serves as the boundary stone between plots of land, but not as the boundary mark between cadastral municipalities.

a

b

c

d

Figure 7: Examples of older types of trigonometric marks made from natural stone: a) Mali Kras, 3rd order, No. 241, trigonometric district Sežana (20 cm × 20 cm, height 17 cm from the ground), b) Stari grad above the city of Planina, 3rd order, No. 25, trigonometric district Postojna (20 cm × 20 cm), c) Pleša on Nanos mountain, 3rd order, No. 2, trigonometric district Postojna (55 cm × 55 cm) in d) St. Anton above the city of Koper, 3rd order, No. 183, trigonometric district Koper (15 cm × 40 cm). Photo: a), b) in c) M. Triglav Čekada, 2021, d) R. Škafar, 2021.

Looking at the spatial distribution of the identified older types of trigonometric marks in Figure 8, we can see that all the preserved older trigonometric marks simultaneously represent boundary marks of the cadastral municipality boundaries (Stari grad above the city of Planina – Figure 7b, Pleša on the Nanos mountain – Figure 7c, Veliki Javornik – Triglav Čekada and Jenko, 2020, Figure 4, p. 473) or even tri-border cadastral municipalities boundary marks (Srnjak – Figure 2a and St. Lovrenc on Hrušica).

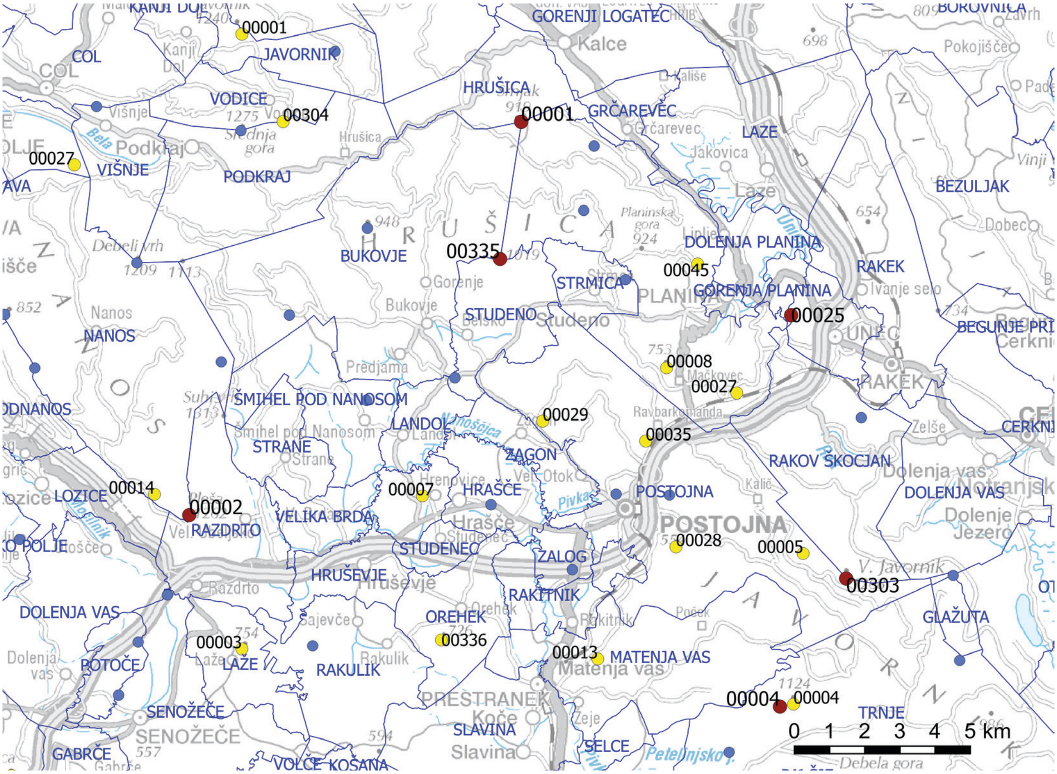


Figure 8: Older types of trigonometric marks in 2nd and 3rd order are often located on the borders of cadastral municipalities (blue lines): red dots – older types of geodetic marks, yellow – Italian type geodetic marks, blue – geodetic marks from the post-Second World War period (source: GURS).

3.3 Other recent features of trigonometric marks in the Primorska region

First of all, we have to mention the reinforcement of existing trigonometric and other geodetic marks with concrete. Between the years 1995 and 1997, colleagues of the Regional Surveying and Mapping Authority from Koper reinforced many of the existing granite geodetic marks around the cities of Ilirska Bistrica and Koper with additional concrete slabs which were placed around the existing granite stones. As an example of such solidified stabilisation, we should mention the trigonometric point at the village of Pomjan of 2nd order No. 322 Z0 from the trigonometric district Koper (Figure 9c). At this trigonometric point we can find, at a distance of approximately 100 m, three different types of old geodetic marks: the Austrian type, the Italian square pillar and the granite stone stabilised after the Second World War, later being also reinforced with a concrete slab.

a b c

Figure 9: Pomjan, 2nd order No. 322, triangulation district Koper: a) C1 original Austrian mark made out of stone, b) C2 the Italian type concrete pillar with original open hole for the signal installation, c) Z0 post–Second World War type reinforced in 1995–1997 with an additional concrete slab (photo: R. Škafar, 2021).

a b

Figure 10: Metal target signals: a) at the installation time in 1996 – Soline above the village of Beka, 3rd order, No. 87, C0, trigonometric district Sežana; at the foot of the metal signal sits Ivan Lojk (photo: archive of I. Lojk), b) today – Črna griža, 4th order, No. 47, C0, trigonometric district Sežana (photo: R. Škafar, 2021).

In 1996, eccentric geodetic metal sighting signals were designed by colleagues from the Regional Surveying and Mapping Authority from Koper and were placed in the trigonometric districts of Sežana, Koper, Ilirska Bistrica and Postojna. Most of them were installed and used for geodetic surveying measurements of the trigonometric district of Sežana. The signal consisted of galvanised metal tubes (the same material as the tubes used for road signs), painted in red and white. Those tubes or target signals were grounded so that they reached 0.5 m beneath the surrounding ground level and 4 m above the ground. Figure 9 shows two examples of such metal signals. The first was photographed at the time of its installation at the Soline hill over the village Beka, 3rd order No. 87 C0, trigonometric district Sežana, where the centre denoted by Z0 is represented by the Italian type square pillar. The second, at Črna griža hill, was inspected and photographed in 2021 and represents the eccentric control point denoted by C0 of the trigonometric point of the 4th order, No. 47, trigonometric district Sežana, where the Z0 is marked by a classical granite stone dating from the post–Second World War period. Additionally, here, at the foot of the metal signal, lies an Italian-type concrete pillar that has been knocked over (Figure 4).

During the same period, 90% of the trigonometric and photogrammetric control points in this area were inspected, as they intended to resurvey them using GNSS, to enable a recalculation of the trigonometric networks from this area, but the GNSS resurvey was later not carried out.

