AB
LAB

شركة المهندس عدنان سليمان بدران للاستشارات الهندسية

Adnan S. Badran Consult Engineering Co

SITE INVESTIGATION
Of
Proposed shale's Buildings Site
For

مشروع القرية السياحية البيئية

OWNER	**خزينة المملكة الأردنية الهاشمية** **سلطة اقليم البتراء التنموي السياحي المحترمين**
Plot No.	**744**
Basin No.	**51**
Location	**البتراء**
Report No.	**15194134**

لإستعمال نقابة المهندسين الأردنيين

1. تسوية كاملة: لا يوجد .

ومنسوب بلاط طابق الارضي لمبنى الوحدات السكنية + (897.11)

2. طابقان فقط بمساحة لا تزيد عن (4200) م^2

التاريخ : /2015/09

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DATE: 21/09/2015

Report No: 15194134

SUBJECT: SITE INVESTIGATION OF SHALES BUILDINGS PROJECT

DEAR CUSTOMER,

ADNAN S. BADRAN CONSULTING ENGINEERING COMPANY is pleased to submit this report on the above subject. It includes the results of the field and laboratory investigation and recommendations to help design foundations of the building.

For any additional information, please contact our office. We would like to thank you for your confidence and we are looking forward for further co-operation.

Very truly yours

Eng: ADNAN BADRAN

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1. INTRODUCTION

Upon the request of MESSERS.

a site investigation was performed for the proposed project of the **project at** (al petra **)** This geotechnical report is submitted to help them to design a sound and safe foundations.

Our investigation was carried out on 05/09/2014, to evaluate the subsurface conditions to design the foundations.

2. SCOPE OF WORK

The method of investigation consists of the following:-

1. Collecting information's and maps particular to the project site such as public survey, site plan and land use maps.
2. Visiting to the site to collect information about present land use, surface topography, geological features and surface drainage.
3. drilling of **twelve (12) boreholes and four (4) trial pits** sampling of disturbed and undisturbed samples.
4. Carrying out necessary field and laboratory tests.
5. Developing conclusions and recommendations for foundation and design construction.

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3- PROJECT CHARACTERISTICS

We have been informed by our client that the proposed project has the characteristic summarized below:

- **SHALES buildings**

4- SITE DESCRIPTION

a. Site Location

The investigated site located at al petra ,
Lot No. (744). Basin No.(51).

b. Existing Structures

No existing structures at the proposed building area, for more details please see the site plan enclosed.

c. Site Topography

The proposed building area has a difference in elevation about 13.0 m. For more details please see the topographic map enclosed, See figure .

d. CLIMATE

Jordan is located within the semi-arid desert climate, except in some highland areas of it, where there is a Mediterranean climate, it rains fall during the winter months in quantities ranging from 400-800 mm and hot, dry summer and moderate relative humidity approx.

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f. GROUND WATER & CAVITIES.

No free water or cavities were encountered at any depth of the boreholes drilled.

5- Geological Setting:

The encountered silty clay materials are considered to be recent deposits, but the exposed rocks found during the drilling of the site are related to the following geological formations:

ALLouvium Formation

According to the geological maps for Jordan, the site area under study belongs to the Jordan valley group (Quaternary) Period which is consist of an uncemented poorly-sorted deposit of chert and limestone clasts locally covers topographical lows and flat area on the eastern plateau soil is developed over an extensive area in the west alluvium in the ephemeral but active watercourses is the most recent deposit.

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6.0 Seismology:

The site under study lays within Zone (2A) according to the seismic map of Jordan 2004 .However other earthquake factors related to this site as follows:

Table no (1) Type Soil Profile and Seismic Factors.

**Type of soil Profile	SD	*Table (1)
Seismic Zone factor (Z)	0.15	*Table (2)
Seismic Index (Ca) related to acceleration	0.22	*Table (3)
Seismic Index (Cv) related to speed.	0.32	*Table (4)

The type of soil profile depending on sub soil of foundation (sand material). for zone (a+b) at all of the site study.

