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Resistance parameters of Alluvial Gravels from Static and Dynamic Triaxial Tests.

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Abstract- **In this paper, we present the results of a program of static and cyclic triaxial tests, isotropically consolidated and drained or not drained, intending to characterize the mechanical parameters of some typical alluvial gravels of the San Juan River. We determined the pre-seismic mechanical properties of these gravels: the hyperbolic curve stress-strain; the variation of the shear resistance in function of the confining pressure; the variation of the Young modulus with the initial confininig pressure; Young modulus with load-unload; the volumetric variation and variation of the B modulus with the confining pressure. In order to carry out this triaxial tests, the following effective pressure values were used in the cell: 1.0 , 2.5 , 5.0 and 9.0 kg /cm2, in the case of the drained and of 1.0 , 2.5 , 5.0 and 8.0 kg/cm2, for not drained. Samples were molded to different relative densities of interest. The cyclic triaxial tests allowed us to determinate the dynamic properties of the above-mentioned gravels: the variation of the pore pressure depending on the number of load cycles applied [u = f(Nc)]; the variation of the axial deformation as a function of the number of load cycles applied [εa = f(Nc)]; the determination of the relationships: ru = f(rn); εa = f(rn) y σdc/2/σ3c´ = f(Nc; for wich it were executed series of triaxial tests to different cyclical effective pressures in the cell: 2.5 ; 5.0 and 7.0 kg/cm2, facing cyclical deviatoric stresses(+/-σdc) who caused the liquefaction of the samples or axial deformation to a total of 10 %, between 5 to 150 load cycles, to different values of relative density of the samples.**

Keywords **- Alluvial Gravels * Static and Dynamic Properties * Cyclic Triaxial Tests.**

I. Introduction

In this paper we present the results of a program of static and dynamic triaxial (cyclical) tests, intending to characterize mechanically some of the typical alluvial gravels of the San Juan River, in the province of San Juan, Argentina, whose soil profile is composed of sandy gravels accompanied by variable proportions of rocks.

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The cyclic triaxial tests were automatized, with controls and register of loads, pore pressure and axial deformation, by the use of transducers and an electronic system of data acquisition. The results presented here correspond to the alluvial gravels of the river and fields located nearby whose characteristics are summarized in Table 1 and Fig Nº 1.

TABLE I. CHARACTERISTICS OF THE ALLUVIAL GRAVELS OF THE SAN JUAN RIVER TESTED.

Property	Properties of the samples tested			
Identification	GP-GM Ullum	GP Zonda	GW Ullum	Measuring Cylinder Test
γs (Kg/m^3)	2664	2666	2645	ϕ = 0.175m H = 0.38m Dmax = 1 ½"
γd máx (Kg/m^3)	2357	2305	2344	
γd mín (Kg/m^3)	1950	1814	1942	

