GDAŃSK UNIVERSITY OF TECHNOLOGY

UWM

Accuracy analysis of determination of the vertical displacements in unstable reference system

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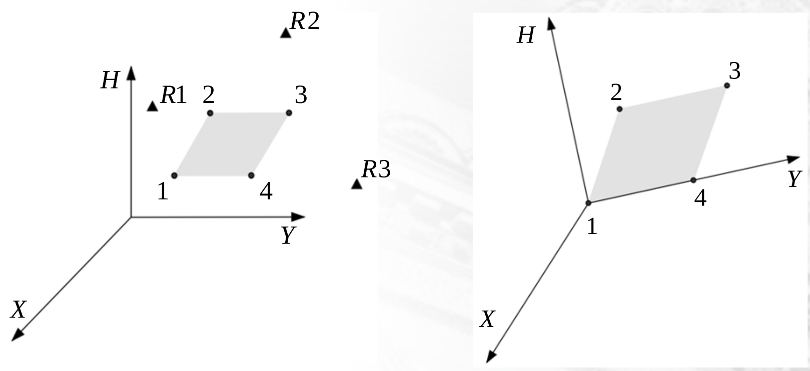
Vertical displacements

Absolute network

Relative network



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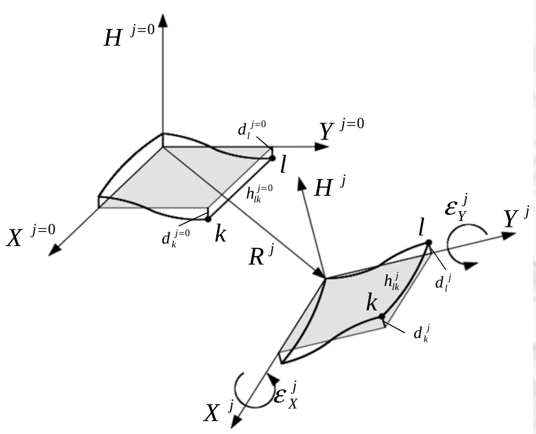
Theoretical basis



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$$v_{lk}^{j} = d_k^j - d_l^j - (Y_k - Y_l)\varepsilon_X^j + (X_k - X_l)\varepsilon_Y^j - h_{lk}^j$$

$$(j = 0,1,2,\ldots)$$

$$\left.\begin{aligned} \mathbf{v}^j &= \mathbf{A}\mathbf{d}^j + \mathbf{B}\boldsymbol{\varepsilon}^j - \mathbf{h}^j \\ \Phi(\mathbf{d}^j,\boldsymbol{\varepsilon}^j) &= (\mathbf{v}^j)^T \mathbf{P}\mathbf{v}^j = \min \\ \Psi(\mathbf{d}^j,\boldsymbol{\varepsilon}^j) &= (\mathbf{d}^j)^T \mathbf{P}_\mathbf{d}\mathbf{d}^j = \min \end{aligned}\right\}$$

$$\boldsymbol{\varepsilon}^j = [\varepsilon_X^j, \varepsilon_Y^j]^T$$

$$\mathbf{d}^j = [d_1^j, \ldots, d_m^j]^T$$

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$$\boldsymbol{\varepsilon}^j - \boldsymbol{\varepsilon}^{j=0} = \Delta\boldsymbol{\varepsilon}$$

ACCURACY ANALYSIS

$$\mathbf{C}_{\boldsymbol{\varepsilon}}^j = \begin{bmatrix} m_{\varepsilon_X}^2 & \operatorname{cov}(\varepsilon_X, \varepsilon_Y) \\ \operatorname{cov}(\varepsilon_Y, \varepsilon_X) & m_{\varepsilon_Y}^2 \end{bmatrix}$$

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Algorithm of determination of the objects vertical displacements

1. Checking if there are any reasons which allow to formulate the conclusion about existing vertical displacements ($\boldsymbol{\varepsilon}^j - \boldsymbol{\varepsilon}^{j=0} = \Delta\boldsymbol{\varepsilon}$ and $m_{\varepsilon_x}, m_{\varepsilon_y}$).
2. Choosing the potentially stable point (non displaced) in both measurement epochs, based on adjustment results and accuracy analysis.
3. Determination of height of all controlled points.
4. Determination of vertical displacements as a differences between heights of controlled points.
5. Carrying out the tests of statistical significance of obtained vertical displacements.