7- Field Exploration and Laboratory Testing:

7-1 Field Exploratory:

7-1-1 Drilling:

TWILVE bore holes were drilled at the site, at the locations shown on the site map enclosed within appendix .They were numbered as u1u2u3u4r1r2r3r4c1c2pl1pl2 inclusive and **4 trial pits** They were numbered as TPI TO TP4 . The depths and elevations of the drilling were fixed on the attached log sheets within appendix and as follows in table 2.

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Table 2: Boreholes Depths and Elevations

Borehole No.	Borehole Depth (m)	
C1	6	
C2	6	
R1	9	
R2	6	
R3	6	
R4	9	
PL1	6	
PL2	6	
U1	9	
U2	6	
U3	6	
U4	9	
K1	6	
K2	6	
K3	9	
TRIAL PITS	DIMENSION	
TP1	1.0	1*1*1
TP2	1.0	1*1*1
TP3	1.0	1*1*1
TP4	1.0	1*1*1

The drilling was carried out with Atlas Copco Rotary drilling rig. The advance of the drilling operation was carried out through rotary air flush drilling method.

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7-1-2 Sampling

Because of sand material SPT test was considered. This is a dynamic test as described in BS1377 and is a measure of the density of the soil. The test incorporates a small diameter tube with a cutting shoe known as the 'split barrel sampler' of about 650mm length, 50mm external diameter and 35mm internal diameter. The sampler is forced into the soil dynamically using blows from a 63.5kg hammer dropped through 760mm. The sampler is forced 150mm into the soil then the number of blows required to lower the sampler each 75mm up to a depth of 300mm is recorded. This is known as the "N" value. For coarse gravels the split barrel is replaced by a 60 degree cone.

(8.0.1) LABORATORY TESTING FOR MATERIALS OF ZONE A :

For the determination of physical and engineering properties of the subsurface materials laboratory tests were performed on selected samples from all boreholes.

The following tests were performed:-

1 - ASTM D2937 Standard Test Method for Density of Soil

2- ASTM D6913-04e1 Standard Test Methods for Particle-Size Distribution (Gradation) of soil Using SIEVE ANALYSIS

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TABLE No 3-1
RESULTS OF TESTING MATERIALS

BH No	Sample Depth	SIEVE ANALYSIS		
		Sand %	Clay%	Silt%
BHR1	3.0	97	2	1
BHU2	3.0	93	4	3
BHPL2	3.0	91	2	7
BHC2	3.0	95	3	2

8.0.2) LABORATORY TESTING FOR MATERIALS OF ZONE B :

- 1- "Laboratory Determination of Water (Moisture) Content of soil,Rock andsoil - Aggregate Mixtures", according to ASTM D 2216 - 80.
- ASTM D2937 Standard Test Method for Density of Soil
- ASTM M -422 -Standard Test Methods for Particle-Size Distribution SIZE ANALYSIS of soils.
- Liquid Limit, Plastic Limit and Plasticity Index of Soils", according to ASTM D4318- 84.
- ASTM D2166-06 Standard Test Method for Unconfined Compressive Strength of Cohesive Soil.

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Table No 3-2
Result of testing materials

BH No.	Sample Depth	Atterberg limits %			Sieve analysis				
		LL	PL	PI	Sand %	Silt %	Clay%	Gravels %	Moisture %
BH C1	2.00	43	21	22	5	36	55	3	22%

9.0 Subsurface Ground Conditions:

9-1 Materials and Properties:

The findings of the boreholes were generally consistent with the anticipated geology of the site area and with each other, with some local variations.

Generalized subsurface profiles C1& C2/U1 U2/U3/U4/R1/R2/R3/R4/PL2/PL1 are presented in (Figures no. 3) . These profiles were constructed by direct interpolation between the similar encountered materials. The line connecting these materials is made for illustration purposes only and not considered as actual line .

Further details and information regarding the materials encountered and Strata thickness is presented in the logs of boring,(see Appendix).

