Report No. SOIL/28/2009 December 5th, 2009

GEOTECHNICAL INVESTIGATION
FOR

Al Hadab School Building
Al Hadab - Palestine

SUBMITTED TO

Messrs.: Al Hadab Local Council
Al Hadab

Al Hadab– Palestine

December 2009

Date:December 5th, 2009 No. Soil/28/2009

Messers: Al Hadab Local Council
Al Hadab– Palestine

SUBJECT: Geotechnical Investigation Report for
Al Hadab Local Council Building

Dear Sirs:

You can find herein the report of our geotechnical investigation for the above-mentioned project proposed in Al Hadab.

This report includes the results of the laboratory tests results and recommendations to choose the type and depth of foundations.

The investigation was conducted on November 21st, 2009.

In the event that additional information or clarifications are needed, please don't hesitate to contact us at your earliest convenience.

I would like to thank you for your confidence and look forward to further cooperation in the near future.

Respectfully Submitted,

Eng. Abdalla Aqel

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1.0 INTRODUCTION

1.1 Purpose

This report presents the results of a Geotechnical Site Assessment prepared by the International Center for Geotechnical & Engineering Studies (ICGES) for the proposed building in Al Hadab. The purpose of the assessment is to provide recommendations for the design of safe and economic foundations and other geotechnical aspects of the proposed construction.

1.2 Scope of Services

The scope of work included the following:

- Review of available data pertinent to the site.
- Conduct a subsurface investigation.
- Conduct basic laboratory testing of the soil.
- Perform a geotechnical engineering analysis regarding the proposed construction, using the information obtained from the subsurface investigation and laboratory testing.
- Prepare a report of our findings, conclusions, and tentative recommendations for the geotechnical engineering aspects of the proposed construction.

1.3 Authorization

This assessment was performed and the report prepared in general accordance with our proposal. ICGES received authorization from the client to proceed with the work.

1.4 Standard of Care

The services performed by ICGES were conducted in a manner consistent with the level of care and skill ordinarily exercised by members of the geotechnical profession practicing contemporaneously under similar conditions in the locality of the project. No other warranty, expressed or implied, is made.

Limitations of this report are discussed in Appendix A. These limitations further explain the realities of geotechnical engineering and the limitations that exist in evaluating geotechnical issues.

This report has been prepared for the exclusive use of Al Hadab Local council, with specific application to the specified building project.

2.0 PROJECT DESCRIPTION

2.1 Proposed Development

It is understood that the proposed development will consist of four floors school building as shown on the Site Plan in Appendix B.

If the locations of the assumed loadings, proposed structures, floor elevations, or any other site features change from what is shown on the site plan included in this report, ICGES should be notified so that the changes can be reviewed to determine if the recommendations presented in this report are still applicable.

2.2 Site Description

The site is located in Al Hadab. A site plan is enclosed in Appendix B. The site is composed of an agrar soil which has been planted with some trees. The site has had experienced no construction activities in the past.

2.3 Project Characteristics

We have been informed by our client that the proposed project is composed of a school building which has the following characteristics:

Type of the project		School Building
Characteristics of the project		
Proposed floors	Total number of floors	4 floors
	Approx. Area of typical floor	≈ 800 m^2
	Number of basements	0
	Basin number	22
	Piece Number	22

3.0 INVESTIGATION AND TESTING

3.1 Subsurface Investigation

The field investigation to determine the engineering characteristics of the subsurface materials included a reconnaissance of the project site, drilling of borings, and obtaining disturbed samples

The drilling consisted of 5 test borings at the locations depicted on the Site Plan (Appendix B). The drilling was carried out on 21/11/2009 using a truck-mounted drilling rig.

The borings' depths are in accordance with the Ministry of Education engineers instructions. The five boreholes were of depths of 8.0 meters depth respectively.

Soil samples were obtained at 1.0 meter intervals in the soil test borings. All samples were identified according to project number, boring number and depth, encased in polyethylene plastic bags to protect them against moisture loss, and transported to the laboratory.

