طوب أكياس البلاستيك
تقنية بناء منخفضة التكلفة

القيم المكتسبة
فى تطبيق التقنية

بروفسير محمد عثمان السمانى
مخترع ومطور التقنية
تلفون 0912863715

1. تمهيد:

طوب أكياس البلاستيك هو تقنية مطورة بمبادرة ذاتية من بروفسير محمد عثمان السمانى، ولف من مصادر معرفية متعددة (قراءات، مشاهدات، تجارب ..الخ) بغرض إستخدامه فى تسهيل عمليات البناء منخفض التكلفة.

المباديء التى قامت عليها التقنية يمكن إيجازها فى: أن تكون المواد المؤلف منها الطوب متوفرة، أن تكون عملية البناء سهلة التطبيق وأن تتوافر فى المبانى التى تستخدم فيها التقنية الضرورات الأساسية، كالسلامة والدوام والبيئة المقبولة، مع خفض التكلفة.

بالنسبة للمواد المتسخدمة فمكونات طوب البلاستيك هى الرمل والجير وقليل من الأسمنت، وجميعها متوفر فى معظم أجزاء القطر. وأكياس البلاستيك كعنصر أساسي فى تشكيل الطوبة يمكن الحصول عليه من المصانع التى تنتجها فى العاصمة. وبالنسبة لعملية البناء فهى سهلة كما دلت التجارب (تدريب ممارستها لمدة لا تزيد عن يوم يومين)، والتى تحققت عبر نتائجها الضرورات التى جاء ذكرها. ويكفى للتدليل على متانة الطوبة المصنعة من الجير، أن من الكيمياء التى درسناها فى المرحلة الثانوية، أن مكون الجير فى حالته اللينة هو Carbonate، وعندما يجف يتحول إلى Bicarbonate، وبتشبعه مع مرور الزمن بالأُكسجين والرطوبة يزداد صلابة {يتحجر} أنظر إلى مبانى الانجليز من حولك، ومن بعد مبانى مصلحة الأشغال التى أُستخدم فيها الجير مع الرمل، كمونة رابطة بين الطوب الأحمر ــ مثال مدرسة أم وابة الوسطى فى مطلع الخمسينات ــ كان الجير يُجلب لها من السميح والرملة متوفرة بالمنطقة.

2. التقنية:

1.2 المواد المكونة وطريقة البناء

1.1.2 أكياس بلاستيك

2.1.2 جير (متواجد بمواقع كثيرة بالولايات)

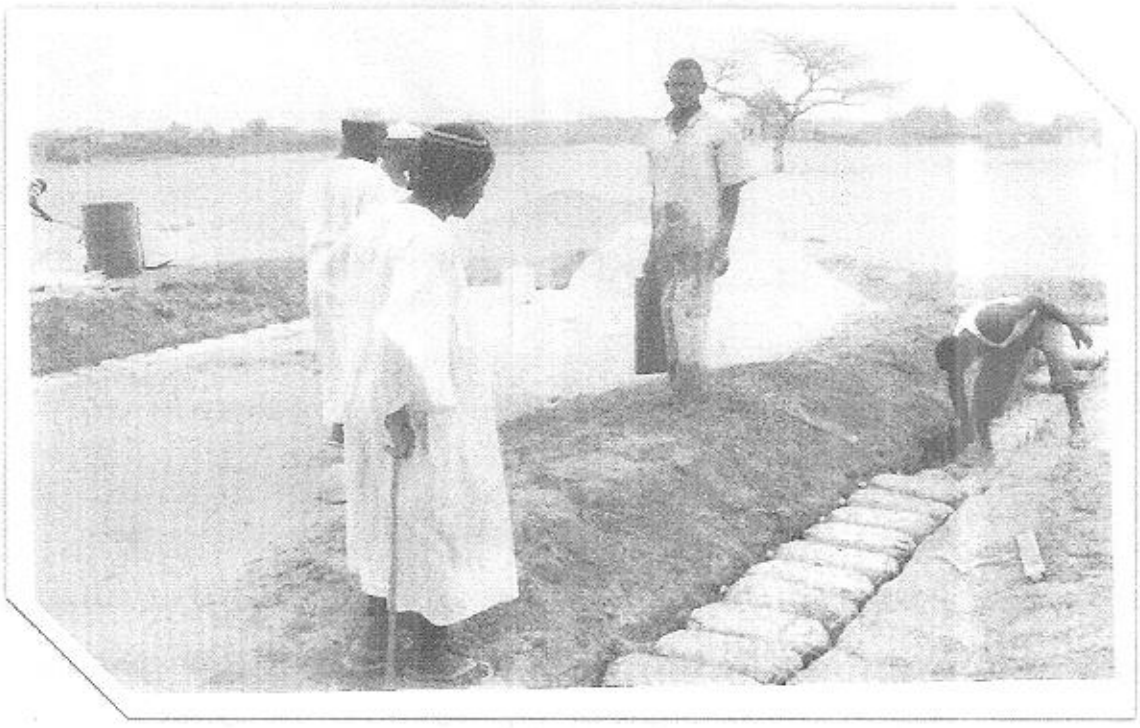
3.1.2 رمل (ناعم أو متوسط الخشونة ــ إذ وضح لنا من التجربة، أن الرمل عالى الخشونة ضعيف التماسك بالجير والاسمنت).