4 DISCUSSION AND CONCLUSION

In a view of the increasingly widespread use of GNSS technology, which, on the one hand, substituted the classic trigonometric networks as the realisation of the national coordinate system and, on the other, allows users in geodetic practice easy access to the national coordinate system, raises the question as to why the national Surveying and Mapping Authorities should preserve and regularly maintain permanently marked national geodetic points in nature. In our view, however, there is no justification for questioning the advisability of maintaining data on these points in the records of the Surveying and Mapping Authority and of maintaining important geodetic points in an appropriately preserved state for further practical use. It should be borne in mind that geodetic points, which are physically marked in nature, represent a link between the physical reality in nature (the state of geometric properties of physical space) and the data and models that represent physical reality that were made by the surveyors and others over time. It is not sensible to preserve geodetic point data in the records of the national Surveying and Mapping Authority without preserving physically marked geodetic points in nature; it is necessary to preserve both the records as well as the geodetic points in physical space.

In everyday surveying practice, we are often faced with the use of various data from the national Surveying and Mapping Authority records in the field. In this task, it is necessary to establish a link between the data in the records and the physical reality in nature. This task can only be carried out with high positional quality if the records contain high-quality data and an sufficient number of geodetic marks are still preserved in nature. Modern surveying technologies enable high-accuracy measurements, and the existing geodetic marks in nature allow us to achieve the necessary time-independent accuracy of geodetic measurements for various data transfers from the records of the national Surveying and Mapping Authority in the physical space.

This paper highlights the permanently marked geodetic points that have long withstood the ravages of time and therefore have great potential for maintaining and ensuring the long-term availability of the national coordinate system and subsequently the data about geometric properties and relations in physical space. For example, they could be used in anticipated long-term activities for geodynamic monitoring of Slovenia based on GNSS measurements initiated by some research groups and the Surveying and Mapping Authority of Slovenia (Stopar et al., 2021). In this context, geodetic marks of higher-order trigonometric network points that have been well stabilised in the past are also relevant. These geodetic marks, in combination with the well-stabilised geodetic or so-called geodynamic points that have been physically built for GNSS surveys throughout the country over the last 35 years, can represent the densification of existing passive (EUREF) and active GNSS networks, such as the SIGNAL network and the Combined Geodetic Network, also named the Zero Order National Geodetic network (Oven et al., 2019; Medved et al., 2018). Additionally, these points could be used as passive GNSS control network points (Majcen, 2020).

The design of higher-order trigonometric marks from the period of the Kingdom of Italy is comparable to specific types of geodetic marks designed for GNSS surveys along active tectonic faults. In Slovenia, the first network measured in this way was the Krško geodynamic network, first surveyed by GNSS already in 1993 (Vodopivec, Miškovič and Jaklič, 1999; Kogoj, 2000). This was followed by the first GNSS survey of the so-called Large geodynamic network of the Velenje Coal Mine in 1996, where the geodynamic activities of the Šoštanj, Smrekovec and Labot faults were studied (Pavlovčič Prešeren, Stopar and Vrabec, 2005). In both cases, the points were stabilised with special types of geodetic marks, in the first case with a bolt embedded in the bedrock bearing a forced centring screw, and in the second case, they were using special concrete pillars or bolts embedded in natural solid rock (Triglav Čekada et al., 2021a). Two of the above-mentioned points stabilised by the Italian types of concrete pillars have already been included in the EUREF measurements of Slovenia in the past, i.e., Velika Milanja (trigonometric point of 2nd order, No. 351) and Veliko Gradišče (2nd order, No. 310), (Berk et al. 2003).

In the presented analysis, we have identified a total of 68 trigonometric points of the 2nd and 3rd orders in the Primorska region, which are in nature marked by the Italian type of geodetic marks, once representing higher-order trigonometric networks. This is a long-term, high-quality stabilisation represented by a larger concrete pillar, which is potentially interesting for new geodynamic GNSS surveys being planned over a longer period. Considering the vegetation coverage at the locations of the inspected trigonometric points, 47 points of the Italian type (56% of all the identified points with this stabilisation type) and 11 points having an even older type of geodetic mark (52% of all the identified points with this stabilisation type) are suitable for immediate GNSS surveys as they are not placed in forested areas. According to this criterion, there are also many suitable geodetic marks in the trigonometric network of the 4th order, but these were not analysed in this paper.

In the trigonometric networks of the 2nd and 3rd orders, we have identified a total of 21 trigonometric points with stabilisation types still dating back to the time of the Austro-Hungarian Monarchy or even earlier, which, in addition to their strict geodetic role, have an important historical role and therefore represent a potential to extensively promote the geodetic technical heritage to the public.

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ZNAČILNOSTI STABILIZACIJ TRIGONOMETRIČNIH TOČK NA PRIMORSKEM

OSNOVNE INFORMACIJE O ČLANKU:

GLEJ STRAN 189

1 UVOD

Različne vrste fizičnih geodetskih in mejnih oznak oziroma znamenj so pomembna geodetska tehnična dediščina (Triglav Čekada in sod., 2021b; Lisec in sod., 2020). Točke geodetskih mrež iz obdobja tako imenovane klasične geodezije so bile stabilizirane z različnimi vrstami fizičnih geodetskih znamenj, ki se razlikujejo po namenu in časovnem obdobju postavitve (Triglav Čekada in Jenko, 2020). Znamenja, postavljena v posameznih preteklih državnih skupnostih, imajo nekatere skupne značilnosti. V članku bomo predstavili posebnosti geodetskih znamenj, ki so bila postavljena na Primorskem, in analizo njihovega današnjega stanja. V nasprotju s preostalim slovenskim ozemljem je ta del države dobrih dvajset let prejšnjega stoletja, uradno med letoma 1920 in 1947, spadal v Kraljevino Italijo. Na tem območju smo preučili stabilizacije vseh geodetskih točk trigonometričnih mrež II. in III. reda ter manjši vzorec geodetskih točk trigonometričnih mrež nižjih redov. Trigonometričnih točk I. reda nismo obravnavali (več o njih v Delčev, Timar in Kuhar, 2014; Stopar in Kuhar, 1997).

Obravnavano območje lahko glede na poznejši razvoj trigonometričnih mrež in s tem povezanih vrst stabilizacij novih točk po drugi svetovni vojni obravnavamo kot sklenjeno celoto. Med letoma 1947 in 1948 je namreč na območju Primorske in Slovenske Istre Geografski inštitut Jugoslovanske armade (kratica GIJNA ali GIJ, kasneje imenovan Vojnogeografski inštitut) razvijal trigonometrično mrežo II. reda. Leta 1955 so bile v okolici Trsta izvedene ponovne meritve v trigonometrični mreži II. reda zaradi nove razmejitve z Republiko Italijo (Jenko, 1987). GIJNA je v letih 1947 in 1948 na Primorskem opravljal tudi dela na trigonometrični mreži III. in IV. reda. Na območju Idrije in Cerknega je pri tem sodeloval še Geodetski zavod Slovenije (GZS), ki je dela dokončal leta 1950 (Jenko, 1990). Zato na teh območjih povečini na trigonometričnih točkah od II. do IV. reda stojijo geodetska znamenja z zgornjo dimenzijo 20 × 20 centimetrov ali 15 × 15 centimetrov, ki gledajo iz tal največ le nekaj deset centimetrov in so lahko iz granita (GIJNA, GZS) ali iz betona – idrijski tip stabilizacije (GZS) (Triglav Čekada in Jenko, 2020). Italijanski tip stabilizacij lahko prepoznamo kot večje betonske stebre štirikotne ali osmerokotne oblike, visoke okrog enega metra in s premerom od 40 do 70 centimetrov (Triglav Čekada in Jenko, 2020).

