INTERNATIONAL SEVEN JOURNAL OF MULTIDISCIPLINARY
ISSN: 2764-9547

Characterization, compaction and CBR (ISC), by the DIRENG-ME-01/87 Method, carried out on typical Latosol from the Brazilian Midwest for an area at the Presidente Juscelino Kubitschek International Airport, Brasília / Distrito Federal

Caracterização, compactação e CBR (ISC), pelo Método DIRENG-ME-01/87, realizado em Latossolo típico do Centro-Oeste Brasileiro para uma área no Aeroporto Internacional Presidente Juscelino Kubitschek, Brasília / Distrito Federal

DOI: 10.56238/isevmjv3n2-020
Receipt of originals: 02/22/2024
Acceptance for publication: 03/12/2024

Rideci Farias[1], Haroldo Paranhos[2], Denilson João da Costa[3].

ABSTRACT
This work presents geotechnical field and laboratory studies, with emphasis on compaction tests according to recommendations of the Test Method for Airport Infrastructure Works (AASHTO Method) and California Support Index tests (ISC or CBR), aiming to determine the CBR by the DIRENG-ME-01/87 method for the subgrade material that considers in the pavement sizing the CBR corresponding to 95% of the dry specific mass compacted in the Modified Proctor energy, resulting from the composition in the graph of the three compaction energies (normal, intermediate and modified). The study involved an extensive bibliographic survey, field and laboratory work with the execution of geotechnical tests, but also the appropriate treatment of the results obtained. Studies have shown that the soils have visual tactile characteristics with a predominance of sandy-silty clay latosol to red silty-sandy clay. Furthermore, the classification by the Unified Soil Classification System (SUCS) showed the predominance of low plasticity silt (ML), but also by the TRB (HRB) a predominance of clayey soils (A-7-5). The CBR values using the DIRENG-ME-01/87 method for the 18 samples studied ranged from 8.1% to 9.0%, with an average value of 8.7%, representing 61% of the average CBR value. of modified energy, which was 14%.

Keywords: Federal District, Juscelino Kubitschek Airport, Tests, Soil, DIRENG Method.

INTRODUCTION

The Federal District, for the most part, has typical geology/geomorphology that is characterized by a layer of oxisols and clayey red lateritic soils, called porous and collapsible

[1] Catholic University of Brasilia (UCB)
UniCEUB, Brasília/DF, Brazil
E-mail: rideci.farias@gmail.com
[2] M.Sc.
UCB / Reforsolo Engenharia, Brasília/DF, Brazil
E-mail: reforsolo@gmail.com
[3] UniCEUB, Brasília/DF, Brazil
E-mail: denilson.costa@sempreceub.com

clay. In this context, the results and analyzes of geotechnical studies carried out in typical oxisol for an area of the Brasília International Airport "Presidente Juscelino Kubitschek", in the Federal District, are presented. The studies consisted of carrying out field and laboratory work. In the field, auger surveys (82 units) were carried out with a view to tactile-visual identification, in addition to 18 inspection wells for soil collection for laboratory tests. In addition to fieldwork, "in situ" densities were carried out.

The inspection wells were carried out with the aid of a backhoe to an approximate depth of 2 (two) meters, while the auger surveys were carried out with a 6 (six) inch auger to a depth of 1.5 meters. In the laboratory part, with the soils collected in the inspection wells, natural moisture content, liquidity limits, plasticity and contraction, granulometry, specific mass of soil grains, compaction tests were carried out according to the recommendations of the Test Method for Works of Airport Infrastructure (AASHTO Method), California Support Index Tests (ISC or CBR), aiming to determine the CBR using the DIRENG-ME-01/87 method for the subgrade material that considers the CBR corresponding to 95 in the pavement sizing % of the dry specific mass compacted in the Modified Proctor energy, resulting from the composition in the graph of the three compaction energies (normal, intermediate and modified).

Among other findings, it was found that the local soils have similar visual tactile characteristics with the predominance of sandy-silty clay/sandy-silt, red latosol type. With the results of the laboratory tests, it was also possible to classify by the Unified Soil Classification System (SUCS), which showed the predominance of low plasticity silt (ML), but also by the TRB (HRB) with a predominance of clayey soils (A- 7-5). The CBR values using the DIRENG-ME-01/87 method for the 18 samples studied ranged from 8.1% to 9.0%, with an average value of 8.7%, representing 61% of the average CBR value. of modified energy, which was 14%.

