TRACK SOIL INVESTIGATION

Proyect: **RAILROAD Montevideo - Paso de losToros**

Block 4

MINISTERIO
DE TRANSPORTE
Y OBRAS PÚBLICAS

TRACK SOIL INVESTIGATION

Purchaser: M.T.O.P.

Project: Railroad Montevideo - Paso de los Toros

Location: Block 4 - Durazno Department

Report Nº: 907-16

1. INTRODUCTION

The present report describes the work carried out for the geotechnical characterization of the subsoil stratigraphy of the area located in Block 4 of the railroad Montevideo - Paso de los Toros.

The work includes geological characterization of the area of the track, the study of 107 drilling points, performing SPT tests and collection of altered samples for laboratory tests, and laboratory analysis of a total of 28 soil samples.

2. OBJECTIVES AND SCOPES

In response of the submitted request the objectives of the survey were:

- general geological-geotechnical characterization of the project area;
- recognition of the subsoil stratigraphy, up to a maximum depth of 5m, in selected points of the railroad´s track (total 107 points);
- direct verification of the existence of groundwater level and bedrock, and localization in depth from the ground level;
- soil laboratory test performed on selected samples along the track (total 7 points, 28 samples)

The scope of this report includes the results of soil investigation in terms field test, descriptions of stratigraphy and soil laboratory tests. It is beyond the scope, recommendations on carrying capacity of the soils, and other geotechnical aspects of the project such as slope stability and foundation design of bridges and buildings related to the project.

3. GEOLOGY

In Block 4, railroad track between the Durazno and Paso de los Toros runs above the following geological units:

- Granito de Santa Bernardina (Granito de Feliciano).
- Formación Cerrezuelo.
- Formación Arapey
- Formación Mercedes
- Reciente y Actual

Some of these geological formations develop a series of geotechnical units on which railroad track is developed. This chapter briefly describes each of the mentioned units, which are mapped on the geological maps in Annex.

The geological maps included in Annex represents the geotechnical units surveyed in the field and described in this chapter. Figure 1 shows the references used in the description of the lithologies identified in field in the area corresponding to Block 4.

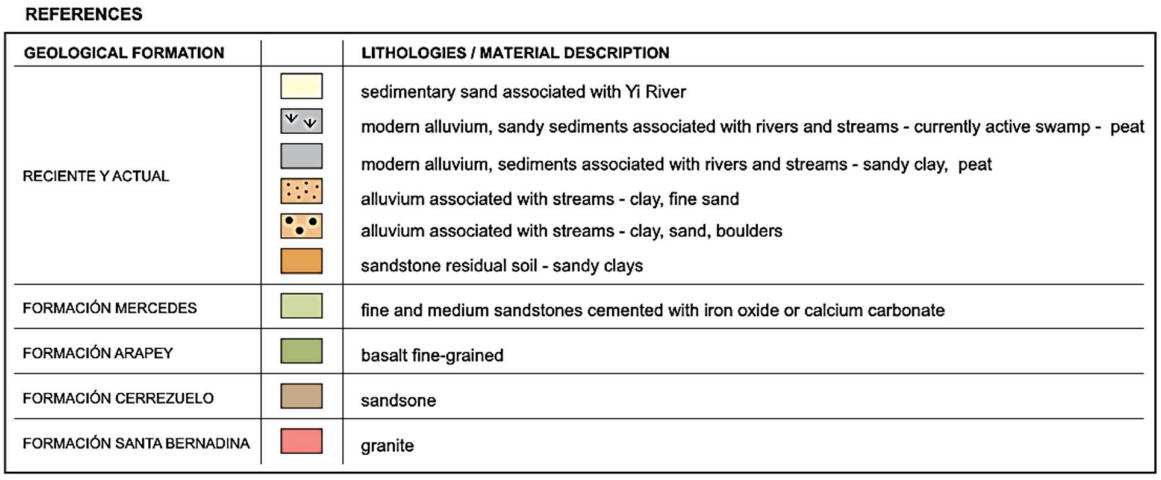

Figure 1. References corresponding to the geological maps

As a result of the hypergenic processes and different transportation processes acting on pre-existing geological units, were generated in the work area, a diferent kind of soils, both Sedimentary as Residuals. The various units associated with geotechnical soil found in the geological analysis described below. Later geological units present are described.