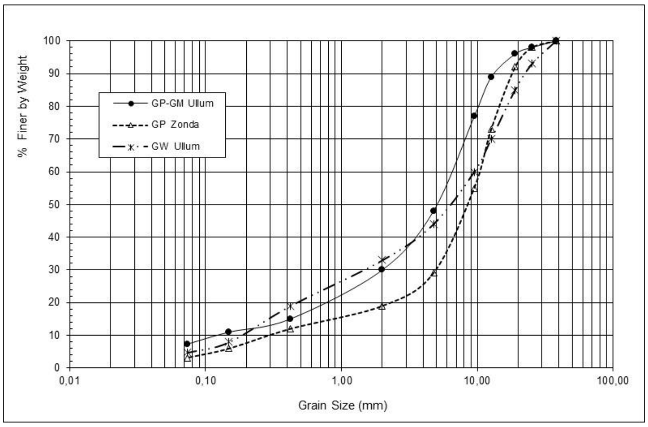

Figure 1. Grain size distribution curve

II. Tests carried out

A. *2) Drained triaxial tests and not drained – Pre-Seismic Static Stability.*

The execution of a program of drained triaxial tests allowed us to determine the effective parameters of shear resistance of the soil: c’ y ϕ’; the hyperbolic parameters: a = 1/Ei and b = 1/$\sigma_{d\ max}$; the relationship between the initial tangent modulus Ei and the confining pressure σ_3, which according to Janbu can be expressed as follows: $E_i/p_a=K (\sigma_3 / p_a)^n$ and the volumetric deformation modulus of the soil, according to Janbu, can be expressed as: $B/p_a=K_b (\sigma_3/p_a)^m$, where K, n, Kb and m are experimental parameters to determine with the program of triaxial tests (Duncan et al 1980, Bolognesi 1987, 1988, Musante ET al 1987, Siddiqi et al 1987). With these data it is posible to model and obtain the pre-seismic stress state and strains in the dam, and verify a static failure of the same, in both conditions, drained as not drained.

On a characteristic gravel (GP-GM, Ullum) of the sediment from the river located in Ullum (Fig. N° 1) were scheduled series of triaxial tests in condition static consolidated drained and not consolidated drained, to a relative density (RD) of 60% and 85 %, corresponding to the compactness of the alluvium of foundation and the granular material for dam shoulders respectively. At the RD of the alluvium of foundation (RD= 60 %) were made static triaxial tests with following effective pressures of cell:1.0 ; 2.5 ; 5.0 and 9.0 kg/cm2 in the case of the drained (Figs. N° 2) and 1.0 ; 2.5 ; 5.0 and 7.0 kg/cm2 for not drained (Figs. No. 3).

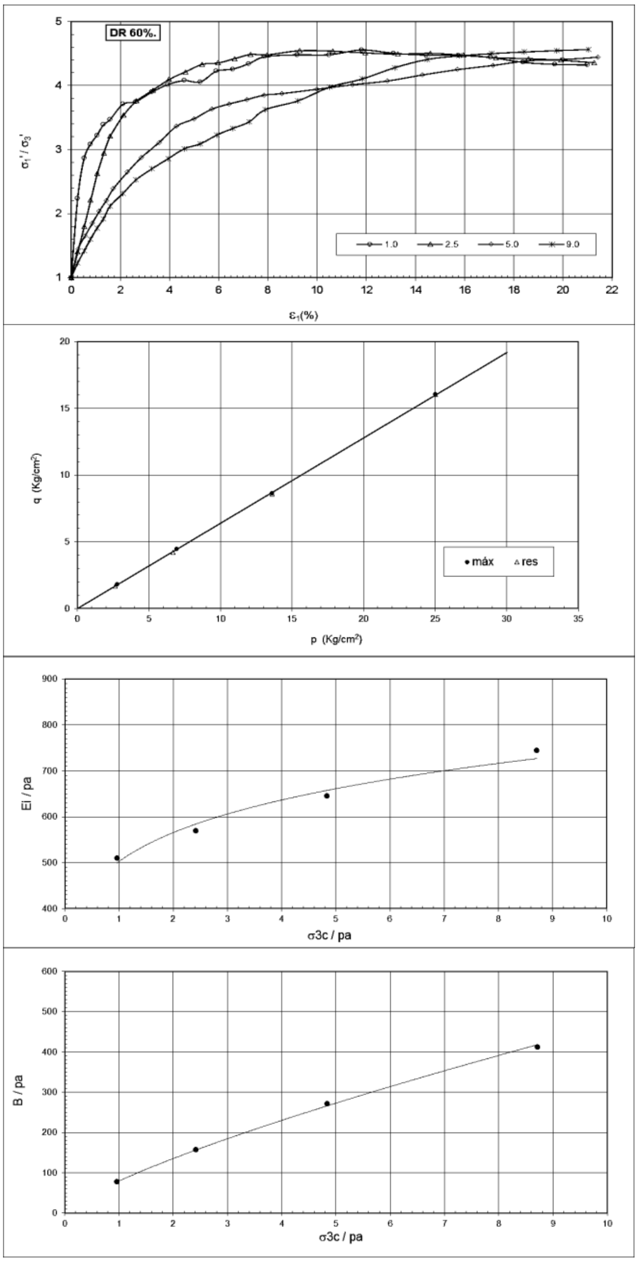

Figure 2. Triaxial drained. Foundation. GP-GM Ullum. DR60 %.

