

Behaviour of a rock mass under action of static and seismic loads.

Direct Foundation Structure in Rock.

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ABSTRACT: The beginning of a research work that will study the response of the foundation structure of a Radio Telescope (RT) in the town of Barreal, 2500m above sea, in San Juan province, the most dangerous seismic zone of the Argentine Republic, is presented. The RT has a satellite dish of 40m in diameter and 1200 tons of its own weight. It is founded in a Direct Superficial way by means of a Square Base of Reinforced Concrete of 27m on each side. All previous studies on the rock mass and their geomechanical properties have been carried out.

An auscultation system has been installed in the Rock mass that will measure accelerations, pressures and deformations. A triaxial accelerometer has been installed, pressure sensors at three points uniformly distributed on the support surface, with their corresponding extensometers that measure displacements at depths equal to B , $0.5B$ and $0.25B$. One of the pressure cells includes an inclinometer. The installation of the RT is expected to take place during the year 2025.

This paper presents the assembly of the measurement system, the geomechanical properties of the foundation rock and the first measurements made. The measurements will continue for several years, so that in the future it is expected to present the study enriched by more measurements and comparative analysis with different theories and constitutive models.

Keywords: Foundations, Rock, Geotechnics.

I. Introduction

The work is related to the study of the variables associated with the behaviour or response of a rock mass, against the action of static and / or dynamic loads caused by an earthquake, measured in situ on a set "Shallow Foundations of concrete-rock mass", of dimensions and weight very important.

The direct measurement of pressures and deformations in a rock mass with known geomechanical properties, caused by the action of a Square Base of Reinforced Concrete of 27m side, which will support a Radio Telescope (RT) with an Antenna of 40m in diameter and 1200 tons of own weight, will allow to evaluate the parameters of theories that allow calculating pressures and deformations.

The study on a real scale 1:1, of the behavior of the known rock mass, will allow to contrast the measurements to be

made in situ with those estimated by various theories or constitutive models and adjust the control parameters of

these theories for a better approximation of the theory to the real behavior of that rock mass.

The study under Seismic Loads of important magnitude is a relevant point of the project, since the system will allow to measure the response of the rock mass directly and simultaneously under the action of a destructive earthquake. What will undoubtedly be a contribution of great scientific value.

The work will be integrated into several presentations as the measurements will continue for many years, so that in



the future the continuation of the work enriched by the measurements that have been made at the moment will be presented

The project is linked to the assembly of the CART40 Radio Telescope in the height station of the CESCO Observatory of the UNSJ in El Leoncito National Park in the province of San Juan. The site corresponds to the area of greatest seismic danger in the Argentine Republic.

At the time of the elaboration of this work, the construction of the square base of reinforced concrete of 27m of side founded at 4m depth, from it a cylindrical reinforced concrete tube of 26m in diameter to the surface of the

ground, has been completed. in Figure 1, an illustration, photomontage, of the work is presented.

Figura 1. Photomontage of the installed Radio Telescope.

In the rocky and base mass, an auscultation system is installed. The system is programmed for simultaneous recording of acceleration, pressure, strain and tilt with differentiated read frequencies under service conditions and during the occurrence of events greater than 0.05g.

For the project and construction of the base, already completed, geotechnical, geological studies, soundings, RQD and other geomechanical, geophysical, structural parameters, mathematical models of the rock mass in interaction with the structure were executed, with which the foundation was projected, and pressures and deformations were estimated.

The system will serve to monitor the base and verify that the deformations are maintained in the range specified by astronomy.

The work aims to make a good contribution to contribute to better adjusting the real response of this rocky massif with that estimated by different theories.

II. Work Location.

The work is located on the Carlos Ulrrico Cesco Observatory, dependent on the National University of San Juan, in the National Park "El Leoncito", Calingasta Department, west of the Province of San Juan – Argentine



Republic, is located in the western premountain range of the Central Andes of the south, Andean premountain

range, at 2420 meters above sea level, coordinates 31°48'10" S and 69°19'25" W. Figure 2 below shows that location.

Figura 2. Location of the work in the Mountain range. View of the original topography.