SEDIMENTARY SAND SOILS

Found on sandbars, associated with deposits bars and floodplain of the Yí River and Negro River. Granular soils with variable grain size, deposited in alluvial and fluvial deposits.

Figura 2. Current sandbars associated with Yí River, at Durazno

Figura 3. Current sandbars associated with Negro River, at Paso de los Toros.

MODERN ALLUVIUM SOILS IN CURRENTLY ACTIVE SWAMPS

Sandy clays black sediments, with organic matter and vegetable scraps; associated with little bodies of water, generating swamps and peat deposits. Figure 4 shows a sample of black clay soil, and a view of its present depositional environment.

Figure 4. Sample of black clay soil, and a view of its present depositional environment

MODERN ALLUVIUM SOILS

Sandy clay sediments, from black to dark brown, with traces of organic matter; associated with inactive plains marshes and modern alluvium. The difference with previous soils is that they are in inactive marshes, are more developed soils that do not contain plant remains preserved in the soil mass.

ALLUVIUM SOILS ASSOCIATED WITH STREAMS

They are sandy clays, with very fine sand, black and gray, evolving in depth to more clayey soils, light brown, which ends towards 4m to a coarse sand with pebbles. They are deposits associated with the plains of inland waterways, as small streams; an example is the plain that develops the Villasboas Stream. Figure 5 illustrates the stratigraphic sequence described.

Figure 5. Example of soil samples collected from a alluvium associated with a stream

ALLUVIUM SOILS WITH BOULDERS ASSOCIATED WITH STREAMS

They are clayey sands, with predominant medium grain size, gray to light brown, presenting content of coarse sand and boulders. Deposits are associated with the headwaters and high plains of inland streams and rivers. Figure 6 shows a sample of coarse sand with boulders, recovered in the test SPT sampler.

Figure 6. Sample of coarse sand thick with boulders, recovered in the test SPT sampler

SANDSTONE RESIDUAL SOILS

They are sandy loams, deposited above the reddish brown sandstone. In depth increases the content of sand and rock clasts occur in contact with the underlying sandstone. They may appear cemented calcium carbonate and iron oxide. Figure 7 shows residual soil profile developed from Formation Mercedes sandstones.

Figure 7. Residual soil profile developed from Formation Mercedes sandstones

MERCEDES FORMATION - Sandstone

Very heterogeneous sequence consisting of sandstones of various sizes, white and pink particles with interbedded conglomeratic, and levels cemented with iron oxide

In the work area are fine, well-selected sandstones; rounded; composed of quartz and feldspar; massive parallel stratification or weak; white, yellow and pink colors. Figure 8 shows details of outcrops and related materials to the Mercedes Formation sandstones, registered in the area of the railroad.

Figure 8. Details of outcrops and related materials to the Mercedes Formation sandstones, registered in the area of Block 4

ARAPEY FORMATION – Basalt

It is composed of basic lavas of tholeiitic Basalt, with spilled structure, eventually intercalated by wind sandstones.

The Arapey Formation is related to the "eruptive rocks of Serra Geral" (Walther 1911) associated with the geology of Brazil, hierarchical as Formation Arapey by Bossi 1966. In the work area, outcropping basalts of the First Zone (Bossi 1966), which are treated olivine basalts, medium to coarse-grained to porphyritic texture, arranged in little thick spills.

In the work area of this report, outcropping Basalts of the First Zone (Bossi 1966), which are olivine basalts, medium to coarse-grained, with porphyritic texture, arranged in little thick spills.

Figure 9. Fine to medium grained Basalts, in front of quarry next to the railroad

CERREZUELO FORMATION - Sandstone

It consists of sandstones, in an essentially detrital sequence cross-stratification, with lenses and levels of kaolinitic clays.

It has been separated into two parts by the various authors who have worked on it:

a) lower part: composed of coarse to medium conglomeratic sandstones, with levels and lenses of fine to medium sandstone;

b) upper part: composed of fine to medium sandstones, siltstones, shales and levels of coarse to medium conglomeratic sandstones.