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The materials encountered in the site are TWO TYPES OF MATERIALS:-

1- light brown, wet, medium dense sand with gravels, of granite and biotite , there are found at all the area of study except the area of bhc1 – **zone a**

2- Brown semi hard silty clay with gravels of basalt , this materials are found at the site of bhc1- **zone b**

9.2 Materials Evaluation

The field investigation and laboratory tests results of the previously Mentioned ground materials show that these materials have the following general properties:

- Top soil consists of fill materials from the surface of site extend to 7.0 m at the site of (bhc1) and for 2.0 m on the other sites followed by:

- Light brown, wet to moist, medium dense sand with gravels, of granite extends from 2.0 m to the end of drilled depths.

TRIAL PITS NO.	DEPTH OF T.P(m)	MATERIALS IN T.P
T.P.01	1.0	SAND
T.P.02	1.0	SAND

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T.P.03	**1.0**	**SAND**
T.P.04	**1.0**	**SAND**

Zone No.	TYPE OF MATERIALS
a	**DARK BROWN SEMI HARD STIFF , SILTY CLAY WITH GRAVELS OF BASALT FOLLOWED BY ROSE TO YELLOWISH SAND**
b	Light brown, wet to moist, medium dense sand with gravels, of granite

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10.0. BEARING CAPACITY (for zone a bh(c2/r1/r2/r3/r4/pl1/pl2/u1/u2/u3/u4/K1/K2/K3) :

10-1-a- Calculation of Bearing Capacity of soil Layer is:-

Calculated from samples which taken from logs .
The foundation soil type light brown, dry, medium dense sand with gravels, of granite
The safe bearing capacity is calculated using standard text result s (SPT) data Meyerhof (1956-1965) suggested the bearing capacity for the estimated 25mm settlement could be obtained directly as .

qa = N /4 for B< 4ft
qa =N / 9 (B+1/B)^2 *Kd B> 4ft

Where:
Q all=Allowable net pressure (Ksf).
N=SPT resistance value at depth 2.0 m=18
B= width of footing (ft)
Kd = coefficient of depth = 1.33

qsafe = 18 / 9 *((5+1)/5))^2 * 1.33 = 3.83 Ksf

Q_{all}= 3.83 Ksf *0.489 =1.25 Kg/cm ^{2}

Q_{all}= 1.30 kg/cm ^{2}

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10-2-a SETTLEMENT

The settlement of foundation can be computed from the theory of clasticity equation:

$$S = Q_{all} / (0.47*N)$$

Where:

S= settlement in (mm)
qall =Allowable net pressure(KN/m ^{2})
N=SPT resistance.

$$S = 160 / (0.47*18) = 18.91 \text{ mm}$$

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10.0. BEARING CAPACITY (for zone b/ bh (c1) :

10-1- Calculation of Bearing Capacity of soil Layer;
Depending on Brown semi hard silty clay with gravels of limestone. The safe bearing capacity is calculated for the samples taken from boreholes no (1) .

$$Qu\ safe = (C\ Nc /F.S) + \gamma D$$

Where;

C: Unconfined compression strength /2 = 1.60/ 2 = 0.8 kg/cm ^{2}
F.S : 3.0 (According to Jordan foundation code for permanent structures will not be less than 3.0)
ϒ: Unit weight of soil = 1.80 kg/cm ^{3}
D : Depth of foundation = 2.0 m
Nc =5.70

$$Qu\ safe = 0.80^* 5.70/3 + 1.80^* 200/1000 = 1.66\ Kg/cm^2$$

$$Qu\ safe = 1.60\ kg/cm^2$$

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10-2- b- Calculation of Maximum Settlement:

For calculation the settlement we recommended to use the following equation:

$$S = \frac{Qusafe * B * IW (1- \mu^2)}{E}$$

Where:-
S = Settlement in mm
B = Width of Strip Footing in(mm)
μ = Pioson's Ratio
E = Modulus Elasticity.
Qu safe =Allowable Bearing Capacity (kg/cm ^{2})

$$S = \frac{1.60*1500 * 1.40 (1- 0.402)}{150} = 24.34 \text{ mm}$$

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10-3-b- Consolidation settlement:

The settlement value is calculated from this equation depending on bearing Capacity value:

$$S = (Cc (H /1 + eo) * (Log \{ (Po + \Delta P) / Po) \}$$

L.L=43

Cc = 0.009*(L.L-10)
Cc = 0.009 *(43 – 10) = 0.29
Cc= 0.29
eo = Initial Void ratio ، نسبة الفراغات
Cc = 0.29 (eo – 0.27)
0.30 = 0.29(eo –0.27)
eo = 0.391/0.3
eo = 1.29
H :((نسبة سمك الطبقة المشوهة بالانضغاط))
H = 0.5 thickness silty clay existing after depth foundation; H: 2.00 m
Po = Overburden pressure under footing to mid of silty clay below foundation;
PO = الكثافة *عمود التربة المجرف
Po = 2.0* 1.60 = 0.34 kg/cm ^{2}
ΔP = the average stress is calculated using Bossinesqs method
Assuming footing dimension =150*150 cm
ΔP = (applied load) معدل الضغط الناتج من الاحمال

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$P = 0.12*(p / (B)^2) = 0.0039$ kg/cm ^{2}

$S = (0.29*2.00/1 + 1.30) \{Log (0.35 + 0.0039/0.35)\} = 0.42$ cm = 4.2 mm

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(11) Conclusion and recommendations:

Analysis of results obtained from field exploration and test result in addition to our previous experience lead to the following conclusions and recommendations.

11-1-a- Type and depth of foundation:

1. According to the Architecture design and Design of foundation Code by JEA The foundation could be laid at a depth not less than **2.00 m** from the finishing floor level surrounding the building for foundation material light brown , wet , medium dense sand with gravels , of granite .
2. RAFT foundation is suitable for this type of soil.

11-2-a Allowable bearing capacity:

The calculated net allowable bearing capacity of the foundation materials is **1.30 kg/cm²** is recommended for design foundation For materials at zone a.

11-1-b Type and depth of foundation:

1. According to the Architecture design and Design of foundation Code The foundation could be laid at a depth not less than 2.0 m

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from the finishing floor level at foundation material Brown semi hard silty clay with gravels of marl stone

2. Shallow foundation is suitable for this type of soil is (strip footing) or (single footing) connected with tie beams

11-2-b Allowable bearing capacity:

The calculated net allowable bearing capacity of the foundation materials is 1.60kg/cm² is recommended for design foundation

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11-3 Type of foundation:

The foundation for this building should be continues and separated foundation for two zones of study area. If the foundations are designed and constructed in accordance with the previous recommendations and if the field conditions are not different from what the boreholes, thus settlement will be negligible.

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التوصيات والاستنتاجات

بعد قيامنا باستطلاع الموقع والقيام بالفحوصات المخبرية اللازمة وبناء على تحليلنا لنتائج البحث والدراسة تبين لنا ما يلي :

1. **طبيعة البناء : الابنية المقترحة هو عبارة عن شاليهات ومبنى مطعم وبرك سباحه منوي قيامهم على قطعة ارض في منطقة البتراء .**
2. **طبقة التأسيس وطبيعة التكوين الجيولوجي في الموقع : تقع قطعة البناء المقترح على التكوين الجيولوجي (وادي السير الجيري WSL) ، وطبيعة مواد التأسيس في الموقع هي طبقات من الرمل البني المصفر مخلوطة مع حبيبات من السليت والجرانيت الحبيبي في كامل منطقة الدراسة باستثناء منطقة البئر c1 فأن مواد التأسيس تكون عبارة عن طبقات من الطين السليتي مخلوطة بحصى من فتاتيات الجرانيتية .**
3. **قوة التحمل :**

- **ان قوة التحمل لمثل هذة المواد من طبقات التأسيس هي 1.30 كغم / سم ^{2}للمواد في منطقة الدراسة كاملة باستثناء منطقة البئر (c1).**

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- **ان قوة التحمل لمثل هذة المواد من طبقات التأسيس هي 1.60 كغم / سم²للمواد في منطقة الدراسة في منطقة البئر (c1).**