INITIAL CONSIDERATIONS

For the development of this work, a broad bibliographical survey was sought that could more faithfully represent the knowledge about the region where the project is located. Below, we present, in general, geological-geotechnical issues relating to the region and area studied.

GEOLOGY/GEOTECHNICS OF THE FEDERAL DISTRICT

In the Federal District (DF) the rock sequences are inserted in the Brasília folding belts. From a regional point of view, the DF area is composed of metasedimentary rocks that include the Paranoá, Canastra, Araxá and Bambuí groups and their respective residual or colluvial soil

INTERNATIONAL SEVEN JOURNAL
OF MULTIDISCIPLINARY
ISSN: 2764-9547

covers (FREITAS-SILVA; CAMPOS, 1998). Figures 1 and 2 show, respectively, the general geological and soil maps of the Federal District.

The Paranoá Group occupies the largest area in the Federal District and concentrates the largest number of urban centers (the Plano Piloto and all Satellite Cities, with the exception of São Sebastião and Vale do Amanhecer). It is the most important unit, with approximately 65% of the territory. It is divided into six units, according to the stratigraphic column, correlatable from base to top in clayey metasiltstone, slate, sandy metarhythmite, medium quartzite, clayey metarhythmite and psammo-pelite-carbonate lilotogies.

The Canastra group covers around 15% of the total space of the DF and is subdivided into three formations, which are Paracatu, Serra do Landin and Serra dos Pilões. This group is made up of low-grade metamorphic rocks, chlorite, carbonaceous phyllites, fine marbles and mostly phyllites with quartzite lenses. The Araxá group occupies a small part of the DF's land, around 5%. It is represented by muscovite schists, quartz-muscovite schists and singular lenses of micaceous quartzites. Finally, the Bambuí group covers 15% of the DF's extension, which is made up of metasiltstones, clayey metasiltstones, metaclaystones and rare arkose intercalations (FREITAS-SILVA & DARDENNE, 1994).

Figure 1. General geology of the Federal District (CODEPLAN, 2017).

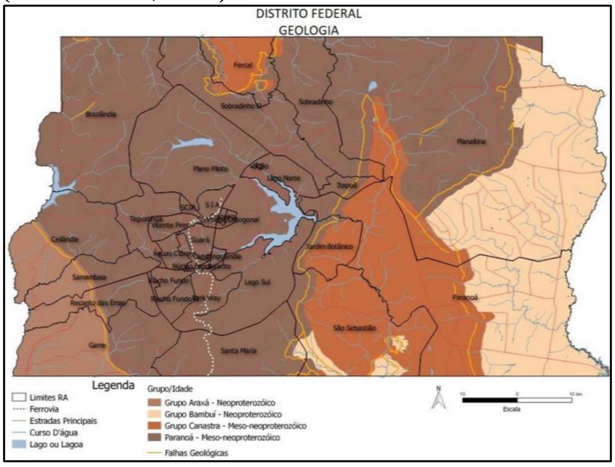
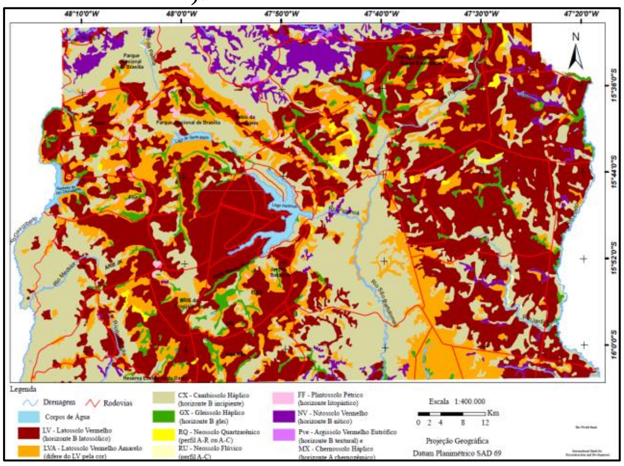


Figure 2. Soil map of the Federal District (ADASA, consulted in 2019).



FEDERAL DISTRICT SOILS

Most of the soils in the Federal District are characterized by porous soils with a thickness of up to 10 meters. Due to the various processes that occurred in its genesis, this coverage presents peculiar characteristics and distinct geotechnical behavior. This soil is very susceptible to erosion, and gullies are common in urban settlements, highways and borrow areas.

