III-161 EFFECTS OF CYCLIC PRESTRAINING ON DEFORMATION CHARACTERISTICS OF GRAVEL IN TRIAXIAL COMPRESSION

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INTRODUCTION: Some field gravel layers may have been subjected to a large number of small or large cyclic shear stresses. A series of triaxial compression tests on a well-graded crushed sandstone gravel with a sub-angular particle shape (**Fig. 1**) were performed by Dong et al. (1992) to study into the effect of cyclic prestraining (**CP**). This and companion papers (Dong and Tatsuoka, 1992a) are the follow-up of that.

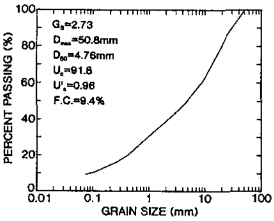

Fig. 1 Grain size distribution of tested crushed sandstone.

Table 1 Summary of Test Conditions and Results

Test Name	γ_d g/cm³	γ'_d g/cm³	σ_3 kgf/cm²	X	Y	N	q_{max} kgf/cm²	E_{max} kgf/cm²	ε_{1r} (%)
SS21	2.21	—	0.2	—	—	—	5.185	2029	—
CS21	2.22	2.22	0.2*	0.10	0.18	75000	5.247	1877	0.39
CS22	2.25	2.19	0.2	0.10 0.19 0.37	0.18 0.34 0.77	1000 1000 1000	5.163	1363	2.51
SS51	2.23	—	0.5	—	—	—	8.782	3803	—
CS51	2.21	2.21	0.5*	0.06	0.15	5000	8.743	2100	0.08
CS52	2.22	2.22	0.5	0.10 0.19 0.35	0.18 0.36 0.71	1000 1000 1000	9.339	2496	1.55
SS81	2.20	—	0.8	—	—	—	12.243	4638	—
CS81	2.21	2.21	0.8	0.11 0.25 0.35	0.21 0.44 0.66	1000 4000 1000	12.681	3717	0.68

*: σ_3 differs from this value during CP. γ'_d: dry density after CP.

TESTING METHOD AND RESULTS: Each triaxial specimen, 30cm in diameter and 60cm in height, was prepared by compacting air-dried gravel in six lifts by using a small vibrator to a high dry density (γ_d= 2.20 - 2.25gf/cm³, **Table 1**), which was selected to simulate actual field gravel layers supporting a railway track. The specimen ends were in contact with a porous stone disk fixed to the cap or pedestal. The confining pressure σ_c was applied by vacuuming. Axial strains were obtained from both the axial displacement of the cap measured with a pair of proximeters (gap sensors) and the local axial compression along the lateral surfaces of specimen measured with a pair of **LDTs** (Local Deformation Transducer, Goto et al., 1991). Axial strains measured by the former method are not reliable, particularly those during primary loading, due to the effect of bedding error. The Young's moduli reported in this paper and Dong et al. (1992, 1992a) were obtained from the axial strains measured with LDTs. The radius change of specimen was measured by means of three clip gages. The specimen volume change was obtained from the measurements of LDTs and the clip gauges.

Fig. 2 shows typical stress -strain curves during **CP**. Many sets of 12 cycles of the same stress amplitude were applied to obtain the relationship between E_{eq} and strain amplitude (the results are not reported here). **X** and **Y** are the neutral stress level and double amplitude cyclic stress in terms of q/q_{max} during the last stage of **CP** having **N** cycles of the largest stress amplitude (see **Fig. 2**). **X** was similar to **Y/2** (see **Table 1**), which means that the stress conditions during **CP** were mostly in triaxial compression. During **CP**, the confining pressure σ_c was kept constant and the same as that during the subsequent monotonic loading (**ML**), except for Tests CS21 and CS51. In these two tests, the value of σ_m= $(\sigma_1+2\sigma_3)/3$ at the neutral stress condition during **CP** was made equal to σ_3 during the subsequent **ML**. In Tests CS22, CS52 and CS81, the specimens were subjected to three stages of **CP**. In Table 1, ε_{1r} is the residual axial strain observed after all the stages of **CP**, and γ_d and γ_d' are the dry densities before and after **CP**.

