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DISCRETE MODEL OF TUNNEL

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Abstract. *With discrete models series "C-MONT" the real technological treatment of doing montage tunnel lining is simulated. The deep tunnel of a round cross section is observed. The primary state is considered homogenous and isotropic in the area of discrete model. Rocky mass is elastic-plastic area which deformity is shown with "work line". By the result interpretation the connection of tension and deformity is made with the distance of the front of the excavation, the processing speed of excavation and by continuity of reological process of the convergency of the contour of excavation. Attention is paid to the influence of the value of the final elements, their density in the zones the tension is concentrated and to the number of integrated points to the accuracy of calculation as well. Finite elements method and programs for dynamic calculation of the construction in nonlinear area is applied.*

Key words: *Tunnel, tunnel lining, underground, pressures, modeling, tension, deformity*

1. MODEL "C-MONT"

The deep tunnel of a round cross section is observed. The primary state is considered homogenous and isotropic in the area of discrete model. Rocky mass is elastic-plastic area which deformity is shown with "work line" with the branch of the load and unload, Fig. 1. The concrete area lining is treated as homogenous, elastic and isotropic area so as to point out characteristically deformity of the rocky mass and to interpret easily its influence.

With discrete models series "C-MONT" the real technological treatment of doing montage tunnel lining is simulated. The boring in the complete profile with the constant speed is simulated with the rhythmical "dying of final elements with which the excavation mass is discreted. Tunnel covering is simulated by bearing." by the elements with which is lining discreted. The lining element is born at the moment of the dying of the corresponding element of excavation by which is the constant distance of the lining from

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the front excavation maintained (kept). The moment of bearing of the lining elements doesn't correspond (suit, fit) to the time of the finishing of montage but the moment of the activation of the lining as the girder. Primary tensions are input model by "giving the initially movements, which are later frozen "by the time functions. The state of tension and deformity for the lining which are activated on different distances from the front of excavation, by the elements "2D-TIP8", is analyzed. Every minute of the real technological process such as in these models. The way of simulation of stoppage in work is shown. Concrete process are compared with the models in which the rhythmics of work is these disturbed.

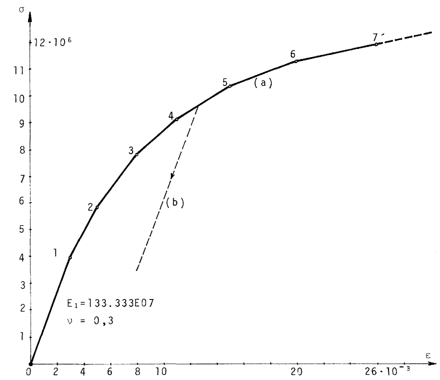


Fig. 1. Work-line - rock mass

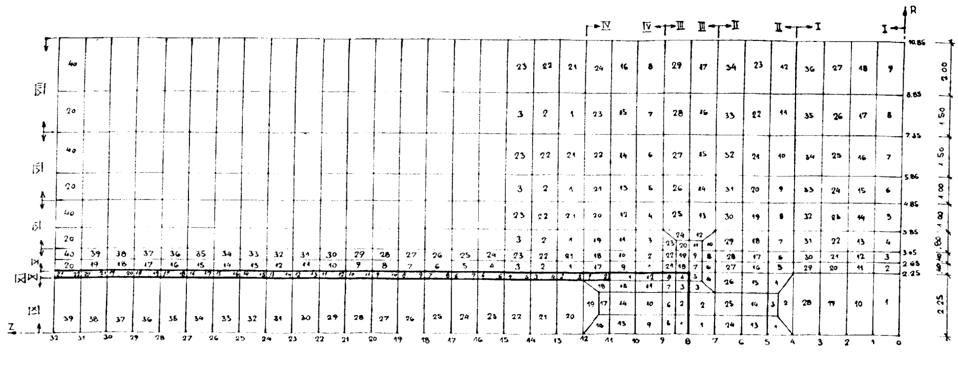
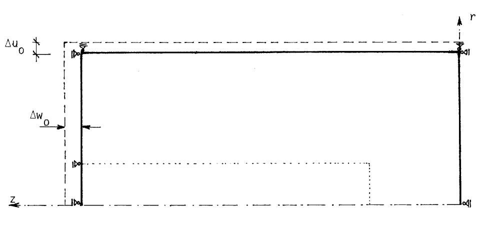