4.1.2 خلط الرمل والجير والأسمنت كمواد ناشفة بنسب: 70% رمل، 20% جير، و 10% أسمنت (ويمكن المغايرة فى هذه بزيادة كمية الجير وتقليل كمية الأسمنت) ومن ثم تعبئة المادة المخلوطة فى أكياس بلاستيك.

ويمكن أن تتم التعبئة يدوياً،

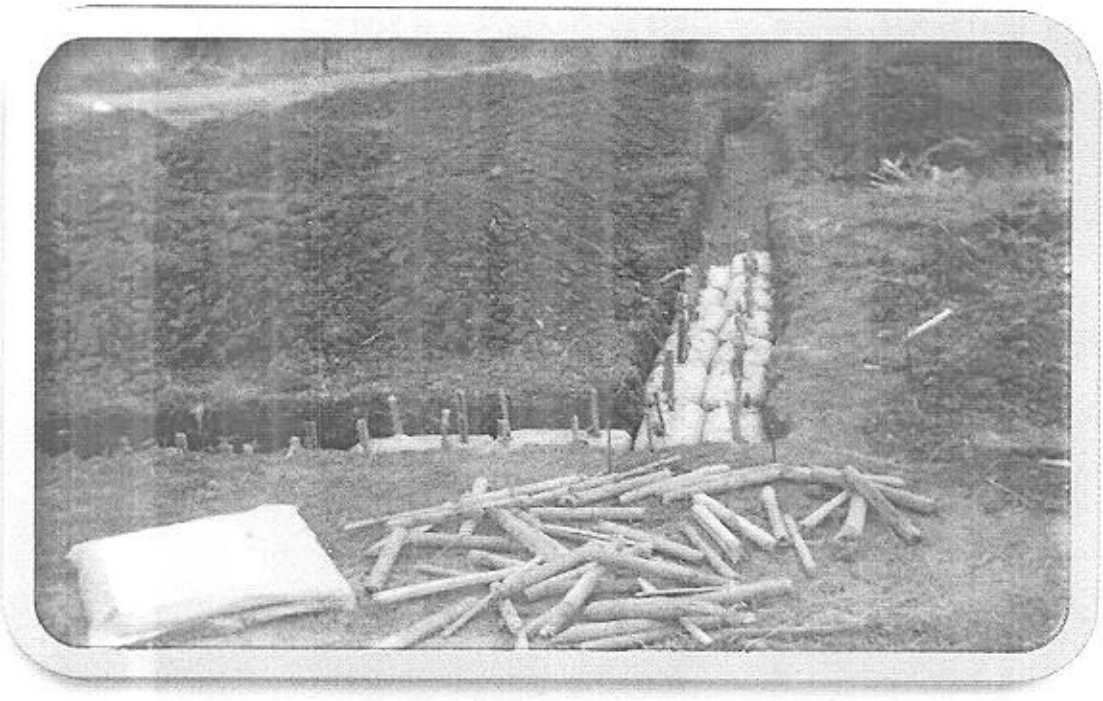
أو باستخدام صبابة (FANNEL)