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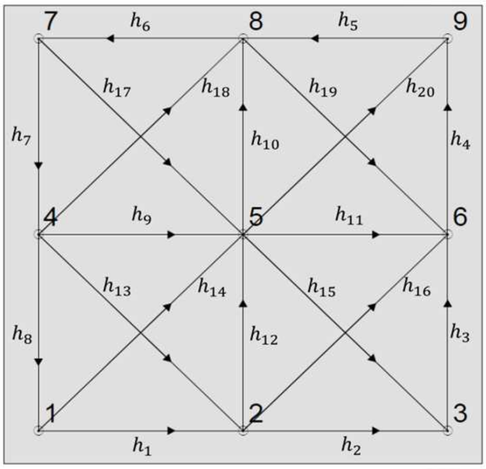
Leveling control network



Epoch: *j*

- Variant 1:
  It was assumed that the subsidence value of point no.3 is 0,005m.
- Variant 2:
  It was assumed that the subsidence value of points no.3, 6 and 9 is 0,005m.
- Variant 3:
  It was assumed that the subsidence value of points no.2, 3 and 6 is 0,005m.

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Results of adjustment for variant 1, 2 and 3

	Angle of rotation	The value of angle of rotation in epoch $t^{j=0}$ [cc]	Mean error of angle of rotation m_ε [cc]	The value of angle of rotation in epoch t^j [cc]	Mean error of angle of rotation m_ε [cc]	$\Delta\varepsilon$ [cc]
Variant 1	ε_X^j	1,3	11,2	27,8	11,2	26,5
	ε_Y^j	-3,5	11,2	23,1	11,2	26,6
Variant 2	ε_X^j	1,3	11,2	80,8	11,2	79,5
	ε_Y^j	-3,5	11,2	-3,5	11,2	0,0
Variant 3	ε_X^j	1,3	11,2	54,3	11,2	53,0
	ε_Y^j	-3,5	11,2	49,6	11,2	53,1

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Controlled point no.	Heights of controlled points H_i in epoch $t^{j=0}$ [m]	Heights of controlled points H_i in epoch t^j. Variant 1 [m]	Heights of controlled points H_i in epoch t^j. Variant 2 [m]	Heights of controlled points H_i in epoch t^j. Variant 3 [m]	Vertical displacements		
					Variant 1	Variant 2	Variant 3
1	0,00000	0,00000	0,00000	0,00000	-	-	-
2	**0,00105**	0,00105	0,00105	**-0,00395**	-	-	**-0,005**
3	**0,00099**	**-0,00401**	**-0,00401**	**-0,00401**	**-0,005**	**-0,005**	**-0,005**
4	0,00136	0,00136	0,00136	0,00136	-	-	-
5	0,00099	0,00099	0,00099	0,00099	-	-	-
6	**0,00063**	0,00063	**-0,00437**	**-0,00437**	-	**-0,005**	**-0,005**
7	0,00087	0,00087	0,00087	0,00087	-	-	-
8	0,00016	0,00016	0,00016	0,00016	-	-	-
9	**0,00036**	0,00036	**-0,00464**	0,00036	-	**-0,005**	-

Example of computation
Variant 1. point no. 3, p_3 = -0,00401 - 0,00099 = -0,005m.

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Conclusions

- The obtained results do not let us to draw too general conclusions.
- The presented proposition of determination the vertical displacements requires carrying out further detailed theoretical and empirical analysis.

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Thank you for your attention.

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