Water level observations were made during the boring operations and the results are noted on the boring logs (no signs of water). Seasonal variations, temperature and recent rainfall conditions may influence the levels of the ground water table and volumes of water will depend on the permeability of the soils.

A field log was prepared for each boring. Each log contained information concerning the boring method, samples attempted and recovered, indications of the presence of various materials such as silt, clay, gravel or sand and observations of ground water. It also contained an interpretation of subsurface conditions between samples. Therefore, these logs included both factual and interpretive information. The boring logs are included in Appendix C.

3.2 Laboratory Testing

Laboratory tests were carried out in a number of selected soil samples in order to acquire necessary information with regards to the physical and mechanical properties of the soil layers and further on to evaluate and determine the parameters required for the calculations. All phases of the laboratory testing program were performed in general accordance with the applicable ASTM Specifications.

The following tests were conducted on the selected soil samples:

- Moisture content
- Sieve analysis
- Direct shear test
- Unconfined test
- Atterberg limits
- GMM

A summary of the laboratory test results is presented in Appendix D. The samples collected will be stored for 30 days from the date of issue of this report, and then disposed of unless otherwise requested in writing by the client.

4.0 SUBSURFACE CONDITIONS

4.1 Stratigraphy

Detailed description of the type of soil layers encountered during drilling is given in the borehole logs (Appendix C). The lines designating the interface between soil strata on the boring logs represent approximate boundaries, transition between materials may be gradual.

Borehole Number	Top depth from ground level	Bottom depth from ground level	Thickness (m)	Color	Description
BH1	0.0	3.0	3.0	Yellowish Brown	Clay (A-7) with Boulders
	3.0	8.0	5.0	Grayish Orange	Medium Hard Rock
BH2	0.0	5.0	5.0	Yellowish Brown	Clay (A-7) with boulders
	5.0	7.0	2.0	Light Brown	Medium Hard Rock
	7.0	8.0	1.0	Yellowish Brown	Clay (A-7) with boulders
BH3	0.0	3.0	3.0	Yellowish Brown	Clay (A-7) with boulders
	3.0	8.0	5.0	Grayish Orange	Medium Hard Rock
BH4	0.0	1.0	1.0	Yellowish Brown	Clay (A-7) with boulders
	1.0	3.0	2.0	Grayish Orange	Medium Hard Rock
	3.0	5.0	2.0	Yellowish Brown	Clay (A-7) with boulders
	5.0	8.0	3.0	Grayish Orange	Medium Hard Rock
BH5	0.0	8.0	8.0	Yellowish Brown	Clay (A-7) with boulders

4.2 Ground Water and Cavities:

Ground water levels may fluctuate with seasonal climatic variations and changes in the land use. Low permeability soils will require several days or longer for ground water to enter and stabilize in the test borings. No underground water has been noticed in the drilled boreholes.

No cavities were encountered in any of the drilled boreholes.

5.0 RECOMMENDATIONS

The recommendations presented in the following sections of this report are based on the information available regarding the proposed construction, the results obtained from our soil test borings and laboratory tests, and our experience with similar projects. Because the test borings represent a very small statistical sampling of subsurface conditions, it is possible that conditions may be encountered during construction that are substantially different from those indicated by the soil test borings. In these instances adjustments to design and construction may be necessary.

This geotechnical report is based on the Site Plan and project information developed by ICGES and the assumptions stated in this report. Changes in the proposed location or design of the structures can have significant effects on the conclusions and recommendations of the geotechnical report. ICGES should be contacted in the event of such changes.

5.1 Site Preparation

Building rubble and any other debris noted at or below the existing ground surface should be removed as part of the site preparation for the proposed construction area. In all new fill and excavation areas, vegetation, topsoil, roots and other deleterious materials (typically 10 to 15 cms), deemed unsuitable shall be removed from the proposed construction areas, and replaced with controlled fill. Site clearing, grubbing and stripping will need to be performed only during dry weather conditions. Operation of heavy equipment on the site during wet conditions could result in excessive rutting and mixing of organic debris with the underlying soils.

5.2 Excavations & Critical Height for an Unbraced Vertical Cut:

The contractor is solely responsible for protecting excavations by shoring, sloping, benching or other means as required to maintain stability of both the excavation sides and bottom. ICGES does not assume any responsibility for construction site safety or the activities of the contractor.