7.1.2 فتح الأساس لمبانى أنجزناها فى أراضى رملية/شبه رملية، شملت النماذج التى بنيناها فصول مدارس بـــ: ود جبر، الشقيق، القادسية وأبو نواره (الدويم).



وفى الأراضى الطينية، شملت عدد 2 مركز تنمية ريفية تحت المشروع الممول بواسطة البنك الدولى، تحت اسم السلام البيئ الولائي لتوفيق أوضاع الرحل. أحد المركزين بالصالحة بالقرب من الدمازين على بعد 70 كيومترات، والآخر بالدبيبات بجنوب كردفان.

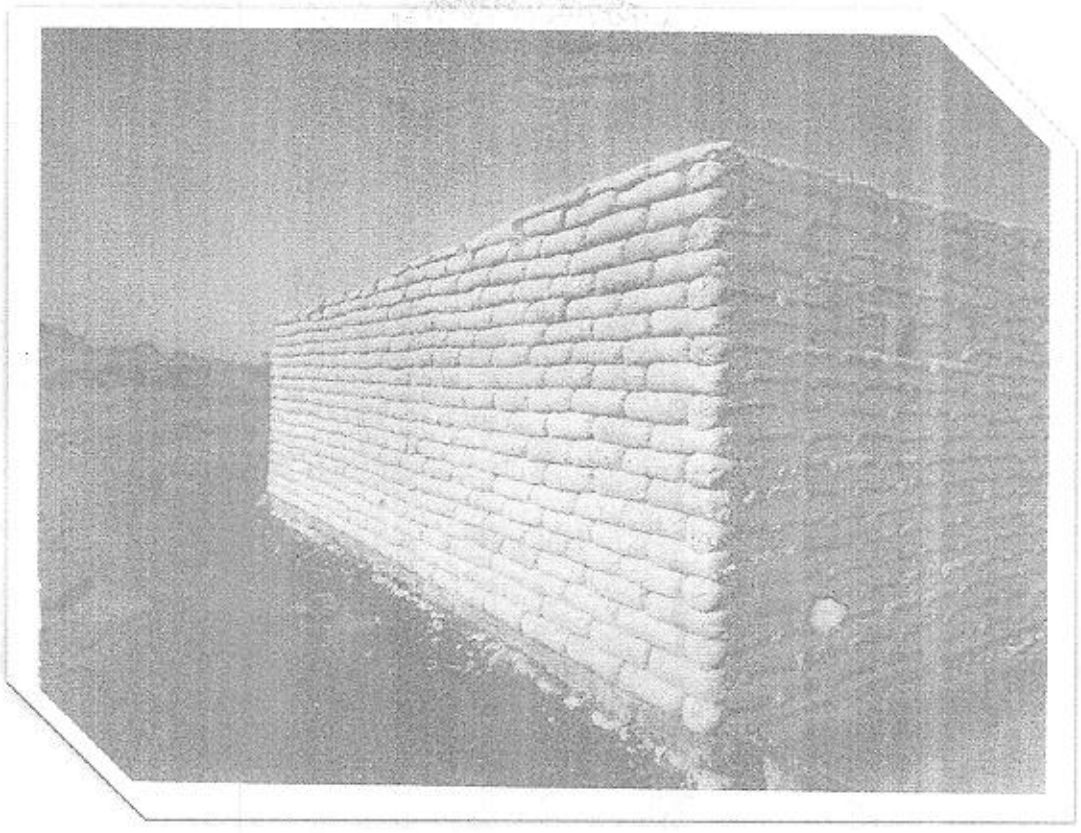
أراضى طينية



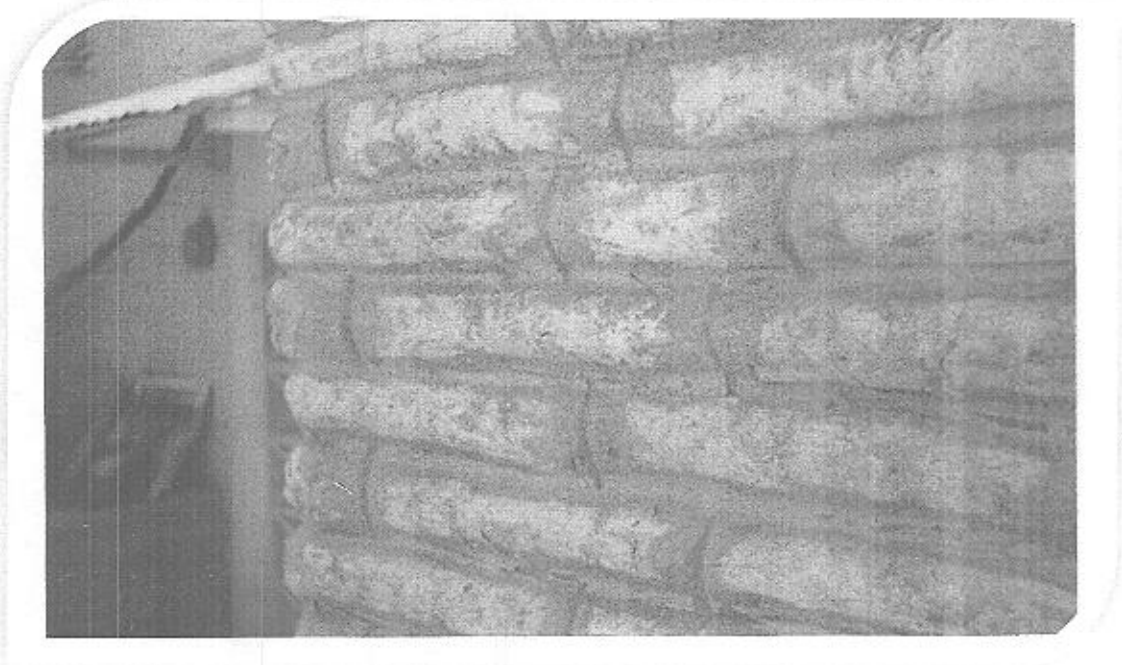
كما شمل موقعاً ثالثاً بقرية أسمها اللقورى، تقع حوالى 30 كيلومتراً شرق كادوقلى بالقرب من جبال. والمبنى عبارة عن ميز معلمات قامت بتموليه منظمة أجنبية تطوعية فى حدود 27 ألف جنيه وهو مكون من غرفتين (4 × 4.5 متر لكل) ومطبخ (3.5 × 3.5 م) وفرندة رابطة الغرفتين والمطبخ بقياسات (8 أمتار × 3.5 م) ومسقوف بالزنك وله أبواب وشبابيك. وحالياً تشغله وحدة الدفاع الشعبى. والمواقع الثلاثة على أراضى طينية معدلات أمطارها السنوية ما بين 600 إلى 700 ملمتر. طبيعة الأراضى الطينية، من ناحية التمدد والإنكماش ما بين الخريف والصيف والتى تتسبب فى حراك أساسات المبانى وتؤدى لتشققها ولكن يبدو أن استخدامنا لطوب البلاستيك التى ياخذ شكل (السجقة) ووجود الفراغ بين (السجقة) وأخرى قد خلق لهذا النوع من البنيان تكيفاً من حراك التربه، ما بين حالتى الجفاف والرطوبة ــ مسألة تحتاج إلى مزيد من التقصى العلمى.