V prispevku bomo podrobneje predstavili različne vrste oznak geodetskih točk v trigonometričnih mrežah, o katerih nam je v okviru ciljnega raziskovalnega projekta *Stalna geodetska znamenja kot temelj za kakovostno delovanje geodetske stroke* informacije posredoval geodet z dolgoletnimi terenskimi izkušnjami Ivan Lojk, zaposlen na območni geodetski upravi v Kopru od leta 1976 do 2016 (Triglav Čekada in sod., 2021a). To so trigonometrične točke, ki so bile z betonskimi stebri stabilizirane v času Kraljevine Italije v obdobju 1920–1947, ter še starejše vrste stabilizacij iz obdobja avstro-ogrske monarhije, kovinski signali iz obdobja po letu 1996 ter ojačanje granitnih geodetskih znamenj z dodatnim betonom iz obdobja 1995–1997. Na podlagi naknadnih terenskih ogledov ter podrobne analize različnih gradiv smo preučili še pogostost današnje pojavnosti predstavljenih znamenj. Prispevek sklenemo z omembo potencialov, ki jih danes ponujajo iz preteklosti ohranjena geodetska znamenja.

2 METODOLOGIJA

Analizo načinov izvedbe fizičnih stabilizacij trigonometričnih točk smo opravili za območje med nekdanjo rapalsko mejo ter današnjo mejo med Republiko Slovenijo in Republiko Italijo. Osredotočili smo se namreč na razpoznavo geodetskih znamenj, ki so bila vzpostavljena v Kraljevini Italiji, in še starejših vrst stabilizacij geodetskih točk iz avstro-ogrske monarhije. Značilnosti stabilizacij trigonometričnih točk na posamezni lokaciji smo preučili s pregledom topografij trigonometričnih točk iz Gursovega arhiva trigonometričnih točk (v nadaljevanju: topografije). Pregledali smo 52 trigonometričnih točk II. reda, 407 točk III. reda in 18 točk nižjih redov.

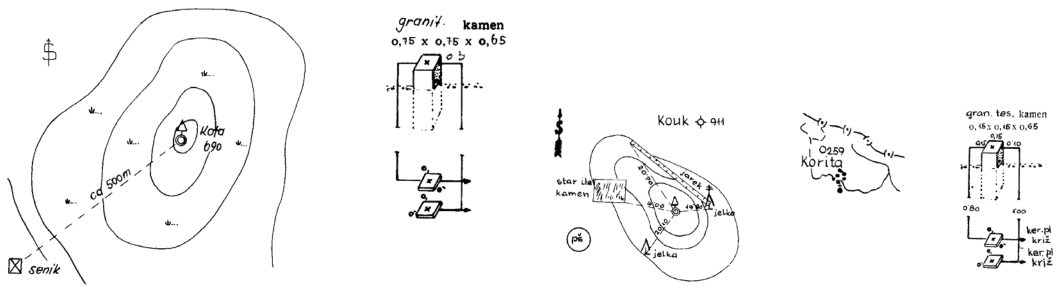
Za vse navedene geodetske točke smo preverili, ali so informacije o načinu njihove stabilizacije tudi na spletni strani *hribi.net*, saj je tam naloženega veliko fotografskega gradiva, vključno s fotografijami vrhov, na katerih so občasno vidna tudi različna geodetska znamenja. Večkrat fotografirani so predvsem italijanski tipi stabilizacij z betonskimi stebri, predvsem zaradi večjih dimenzij in na njih velikokrat pritrjenih planinskih skrinjic z vpisno knjigo ali žigom. Na spletni strani *hribi.net* smo tako lahko preverili 27 lokacij trigonometričnih točk II. reda in 87 lokacij III. reda. Če smo iz pregleda topografij sklepali, da je na posamezni lokaciji stal italijanski tip stabilizacije geodetske točke, na spletni strani *hribi.net* pa je ni bilo mogoče videti, smo lokacijo in geodetsko točko obravnavali kot točko, na kateri prvotni način stabilizacije ni ohranjen. Če na podlagi topografij nismo mogli sklepati, da gre za geodetsko točko z italijanskim tipom stabilizacije, vendar je bila ta na fotografijah vidna, smo geodetsko točko vseeno šteli med geodetske točke z italijanskim načinom stabilizacije.

Posamezne lokacije geodetskih točk, ki so v nižinskih predelih, smo pregledali tudi v aplikaciji *Google Street View*. Kar nekaj lokacij točk pa smo preverili še v naravi. Ker pa v naravi nismo mogli preveriti vseh lokacij geodetskih točk, smo predpostavili, da je na posamezni lokaciji še vedno takšen tip stabilizacije geodetske točke, kot je bil naveden na topografiji točke. Topografije geodetskih točk smo obravnavali kot ustrezen vir informacij o načinu stabilizacije geodetskih točk, saj so bile večinoma izdelane pred, med ali neposredno po geodetski izmeri na lokaciji posamezne geodetske točke, praviloma v prvih dveh desetletjih po drugi svetovni vojni.

V topografijah geodetskih točk, ki so bile stabilizirane v Kraljevini Italiji, ne moremo enolično določiti načina stabilizacije, saj se kot opis načina stabilizacije pojavi navedba: *star italijanski kamen, betonski ali* napačno *granitni kamen večjih dimenzij* (slika 1a), *betonski steber*, občasno pa tudi samo *betonski kamen brez dimenzij*. Če je v topografiji zapisano samo *betonski kamen*, to lahko pomeni tudi, da je govor o posebnem tipu stabilizacije geodetske točke, ki je bila vzpostavljena za potrebe geodetskih in jamomerskih meritev za rudnik živega srebra v Idriji. To so betonski kamni z izbočenim kovinskim čepom z vrhnjo dimenzijo 15 × 15 centimetrov ali 20 × 20 centimetrov.

Naleteli smo tudi na primere topografij, v katerih je bil star betonski steber uporabljen samo kot fizična označba v naravi, glede na katero se je merila ena ali več dolžin, navedenih na topografiji geodetske točke (slika 1b). Tu je treba poudariti, da ob fizični postavitvi geodetske točke in izmeri v okviru trigonometričnih mrež takoj po drugi svetovni vojni ni bilo zahtevano, da se privzamejo stare, že stabilizirane geodetske točke, temveč jih je bilo treba zamenjati oziroma nadomestiti z novimi (Triglav Čekada in Jenko, 2020). Nekatere, sicer maloštevilne, geodetske točke, pri katerih je bila privzeta stara izvedba stabilizacije, imajo v atributnem delu topografije zapisano *privzet star ita. kamen*. Samo navedba *kamen brez dimenzij* pa se pri terenskem ogledu ni izkazala za enolično in nedvoumno določeno vrsto stabilizacije (slika 2). Izkazalo se je, da se takšna navedba le izjemoma navezuje na italijanski steber osmerokotne oblike, večinoma gre za starejši tip stabilizacije geodetske točke – ali za stabilizacijo geodetske točke, ki je hkrati mejna in geodetska točka, ali za križ, vklesan v naravno skalo, občasno naletimo tudi na kasnejšo klasično vrsto stabilizacije z manjšim granitnim kamnom, ki pa v topografijo ni bila dodana.