However, the responsibility for the decision about those matters lies of course on the structural Engineer in charge of the design of the Building.

Excavation construction slopes should be closely observed for signs of mass movement, such as tension cracks near the crest, bulging at the top of the slope, etc.

5.3 Structural Fill:

It is recommended that structural fills be constructed as controlled, well-compacted engineered fills. Structural engineered fill should be inorganic, low plastic clay, sand, or gravel. Any existing soils with a high organic content (browns) are suitable for reuse as fill in landscaping areas only. It is recommended that only granular fill be used within the building footprint and within 1.5m of the building footprint. The intent of these recommendations is to reduce the potential for consolidation and settlement of new fills.

Laboratory testing should be performed on the fill materials to determine the appropriate moisture-density relationship of the fill being placed. Adjustments to the soil moisture by wetting or drying should be made as needed during fill placement.

During grading operations, representative samples of the proposed imported structural fill materials should be periodically checked via laboratory testing. A full-time representative from the testing agency should be called to monitor excavation and grading operation as well as the suitability of fill materials.

Suitable fill material should be placed in thin lifts (lift thickness depends on type of compaction equipment, but in general, lifts of 20 cm loose measurement are recommended). The soil should be compacted by the necessary compaction equipment to meet the specified compaction recommendations.

Self-propelled compactors with tamping feet or sheepsfoot rollers may be required to adequately compact fine-grained fill material (silts and clay). If the fill material is granular (sands and gravels) with less than 10% clays and silts, smooth-drum vibratory compactors should be used. In addition, a smooth-drum roller should be provided to “seal” the fill at the end of each workday to reduce the impact of precipitation. In areas undergoing removal of seepage water, the engineered fill should be limited to well-graded sand and gravel or crushed stone.

Within small excavations, such as in utility trenches (less than 60 cm in width), around manholes or behind retaining walls, we recommend the use of "wacker packers", "Rammax" compactors or vibrating plate compactors to achieve the specified compaction. Loose lift thickness of 10 cm are recommended in small area fills.

We recommend that the structural fill and backfill be compacted in accordance with the criteria stated in Table 1. A qualified field representative should periodically observe fill placement operations and perform field density tests at various locations throughout each lift, including trench backfill, to indicate if the specified compaction is being achieved.

TABLE 1
STRUCTURAL FILL PLACEMENT GUIDELINES

Areas of Fill Placement	Compaction Recommendation (ASTM D698-Standard Proctor)	Moisture Content (Percent of Optimum)
Granular cushion beneath Floor Slab and over Footings	98%	As necessary to obtain density
Structural fill supporting Footings	98%	-1 to +3 percent
Structural fill placed within 1.5m beyond the perimeter of the building pad	98%	-1 to +3 percent
Grade-raise fill placed within 0.3m of the base of the pavement	98%	-1 to +3 percent
Structural fill placed below the base of the Pavement Soil Subgrade	95%	-1 to +3 percent
Utility Trenches - Within building and pavement areas	98%	-1 to +3 percent
Beneath Landscaped/Grass Areas	92%	As necessary to obtain density

The fill soils should be relatively free of organic materials and other deleterious material (less than about two hundredths of a percent by weight). In addition, the soils should preferably not contain particle sizes larger than three inches.

5.4 Foundation Design

The bearing capacity of the soil is not only a function of the intrinsic properties of the soil alone but depends also on the type of footing being used. Estimation of the bearing capacities of the foundation layer - for both rectangular and strip footing – is based here on the results of the direct shear test. According to the relation formulated according to Shultze:

Stratified Deposits

Bearing Capacity Calculations

The ultimate bearing capacity of a rectangular or strip footing according to Shultze:

$q_{ult}=(1+0.3B/L)*cN_c+¥_0DN_{q+}0.5(1-0.2B/L)¥_1BN_g$ .... ***eqn(1)***

$¥_{o=}$ unit weight of soil above foundation level.

$¥_{1=}$ unit weight of soil below foundation level.

B,L= width & length of foundation in m respectively.

