Handout to prepare homework Settlement Monitoring of a Building in Field Course of Structural Geodesy.

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At first you have to calculate a levelling line. Distances, height differences and the reduced level value of the start and the end point are given as follows:

point	distance	height difference					RL
		forward	reversed	average	correction	corrected	
XXI							105.7891
XXII	13.1	-3.382	+3.355				
XXIII	4.8	+8.640	-8.603				
XXIV	10.6	-0.430	+0.395				
XXV	6.7	-9.664	+9.674				105.7407

Steps of calculation:

1. Calculate the mean of the forward and reversed measurements. Please note that the forward and reversed height differences have opposite sign, the mean height difference is calculated as the mean of the absolute values of forward and reversed measurements. Furthermore the mean height difference has the same sign as the forward one. Do not forget to put the sign, even in case of positive values! Please also note that height differences are expressed in centimetre with hundredth of mm precision (with three decimals). This also means that mean values should be expressed with the same precision, not more and not less than three decimals. In case of the mean value mathematically ends with half hundredth of mm, like in the first row, the mean value according to the Hungarian customs should be rounded to the even integer value.
2. Calculate the sum of the mean values which is the measured height difference of start and end points.

point	distance	height difference					RL
		forward	reversed	average	correction	corrected	
XXI							105.7891
XXII	13.1	-3.382	+3.355	**-3.368**			
XXIII	4.8	+8.640	-8.602	**+8.621**			
XXIV	10.6	-0.430	+0.395	**-0.412**			
XXV	6.7	-9.664	+9.674	**-9.669**			105.7407
				Σ=-4.828			

3. Calculate the height difference of start and end point from the given reduced levels!
4. Compare the measured and given height differences. If they fit to each other within the preliminary given tolerance, which is a few tenth of millimetre in the exercise, the measured value should be adjusted to the given one. Their difference is called closure error (or misclosure), in this example this is -0,012 centimetre or -0,12 millimetre. Pay special

attention to the sign of closure error!

point	distance	height difference					RL
		forward	reversed	average	correction	corrected	
XXI							105.7891
XXII	13.1	-3.382	+3.355	-3.368			
XXIII	4.8	+8.640	-8.602	+8.621			
XXIV	10.6	-0.430	+0.395	-0.412			
XXV	6.7	-9.664	+9.674	-9.669			105.7407
				-4.828	**-0.012**		**Δ=-0.0484**

5. The closure error should be divided proportionally with distances. The longer the distance is the higher the correction becomes. Please note that precision is still the same (three decimals in centimetre)! Check the sum of the corrections! It should be exactly equal to the closure error.

point	distance	height difference					RL
		forward	reversed	average	correction	corrected	
XXI							105.7891
XXII	13.1	-3.382	+3.355	-3.368	**-0.004**		
XXIII	4.8	+8.640	-8.602	+8.621	**-0.002**		
XXIV	10.6	-0.430	+0.395	-0.412	**-0.004**		
XXV	6.7	-9.664	+9.674	-9.669	**-0.002**		105.7407
	35.2			-4.828	**-0.012**		-0.0484

6. Correct your measurements!
7. Calculate the sum of your corrected measurements! It should be exactly the same as the given height difference of the start and the end point!

point	distance	height difference					RL
		forward	reversed	average	Correction	corrected	
XXI							105.7891
XXII	13.1	-3.382	+3.355	-3.368	-0.004	**-3.372**	
XXIII	4.8	+8.640	-8.602	+8.621	-0.002	**+8.619**	
XXIV	10.6	-0.430	+0.395	-0.412	-0.004	**-0.416**	
XXV	6.7	-9.664	+9.674	-9.669	-0.002	**-9.671**	105.7407
	35.2			-4.828	-0.012	**Σ=-4.840**	-0.0484

8. Calculate the height of the points in the line! Do not forget that height differences are expressed in cm, but the reduced levels (RL) are in metre! As a final check, you will get the given RL of your end point. Despite the fact that the RL of the start and the end points are given with the precision of “only” one tenth of mm, the RLs should be computed with the precision of the observations (one hundredth of millimetre). The final RLs will be rounded

later to one tenth of a millimetre, since the accuracy of the RLs is about a few tenth of a millimetre.

point	distance	height difference					RL
		forward	reversed	average	correction	corrected	
XXI							105.7891
XXII	13.1	-3.382	+3.355	-3.368	-0.004	-3.372	**105.75538**
XXIII	4.8	+8.640	-8.602	+8.621	-0.002	+8.619	**105.84157**
XXIV	10.6	-0.430	+0.395	-0.412	-0.004	-0.416	**105.83741**
XXV	6.7	-9.664	+9.674	-9.669	-0.002	-9.671	**105.7407**
	35.2			-4.828	-0.012	Σ=-4.840	-0.0484

In the second part of your homework, please download the previously observed RLs of your points from the homepage of the course! Calculate the vertical displacements of the points with respect to the initial and the previous measurement. In this calculation millimetre dimension with one tenth of a mm precision is suggested. Finally the recent displacement rates are calculated. This information in the real life is important for example to plan the epoch of the next measurement.

	XXI	XXII	XXIII	XXIV	XXV
01.04.2009	105.8034	105.7683	105.8525	105.8502	105.7539
08.05.2014	105.7943	105.7610	105.8471	105.8434	105.7462
26.09.2014	105.7891	105.7554	105.8416	105.8374	105.7407
Subsidence wrt the initial epoch [mm]	**14.3**	**12.9**	**10.9**	**12.8**	**13.2**
Subsidence wrt the previous epoch [mm]	**5.2**	**5.6**	**5.5**	**6.0**	**5.5**
Recent displacement rate [mm/month]	**1.1**	**1.2**	**1.2**	**1.3**	**1.2**

In the third part the numerically given vertical displacements are visualized. At the end of the practice several examples were presented. Choose one of them or use another way, as you prefer. Please note that the vertical displacements should be visualized, not the reduced level of the points!