EFFECTS OF MATERIAL NON-LINEARITY ON TUNNEL MOVEMENTS

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INTRODUCTION

Stresses and displacements in a rock surrounding a tunnel are fundamentally important in planning the tunnel and support systems, and which depend on stress-strain relationships, ground failure criteria, initial stresses of the ground and executive conditions. Stress-strain relationships for a rock show non-linearity, and mechanical parameters involved in this relationships are affected by confining pressure. Also, under a high initial stress state, the strength of the rock decreases from its peak strength to a residual one and the volumetric change in the residual strength region gives big influence on tunnel movements.

In order to make tunnel movements clear by taking into account the realistically mechanical behavior mentioned above, considerations to a simple axisymmetric tunnel problem are presented.

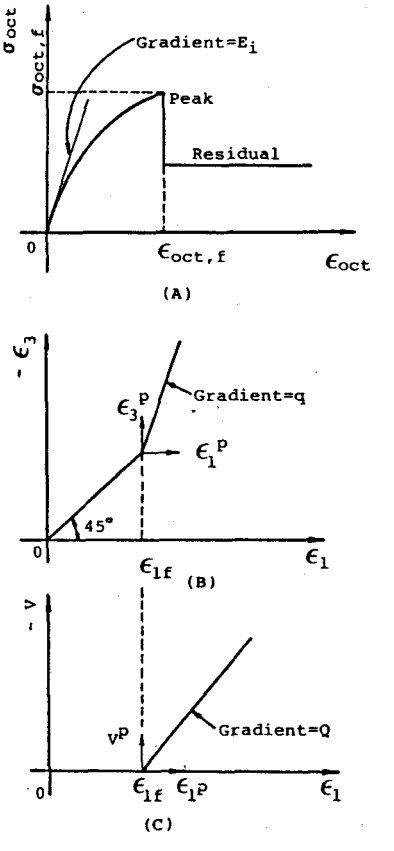

Fig.1 Constitutive relations

ANALYSIS[1)]

Stress-Strain Relation and Strength Criterion

In this analysis, a generalized hyperbolic stress-strain relationship in an octahedral space is employed as shown in Fig.1, in which the non-linear relation from the initial to the peak, the brittle-stress softening and the post-peak dilatancy are taken into account. Experimental results show that the initial tangent modulus(Ei) and the observed maximum stress($\sigma_{oct,f}$) occurred at a finite strain increase with increasing confining pressure, but the change in Ei and $\sigma_{oct,f}$ due to change of confining pressure compensates for each other.

Therefore, this evidence(Ei/σoct,f =const.) is also considerd in this analysis. The non-linear failure criteria for the peak and the residual strengths are employed.

CONSIDERATIONS

Effects of P/σc and R on Broken Zone

Fig.2 shows the effects of non-linear parameter(R) on the broken zone radius(r*), where P, σc and r_i are, respectively, an initial stress of the ground, an uniaxial strength and a tunnel radius. The value of r* decreases with the increase of R(=the increase of non-linearity) under the same condition of the other parameters.

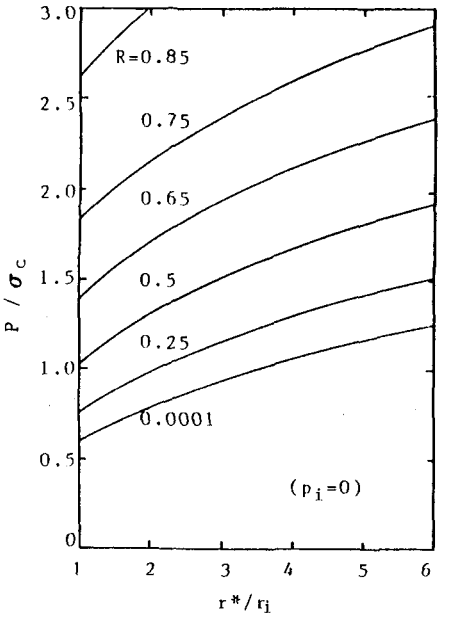

Fig.2 Effects of non-linear parameter(R) on the broken zone radius(r*)

Displacement Characteristics

Fig.3 shows the effects of the internal pressure(p_i) on the displacement(u) at a tunnel boundary. If the internal pressure is greater than a critical internal pressure, a small value of displacement is produced and this displacement has a linear relationship with the internal pressure. On the other hand, if the internal pressure is less than the critical internal pressure, the displacement increases greatly with the decrease of the internal pressure.

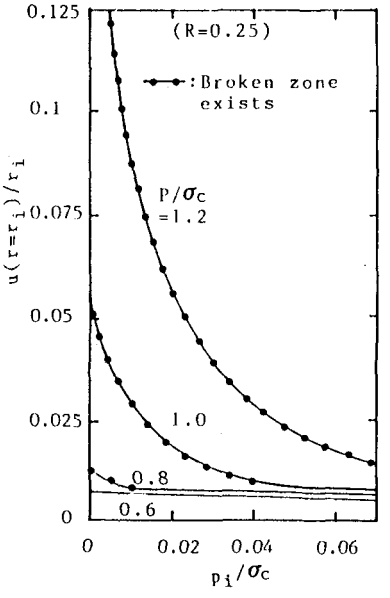

Fig.3 Effects of internal pressure(p_i) on the tunnel boundary displacements(u(r=r_i))

REFERENCES

1) Hisatake,M. and Cording,E.J.:Tunnel analysis considering non-linear stress -strain relation and residual strength , Proc. 41th Annual Conf. JSCE, Vol.3, 1986.