Fig. 2. "C-MONT" finite element net



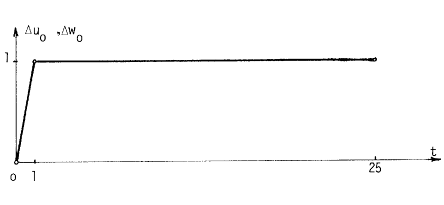


Fig. 3. Primar tensions "input"

Fig. 4. Initial movements "frozen"

2. DISCRETION

The state of tension and deformabilities for linings which activate on the distances from the front excavation L = 4, 3, 2, 1 and L = 0 m and primar tensions of 9 MPa are calculated by the programs MAR2 - MAR6.

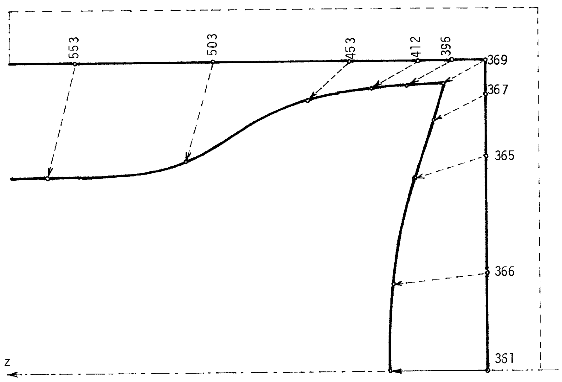


Fig. 5. Front excavation - movements

The net of final elements has 11 groups with thoroughly 368 "2D-TYP8" elements with 9 integrated dots and 1461 joints, fig. 2. Primar tensions are "input" into the model making initial movement (Fig. 3) which are after achieving its complete value, "frozen" till the end of the course of numeric process, fig. 4.

The way of simulation of tehnological process, with the times of "dying" and "bearing" is shown on the fig. 6 on the example of the program MAR2.

On the fig. 5 is vector shown diagram of the movement of important dots in the zone of front excavation (MAR2).

On the fig. 7 is shown the diagram of tension in lining depending on the distance lining from the front excavation in the moment of its activation, for integrated joint 2.

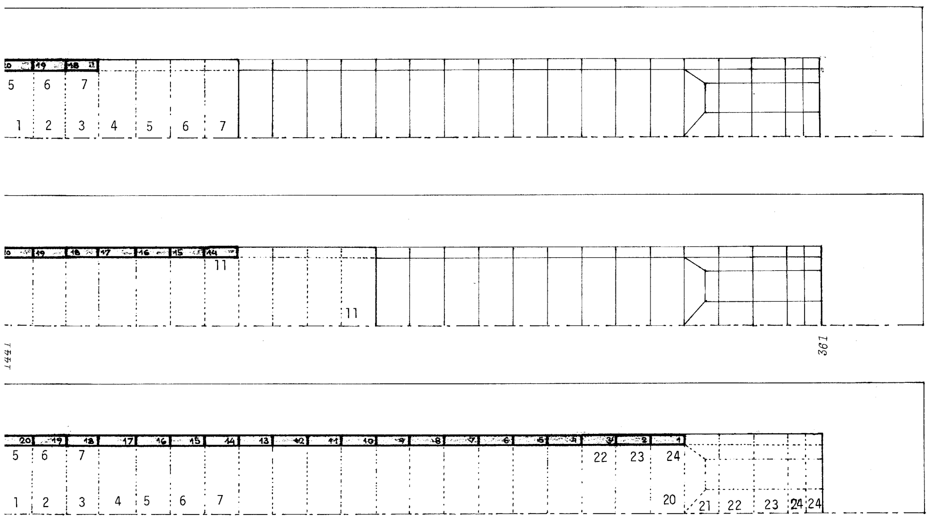


Fig. 6. Tehnological process simulation - step times dying and bearing

The diagram of the fig. 8 shows the independence of final radial movement from the distance of the front excavation lining.

