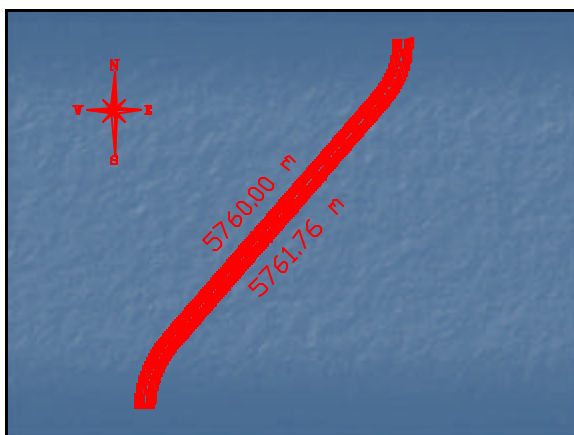


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Munich , Germany

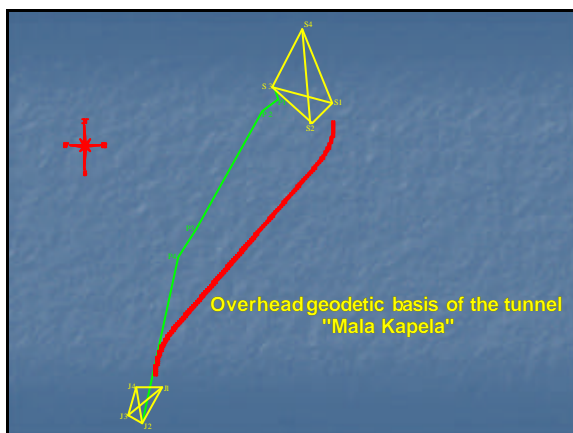
Underground Geodetic Basis of the Tunnel "Mala Kapela"

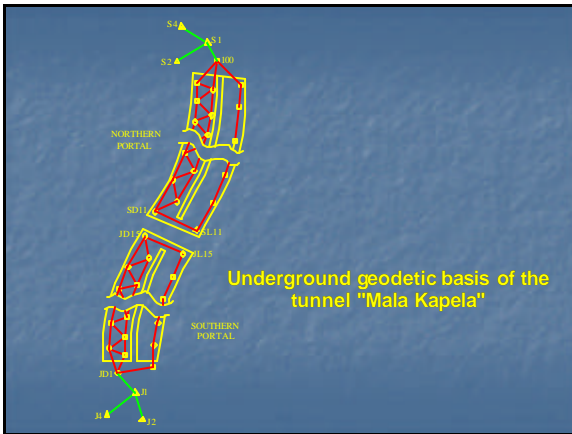
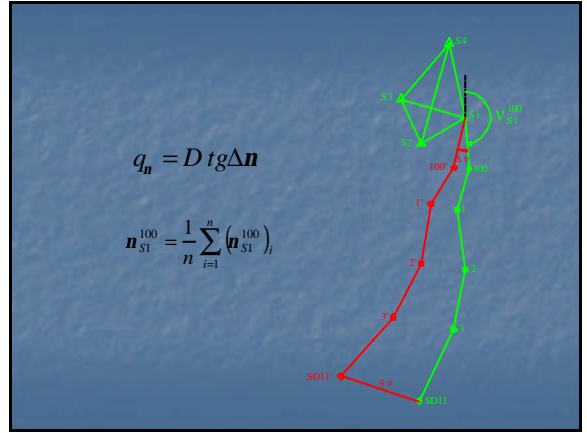
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According to the Book of Rules on Technical standards and conditions for the design and construction of tunnels on the roads of the Republic of Croatia, Art. 53 of the Law on Standardisation, the allowed transverse deviation for the tunnel "Mala Kapela" ($L = 5760.00$ m) is:

$$\Delta = 60 \text{ mm} \sqrt{L_{\text{km}}} = 60 \text{ mm} \sqrt{5.760} = 144 \text{ mm}$$





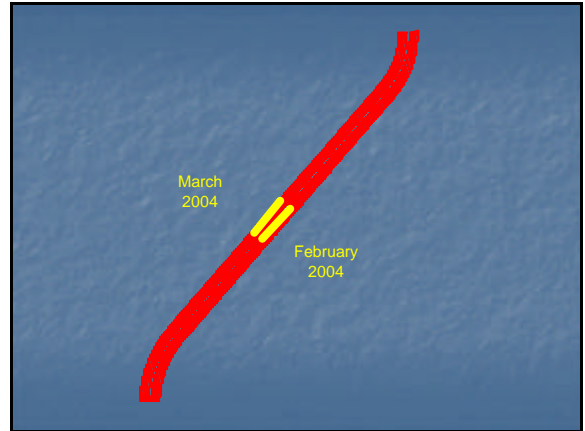
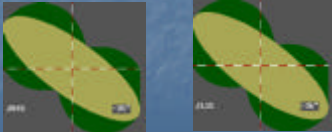
GPSurvey

T _n	Standard deviations	
	S _y [cm]	S _x [cm]
SD11	3.9	2.9
SL11	4.0	2.9
JD15	5.9	4.5
JL15	5.9	4.6

The error ellipses on the northern tunnel portal



The error ellipses on the southern tunnel portal



Positional uncertainty of cutting point in the right tunnel tube:

Cutting point	Coordinate	Northern portal (1)	Southern portal (2)	Difference (1) - (2) [cm]	Transverse deviation s_{\perp} [cm]	Longitudinal deviation s_{\parallel} [cm]
A	y	5 518 063.287	5 518 063.267	2.0	0.8	2.1
	x	4 994 441.017	4 994 441.006	1.1		

Positional uncertainty of cutting points in the left tunnel tube:

Cutting point	Coordinate	Northern portal (1)	Southern portal (2)	Difference (1) - (2) [cm]	Transverse deviation s_{\perp} [cm]	Longitudinal deviation s_{\parallel} [cm]
B	y	5 518 096.040	5 518 096.017	2.3	1.0	2.2
	x	4 994 427.541	4 994 427.533	0.8		

CONCLUSION

- This paper presents the performed analysis connected with the errors in angle measurements on the underground geodetic basis, and their influence on the accuracy of tunnel cutting, and on the basis of measurements data obtained on the underground geodetic basis of the tunnel "Mala Kapela"
- In constructing the tunnel "Mala Kapela" several methods were used in order to overcome the difficulties associated with accurate surveying of the tunnel
- We determined the direction angle orientation by means of all the points of the overhead geodetic basis that we could observe

- The geodetic basis in the right tunnel tube was designed and used for calculation in the form of a triangle chain which gave us the possibility to adjust the angles in triangles to the theoretical value $(n - 2)180^\circ$
- In order to reduce the influence of refraction, the sighting line was at a distance of at least 1.5 m from the side walls
- The measurements at the entrance and exit of the tunnel should be done at the approximately adjusted temperature both inside and outside the tunnel
- For tunnels of extensive lengths the underground geodetic basis that is used for tunnel cutting should be checked after every 500 m of cut