ML tests were performed at an axial strain rate of 0.06%/m. at a constant σ_3 with several small unload/ reload cycles. The entire **q-** ε_1 relations are shown in Fig. 5 of Dong et al. (1992). **Fig. 3** is those for σ_3= 0.2kgf/cm^2. Similar ones for σ_3= 0.5kgf/cm^2 are presented in Fig. 7 of Dong et al., (1992), and those for σ_3= 0.8kgf/cm^2 are presented in Fig. 1 of Dong and Tatsuoka (1992). The overall stress-strain relationship had been distorted by **CP (Fig. 3a)**, particularly for the largely prestrained specimen (Test CS22). However, the peak strength did not change by

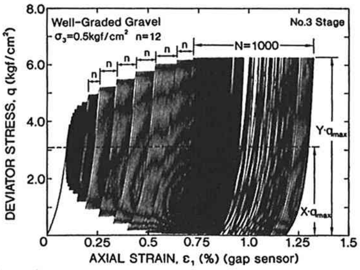

Fig. 2 Stress-strain curves during the last stage of **CP**, σ_3= 0.5kgf/cm^2 (ε_1 measured with proximeters are shown).

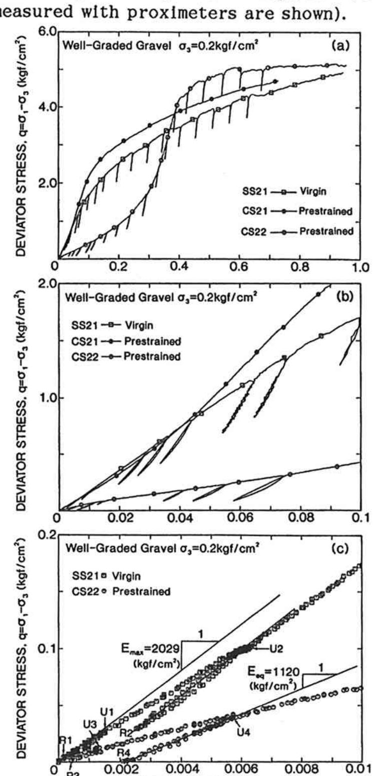

Fig. 3 **q** - ε_1 relations during **ML** at σ_3= 0.2kgf/cm^2 (the result of Test CS21 is omitted in Fig. (c) for simplicity).

CP (see also Table 1). As seen From **Fig. 3(c)**, for the virgin specimen (Test SS21), at the very beginning stage of axial strains< about 0.0015% is linear and recoverable as noted from that the unload/ reload cycle between Points U1 and R1 overlaps the primary curve. The initial and maximum Young's modulus E_{max} was 2,029kgf/cm^2. In Test CS21 after a relatively small degree of **CP**, the initial stiffness at ε_1< about 0.001% was 1,877kgf/cm^2, which was slightly lower than E_{max}= 2,029kgf/cm^2. In Test CS22 after a relatively large degree of **CP**, however, the initial stiffness was only 1,363 kgf/cm^2 (see Table 1), which was similar to the average equivalent stiffness E_{eq} of 1,120kgf/cm^2 for a unload/reload cycle between U4 and R4. Obviously, this decrease cannot be explained by the decrease in γ_d due to **CP**, since γ_d' after **CP** in Test CS22 was similar to γ_d of the virgin specimen. As also seen from Fig. **4(c)**, the strain range of linear elastic behaviour decreased by **CP**.

On the other hand, for the **CP** specimens, as the stress level increased, the tangent stiffness increased (not decreased as the virgin specimen), and then became larger than that of the virgin specimen. This tendency was larger for the more largely prestrained specimen of Test CS22.

CONCLUSIONS: Due to cyclic prestraining in triaxial compression, the initial stiffness during the subsequent monotonic triaxial compression decreased, while as the stress level increased, the tangent stiffness increased and became much larger than that of the virgin specimen.

REFERENCES: Dong,J., Tatsuoka,F., and Sato,T.(1992): Effects of cyclic prestraining on stress-strain behaviour of gravel in triaxial test, Proc. 27th Japan National Conf. on SMFE, Kochi. Dong,J. and Tatsuoka,F.(1992a): Effect of cyclic prestraining on stiffness of gravel in triaxial compression, Proc. 47th Annual Conf. of JSCE, Vol.III. Goto,S., Tatsuoka,F., Shibuya,S., Kim,Y.-S. and Sato,T.(1991): A simple gauge for local small strain measurements in the laboratory, Soils and Foundations, 31-1, pp.169-180.