The trials done at the relative density corresponding to the dam shoulders (RD = 85 %) were carried out at pressures of cells of 1.0 ; 2.5 ; 5.0 and 9.0 kg /cm2, for the drained (Fig 4) and the not drained (Fig 5).

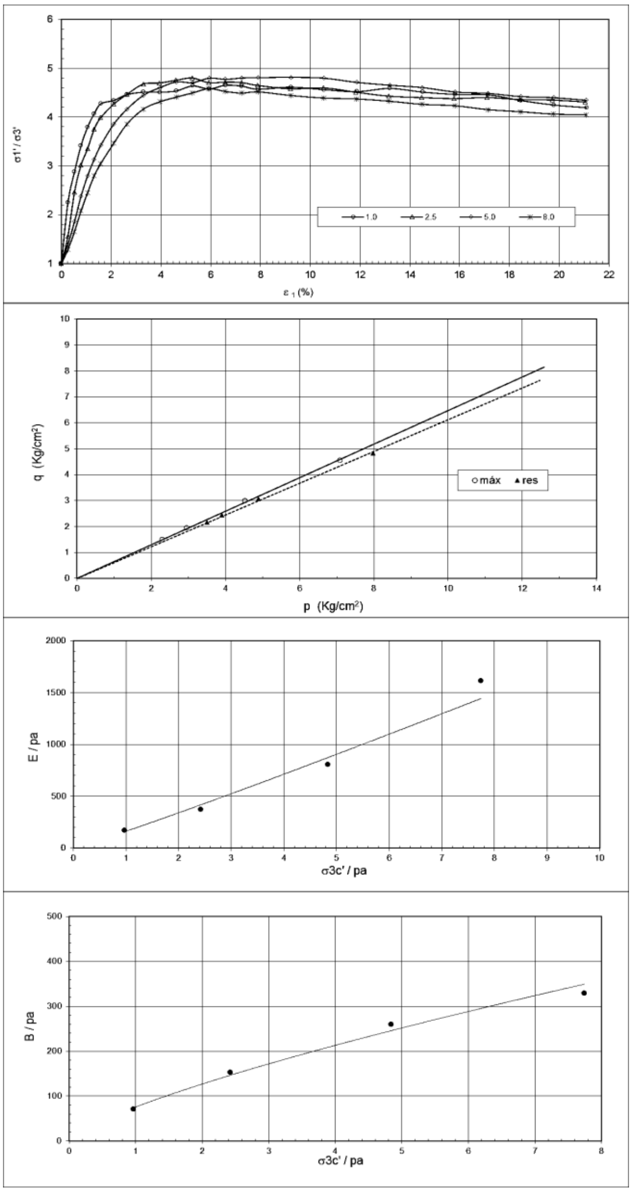

Figure 3. Not drained Triaxial. Foundation. GP-GM Ullum DR 60 %.

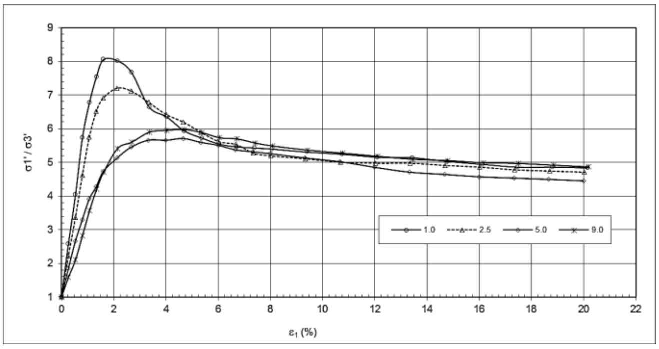

Figure 4. Triaxial drained. Espaldones. GP-GM Ullum DR 85 %.