Starejše tipe stabilizacij smo določili predvsem s terenskim ogledom. Za takšne tipe stabilizacije je v atributnih podatkih ali na topografijah včasih navedeno *stara stabilizacija*, redkeje pa smo na spletni strani *hribi.net* naleteli na večja mejna znamenja, ki jih tudi štejemo med starejše tipe stabilizacij (slika 2a). Za odločitev, ali gre za mejno znamenje večjega pomena in posledično večjih dimenzij ali za ostanek italijanske stabilizacije geodetske točke, smo si pomagali še s podatki o mejah med katastrskimi občinami. Če je trigonometrična točka na meji katastrskih občin, je velika verjetnost, da to ni italijanski tip stabilizacije geodetske točke, ampak je mejnik katastrskih občin večjih dimenzij.



a) b)

Slika 1: Dva primera topografij, iz katerih lahko posredno sklepamo, da je tip stabilizacije geodetske točke v naravi italijanski: a) Rodne, trig. točka III. reda št. 31, trig. okraj Idrija: na podrobni skici stabilizacije na topografiji (desno) so zapisane večje dimenzije »granitnega kamna«, ki je v naravi sicer betonski, steber se vidi tudi na fotografijah na spletni strani https://www.hribi.net/gora/rodne/21/1964; b) Kovk, trig. točka III. reda št. 259, trig. okraj Idrija: na pregledni skici v topografiji (levo) je ena razdalja odmerjena do »starega italijanskega kamna« (vir: GURS).

Z uporabo različnih virov, od fotografij na spletni strani *hribi.net* do ortofotov cikličnega aerofotografiranja Slovenije, smo določili še vrsto terena, na katerem točka stoji: gozd, travnik, njive, skale, odprto in pozidano zemljišče, za potrebe morebitnega kasnejšega ogleda na terenu smo dodali podatek o poteh in cestah v bližini. Na podlagi prve informacije bomo ocenjevali potencial, ki ga imajo identificirane točke za takojšnjo GNSS-izmero. Tiste, ki stojijo na odprtem, namreč lahko takoj vključimo v nove izmere z GNSS.

a) b)

Slika 2: Dva primera na terenu pregledanih trigonometričnih točk, ki sta v topografijah označeni kot »kamen brez dimenzij«: a) Srnjak, trig. točka III. reda št. 1, trig. okraj Postojna in hkrati tromeja katastrskih občin: na njej je na eni strani letnica 1878, na drugi oznaka MT (nem. *Militärische Triangulation* = vojaška triangulacija), ki pove, da gre za staro avstro-ogrsko stabilizacijo točke, na temelju pa vidimo še napis 1928 RA (it. *Rete Artiglieria* = artilerijska mreža), ki označuje, da so jo uporabili tudi za izmero v Kraljevini Italiji (foto: M. Triglav Čekada, 2021); b) Kal nad Kostanjevico, trig. točka III. reda št. 76, trig. okraj Nova Gorica: stabilizacija iz časa po drugi svetovni vojni – granitni kamen, obdan z betonsko ploščo (foto: R. Škafar, 2021).

3 REZULTATI

3.1 Obseg ohranjenih italijanskih in starejših stabilizacij geodetskih točk trigonometričnih mrež II. in III. reda

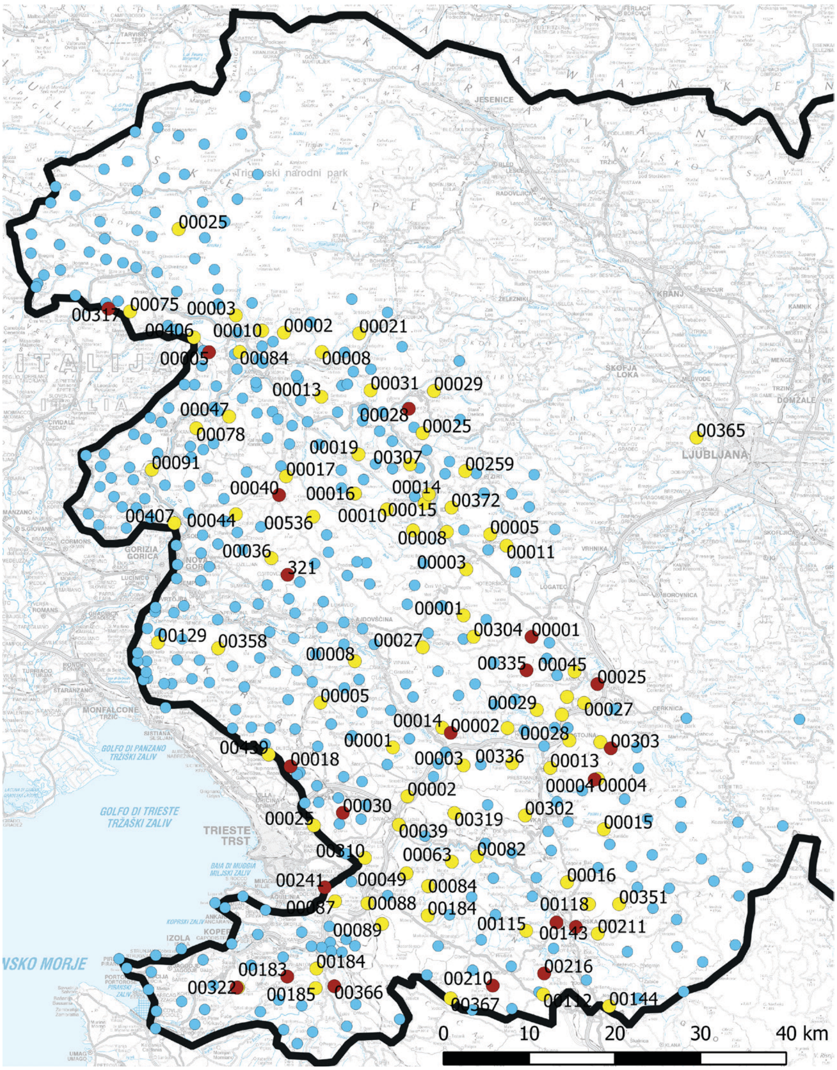
V trigonometrični mreži II. reda smo na pregledanem območju odkrili 30 % geodetskih točk, na katerih se je najverjetneje ohranil italijanski tip stabilizacije, in 12 % točk s še starejšim tipom stabilizacije. V trigonometrični mreži III. reda pa je 17 % najverjetneje italijanskih tipov stabilizacij ter 4 % še starejših. Deležev obeh vrst stabilizacij pri trigonometrični mreži nižjega reda ne moremo oceniti, saj smo s terenskim ogledom preučili le manjši vzorec teh točk, pa še pri teh smo glede na opise na topografijah že vnaprej sklepali, da gre za italijanski tip stabilizacije.