The sandstones comprising this formation present fair to good selection, are subrounded, arkosic and muscovítics. They can be massive or with intersecting and parallel stratification planes, with frequent rib structures. Their colors are varied; white, red and light brown. Figure 10 shows an example of coarse to medium sandstones, from the lower part of the Cerrezuelo Formation.

Figure 10. Example of coarse to medium sandstones, from the lower part of the Cerrezuelo Formation

GRANITO DE SANTA BERNARDINA – Granite

This unit crops out around the city of Durazno, and in the railroad track, in the north of Rio Yí. Figure 11 illustrates the typical Granite Santa Bernardina´s texture.

Overall this Granite rocks develop certain foliation which gives them a fairly definite gneissic character. This unit can eventually appear cut by veins of quartz, aplite and pegmatite, with variable thickness from 10 to 50 cm.

Figure 11. Typical texture of Granite Santa Bernardina

The most frequent textures of these rocks are: quartz-feldspar walls or networks, with changes to cataclastic mesh textures of quartz, and muscovite or quartz networks.

Mineralogical consists of plagioclase, microcline and quartz with some muscovite and biotite.

In Annex geological maps for the area of block 4 are presented.

4. FIELD WORKS

The fieldwork corresponding to this report were carried out by two teams, working simultaneously, during the period from October 6 to October 24, 2016.

During the fieldwork, perforations are made using hand tools, with SPT test and collection of disturbed samples for laboratory tests. Additionally, various general inspection tours were done in the study area for the purpose of surveying the geological conditions.

All works were done at positions located in the field using handheld GPS unit, according to the coordinates UTM - WGS84 - 21S provided by the purchaser, which are presented in Table 1. In the field the sounding points were marked by a red wooden stake with the corresponding number, as seen in Figure 12.

Figure 12. Red wooden stake marking a sounding point

During manual drilling applied to every sounding point, the following tasks were performed:

- soil characterization by tactile-visual description of the materials resulting from the drilling process,
- direct determination of the groundwater level and bedrock, depth measurement from the top of the borehole,
- at selected points, collecting disturbed soil samples for laboratory tests,
- determination of N(SPT) at every meter depth,
- determining N(SPT) at each meter drilling progress, starting at 0.50m depth.

The drilling process was performed by rotating hand tools, as shown in Figure 13.

Figure 13. Rotating manual drilling tool used in soundings points

SPT tests were performed using manual hoist of the weight using a tripode and pulley, as shown in Figure 14.

Tripode

Terzaghi sampler

Figure 14. Equipment used for performing the SPT tests

In order to provide additional information on the location of the sounding points, a photographic record was made in each location, including a location overview, a detailed view of the stake and a view of the soil samples collected. Figure 15 shows an example of a sheet corresponding to the photographic record, which is presented in electronic file format.

UPM	Track Soil Investigation	INSUELOS
	Job number: 1_4	
	Trackline: Durazno - Paso de los Toros	
	Borehole number: 401	

PHOTOGRAPHIC RECORD

Location overview

Detailed view of the stake

view of the soil samples (schematic stratigraphy)