Among the soil classes that occur in the DF and in the area under study, the main ones are presented and described in a soil reclassification work by Embrapa (2004) in which there are oxisols and cambisols with an approximate sum of 85.48%.

Oxisols

These are highly weathered soils, popularly called old soils, resulting from the removal of silica and exchangeable bases from the profile. Because of this, secondary minerals from the kaolinite group, oxides, hydroxides and oxyhydroxides of Fe and Al such as hematite, goethite, gibbisite and others agglomerate. Quartz, being quite resistant to weathering, persists as a residual mineral in the alteration profile. They cover around 54.5% of the area of the Federal District and comprise red latosols, with 38.92% of the area, and red-yellow latosols, with 15.58%. They contain a reduced level of silt, ranging between 10% and 20%, and clay, ranging between 15% and 80%. They may be excessively drained, depending on the nature of the texture, structure and topographic situation. Due to its composition, it is a soil that contains high water permeability.

Cambisols

These are soils that point to a subsurface horizon subject to little physical and chemical alteration, considered a new soil, however sufficient for the development of color and structure. In general, they present easily weatherable primary minerals, higher silt contents, indicating a low degree of weathering. They correspond to close to 30.98% of the DF area. Generally, they are associated with busier reliefs (wavy and strongly undulating) that vary from shallow to deep, mostly reaching 0.2 m to 1 meter. These are soils that are bruno-yellowish in color on the surface horizon and red-yellowish on the surface. The structure is quite variable, with subangular blocks predominating. They have a varied texture, from very clayey to sandy loam, with or without gravel.

LOCATION OF THE STUDY EXECUTION AREA

The area for developing the studies is made up of typical latosol from the Central-West region of Brazil and is located on the premises of the Brasília International Airport "Presidente Juscelino Kubitschek", in the Federal District, and is intended for a set of works that are currently underway. Figures 3 to 5 show macro and micro views of the study execution areas.

INTERNATIONAL SEVEN JOURNAL
OF MULTIDISCIPLINARY
ISSN: 2764-9547

Figure 3. Macro view of the study execution area.

Figure 4. Macro view of the study execution area.

Figure 5. Micro view of the study execution area.

WORK METHODOLOGY

The methodology involved an extensive bibliographic survey, field and laboratory work with the execution of geotechnical tests, but also the appropriate treatment of the results obtained. In the field, inspection wells were carried out with the aid of a backhoe to a depth of 2 (two) meters, while auger surveys were carried out with a 15 cm diameter auger to a depth of 1.5 meters. In the laboratory part, with the soil collected in the inspection wells, geotechnical tests were carried out as shown in Table 1 with the respective quantity of each test.

Figures 6 and 7 show the location of the inspection wells and auger surveys carried out. These Figures illustrate a rectangular grid with the location of the studied points. Each located point corresponds to the crossing of a number and a letter, as per example: crossing the vertical line number “8” with the horizontal line “D” gives the studied point “8D”. Where the study was not possible due to various interferences, the closest possible point was sought. The respective soil samples for the laboratory tests were collected at the following points: 2B, 2D, 2F, 3C, 3E, 5B, 5D, 5F, 7B, 7D, 8C, 8E, 9D, 10B, 10G, 10H, 13C and 14E. Figures 8 and 9 present, respectively, views of one of the inspection wells and samples collected for carrying out tests in the laboratory.

Table 1. Summary of studies carried out.

Item	Service/Study	Amount
1	Auger surveys up to 1.5 m	82
two	Inspection pits (trench) for soil collection	18
3	Moisture content at 0.5m; 1.0m and 1.5m at the trench opening locations	18
4	Natural specific mass “in situ” at 0.5m; 1.0m and 1.5m in the trenches	18
5	Liquidity limit	18
6	Plasticity limit	18
7	Contraction limit	18
8	Granulometry (sieving and sedimentation)	18
9	Actual grain density	18
10	Compaction (AASHTO). Set (normal, intermediate and modified)	18
11	CBR (ISC). Trench samples (DIRENG-ME-01/87 method) – Set.	18

Figure 6. Micro view of the study execution area.

Figure 7. Area with approximate location of the studied soils.