Na sliki 3 prikazujemo prostorsko razporeditev trigonometričnih točk II. in III. reda, na katerih se je najverjetneje ohranil italijanski tip stabilizacije. Opazimo, da so se ohranile predvsem na manj poseljenih hribovitih območjih širšega Idrijskega in Cerkljanskega hribovja, Brkinov ter tudi Pivškega podolja z Vremščico. Na bolj poseljenih hribovitih delih Zgornjega Posočja, Kambreškega in Brd, Krasa ter Koprskih brd pa se jih je ohranilo manj.

V preglednici 1 vidimo višji delež italijanskih in še starejših tipov stabilizacij trigonometričnih točk na odprtih, s travo poraščenih ali celo golih vrhovih v trigonometrični mreži II. reda, kjer bi bila takoj mogoča tudi nova izmera z GNSS. V trigonometrični mreži III. reda je približno polovica trigonometričnih točk, stabiliziranih z obema tipoma stabilizacij, v gozdu, kar pomeni, da so neprimerne za takojšnjo novo izmero z GNSS. To je pričakovano, saj trigonometrične točke II. reda pravilom stojijo na višjih vrhovih kot trigonometrične točke III. reda.

Preglednica 1: Verjetni italijanski ali še starejši tip stabilizacije trigonometričnih točk II. in III. reda na območju med nekdanjo rapalsko mejo in današnjo mejo med Republiko Slovenijo in Republiko Italijo. Za oba reda trigonometričnih točk je dodan še stolpec z navedbo števila točk, ki niso v gozdu, kar pomeni, da bi bile potencialno uporabne za morebitno novejšo GNSS-izmero.

Trigonometrična mreža	Število pregledanih točk	Število verjetno italijanskih stabilizacij	Število italijanskih stabilizacij, ki niso v gozdu	Število verjetno še starejših stabilizacij	Število starejših stabilizacij, ki niso v gozdu
II. reda	52	**16**	12 (75 %)	**6**	4 (67 %)
III. reda	407	**68**	35 (51 %)	**15**	7 (47 %)



Slika 3: Pregledane lokacije trigonometričnih točk II. in III. reda med nekdanjo rapalsko mejo in današnjo mejo med Republiko Slovenijo in Republiko Italijo: modre – pregledane, rumene – verjetno italijanski način stabilizacije, rdeče – še starejši način stabilizacije iz avstro-ogrske monarhije.

S tem pregledom smo povzeli le trigonometrične točke, ki so stabilizirane z italijanskim ali še starejšim tipom stabilizacije in so še v naravi, kar pomeni, da jih lahko obravnavamo kot aktivne točke trigonometričnih mrež. Koliko pa je v naravi še ohranjenih podrtih italijanskih betonskih stebrov, ki ležijo ob novejših stabilizacijah (slika 4), saj so jih med stabilizacijami novih točk po drugi svetovni vojni zamenjali z novejšimi granitnimi znamenji, vendar starih ostankov niso zarisali v topografije, pa žal brez celovitega terenskega pregleda ne moremo vedeti. Tako na vzpetini Lačna nad vasjo Gračišče poleg nove stabilizacije trigonometrične točke II. reda št. 366 z granitnim kamnom stoji še podrt italijanski betonski steber. Ker je ta trigonometrična točka tudi na meji katastrskih občin, na spletni strani *hribi.net* (https://www.hribi.net/gora/lacna/26/1705) vidimo v suhem zidu še en starejši mejnik katastrskih občin večjih dimenzij, ki se je lahko pred tem uporabljal tudi za trigonometrično izmero[1]. Lojk je povedal še za nekdanji italijanski betonski steber v vasi Črnotiče, to je nekdanja trigonometrična točka II. reda št. 345, ki pa so ga podrli ob širitvi kamnoloma Črni kal. Podobno je na hribu Karlovica nad vasjo Pregarje stala trigonometrična točka II. reda št. 350, najverjetneje stabilizirana z osmerokotnim stebrom, ki pa so ga pozneje podrli in ekscentrično glede na prvotno lokacijo postavili novo stabilizirano označbo trigonometrične točke.

Slika 4: Primer podrtega italijanskega stebra na Črni griži ob novi trigonometrični točki IV. reda št. 47, trigonometrični okraj Sežana (foto: R. Škafar, 2021).

3.2 Primeri zanimivih italijanskih ali starejših tipov stabilizacij trigonometričnih točk

Čeprav so bili italijanski stebri izdelani iz betona že pred približno sto leti, jih je večina še vedno precej dobro ohranjenih. Na njih je velikokrat vklesano leto izdelave in napis RA (it. *Rete Artiglieria* = artilerijska mreža). Napis RA občasno najdemo tudi v kombinaciji s še starejšimi geodetskimi znamenji, kot sta trigonometrični točki III. reda št. 1 Srnjak na sliki 2a, št. 4 C0 Sveta Trojica na sliki 6 v trigonometričnem okraju Postojna ter trigonometrična točka II. reda št. 322 v vasi Pomjan na sliki 9.

[1] *Lokacija je označena kot točka za numerično triangulacijo že na karti 3. vojaške topografske izmere avstro-ogrske monarhije iz obdobja 1880–1885.*

V nadaljevanju podrobneje predstavljamo še nekaj italijanskih stebrov na območju južne Primorske, za katere nam je povedal Lojk ali pa smo preostali avtorji preverili njihovo stanje na terenu:

Velika Milanja, trig. točka II. reda št. 351 Z0: italijanski osmerokotni steber trigonometrične točke višjega reda, leta 1976 prvič obnovljen, leta 1996 saniran v okviru dodatne EUREF GNSS-izmere (kratica točke MILO).

Razsušica ali Glavičorka na slovensko-hrvaški meji, II. red, št. 367: italijanski steber osmerokotne oblike. Visok je en meter, z vrhnjo dimenzijo približno 50 × 50 centimetrov.

Veliko Gradišče nad vasjo Vrhpolje nad Krvavim Potokom, II. red, št. 310: italijanski štirikoten steber vrhnje dimenzije 30 × 30 centimetrov, z originalno štirikotno odprtino za namestitev vizurnega signala. Med dodatno EUREF-kampanjo[2] 1996 (kratica točke VGRA) je bil v sredino zapolnjene odprtine zabetoniran vijak za prisilno centriranje antene GNSS.

Hribček nad vasjo Dvori, IV. red, št. 96 Z2, trig. okraj Koper, letnica 1931 in napis RA (slika 5a): italijanski štirikoten betonski steber z odprtino za namestitev vizurnega signala. Med gradnjo obvoznice okrog vasi Dvori so stabilizacijo Z0-trigonometrične točke uničili. Ohranila se je samo italijanska stabilizacija Z2, ki so ji še med obstojem Z0 zabetonirali aluminijast čep ter na njej hkrati z Z0 opravili ponovno izmero.