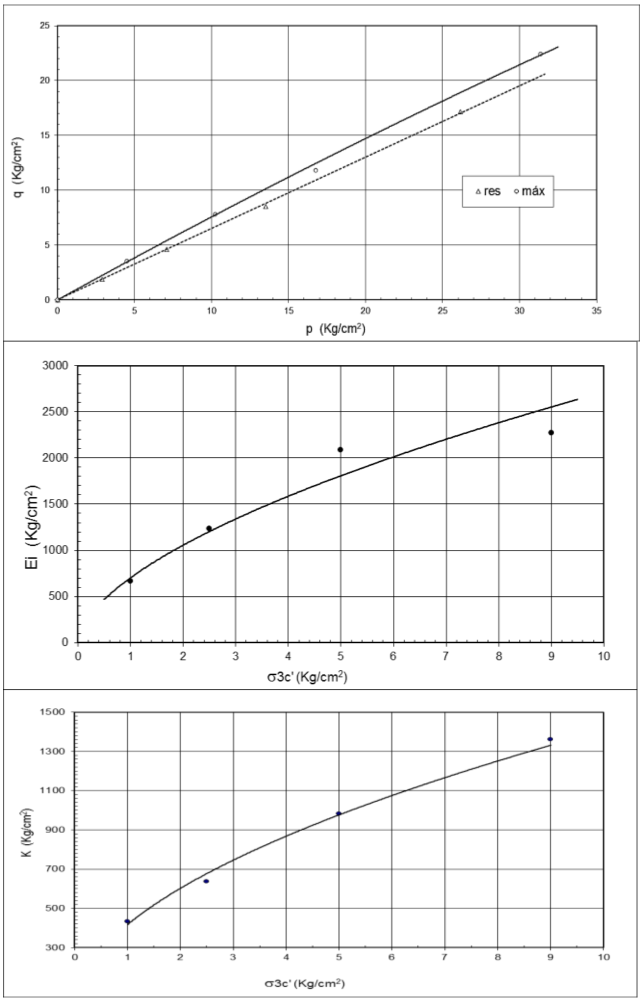

Figure 4. Cont.drained Triaxial. Dam Shoulders. GP-GM Ullum. DR85 %.

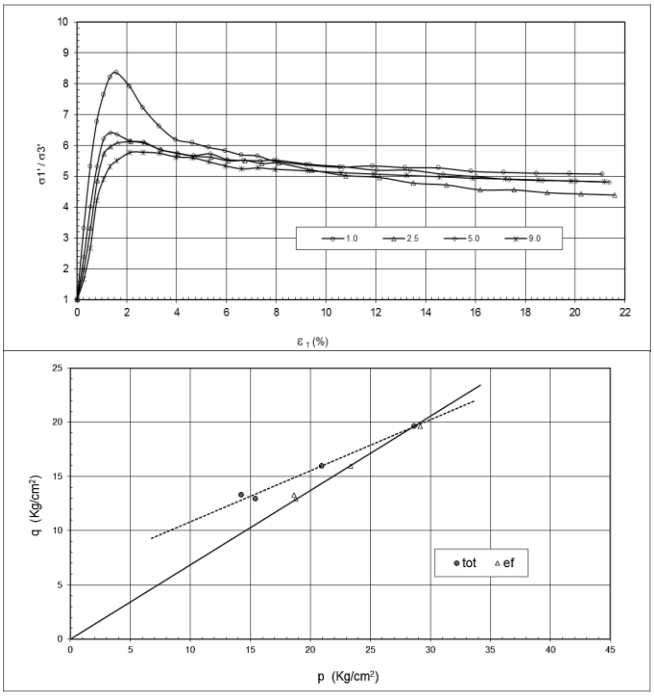

Figure 5. Not drained Triaxial. Dam Shoulders. GP-GM Ullum. DR85 %.