www.insuelos.com

Figure 15. Example of a sheet corresponding to the photographic record

Table 1. Relevant data of the Sounding Points

Borehole number	Track km	COORDINATES X	Y	Z	Date of investigation	Water table	Máx. depth	Observ.
401	206+000	21543681	6306171	85	6102016	-	5,0	Durazno St.
402	206+820	21543567	6306969	80	6102016	3,2	5,0	
403	207+400	21543539	6307556	79	6102016	1,5	2,5	
404	208+164	21544005	6308279	73	6102016	1,2	5,0	bridge
405	208+820	21544305	6308872	75	6102016	2,3	3,8	bridge
406	209+600	21545075	6309002	80	7102016	2,5	5,0	culvert
407	210+400	21545649	6309505	75	8102016	1,7	4,0	
408	211+178	21545918	6310228	82	8102016	2,2	5,0	bridge
409	212+000	21546033	6311025	92	8102016	4,0	5,0	
410	212+800	21545929	6311812	96	9102016	-	5,0	
411	213+600	21546100	6312572	90	16102016	-	0,1	
412	214+400	21546435	6313300	99	16102016	-	0,2	
413	215+185	21546768	6314025	94	9102016	-	0,5	
414	216+000	21547103	6314755	98	9102016	-	3,0	
415	216+757	21547353	6315513	98	10102016	-	3,0	
416	217+617	21547550	6316293	98	10102016	0,4	2,0	
417	218+100	21547672	6316776	103	10102016	1,4	4,0	
418	219+200	21547934	6317839	114	10102016	-	4,0	
419	220+200	21547697	6318794	115	11102016	-	2,0	
420	221+000	21547848	6319578	124	11102016	-	4,0	
421	221+800	21548089	6320336	121	11102016	-	3,0	
422	222+800	21548586	6321205	117	11102016	-	2,0	
423	223+300	21548838	6321639	117	12102016	-	1,0	
424	224+200	21549277	6322423	120	12102016	-	2,0	
425	225+000	21549389	6323205	119	12102016	-	2,0	
426	225+519	21549387	6323699	113	12102016	1,0	2,0	culvert
427	226+400	21549330	6324595	111	13102016	-	4,0	
428	227+200	21549231	6325381	95	13102016	-	2,0	
429	228+000	21549114	6326186	92	13102016	0,9	4,0	bridge
430	228+893	21549068	6326563	90	13102016	1,1	4,0	bridge
431	228+900	21549002	6327162	100	14102016	-	2,0	Villasboas St.
432	229+600	21548927	6327761	99	14102016	0,4	5,0	culvert / swamp
433	230+165	21549098	6328295	99	18102016	0,5	0,5	
434	230+781	21549355	6328850	104	18102016	-	0,2	
435	231+500	21549660	6329496	102	18102016	0,5	2,0	
436	232+325	21549993	6330249	106	18102016	-	2,0	

Table 1 (cont.). Relevant data of the Sounding Points

Borehole number	Track km	COORDINATES X	Y	Z	Date of investigation	Water level	Máx. depth	Observ.
437	232+600	21549995	6330554	103	18102016	0,8	2,7	
438	233+160	21549870	6330981	105	18102016	0,5	2,0	bridge
439	233+500	21549743	6330983	99	22102016	-	2,0	bridge
440	234+000	21549595	6331872	110	22102016	1,2	3,0	
441	234+167	21549564	6332018	109	22102016	0,5	2,0	
442	234+500	21549593	6332311	116	22102016	-	0,2	
443	235+500	21549781	6333317	131	23102016	-	3,0	
444	236+400	21549816	6334209	123	23102016	3,5	4,0	
445	236+785	21549707	6334574	126	23102016	-	3,0	
446	237+400	21549680	6335179	138	23102016	-	0,3	
447	237+800	21549720	6335587	134	24102016	-	3,0	
448	238+300	21549789	6336072	138	24102016	-	3,0	
449	238+800	21549883	6336565	135	24102016	-	2,0	
450	239+386	21550074	6337117	143	17102016	-	3,0	
451	240+095	21550341	6337777	133	14102016	1,2	4,0	
452	240+500	21550317	6338176	139	17102016	-	3,0	
453	241+100	21550144	6338751	135	17102016	-	3,0	
454	241+700	21549969	6339326	133	17102016	-	2,0	
455	242+300	21549784	6339894	136	24102016	-	1,0	
456	242+700	21549690	6340262	137	24102016	-	1,2	
457	243+200	21549529	6340738	133	24102016	-	0,1	
458	243+500	21549455	6341022	138	20102016	-	1,5	
459	244+300	21549088	6341735	132	20102016	-	1,0	
460	245+300	21548336	6342393	137	20102016	-	3,0	
461	246+000	21547812	6342857	132	21102016	-	1,8	
462	246+400	21547538	6343144	128	21102016	-	2,0	
463	247+000	21547308	6343696	131	17102016	-	0,5	
464	247+700	21547068	6344360	129	16102016	-	2,0	
465	248+400	21546894	6345035	129	13102016	-	4,0	
466	249+200	21547033	6345818	124	13102016	-	3,0	
467	250+100	21547312	6346769	109	13102016	0,8	1,0	bridge
468	250+900	21547508	6347441	123	17102016	-	1,2	
469	251+200	21547586	6347725	127	17102016	-	4,0	
470	252+200	21547433	6348495	128	18102016	-	1,0	
471	252+700	21547164	6349140	127	18102016	-	1,5	
472	253+700	21546781	6350059	114	22102016	-	2,0	