Kubeljska varda, III. red, št. 184, trig. okraj Koper (slika 5b): italijanski štirikoten steber z vrhnjo dimenzijo 70 × 70 centimetrov, luknja za signale je zapolnjena z vstavljenim čepom, na katerem je vklesan križ. Okrog leta 2000 je bila točka preimenovana iz 2B v 184, nahaja se v III. glavnem redu. Postavljena je bila v 1930. letih zaradi načrtovane gradnje vodovoda oziroma rezervoarja, ki naj bi napajal celotno koprsko okolico, vendar vodovoda niso dokončali, ker jih je prehitela druga svetovna vojna. Po vojni so sicer predlagali, da bi gradnjo nadaljevali, a se to ni uresničilo.

Hrib nad vasjo Popetre, III. red, št. 185 Z0, trig. okraj Koper: italijanski štirikoten steber vrhnje dimenzije 50 × 50 centimetrov, visok 70 centimetrov. Okoli leta 2000 je bila točka preimenovana iz 3B v 185.

Velika Čebulovica, III. red, št. 2, trig. okraj Sežana: štirikotni italijanski steber, visok en meter, vrhnje dimenzije 40 × 40 centimetrov.

Jelovica nad Postojno, III. red, št. 28, trig. okraj Postojna (slika 5c): štirikoten italijanski steber s poitalijančenim izpisom kraja Jellovicca, RA, 1926. Visok je 1,15 metra z vrhnjo dimenzijo 43 × 43 centimetrov. Polovica vrhnje ploskve stebra je odbita.

Počivalnik, III. red, št. 27, trig. okraj Postojna (slika 5d): štirikoten italijanski steber s poitalijančenim izpisom kraja Pocivalni, RA, 1926, ohranjena je originalna štirikotna odprtina na vrhu za vizurni signal 12 × 15 centimetrov, ki je globoka 33 centimetrov, sam steber je visok 105 centimetrov in ima vrhnjo dimenzijo 39 × 39 centimetrov.

Goli vrh na slovensko-italijanski meji, III. red, št. 25, Z0, trig. okraj Sežana: italijanski štirikotni steber, kasneje so postavili še ekscenter za lažja GNSS-opazovanja. Sam steber je visok en meter in ima vrhnjo dimenzijo 40 × 40 centimetrov.

Enostavnejše tipe stabilizacij trigonometričnih točk starejšega datuma, z vrhnjimi dimenzijami 15 ×15 centimetrov ali 20 × 20 centimetrov, torej iz obdobja Avstro-Ogrske ali morebiti še starejše, razpoznamo po tem, da so izdelani iz klesanih naravnih kamnov in so velikokrat opremljeni s križem, katerega kraki so pravokotni na smer stranic vrhnje ploskve kamna, medtem ko kraki križa pri novejših potekajo v smeri oglišč vrhnje ploskve

[2] *Med letoma 1994 in 1996 so bile izvedene tri EUREF GNSS-kampanje, v okviru katerih so izmerili različne točke na območju Slovenije. Izmera na Veliki Milanji in Velikem gradišču je bila del tako imenovane tretje kampanje, namenjene zgostitvi točk za območje Hrvaške, v njej je bilo izmerjenih tudi šest točk na območju Slovenije (Berk in sod., 2003).*

kamna (slika 7a, 7b in 7d). Na nekaterih najdemo na stranski ploskvi vklesani črki MT (nem. *Militärische Triangulation* = vojaška triangulacija), kot na primer na Starem gradu nad Planino, III. red, št. 25, trig. okraj Postojna (slika 7b). Najdemo pa še dva tipa stabilizacij večjih velikosti, ki jima lahko ponovno rečemo stebri: prvi so izklesani iz naravnega kamna v kvadratno obliko, drugi pa so zidani stebri valjaste oblike. Skico slednjih najdemo že v *Instrukcijah za astronomsko-trigonometrično izmero* iz leta 1844 (Instrukcije… 1844, 233).

a

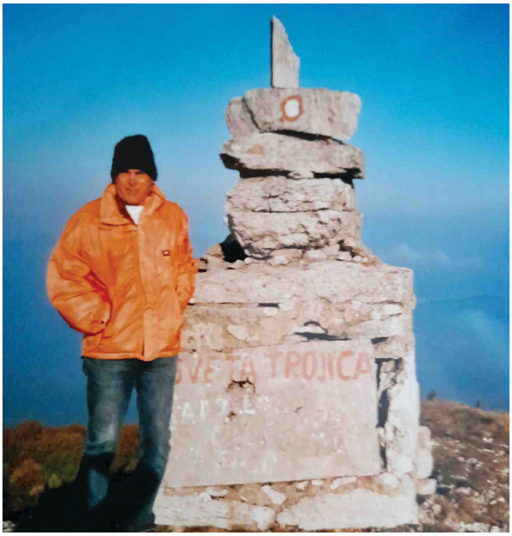
b

c

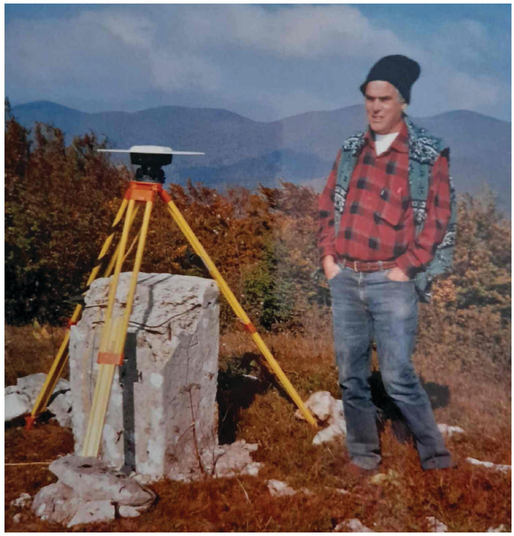
d

Slika 5: Primeri italijanskih stabilizacij trigonometričnih točk: a) na Hribčku nad vasjo Dvori, IV. red, št. 96, trig. okraj Koper (foto: R. Škafar, 2021); b) Kubeljska varda, III. red, št. 184, trig. okraj Koper (foto: R. Škafar, 2021); c) Jelovica, III. red, št. 28, trig. okraj Postojna (foto: R. Škafar, 2021); d) Počivalnik, III. red, št. 27, trig. okraj Postojna (foto: M. Triglav Čekada, 2021).

Stebre, izklesane iz naravnega kamna vrhnje dimenzije 55 × 55 centimetrov, najdemo na Pleši na Nanosu, danes trig. točka III. reda št. 2 (slika 7c) in Matajurju, 317, II. reda, št. 317 (https://www.hribi.net/gora/matajur/1/747). Obe lokaciji sta bili že označeni na kartah 3. vojaške topografske izmere avstro-ogrske monarhije iz let 1880–1885 kot triangulacijske točke: prva za grafično izmero, druga za numerično izmero. Ogromen steber, kjer je vsaj spodnji ohranjen podstavek iz klesanega kamna, najdemo še na Sveti Trojici 1106 metrov nad Slovensko vasjo na Pivškem, trig. točka III. reda št. 4, trig. okraj Postojna (slika 6).



a



b

c

d

Slika 6: Sveta Trojica, 1106 m, in Lonica ,1124 m, III. red, št. 4 C0 in Z0, trig. okraj Postojna, nad Slovensko vasjo na Pivškem, spreminjanje skozi čas: zgoraj leta 2005 ob izmeri GNSS (foto: arhiv I. Lojk) in spodaj kmalu po drugi svetovni vojni (foto: arhiv V. Bric); a) in c) C0 Sveta Trojica najverjetneje še avstrijski tip stabilizacije, b) in d) Z0 Lonica italijanski štirikoten steber.