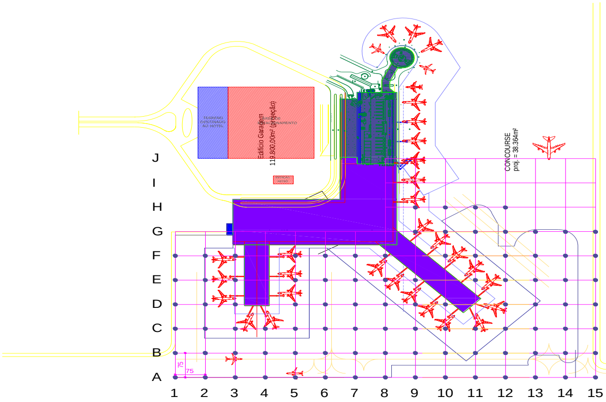


Figure 8. Inspection trench for carrying out “in situ” testing and collecting soil samples.

Figure 9. Soil samples for carrying out laboratory tests.

RESULTS AND ANALYSIS

With the execution of inspection wells and auger surveys, it was found that the soils had similar visual tactile characteristics with a predominance of sandy-silty clay latosol to red silty-sandy clay, with the exception of the vicinity of the point classified as C3 in which a red-yellow oxisol was found. It should be noted that in some places there is a layer of compacted landfill with an approximate thickness of up to 0.50 meters.

Table 1 presents the characterization results for the 18 soil samples collected. In terms of particle size, tests carried out by sieving and sedimentation, there is a certain balance of clayey-silty sand / sandy-silty clay, with average contents of 38.7% sandy, 36.9% clayey and 24.3% silty.

For the Atteberg limits, there are average values with 48.7% liquidity, 36.9% plasticity, and a plasticity index, close to 12%, fitting a material with medium plasticity.

As for the Group Index (GI), the lowest value was found for samples 10B and 14E, corresponding to 3.9. The highest GI value was observed for sample 5B, representing 10.2. The classification by the Unified Soil Classification System (SUCS) showed a predominance of low plasticity silty soils (ML), but also by the TRB (HRB) with a predominance of clayey soils (A-7-5), indicative of weak to poor soil for application in pavement sub-grades.

Figures 10 and 11 present, respectively, the particle size and liquidity limit behavior for the eighteen samples studied, in addition, Table 2 consolidates the characterization and classification results of these samples.

Table 2. Characterization and classification results for the 18 soil samples.

Sample	Granulometry (Sieving and sedimentation)				L.L.	LP	IP	Soil Classification		
	Fine gravel	Sand	Silt	Clay				IG	SUCS	TRB
2B	0.00	37.78	17.47	44.75	49.5	38.5	11.0	7.1	ML	A-7-5
2D	0.00	35.08	26.90	38.02	49.5	38.5	11.0	7.8	ML	A-7-5
2F	0.11	40.87	21.06	37.97	48.8	33.5	15.3	8.0	ML	A-7-5
3C	0.25	33.94	32.93	32.87	47.7	37.6	10.1	7.4	ML	A-7-5
3E	0.10	33.61	28.78	37.51	50.2	35.3	14.9	9.7	MH	A-7-5
5B	0.21	29.22	32.63	37.93	49.7	36.4	13.3	10.2	ML	A-7-5
5D	0.22	41.89	24.61	33.29	49.2	37.2	12.0	6.4	ML	A-7-5
5F	0.00	35.22	27.26	37.52	49.7	36.9	12.8	8.5	ML	A-7-5
7B	0.00	43.02	17.65	39.34	49.1	35.3	13.8	6.9	ML	A-7-5
7D	0.00	38.60	24.40	37.01	50.2	37.1	13.1	7.9	MH	A-7-5
8C	0.00	38.60	24.40	37.01	50.0	36.6	13.4	7.0	ML	A-7-5
8E	0.33	36.10	26.60	36.97	45.2	36.2	9.0	6.5	ML	A-5
9D	0.35	37.77	22.88	39.00	49.0	37.2	11.8	7.3	ML	A-7-5
10B	0.17	49.46	15.69	34.68	48.1	37.6	10.5	3.9	ML	A-7-5
10G	0.19	39.83	29.81	30.17	47.2	37.2	10.0	5.9	ML	A-5
10H	0.32	38.30	24.00	37.38	49.4	39.6	9.8	6.5	ML	A-5

13C	0.32	38.30	24.00	37.38	48.0	36.7	11.3	6.7	ML	A-7-5
14E	0.00	48.75	16.31	34.94	46.9	36.8	10.1	3.9	ML	A-7-5
Average	0.14	38.7	24.3	36.9	48.7	36.9	11.8	7.1		

Taking compaction energy into account, an average value of 30.2% of optimum humidity was found for normal energy, with a variation from 27.55% to 31.91%. Average compacted dry specific mass of 13 kN/m ^{3}, variation from 12.38 kN/m ^{3} to 13.64 kN/m ^{3}, and for the CBR values, there is an average of 7.5%, with a variation of 7.05% to 8.10%.