D= depth of foundation below ground level.

N_c,N_q and $N_¥$=bearing capacity coefficients depending on the angle of internal shearing resistance of the soil (c) below foundation level (dimensionless).

In the cace of circular footing of radius **R** :

$q_{ult}=1.3cN_c+¥_0DN_{q+}0.6¥_1RN_g$ .... ***eqn(2)***

Allowable Bearing Capacity $q_{safe:}$

The safe bearing capacity of soil beneath a given foundation can be determined from the following equation:

$q_{safe}=(q_{ult}-¥_0D)/F_+¥_oD$ .... ***eqn(3)***

F= Safety factor.

The following table calculates the ultimate and safe bearing capacity of the different layers of the borehole for a strip and rectangular footing using the following assumptions:

Based on the results of c and ¤, two sets of strength parameters were obtained. Reduced values for each set were used in the bearing capacity calculation to count for drainage conditions and any possible rock discontinuities. The following table shows the pairs of strength parameters:

Set Number	Lab Values		Adopted Reduced Values	
	¤=E°)	c kg/cm^2	¤=E°)	c kg/cm^2
1st Set	21.2	0.66	10.0	0.45
2nd Set	45.4	0.24	30.0	0.15

B.C of Group 1 (Clay Soil)

Soil Parameters							
$¥_o$=	$¥_1$=	***B***	***D***	***B/L***		Φ^o	
ton/m^3	ton/m^3	m	m	Rect.	Strip		Safety Factor F
1.8	1.8	1	2	1	0	<=40	3

Friction	Cohesion	B.C Coefficients			q_{ult} ton/m^2		q_{safe} ton/m^2	
Φ°	C Kg/cm^2	**Nc**	**Nq**	**N¥**	Rectan-gular	Strip footing	Rectan-gular	Strip footing
10.00	0.45	8.3	2.5	1.2	58.6	47.6	21.9	1.8

Bearing Capacity Calculations							
Square footing				***Strip Footing***			
B (m)	q_{ult} (t/m^2)	q_{ult} (kg/cm^2)	q_{all} (kg/cm^2)	B (m)	q_{ult} (t/m^2)	q_{ult} (kg/cm^2)	q_{all} (kg/cm^2)
1	58.6	5.9	2.2	0.6	47.1	4.7	1.8
1.2	58.8	19.6	2.2	0.8	47.3	4.7	1.8
1.4	58.9	19.6	2.2	1	47.6	4.8	1.8
1.6	59.1	19.7	2.2	1.2	47.8	4.8	1.8
1.8	59.3	19.8	2.2	1.4	48.0	4.8	1.8
2	59.5	19.8	2.2	1.6	48.2	4.8	1.8
2.2	59.7	19.9	2.2	1.8	48.4	4.8	1.9
2.4	59.8	19.9	2.2	2	48.7	4.9	1.9
2.6	60.0	20.0	2.2	2.2	48.9	4.9	1.9

B.C of Group 2 (Rock)

Soil Parameters								
¥$_o$=	¥$_1$=	***B***	***D***	***B/L***		Φ°		
ton/m^3	ton/m^3	m	m	Rect.	Strip		Safety Factor F	
2.0	2.0	1	1	1	0	<=40	3	
Friction	Cohesion	**B.C Coefficients**			q_{ult} ton/m^2		q_{safe} ton/m^2	
Φ°	C Kg/cm^2	**Nc**	**Nq**	**N¥**	Rectan-gular	Strip footing	Rectan-gular	Strip footing
30.00	0.10	*30.1*	*18.4*	*22.4*	*141.1*	*131.6*	*49.4*	*4.6*

Bearing Capacity Calculations							
Square footing				***Strip Footing***			
B (m)	q_{ult} (t/m^2)	q_{ult} (kg/cm^2)	q_{all} (kg/cm^2)	B (m)	q_{ult} (t/m^2)	q_{ult} (kg/cm^2)	q_{all} (kg/cm^2)
1	141.1	14.1	4.9	0.6	123.6	12.4	4.4
1.2	144.4	48.1	5.1	0.8	127.6	12.8	4.5
1.4	147.6	49.2	5.2	1	131.6	13.2	4.6