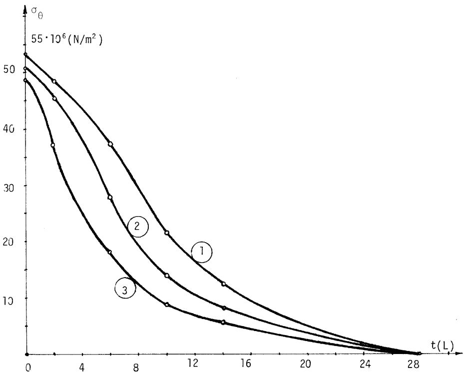


Fig. 7. Diagram tensions in lining σ_Θ = f(t,L)

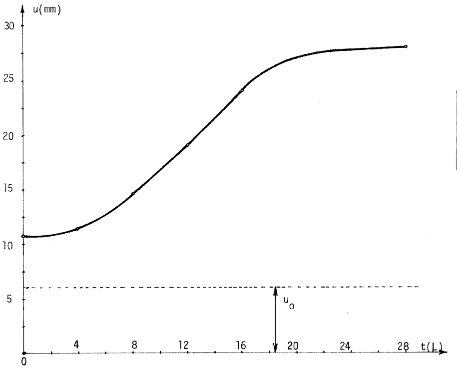


Fig. 8. Radial movements as f(L,t)

During the work excessive situations can happen, stoppage and forced excavation. Disturbances of the stationary technological process are simulated by the programs M2.24C and M2.41C.

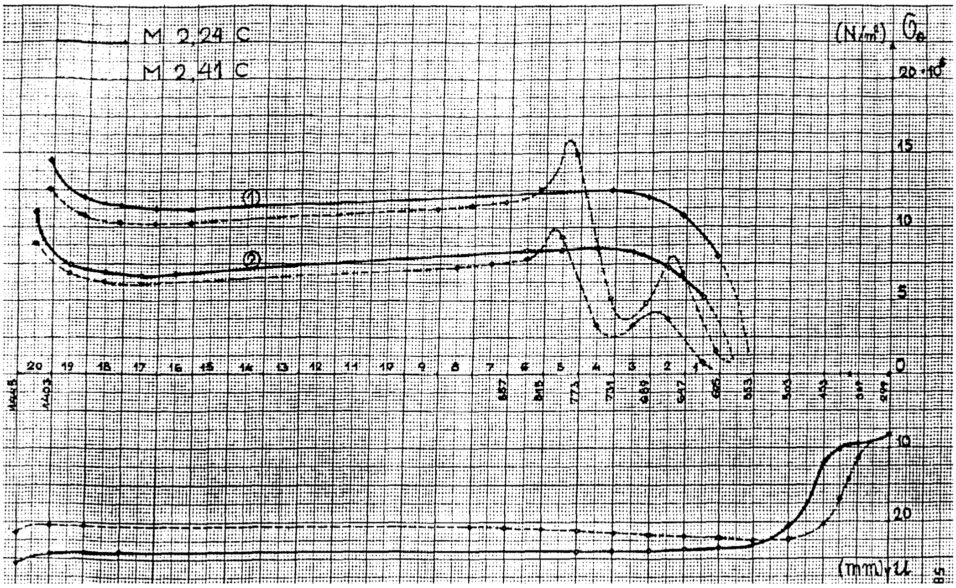


Fig. 9. Excessive situations modeling - tensions and movements

With the program M2,41C in moduled the process in which after normal start, some time is going on some standard act as for models MAR2 - MAR6, then the excavation is done "manually" in two times, with different speed (groups of elements 16, 17, 18, 19 and 1, 2, 3, ... 8). Simulation is done with 41 step so that the excavation elements which number in vertical unit width is changed, are ordered to die by units, not in groups.

The consequence is that some lining elements "wait" shorter or longer, to die the elements which present manual excavation. In the example M2,41C, the lining elements number 5 and number 2 wait for excavation longer than the others, which causes differences in the uholl series in the state of pressure and deformability, characteristic with jumps on the diagram of pressure (fig. 9). On the same picture are as comparation is concerned shown proper diagrams got for model M2,24C with 24 time steps, which corresponds to the standard model MAR2.