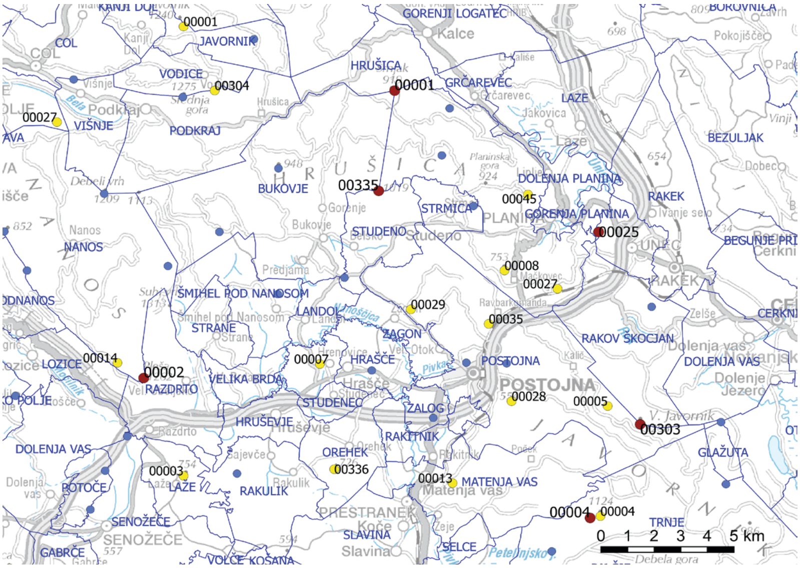
Iz kamnov zidan steber valjastega preseka, za katerega že v bazi trigonometričnih točk piše, da bi lahko bila stara avstrijska točka, je dolgo razpadal na vrhu Svetega Lovrenca na Hrušici, trig. točka II. reda št. 335. Med letoma 2005 in 2007 ga je obnovilo lokalno turistično društvo. Podoben zidan steber je še na Velikem vrhu (Lajše), III. red, št. 28, trig. okraj Idrija (https://www.hribi.net/slika_gora/veliki_vrh_lajse/7575), ter na hribu z imenom Deveti konfin nad Volčami, III. red, št. 5, trig. okraj Tolmin (https://www.hribi.net/slika_pot/solarji_deveti_konfin_cez_jezo/150458). Žal za slednjo stabilizacijo ne moremo ponuditi dokončnih ugotovitev, ker kaže, da je bila pred kratkim obnovljena ali pa postavljena povsem na novo. Je pa ta lokacija na karti 3. vojaške topografske izmere avstro-ogrske monarhije iz let 1880–1885 označena kot točka, na kateri se je izvajala tako imenovana numerična triangulacija, kar je pomenilo, da so se na točki izvedle geodetske meritve in naknadno izračunale koordinate te točke. Znamenje označuje še mejo med parcelami, ne pa tudi meje med katastrskimi občinami.

a b

c d

Slika 7: Primeri starejših tipov stabilizacij trigonometričnih točk, izdelanih iz naravnega klesanega kamna: a) Mali Kras, III. red, št. 241, trig. okraj Sežana (20 × 20 cm, 17 cm iz tal); b) Stari grad nad Planino, III. red, št. 25, trig. okraj Postojna (20 × 20 cm); c) Pleša na Nanosu, III. red, št. 2, trig. okraj Postojna (55 × 55 cm) , in d) Sv. Anton nad Koprom, III. red, št. 183, trig. okraj Koper (15 × 40 cm) (foto: a), b) in c) M. Triglav Čekada, 2021; d) R. Škafar, 2021).

Če na sliki 8 pogledamo prostorsko razporeditev identificiranih starejših tipov stabilizacij trigonometričnih točk, hitro vidimo, da so vse ohranjene starejše stabilizacije hkrati mejna znamenja na mejah katastrskih občin (Stari grad nad Planino – slika 7b, Pleša na Nanosu – slika 7c, Veliki Javornik – Triglav Čekada in Jenko, 2020, slika 4, str. 473) ali celo mejna znamenja na tromejah katastrskih občin (Srnjak – slika 2a in Sv. Lovrenc na Hrušici).



Slika 8: Starejši tipi stabilizacij trigonometričnih točk II. in III. reda so velikokrat na mejah katastrskih občin (modre linije): rdeče pike – starejši tipi stabilizacij, rumene – italijanske stabilizacije, modre – stabilizacije iz obdobja po drugi svetovni vojni (vir: GURS).

3.3 Druge novejše posebnosti stabilizacij trigonometričnih točk na Primorskem

Najprej omenimo utrditev obstoječih načinov stabilizacij trigonometričnih in drugih geodetskih točk z betonom. V letih 1995–1997 so kolegi z območne geodetske uprave v Kopru veliko obstoječih granitnih kamnov trigonometričnih točk na ilirskobistriškem in koprskem območju zavarovali z dodatno betonsko ploščo, ki so jo zabetonirali tako, da je obdajala obstoječi granitni kamen. Kot primer tako nadgrajene stabilizacije omenimo točko II. reda 322 Z0 Pomjan iz trig. okraja Koper (slika 9c), kjer najdemo na razdalji kakšnih sto metrov tudi tri primere različnih starih tipov stabilizacij geodetskih točk: avstrijsko C1, italijanski betonski štirikotni steber C2 in kasnejši granitni kamen, stabiliziran po drugi svetovni vojni Z0, ki je bil naknadno utrjen z betonom.

a b c

Slika 9: Pomjan, II. red, št. 322, trig. okraj Koper: a) C1 originalno še avstrijski kamen, b) C2 italijanski steber z odprto originalno luknjo za namestitev signala, c) Z0 povojna stabilizacija, utrjena v letih 1995–1997 z dodatnim betonom (foto: R. Škafar, 2021).