At intermediate energy, the average values of optimum humidity, compacted dry specific mass and CBR were, respectively, 29.3%; 13.8 kN/m ^{3} and 8.2%. For modified energy, the values of optimal humidity, dry specific mass and CBR were, respectively, 28.7%; 14.9 kN/m ^{3} and 10%.

The CBR values using the DIRENG-ME-01/87 method for the 18 samples studied ranged from 8.1% to 9.0%, with an average value of 8.7%, representing 61% of the average CBR value. of modified energy, which was 14.1%.

Table 3. Results of compressions and CBR DIRENG Method. [Woptimal (%), γ_d (kN/m ^{3}); CBR (%)].

Ground	Normal Energy			Intermediate Energy			Modified Energy				CBR (%) DIRENG
	W_{great}	γ_d	CBR (%)	W_{great}	γ_d	CB R (%)	W_{great}	γ_d	CBR (%)	95% x γ_d Modified	
2B	31.20	13.50	7.35	30.30	14.00	8.00	29.50	14.80	10.15	14.06	8.20
2D	30.65	13.00	7.46	29.50	13.58	8.15	28.00	14.60	10.15	13.87	8.80
2F	31.22	13.08	7.41	30.80	13.82	8.50	30.40	14.70	10.15	13.97	8.80
3C	30.80	12.83	8.10	29.90	13.72	8.65	29.50	14.75	9.58	14.01	8.90
3E	30.73	13.26	7.90	29.15	13.86	8.35	28.40	14.90	9.77	14.16	8.70
5B	31.45	13.13	7.85	30.95	13.57	8.12	30.40	14.75	10.15	14.01	8.80
5D	31.91	12.95	7.22	30.85	13.84	7.80	30.50	14.88	9.96	14.14	8.35
5F	30.54	12.62	7.05	29.90	13.49	7.65	29.50	14.50	9.39	13.78	8.10
7B	30.50	13.17	7.05	29.62	13.62	7.70	29.20	14.80	9.77	14.06	8.45
7D	29.20	12.99	7.53	28.10	13.88	8.59	27.00	14.93	10.15	14.18	9.00
8C	29.30	13.64	7.68	28.15	14.42	8.32	27.50	15.50	10.34	14.73	8.80
8E	29.20	13.05	7.75	28.90	13.95	8.45	28.35	15.00	9.96	14.25	8.80
9D	31.60	12.70	7.95	31.10	13.58	8.75	30.40	14.60	10.15	13.87	9.10
10B	27.55	13.44	7.32	26.60	14.37	8.02	25.50	15.45	9.77	14.68	8.50
10G	30.65	12.38	7.20	29.90	13.25	7.99	29.60	14.40	9.77	13.68	8.60
10H	28.60	12.95	7.30	27.90	13.75	8.10	27.70	14.90	10.34	14.16	8.70
13C	28.60	12.95	7.30	27.90	13.75	8.10	27.70	14.90	10.34	14.16	8.70
14E	29.10	13.05	7.05	27.95	13.80	7.85	27.10	15.00	9.77	14.25	8.60
Average	30.2	13.0	7.5	29.3	13.8	8.2	28.7	14.9	10.0	14.1	8.7

Figure 12 presents, for Sample 2B, the compactions at normal, intermediate and modified energy, with respective results of optimal humidity (31.2%; 30.3% and 29.5%), specific dry mass (13.5 kN/m3 ; 14.0 kN/ ^{m3} and 14.8 kN/m ^{3}), and CBR (7.3%; 8.0% and 10.1%). It can be seen that the behavior of the soil was quite similar in tests carried out with close values for the three compaction energies. Furthermore, it is worth highlighting the little gain in the CBR value in all the tests carried out. This behavior has already been verified by the authors in some soils studied in the Central-West. This occurrence is mainly due to the immersion in water for 96 hours required in the process.