1.6	150.8	50.3	5.3	1.2	135.6	13.6	4.8
1.8	154.0	51.3	5.4	1.4	139.7	14.0	4.9
2	157.3	52.4	5.5	1.6	143.7	14.4	5.0
2.2	160.5	53.5	5.6	1.8	147.7	14.8	5.2
2.4	163.7	54.6	5.7	2	151.8	15.2	5.3
2.6	167.0	55.7	5.8	2.2	155.8	15.6	5.4

If a raft foundation is to be selected by the designer, the modulus of subgrade reaction is needed. This modulus can be obtained using the bearing plate test or using the following formula:

$K_s = 120\ q_a$ where:

q_a is the allowable bearing capacity of soil in KN/m^2, taken in this case as:

$K_s = 120 * 200\ KN/m^2 = 24000\ KN/m^2$

The modulus of elasticity to be assumed for this type of foundation layer as

$E_s = 12000\ KN/m^2$

For the purpose of settlement calculations, poisons ratio may be used as 0.3.
Other parameters needed may be calculated from atterberg limits and natural water content in the appendices.
The bearing capacity results given are strictly calculated using Shultze equation and the results of direct shear tests at the natural moisture contents. Different bearing capacity values might result at different moisture contents.
Based on the results of the soil test borings, laboratory testing and our engineering evaluation, it is our opinion that the subsurface conditions are suitable for supporting the proposed structure on an isolated or strip foundations. This is dependent on the column loads that are obtained from the analysis of the structure.

It is possible that some soils at the site will have an allowable soil bearing pressure less than the recommended design value. Therefore, foundation bearing surface evaluations should be performed by an ICGES representative during foundation construction to aid in the identification of such soils. After the evaluations and any required remedial measures are performed, concrete should be placed as quickly as possible to avoid exposure of the foundation sub-soils to wetting, drying or freezing. If soils in the areas of foundation support are subjected to such conditions, the footings should be re-evaluated.

5.5 Foundation Settlement

The settlement is expected to be of importance since two different foundation layers are encountered and this is also dependent on the load distribution of the structure. We may help the designer in settlement calculations if we were provided by the column load distribution and to suggest the needed precautions accordingly.

However, if during excavation it appeared that the rock areas in the site has pockets of soil they should be filled with rubble and concrete.

In accordance with Jordanian Building Code and in view of the results of the geotechnical investigation we recommend the adoption of the following:

-Allowable bearing capacity

* A recommended value of 2.0 kg/cm^2 for the isolated footing, 1.6 kg/cm^2 for the strip footing when founding on the stiff clay layer, provided that surface water should be kept away from affecting the foundations layer.
* A recommended value of 5.0 kg/cm^2 for the isolated footing, 4.5 kg/cm^2 for the strip footing when founding on the rock clay layer.

The designer may elect to use the same bearing capacity as the conservative value.

-Type of foundation

* Continuous strip, isolated footings or raft foundation based on the column loads a

-Depth of foundation

* Minimum depth of 1.0 meters from the final ground level to count for frost effect on the foundations. However, as per the soil profile which is in consistent, 1.0 meter from the BH4 location level which reflects an excavation that varies from 1.0 meter in the vicinity of BH4 to about 4.0 meters in the vicinity of BH5.

-Settlement of foundation

* Settlement is based on the type of foundation selected and the column loads

5.7 Floor Slab Subgrade Preparation

The soil subgrade in the areas of concrete slab-on-grade support is often disturbed during foundation and superstructure construction. Additionally, floor slab areas are often disturbed by construction equipment traffic between the time of initial grading and final pavement construction. The subgrade should be excavated to the design depth of the bottom of slab gravels. To prepare the subgrade, the top 20 cm of the subgrade should be compacted to a minimum of 98% of the maximum dry density as determined by ASTM D698, Standard Proctor Moisture-Density Relationship. The moisture content should also be controlled to -1 to +3% of the optimum.