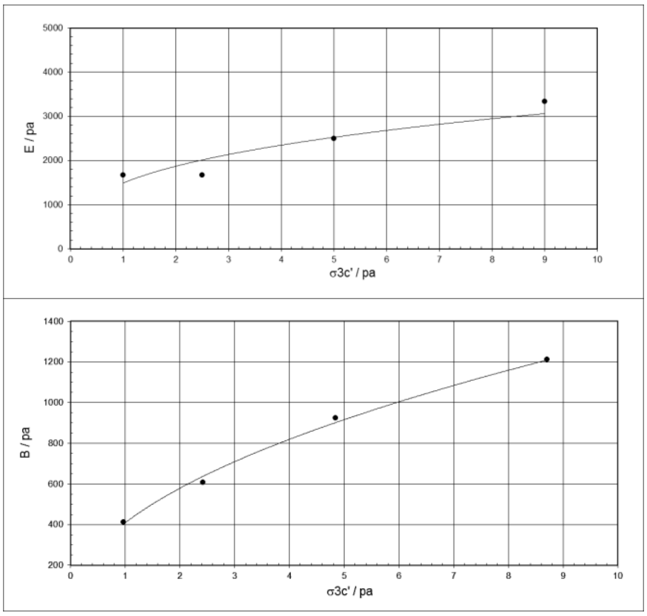

Figure 5. Cont. T. not drained. Dam Shoulders. GP-GM Ullum. DR85 %.

B. *Cyclic Triaxial Tests: Dynamic Stability of dams of loose materials.*

The program of cyclic triaxial tests (isotropically consolidated and not drained) was done with the analytical Method of Seed, Lee and Idriss (Berkeley School) for the verification of the stability of granular materials under the action of seismic loads. Based on these considerations, the testing program has allowed the determination of the dynamic properties of the materials: variation of pore pressure depending on the number of load cycles applied; variation of the axial deformation depending on the number of load cycles applied; determination of the relationships : ru = f(rn); εa = f(rn) y $\sigma_{dc}/2/\sigma_{3c}'$ = f(Nc) (Seed and Peacock 1970, Silver and Seed 1970, Evans and Seed 1987, Banerjee et al 1979). The cyclic triaxial tests were carried out on effective pressures at the cell of 2.5 ; 5.0 and 7.0 kg/cm2 and facing cyclical deviatoric stresses (+ /-$\sigma_{dc)}$ who caused the liquefaction of the samples or an axial deformation ε_{to} total of 10 %, between 5 to 100 load cycles. The sampling studied, a characteristical gravel (GW, Ullum) of the alluvium from the river in Ullum (Fig N° 1), was tested on two different relative densities (RD), 60% and 85 %, corresponding to the grade of compactness of the alluvium of foundation and the granular material for dam shoulders respectively.

The cyclic triaxial equipment of the Laboratory at the IMS Institute operates hydraulically with MTS electronic servocontrols, applies deviatoric efforts in ranges from 2,000 to 30,000 kg and with frequencies up to ½ Hz. Once completed the consolidation of the already saturated samples, the deviatoric stress was applied cyclical ± σ_{dc} at a frequency of 1/4 Hz, registering by means of electronic transducers attached to a system of digital data acquisition, the changes in pore pressures Δu and the axial strain $\varepsilon_{a.}$ The graphics of the digitally obtained records during the development of one of the tests, can be appreciated in the Fig Nº 6.