Figure 13 presents the composition of the CBR values for Sample 2B, with a view to determining the CBR using the DIRENG-ME-01/87 method for the subgrade material. This method considers the CBR corresponding to 95% in Modified Proctor energy when designing the pavement, with the composition of the graph resulting from the three compaction energies (normal, intermediate and modified). In this sample, the CBR value using the DIRENG-ME-01/87 method was 8.2%, representing 80% of the CBR of the modified energy, which was 10.15%.

Figure 10. Compaction for Sample 2B.

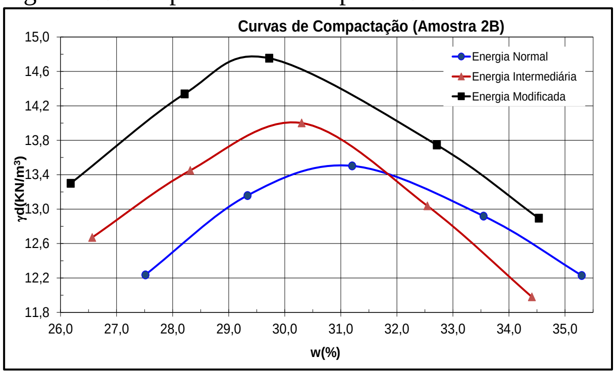
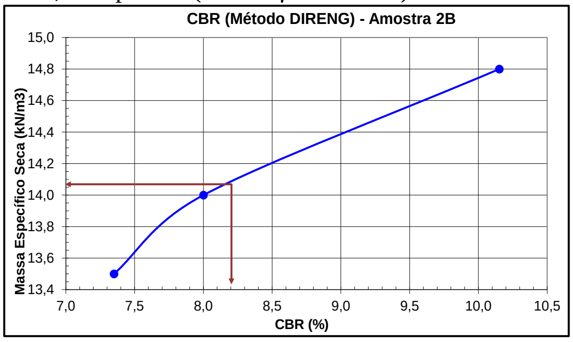


Figure 11. Determination, DIRENG method, of CBR, Sample 2B (95% x γ_d Modified).



FINAL CONSIDERATIONS

In light of the bibliographical surveys, field and laboratory studies, and the appropriate analyses, it can be considered:

a. The importance of the geological-geotechnical research program is to consist of a campaign with bibliographical survey, field and laboratory investigations;

b. The studies showed little gain in the CBR value for the soils studied in consideration of normal, intermediate and modified energies. This behavior has already been observed in some soils in the Center-West studied by the authors. This occurrence is mainly due to immersion in water for 96 hours required in the test's executive process;

c. In view of the analyzes carried out, it was verified the real need to carry out studies with the incorporation of additives, such as cement or lime, which could bring improvements to the local soil with the aim of using it in the subgrade;

d. The studies led to a better knowledge of the distribution and behavior of soils in order to minimize uncertainties related to behaviors that could compromise the quality of the work.

ACKNOWLEDGMENT

To the Catholic University of Brasília (UCB), Centro Universitário de Brasília (UniCEUB), ATP Engenharia Ltda. and Infraero, whose important contributions made this work possible.

REFERENCES

AGÊNCIA REGULADORA DE ÁGUAS, ENERGIA E SANEAMENTO BÁSICO DO DISTRITO FEDERAL. Mapas. Distrito Federal. Disponível em: http://www.adasa.df.gov.br/monitoramento/mapas. Acesso em: 04 out. 2019.

Companhia de Planejamento do Distrito Federal. Atlas do Distrito Federal. Brasília, 2017.

Empresa Brasileira de Pesquisa Agropecuária. Mapa Pedológico Digital – SIG Atualizado do Distrito Federal Escala 1:100.000 e uma Síntese do Texto Explicativo. Planaltina, 2004.

FARIA, A. Estratigrafia e sistemas deposicionais do Grupo Paranoá nas áreas de Cristalina, Distrito Federal e São João D'Aliança-Alto Paraíso de Goiás. 1995. Tese (Doutorado em geologia regional) - Instituto de Geociências, Universidade de Brasília, Brasília, 1995.

Freitas-Silva, F.H.; Campos, J. E. G. Mapa Geológico do Distrito Federal em formato digital, na escala 1:100.000, Instituto de Geociências da Universidade de Brasília. Brasília: IEMA/SEMATEC/UnB, 1998.

Freitas-Silva, F.H.; Dardenne, M. A. Proposta de subdivisão estratigráfica formal para o Grupo Canastra no oeste de Minas Gerais e leste de Goiás. Brasília, 1994.