3. Instead of Conclusion

By the result interpretation the connection of tension and deformity is made with the distance of the front of the excavation fig. 10, the processing speed of excavation and by continuity of reological process of the convergency of the contour of excavation.

Attention is paid to the influence of the value of the final elements, their density in the zones the tension is concentrated and to the number of integrated points to the accuracy of calculation as well.

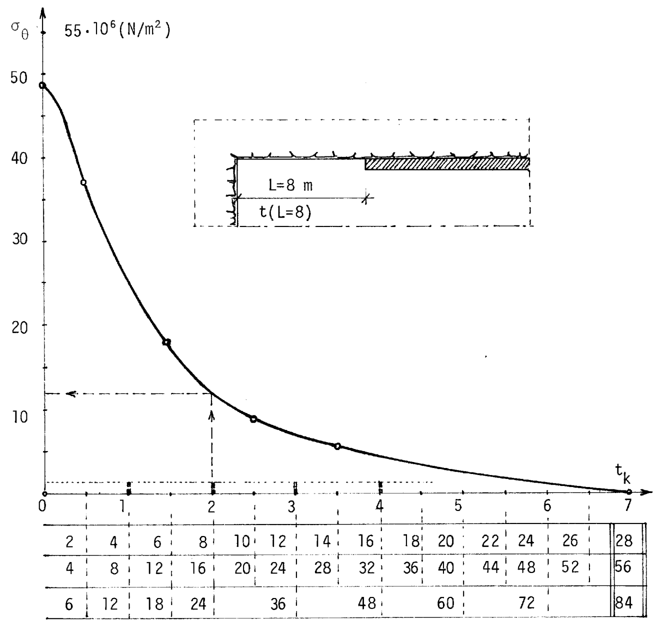


Fig. 10. Interpretation lining tension $\sigma_\Theta = f(L)$ as $\sigma_\Theta = f(t)$

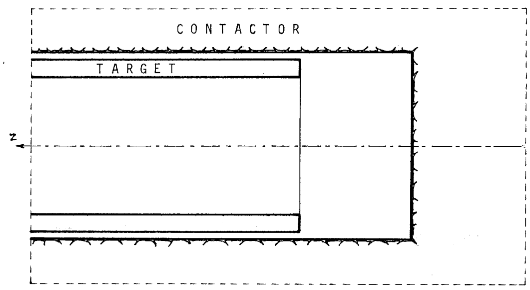


Fig. 11. Modeling with contact-elements

Tehnological process of montage lining tunnel without successive filling of the clearance of the rock, that is without bounding of tubing can't be simulated by analyzed models. Such processes can be simulated by the method of contact elements, fig. 11. They correspond to the covering treatment as cylindrical shell made of series montaged elements, determined diameter in advance which is smaller then the excavation diameter at the moment of montage. Rocky mass and lining are at the beginning independent bodies. There interaction begins at the moment when the contours of the excavation convergency reaches the value of clearance, that is at the moment of the contact of establishment.

Such process can be exclusively modeled as three-dimensional, with the final elements type "3D-8", which means considerable detailed usage of programmers and computer work.

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DISKRETNI MODEL TUNELA

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Diskretnim modelima serije "C-MONT" simuliran je realan tehnološki postupak izvođenja montažne obloge tunela.

Posmatra se duboki tunel kružnog poprečnog preseka. Primarno stanje napona se smatra homogenim i izotropnim u prostoru diskretnog modela. Stenska masa je elasto-plastična sredina čija je deformabilnost prikazana "radnom linijom". Interpretacijom rezultata je uspostavljena veza napona i deformacija sa rastojanjem obloge od čela iskopa, brzinom napredovanja iskopa, i trajanjem reološkog procesa konvergencije konture iskopa. Skreće se pažnja na uticaj veličine konačnih elemenata, njihovu gustinu u zonama u kojima dolazi do koncentracije napona, kao i broj integracionih tačaka na tačnost proračuna. Korišćen je program za dinamičke proračune metodom konačnih elemenata u nelinearnoj oblasti. Doprinos rada je u jednoj novoj definiciji diskretnog modela za numeričku analizu tunelske obloge.

Ključne reči: *tunel, obloga, podzemni pritisak, modeliranje, napon, deformacija*