4. **نوع وعمق الأساسات :-**

- **بناء على كود البناء الوطني والتعليمات الفنية السارية في النقابة فأن عمق الأساسات لايقل عن**
- **2 متر من المنسوب النهائي حول المبنى (2.0 م) لمواد التأسيس .**
- **طبقة التأسيس عبارة عن طبقات من الرمل المخلوط بالسلت والجرانيت الحبيبي لمنطقة الدراسة كاملة باستثناء منطقة البئر (c1) .**

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5. **نوع الاساسات :-**

- **نوع الاساسات الذي نوصي به لمثل هذا النوع من المباني هي اساسات مستمرة ومعزولة كذلك استعمال الدبش والباطون بسماكة 40 سم وذلك لتدعيم وتقوية تربة التأسيس .**
- **ضرورة استخدام الاسمنت المقاوم للاملاح في منطقة القواعد وكذلك التقيد بشروط العزل للاساسات تجنبا للتاكل والتفاعل مع الكبريتات والاملاح والمياه حيث ان العينات تحتوي رطوبة عالية .**
- **كما يجب وضع مضخات في الموقع لسحب المياه المتوقع تجمعها حول منطقة الاساس**
- **اتباع انظمة العزل المناسبة لضمان حماية القواعد والاساسات من التأكل والتفاعل مع الماء وذلك بالطرق التي يراها المهندس المصمم مناسبة .**

ملاحظة هامة :

- **ضرورة اتباع حماية لجوانب الحفرية ومنذ مباشرة التجريف على المكتب المصمم اتخاذ كافه الاجراءات لتدعيم جوانب الحفرية تحسبا لحدوث انهيارات او انجرافات للتربة وحسب طريقة التدعيم**

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التي يراها المصمم مناسبة بناء على انحدار الموقع وطبيعة طريقة التجريف وكذلك نوعية المواد في الموقع .

11-4 Excavation Method and Side Slopes:

It is expected that the excavation will be through the top soil extended to the silt & sand materials mentioned previously. Therefore mechanical equipment such as loaders and bulldozers will be required; Jack Hammer and/or compressor will be required to break the large boulders or hard materials of limestone.

The last excavated 15 cm of this material shall be accomplished using manual equipment unless large boulders or hard materials are encountered. Moreover, the foundation level should be clean and free from accumulation of soils or water and/or any deleterious matters. This level shall be compacted properly before the construction of the foundation.

Maximum allowable slope means the steepest incline of an excavation face that is acceptable for the most favorable site conditions as protection against cave-ins, and is expressed as the ratio of horizontal distance to vertical rise (H:V).

TABLE No 4
MAXIMUM ALLOWABLE SLOPES

SOIL OR ROCK TYPE	MAXIMUM ALLOWABLE SLOPES (H:V)(1) FOR EXCAVATIONS LESS THAN 20 FEET DEEP(3)
STABLE ROCK TYPE A TYPE B	VERTICAL (90º) 3/4:1 (53º) 1:1 (45º)

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TYPE C	1 ½:1 (34º)

Footnote (1) Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal.
Footnote(2) A short-term maximum allowable slope of 1/2H:1V (63º) is allowed in excavations in Type A soil that are 12 feed (3.67 m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67 m) in depth shall be 3/4H:1V (53º).
Footnote (3) Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer.

*Type (A) Cohesive soils are: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam
*Type (B) Cohesive soil with an unconfined compressive strength greater than (48 kPa) but less than (144 kPa) or Granular cohesion less soils including: angular gravel (similar to Crushed rock).
*Type (C) Cohesive soil with an unconfined compressive strength of (48kPa) or less; or Granular soils including gravel, sand, and loamy sand; or Submerged soil or soil from which water is freely seeping; or Submerged rock that is not stable, or Material in a sloped layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H: 1V) or steeper.

11-5 Drainage system:

An effective rain water drainage system must be designed to get rid of rain water percolation into the soil layers by constructing a series of manholes and gutters such that the surface water is properly collected and drained away. It is also important to prevent

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domestic water seepage and septic-sewage water saturating the soil layers especially around the basement.