V letu 1996 so v trigonometričnih okrajih Sežana, Koper, Ilirska Bistrica in Postojna pričeli postavljati ekscentrične geodetske vizurne signale lastne izdelave. Največ so jih postavili in tudi na njihovi podlagi izvedli geodetsko izmero v trigonometričnem okraju Sežana. Uporabili so pocinkane, kovinske cevi (iz enakega materiala, kot so cevi za prometne znake), pobarvane rdeče-belo. Cevi oziroma vizurni signali so bili zabetonirani tako, da so na spodnji strani segali pol metra pod raven okoliškega terena. Vizurni signali so bili visoki štiri metre. Na sliki 9 vidimo dva primera takih kovinskih signalov, prvi je fotografiran ob postavitvi na točki Soline pod Beko, III. red, št. 87 C0, trig. okraj Sežana, center Z0 na tej točki predstavlja italijanski štirikotni steber. Drugega na Črni griži smo pregledali v letu 2021 in predstavlja ekscenter trig. točke IV. reda št. 47 C0, trig. okraj Sežana, katere Z0 je stabiliziran s klasičnim granitnim kamnom iz obdobja po drugi svetovni vojni. Tu ob vznožju kovinskega signala leži še prevrnjen star italijanski betonski steber (slika 4).

a

b

Slika 10: Kovinska signala: a) ob postavitvi leta 1996 – Soline pod Beko, III. red, št. 87 C0, trig. okraj Sežana, ob vznožju kovinskega signala sedi Ivan Lojk (foto: arhiv I. Lojk); b) danes – Črna griža, IV. red, št. 47 C0, trig. okraj Sežana (foto: R. Škafar, 2021).

V istem obdobju je bilo na tem območju pregledanih 90 % trigonometričnih in oslonilnih točk, ki naj bi jih pozneje uporabili za GNSS-izmero, namenjeno sanaciji že znanih odstopanj v trigonometrični mreži na tem območju, ki pa ni bila izvedena.

4 RAZPRAVA IN SKLEP

Glede na vse bolj razširjeno uporabo tehnologije GNSS, ki na eni strani zagotavlja realizacijo državnega koordinatnega sistema in na drugi strani omogoča uporabnikom v geodetski praksi enostaven dostop do državnega koordinatnega sistema, se, tudi v strokovni javnosti, postavlja vprašanje, ali je še treba ohranjati podatke o trajno stabiliziranih geodetskih točkah v evidencah geodetske službe ter vzdrževati označbe teh točk v naravi. Po našem mnenju pa dvomi o smiselnosti ohranjanja podatkov o teh točkah v evidencah državne geodetske službe in vzdrževanje ključnih geodetskih točk v stanju, primernem za praktično uporabo, niso upravičeni. Vedeti je namreč treba, da so fizično stabilizirane geodetske točke v naravi vez med fizično stvarnostjo (stanjem v naravi oziroma v prostoru) in podatki ter modeli o fizični stvarnosti, ki jih vodi geodetska in številne druge stroke v okviru svojih evidenc. Ohranjanje podatkov o geodetskih točkah v evidencah državne geodetske službe brez ohranjanja v naravi fizično stabiliziranih geodetskih točk ni smiselno, treba je ohraniti oboje, tako evidence kot geodetske točke v naravi.

V vsakdanji geodetski praksi se pogosto srečujemo s prenašanjem različnih podatkov iz evidenc državne geodetske službe v naravo. Pri tem prenosu pa je treba vzpostaviti povezavo med podatki v evidencah in fizično stvarnostjo oziroma stanjem v naravi. Ta prenos je lahko položajno kakovostno opravljen le, če imamo v evidencah ustreznih služb in strok na voljo kakovostne podatke in kakovostno ohranjeno stanje ustreznega števila geodetskih in drugih ohranjenih fizičnih točk v naravi. Sodobne merske tehnologije nam zagotavljajo visoko natančnost meritev, izmerjene obstoječe trajno stabilizirane geodetske točke v naravi pa nam omogočajo tudi ustrezno časovno neodvisno točnost geodetskih meritev za prenos različnih podatkov iz evidenc državne geodetske službe v naravo.

Izpostavljene trajno stabilizirane geodetske točke že dolgo kljubujejo zobu časa, zato imajo velik potencial tudi za vzdrževanje in zagotavljanje dolgoročne stabilnosti državnega koordinatnega sistema. V načrtih državne geodetske službe so predvidene dejavnosti dolgoročnega spremljanja geodinamike z novimi GNSS-izmerami (Stopar in sod., 2021). Pri tem pridejo v poštev tudi v preteklosti kakovostno stabilizirane točke geodetskih mrež višjih redov. Te točke lahko v povezavi s kakovostno stabiliziranimi geodetskimi oziroma tako imenovanimi geodinamičnimi točkami, ki smo jih na območju celotne države fizično stabilizirali za potrebe izvajanja GNSS-izmer v zadnjih 35 letih, predstavljajo zgostitev aktivnih GNSS-omrežij, kot sta omrežje SIGNAL in kombinirana geodetska mreža oziroma mreža 0. reda (Oven in sod., 2019; Medved in sod., 2018). Pri tem pridejo v poštev tudi za uporabo kot pasivne kontrolne GNSS-mreže (Majcen, 2020). Način stabilizacije trigonometričnih točk višjih redov iz obdobja Kraljevine Italije je primerljiv s posebnimi tipi stabilizacij, namenjenih GNSS-izmeram ob aktivnih tektonskih prelomih. Kot prvo na takšen način izmerjeno mrežo pri nas omenimo geodinamično mrežo Krško, ki je bila prvič izmerjena z GNSS že leta 1993 (Vodopivec, Miškovič in Jaklič, 1999; Kogoj, 2000). Sledijo leta 1996 prvič izvedene GNSS-meritve velike geodinamične mreže Premogovnika Velenje, kjer se preučujejo aktivnosti šoštanjskega, smrekovškega in labotskega preloma (Pavlovčič Prešeren, Stopar in Vrabec, 2005). Obakrat so bile točke stabilizirane s posebnimi tipi stabilizacij, v prvem primeru s svornikom, na katerem je vijak za prisilno centriranje, zabetoniranim v skalo, v drugem pa so uporabili posebne betonske stebre ali svornike, vgrajene v naravno čvrsto skalo (Triglav Čekada in sod., 2021a). Dve prej navedeni točki, stabilizirani z italijanskima tipoma stabilizacij, to sta točki Velika Milanja (trigonometrična točka II. reda št. 351) in Veliko Gradišče (II. red, št. 310), sta bili v preteklosti že vključeni v EUREF-izmere na območju Slovenije (Berk in sod., 2003).

S pričujočo analizo smo na Primorskem identificirali skupno 68 trigonometričnih točk II. in III. reda, ki so v naravi stabilizirane z italijanskim načinom stabilizacije geodetske točke višjega reda. To je kakovostna stabilizacija, ki je potencialno zanimiva tudi za izvajanje geodinamičnih GNSS-meritev v daljšem časovnem obdobju. Glede na tip vegetacije, ki trenutno prekriva pregledane trigonometrične točke, je za takojšno izvedbo izmere GNSS potencialno primernih 47 točk, stabiliziranih z italijanskim tipom stabilizacije (56 % od vseh identificiranih točk s tem tipom stabilizacije) ter 11 točk s še starejšim tipom stabilizacije (52 % od vseh identificiranih točk s tem tipom stabilizacije). Še kar nekaj primernih točk je v trigonometrični mreži IV. reda, vendar jih v tem prispevku ne obravnavamo.

V trigonometričnih mrežah II. in III. reda smo identificirali skupno še 21 trigonometričnih točk s stabilizacijo še iz avstro-ogrske monarhije, ki imajo poleg ozko geodetske še pomembno zgodovinsko vlogo in ponujajo tudi možnosti za promoviranje geodetske tehnične dediščine.

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