III. Foundation Rock Mass

A. Geology

Regional Geology

The Geology within the El Leoncito National Park consists of a set of Paleozoic rocks. The stratigraphy begins with calcareous rocks, belonging to the Los Sombreros Formation, with an estimated thickness of 500m. The antiquity has been established from the Cambrian to the Ordovician, based on trilobites and graptolites, respectively (Bracco and Contreras, 2000). Then there is the Portezuelo del Tontal formation, limited in its base and roof by faults, formed mainly by layers interspersed with rocks of varied granulometry between clayey and sandy, reaching conglomerates, of Middle Ordovician age, determined on the basis of associations of graptolites (Bracco and Contreras 2000).

Regional structure

The structure of the Western Precordillera Geological Province (Baldis et al., 1982), is characterized by the development of a folded and running thin skin belt (Cristalini and Ramos, 2000) with predominantly oriental vergence. However, in certain sectors; for example, in the western slopes of the Sierra del Tontal, among others, inverse fractures of antithetical character to the regional deformation are observed (Baldis et al., 1982). These structures of vergence opposite to the main transport direction, have been interpreted by Cortes et al. (2006) as the result of the andic tectonic inversion, related to the differences of pre-neogenous anisotropies.

These differences are associated to three superimposed tectonic events, two compressive events during the early Paleozoic and late Paleozoic and one extensional that would have developed between the Late Permian and the Middle Triassic.

Local geology

Locally, the unit is observed with a cracking effect in different periods, which shows the different tectonic stages. One of them corresponds to a set of diaclases that are cemented by oxidized fluids. These systems in general have a certain degree of cementation, which works as take-off planes when the rock is subjected to stress.

B. Geotechnics.

The work developed in the field corresponds to the realization of Four test pits and three (3) vertical drilling with core extraction; Subsequently, geotechnical logging, sampling of witnesses, RMR geomechanical classification, Geophysical Test: Seismic, Down Hole, Test samples were developed in laboratories of the National University of San Juan.

Vertical drilling

During the logging of the wells, different geotechnical information was obtained, such as: Recovery, Mass quality

(RQD), Frequency of fractures, Resistance of intact rock, Degree of weathering, Description of joints: alpha, beta orientation, type of structure, type of filler, shape and roughness.

The RMR classification (Bieniawski, 1976) has been carried out for each of the drillings.

For the first 5.0 m depth, the calculated value of RMR is between 30 to 34. The rock mass can be classified as Class IV, Bad Quality, (Rating between 21 to 40).



Figura 3. Wall detail of pits CA01.



Figura 4. Wall detail of pits CA_02.

Geophysical Test: Seismic and Down Hole

Geophysical studies were carried out with the seismic refraction tomography method and the Down-Hole method. The Down Hole and Cross Hole measurements were carried out in the boreholes described above. Figure 5 presents some results obtained.

The values of V_s vary from 160 to 924m/sec from the surface to a depth of 24m. Furthermore, Poisson's ratio values range from 0.363, for very fractured rock, to 0.251 for good quality rock.

According to the analysis of the dispersion curves of the Surface Waves (Rayleigh), a value of V_{s30} (value of the average Shear Wave up to 30m depth) is obtained: $V_{s30} = 935.4$ m/sec.

It should be noted that the value of $V_s = 935.4$ m/sec is representative of the type and condition of geological formation studied.

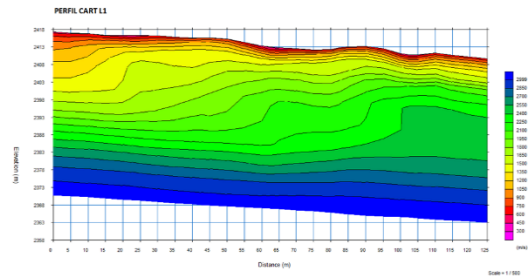


Figura 5. Geophysical Perfil. V_p (m/seg)

Laboratory Tests

A program of simple compression resistance tests (UCS) was carried out on selected samples of the drillings. Table 1 shows the resistance values obtained in simple compression tests. Table 2 shows the values of resistance to simple compression vs depth.

According to the classification of ISRM (1981), soft rock (R2) can be classified.