11-6 Mechanical works:

In the ground floor and basements, if any, mechanical works like hot and cool water lines, etc., should be properly fitted and checked to avoid any future water seepage through soil layers around foundations.

11-7Side walks:

One meter width side walks around the building will be useful in protecting foundations from water passing through soil adjacent to walls and over foundations itself. The side wakes
Should be slope outwards, and the top level of it must never be higher than the floor level inside the building.

11-8 Surroundings:

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All water pipes, sewers or any sources of water like small ponds around foundations must be under control and maintenance to avoid seepage of water. If the lot is not served in the city sewer system, then, the septic hole must be away from foundations and constructed of reinforced concrete and properly deep roots, or it must be away from building location, and home plants which need continuous irrigation must be planted away of the perimeter of the building.

11-9 Concrete works

- A layer of blinding concrete 10 cm. thick should be placed under the footings in order to minimize chemical reaction between cement mortar and native rock..
- Ordinary Portland cement can be used for substructure works.

11-10 Backfill material

A Filter material consists of single size material should be used behind the retaining wall, however the recommended back fill material which will be used should be granular in general and should not contain the following:

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- Should not be classified as A6 or A7 if the material to be back filled from the excavated material.
- Should be classified as A2-5, A2-4, A1-a, or A1-b if the material to be back filled from outside of the site.
- Clayey soil which would reach maximum dry density after compaction lowers than 1.6gm/cm².
- Clayey soil with a natural moisture content 5% or more in excess of the optimum moisture content.
- Soils with more than 5% of organic impurities.
- Boulders or rock fragments exceeding 2/3 of the thickness of layer to be compacted.

12.0-a Earth Pressure Coefficients (for zone a):

- Bearing capacity = 1.30 kg/cm ^{2}
- Bulk density = γ = 1.50 gm/cm ^{3}
- Angle of internal shearing resistance of the soil ϕ = 27.0 °
- The lateral earth pr. at rest Ko = 1 -sin ϕ = 1- 0.57= 0.43
- Subgrade reaction coeff. Ks = 120 Qa
  = 120 x 1.30 = 156 Kg/m^2/m.
- Active coeff. in cohesionless soils Ka = 1- sin ϕ / 1 + sin ϕ
  = 1-0.57/ 1 + 0.57= 0.274
- Passive Coeff. of cohesive soil = Kp = 1 + sin ϕ / 1- sin ϕ
  = 1+ 0.42 / 1- 0. 42= 3.65

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12.0-b Earth Pressure Coefficients (for zone b):

- Bearing capacity = 1.60 kg/cm ^{2}
- Bulk density = γ = 1.65 gm/cm ^{3}
- Angle of internal shearing resistance of the soil ϕ = 27.0 °
- The lateral earth pr. at rest Ko = 1 -sin ϕ = 1- 0.57= 0.43
- Subgrade reaction coeff. Ks = 120 Qa
  = 120 x 1.60 = 192 Kg/m^2/m.
- Active coeff. in cohesionless soils Ka = 1- sin ϕ / 1 + sin ϕ
  = 1-0.57/ 1 + 0.57= 0.274
- Passive Coeff. of cohesive soil = Kp = 1 + sin ϕ / 1- sin ϕ
  = 1+ 0.42 / 1- 0. 42= 3.65

Important Note:

This report was prepared by Adnan Badran Consult Engineering Co. The above recommendations are based mainly on the information obtained from the drilled boreholes and not necessarily reflect any variation which may encountered. Re-evaluation of the above mentioned recommendations and results becomes necessary if such variation is encountered.

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* The owner should call us when the excavation work of the site had been done or he would be responsible.

APPENDIX

The followings are enclosed to this report:

- **Site plan**
- **15 log sheets**
- **4 TRIAL PITS**
- **2 Geological profile**

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- **Geological Map**
- **FIG(3.4)**
- **SEISMIC MAP OF JORDAN**
- **TABLE NO (1) TYPE SOIL PROFILE AND SEISMIC FACTORS**

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