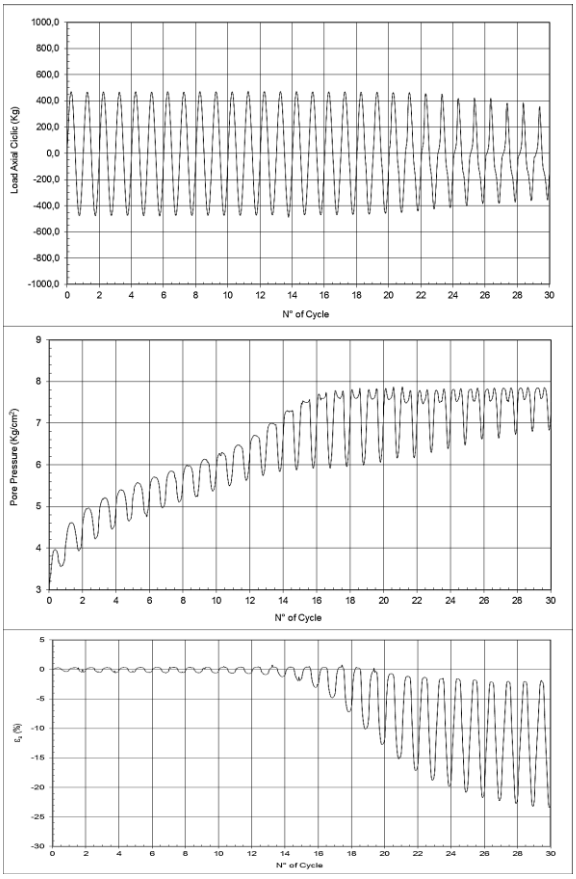

Figure 6. Cyclic triaxial test - gravel GW Ullum

Relationships ru = f(rn); ε_a = f(rn) y (σ_{dc} / 2) / σ_{3c}' = f(Nc) obtained for the relative densities of interest (RD = 60% and 85 %) and for different confining pressures (σ3c') and different cyclical deviatoric stresses (σ_{dc}), (Fig. Nº7), allow by means of an appropiated computer program to find the pore pressure and/or the specific strain at any point of the dam or of its foundation, while the action of an earthquake.

III. 5) Conclusions

The information obtained from both the drained triaxial tests, not drained and the constant strain status, as the cyclic triaxial tests have yielded values of shear resistance; stress-strain relationships, deformation modulus (Ei and (B); residual resistance and lines of constant strain status; consistent with the results from other known alluvial gravels in the technical literature on the subject, for example, the "Oroville Gravel" and the "gravels of the Limay River (Michihuao - Hidronor) ". We believe therefore that the results obtained are broadly satisfactory, not only in the training of human resources, but also in the theoretical-practical work, in techniques of laboratory, in the development and adaptation of the equipment, such as in the specific technical results. Due to reasons of space is not included in this job all the information that would have been desirable, occurs only with a summary of the considered the most significant or exemplary, but the rest of the same can be consulted in the Institute of Materials and Soils, Faculty of Engineering -UNSJ.

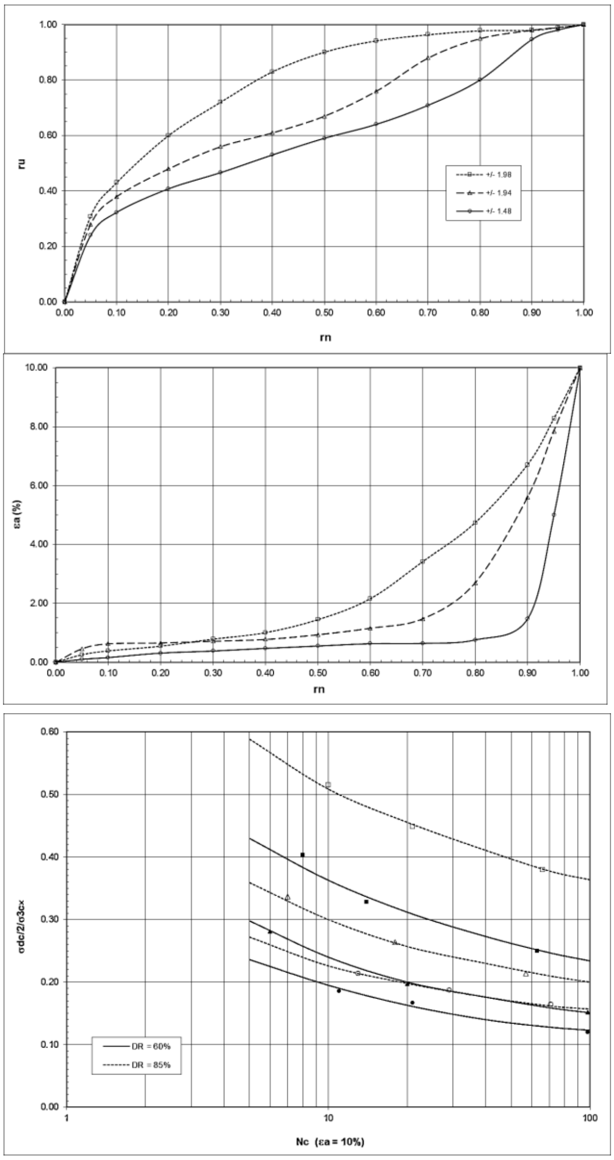

Figure 7. Parameters resistant. Cyclic triaxial test - gravel GW Ullum

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