The final subgrade should be proof-rolled and evaluated by a representative of ICGES immediately prior to placement of the engineered fill to detect any localized areas of instability or soft areas. If unstable soils are encountered which cannot be adequately densified in place, such soils should be removed and replaced with well-compacted fill material placed in accordance with the Structural Fill section of this report. The subgrade should be graded to a shallower slope than five horizontal to one vertical (5H:1V) prior to receiving general engineered fill material to reduce the effects of differential fill thicknesses. The prepared subgrade should be protected from drying, excessive moisture, and freezing.

5.8 Drainage and Groundwater Considerations

The site should be graded to provide positive drainage to reduce storm water infiltration. A minimum gradient of one percent for asphalt areas should be maintained. A three percent gradient should be maintained for landscaped areas immediately adjacent (within 3 m) to the building. In general, water should not be allowed to collect near the surface of the foundation or floor slab areas of the structures during or after construction. If water was allowed to accumulate next to the foundation, it would provide an available source of free water to the expansive soil underlying the foundation. Similarly, surface water drainage patterns or swales must not be altered so that runoff is allowed to collect next to the foundation.

Temporary drainage provisions should be established, as necessary, to minimize water runoff into the construction areas. Since soils generally tend to soften when exposed to free water, provisions should be made to remove seepage water from excavations, should it occur. Also, undercut or excavated areas should be sloped toward one corner to facilitate the collection and removal of rainwater or surface runoff. Adequate protection against sloughing of soils should be provided for workers and inspectors entering the excavations. This protection should meet the applicable building codes.

Ground water seepage was not encountered in our borings during drilling. However, minor ground water seepage may be encountered within the proposed building foundation, utility trenches and grading excavations at the time of construction, especially after periods of heavy precipitaion. Small quantities of seepage may be handled by conventional sump and pump methods of dewatering.

6.0 ADDITIONAL SERVICES

The recommendations presented in this report are contingent on ICGES observing and/or monitoring:

- Proofrolling and fill Subgrade conditions;
- Backfilling and compaction of excavations;
- Suitability of borrow materials;
- Fill placement and compaction;
- Foundation subgrades; and
- Compliance with the geotechnical recommendations.

7.0 CLOSURE

We trust that this report will assist you in the design and construction of the proposed project. ICGES appreciates the opportunity to provide our services on this project and looks forward to working with you during construction and on future projects. Should you have any questions, please do not hesitate to contact us.

This report was prepared by Eng. Abdalla Aqel.

APPENDIX A
LIMITATIONS

This report was prepared for the exclusive use of Al Hadab Local Council for the design of the proposed project described in Section 2. The report may not be relied upon by any other person or entity without the written permission of the International Center of Geotechnical Engineering Studies. This report was prepared in accordance with current, generally accepted geotechnical engineering practices. No other warrantee is provided.

ICGES should be given the opportunity to review the geotechnical aspects of plans and specifications prior to construction, to allow confirmation of the correct interpretation of the recommendations provided in this report.

Foundations, earthworks, underground construction, and pavement construction should be undertaken only with full time monitoring by qualified personnel. ICGES can provide these services on request.

The conclusions and recommendations submitted in this report are based upon the data obtained from a limited number of widely spaced subsurface explorations. The nature and extent of variations between these explorations may not become evident until construction or further investigation. If variations or other latent conditions do become evident, it will be necessary to re-evaluate the recommendations of this report.

The recommendations contained herein are not intended to dictate construction methods or sequences. Instead, they are furnished solely to help designers identify potential construction problems related to foundation and earth plans and specifications, based upon findings derived from sampling. Depending upon the final design chosen for the project, the recommendations may also be useful to personnel who observe construction activity. Potential contractors for the project must evaluate potential construction problems on the basis of their review of the contract documents, their own knowledge of and experience in the local area, and on the basis of similar projects in other localities, taking into account their own proposed methods and procedures.

The scope of services did not include any environmental assessment for the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below or around this site. Any statements in this report or on the boring logs regarding odors, colors or unusual or suspicious items or conditions are strictly for the information of the client.

APPENDIX B
DRAWINGS

APPENDIX C
BOREHOLE LOGS & SECTIONS

APPENDIX D
LABORATORY RESULTS