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New way of constructing the tunnel

Abstract: The design and construction of the tunnel surface requires considerable time and cost. Therefore, improved methods of constructing the surfaces of underground structures is an urgent task in the mine industry. Everyone knows that the surface of the tunnel is a complex curvilinear surface, which must meet the pre-determined requirements. The article presents a new way of constructing the tunnel surface according to predefined conditions using the biquadratic transformation of the plane, which allows one to describe the design of each tunnel section by a single equation.

Key words: transformation, biquadratic transformations, graphical model, tunnel, tunnel section.

1. Obtaining the section of the tunnel

The definition of the section of the tunnel surface can be specified in various ways [1]. In the proposed method, the preimage (curve *n*) undergoes a geometric transformation L_8, resulting in an image (the desired curve n') [2]. In this case, the inverse image is given by the equation:

$$x_2 = kx_1 + m,$$

where: *k*, *m* are constant coefficients.

The biquadratic transformation L_8 is given by the equations:

$$\begin{cases} x_1' = \sqrt{x_1^2 + x_2^2} \\ x_2' = \sqrt{x_2^2 - x_1^2} \end{cases}, \qquad \begin{cases} x_1 = \sqrt{\dfrac{x_1'^2 - x_2'^2}{2}} \\ x_2 = \sqrt{\dfrac{x_1'^2 + x_2'^2}{2}} \end{cases},$$

where: $x_1^{/}, x_2^{/}$ - are the coordinates of the points of the image;
x_1, x_2 - are the coordinates of the points of the preimage.

The equation of the obtained curve n / is written in the form:

$$\sqrt{\frac{x_1^{/2} + x_2^{/2}}{2}} = k\sqrt{\frac{x_1^{/2} - x_2^{/2}}{2}} + m,$$

where: k, m - are constant coefficients.

2. Tunnel construction with given parameters

The essence of the transformation is as follows. We take several points of the preimage n in correspondence, then each of these points is subjected to the transformation L_8. We find the sets of points, smoothly joining which we obtained the curve n. In this case, the shape of the curve $n^{/}$ depends on the values of the coefficients m, k of the preimage n.

The surface of the tunnel is formed, as a result of the displacement of a flat curve of the fourth order (section) along the axis of the guide curve.

Using the graphical model of the biquadratic transformation L_8, the shape of the channel surface of the tunnel was constructed in the following way:

1. The initial data for solving this problem is the axial line of the channel surface of the tunnel and the laws of changing the parameters of the cross sections a and b. Each cross-section of the $n^{/}$ tunnel is a curve of the fourth order, obtained using the biquadratic transformation L_8. The parameters a and b of each cross section are determined from the formulas:

$$a = \gamma(l), b = \gamma(l) \qquad (1)$$

where: l - is the distance from the start of the tunnel to the cross section in question.

2. We use the biquadratic transformation L_8 given by the equations:

$$\begin{cases} x_1' = \sqrt{x_1^2 + x_2^2} \\ x_2^1 = \sqrt{x_2^2 - x_1^2} \end{cases} \quad (2)$$

where: x_1, x_2 - coordinates of the point of the pre-image; x_1', x_2' - coordinates of the point of the image.

3. As a preimage, we take a straight line of general position *n*, whose equation has the form:

$$x_2 = kx_1 + m, \quad (3)$$

where: *k, m* - are constant coefficients.

4. Next we determine the coefficients *k, m* of the equation (3). To do this, we use the properties of the biquadratic transformation L_8:

a) the inverse image point *B* and the image point B_2' have the same height. The point B_2' is an outline point of the section n'. Therefore, the point *B* of the preimage *n* has coordinates:

$$x_{1_B} = 0, \quad (4)$$

$$x_{2B} = a/2. \quad (5)$$

b) the point-inverse image of *C* is transformed into points-images C_1'=C_3' and C_2'=C_4', which lie on the axis O_x'. Point C_1 has coordinates (*b+c; 0*). To point C_1, there corresponds a point *C*, which coordinates satisfy the condition:

$$x_{1_C} = x_{2_C}. \quad (6)$$

We determine the coordinates of the point *C*. From the course of constructing the point C_1', we can obtain the following equation:

$$(b+c)^2 = x_{1_C}^2 + x_{2_C}^2, \quad (7)$$

where: c=$a/2$.