TABLE I. TYPICAL RESISTANCE VALUES OBTAINED IN SIMPLE COMPRESSION TESTS (UCS)

Hole	Litology	From [m]	To [m]	σ_{rot} [MPa]	ISRM Clasif. (1981)
C_01	sandstone	5,5	5,8	13,20	R2
C_02	sandstone	7	7,22	13,70	R2
C_03	sandstone	7,25	7,55	35,83	R3
C_04	sandstone	12,00	12,40	10,38	R2

Triaxial Compression Tests

Triaxial compression resistance tests were performed on the samples selected and sent to the laboratory. Table III shows the resistant parameters of the Mohr Coulomb rupture envelopes (c and σ) and Hoek & Brown (1980) c and ϕ of the intact rock samples.

TABLE II. TYPICAL TRIAXIAL COMPRESSION RESISTANCE TESTS

Hole Sample	C Mpa	ϕ
C_03 M8	3,4	58°
C_02 M5	1,5	51°
C_04 M10	11	34°

IV. Reinforced Concrete Base.

The foundation structure of the Radio Telescope is a square reinforced concrete slab 1.00m thick and 27m side. The foundation level is -4.00m. From the bottom slab emerges a hollow cylinder that culminates in a slab at surface level.

The cylinder is rigidized by reinforced concrete interior walls.



Figura 6. View of the work, the reinforcement of the foundation slab and the emerging cylinder can be seen.



Figura 7. Finished Base Overview.

v. Monitoring System

The Auscultation and Monitoring system is conformed according to what is indicated in Figure 8, consisting of: Potentiometric extensometers located in the three sites indicated in Figure 8. At each site the measurement is made at points located at three different depths and equal to 1B; 0.5B and 0.25B below the base support level. Pressure cells placed at the same point of the extensometer.

One of them has an inclinometer. One accelerometer triaxial. External topographic support system.

The Auscultation and Monitoring system automatically and simultaneously records all measurement elements in a Data Logger with an in-service frequency of one reading per day. When an event occurs that causes an acceleration of 0.05g, the system modifies the reading frequency to 400 points per second, simultaneously registering acceleration (3 axes), pressure, deformation and inclination. The recording frequency is maintained for one hour after the acceleration is less than 0.05g and is reactivated at each replica.

Additionally, it can be configured for particular registers such as the time of assembly of the 1200 ton antenna.

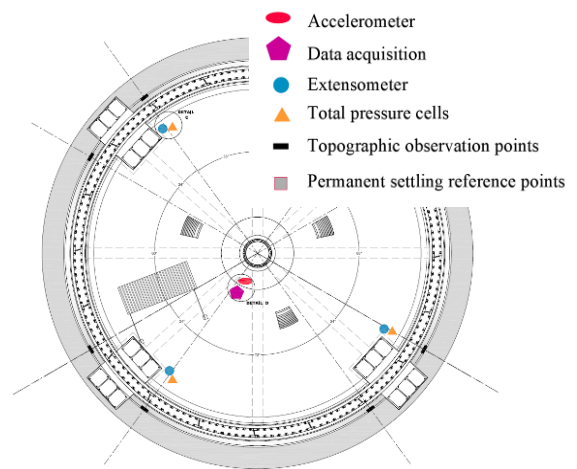


Figura 8. Auscultation and Monitoring System

VI. RECORDS

So far, the antenna of 40m in diameter and 1200 tons of weight has not been mounted. There have also been no significant seismic events, with accelerations greater than 0.05g, so there are still no measurements to evaluate the behavior of the rock massif.

Figure 9 shows a typical graphical report that yields the accelerometer and a measurement point of an extensometer.

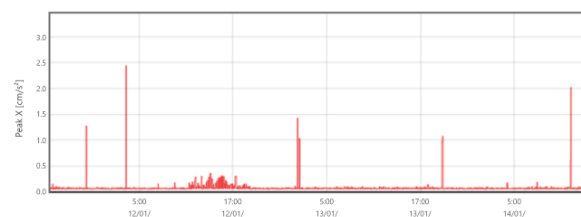


Figura 9. Typical graphic record of the accelerometer report, can see the daily occurrence of movements of very small magnitude.

VII. Conclusions

In this work, the project and the relevant information regarding the rock mass and auscultation system were presented.

It is expected that during the year 2025 the assembly of the antenna and the first strain load record will be carried out. With this the first attempts of approximation will be made with the theories of load capacity, deformation and constitutive models available from different authors.

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