Table 1 (cont.). Relevant data of the Sounding Points

Borehole number	Track km	COORDINATES X	Y	Z	Date of investigation	Water table	Máx. depth	Observ.
473	254+100	21546646	6350437	125	22102016	-	5,0	
474	254+800	21546514	6351122	119	21102016	-	1,5	
475	255+600	21546385	6351910	126	12102016	-	2,0	
476	256+400	21546256	6352698	124	12102016	-	1,6	
477	257+000	21546159	6353289	115	12102016	-	2,0	
478	257+600	21546062	6353880	116	11102016	-	1,7	
479	258+100	21545966	6354473	122	11102016	-	1,2	Parish Station
480	258+700	21545879	6355064	111	11102016	0,8	2,0	
481	259+500	21546137	6355854	105	22102016	-	1,3	bridge
482	260+200	21546450	6356474	100	23102016	-	1,5	
483	260+950	21546608	6357212	90	23102016	-	2,5	bridge
484	261+200	21546658	6357457	94	23102016	2,3	3,0	
485	261+900	21546943	6358096	88	23102016	-	3,0	
486	262+300	21547024	6358962	85	14102016	0,8	5,0	
487	262+800	21546950	6358961	89	10102016	0,5	3,0	
488	263+000	21546906	6359007	85	10102016	-	0,1	bridge
489	263+300	21546888	6359361	87	10102016	1,1	1,4	bridge
490	264+100	21546770	6360152	87	10102016	-	1,8	
491	264+900	21546646	6360937	84	10102016	-	1,5	
492	265+300	21546566	6361389	77	9102016	0,4	3,7	bridge
493	265+800	21546504	6361864	83	9102016	-	1,0	
494	266+052	21546464	6362168	70	8102016	-	0,1	bridge
495	266+700	21546358	6362793	76	8102016	-	0,3	
496	267+100	21546350	6363192	77	8102016	-	0,1	
497	267+840	21546351	6363942	72	8102016	0,5	1,8	bridge
498	268+300	21546340	6364361	76	8102016	-	0,1	
499	268+900	21546133	6364950	70	8102016	-	0,5	
500	269+400	21545953	6365410	63	9102016	1,8	2,0	
501	269+700	21545841	6365690	73	7102016	-	0,1	
502	270+100	21545698	6366061	67	7102016	-	0,1	
503	270+600	21545509	6366533	73	7102016	-	0,5	
504	271+100	21545327	6366996	67	7102016	-	0,1	
505	271+440	21545300	6367325	74	7102016	-	0,1	
506	271+900	21545407	6367760	76	7102016	-	0,1	
507	272+160	21545450	6368015	62	12102016	-	0,1	

5. LABORATORY WORKS

During drilling, at selected points, disturbed soil samples were collected for laboratory tests. The processed samples were selected to characterize the different lithologies identified in the geological analysis.

On each of the selected samples they were conducted the following laboratory tests: sieve analysis (ASTM D6913 - ASTM D1140); Atterberg Limits (ASTM D4318) and natural moisture (ASTM D2216). After completing the tests referred, from the information obtained, soil classification of the processed samples was performed using the Unified Soil Classification System USCS (ASTM D2487).

Table 2 summarizes the analyzed samples, indicating the points that were collected, the number of samples analized and lithology to which they correspond. Lithologies referred correspond to those described in the geological analysis, referenced in Figure 1.

Table 2. Analyzed samples in soil laboratory tests

Borehole number	Lithology	number of samples
404	alluvium associated with streams - clay, fine sand	5
410	residual soil on Granite rock	5
430	alluvium associated with streams - clay, fine sand	4
469	sandstone residual soil - sandy clays	4
471	sandstone residual soil - sandy clays	2
473	sandstone residual soil - sandy clays	5
485	residual soil on Basalt rock	3

The delivery of the report includes a main report of 21 pages, 107 Sounding Prints Excel files, 107 Designing System text files, 7 Excel files of Laboratory Results of a sieve analysis including a total of 28 samples analyzed, and photographic record files corresponding to points of study.

1° November, 2016

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