Taking into account condition (6), from equation (7) we obtain

$$(b+c)^2 = 2x_{1_C}^2, \quad \text{and} \quad x_{1_C}^2 = (b+c)^2/2 = x_{2_C}^2 . \tag{8}$$

The inverse image of *n* passes through points *B* and *C*. Given this, we compose the following system of equations:

$$\begin{cases} a/2 = k \cdot 0 + m, \\ (b+c)/\sqrt{2} = k(b+c)/\sqrt{2} + m. \end{cases} \tag{9}$$

Solving this system of equations, we get:

$$m = a/2, \tag{10}$$

$$k = 1 - (a(2b+a))/(2\sqrt{2}). \tag{11}$$

5. By inverting the *n* to the biquadratic transformation L_8, we obtain the required section of the tunnel, which satisfies the preassigned conditions. The algebraic equation of this section has the form:

$$x_1^{/2} + x_2^{/2}(k^2+2) + (m/k)^2 = 0. \tag{12}$$

where: - *k, m* are the pre-image parameters described by equations (10) and (11).

The parametric equation of the tunnel cross section has the form:

$$\begin{cases} x_1' = \sqrt{x_1^2 + (kx_1+m)^2} \\ x_2' = \sqrt{(kx_1+m) - x_1^2} \end{cases}, \tag{13}$$

where: x_1 – parameters $\frac{(b+c)^2}{2} \le x_1 \le \frac{c}{\sqrt{2}}$; $m = \frac{a}{2}$, $k = 1 - \frac{a(2b+a)}{2\sqrt{2}}$.

6. In a similar way, we construct any required section of the tunnel surface under consideration.

7. The equation of the channel surface of the tunnel is written as:

$$\begin{cases} x_3 = \phi(x_1), \\ x_2 = l_0. \end{cases} \tag{14}$$

where: $\varphi(x_1)$ - is a function describing the contour of the tunnel cross-section;

l_0 - the distance from the cross section to the beginning of the tunnel, $x_3^{rocked} \leq l_o \leq x^{end}$.

Conclusion

Thus, the proposed method of construction using a biquadratic transformation makes it possible to obtain various classes of channel surfaces and to determine the equation of the qroup of cross-sections of the surface under consideration, which facilitates further geometric calculations on a computer.

References

1. Baidabekov A.K. Development theory quadratic conformity and their prominence. –Moscow: Company "Sputnik", 2005. - 95 p.
2. H. Hudson. Cremona transformations in plane and space. –Cambridge: Cambridge University Press, 1927. -321 p.

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Туннель конструкциясының жаңа әдісі

Аннотация: Туннельдер бетінің дизайны мен құрылысы айтарлықтай уақыт пен шығынды талап етеді. Сондықтан жерасты құрылыстарының беттерін салудың жетілдірілген әдістері шахта өнеркәсібінде өзекті мәселе болып табылады. Туннельдің беті алдын-ала белгіленген талаптарға сай болуы тиіс күрделі қисық сызық бетін біледі.

Мақалада, әр туннель қимасының дизайнын бір теңдеу арқылы сипаттауға мүмкіндік беретін, жазықтықтың биквадрат түрлендіруін қолдана

отырып, алдын-ала анықталған шарттарға сәйкес туннель бетінің құрылымы үшін жаңа әдіс ұсынылған.

Кілт сөздер: түрлендірулер, биквадраттық түрлендірулер, графикалық модель, туннель, туннель тілігі.

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Новый способ конструкции туннеля

Аннотация: Проектирование и строительство поверхности туннеля требует значительного времени и затрат. Поэтому совершенствование методов конструирования поверхностей подземных сооружений является актуальной задачей в шахтостроении. Всем известно, что поверхности туннеля являются сложной криволинейной поверхностью, которая должна соответствовать наперед заданным требованиям.

В статье излагается новый метод конструирования поверхности туннеля по наперед заданным условиям с использованием биквадратичного преобразования плоскости, который позволяет описать конструирование каждого сечения туннеля одним уравнением.

Ключевые слова: преобразования, биквадратичные преобразования, графическая модель, туннель, туннельный разрез.

References

1. Baidabekov A.K. Development theory quadratic conformity and their prominence. –Moscow: Company "Sputnik", 2005. - 95 p.
2. H. Hudson. Cremona transformations in plane and space. –Cambridge: Cambridge University Press, 1927. -321 p.