8.1.2 لتحويل الخلطة الناشفة داخل كيس البلاستيك إلى عجينة مونه تستعمل أحدى طريقتين وكلاهما يقود إلى نفس النتيجة: إما بتوفير أحواض تملا بالماء، أو حفر حفرة وتغطيتها بمشمع من النوع المتوفر بالسوق مثال (4 × 4 أمتار بسعر 40 جنيه) وملاءه بالماء بواسطة عربة كارو من أى مصدر قريب. ومن بعد غمر الأكياس المعباه بالمادة فى الحواض والحفرة المغطاه بالمشمع وتخريم جنبات الكيس ليغمر الماء ما بداخله حتى درجة التشبع.

ب. ويتقدم البنيان ويأخذ المبنى شكله، وتبدأ معالمه فى الظهور

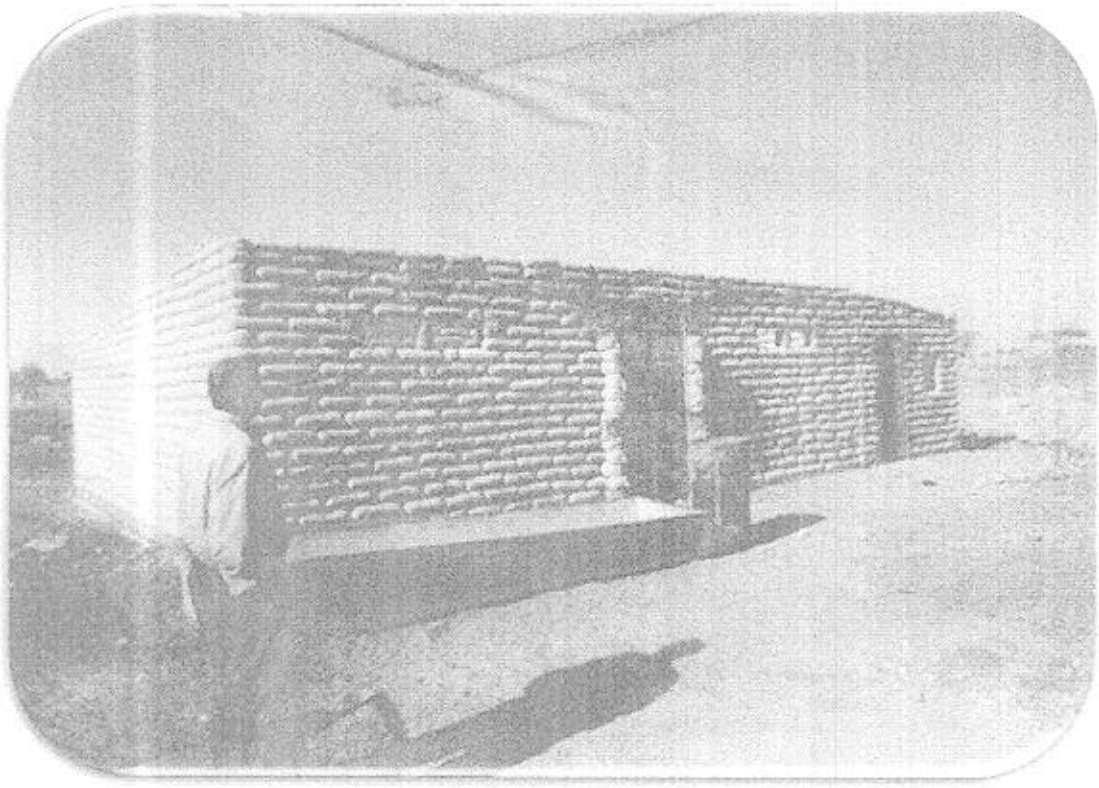


ج. حائط خام لازال مغطاه بأكياس البلاستيك

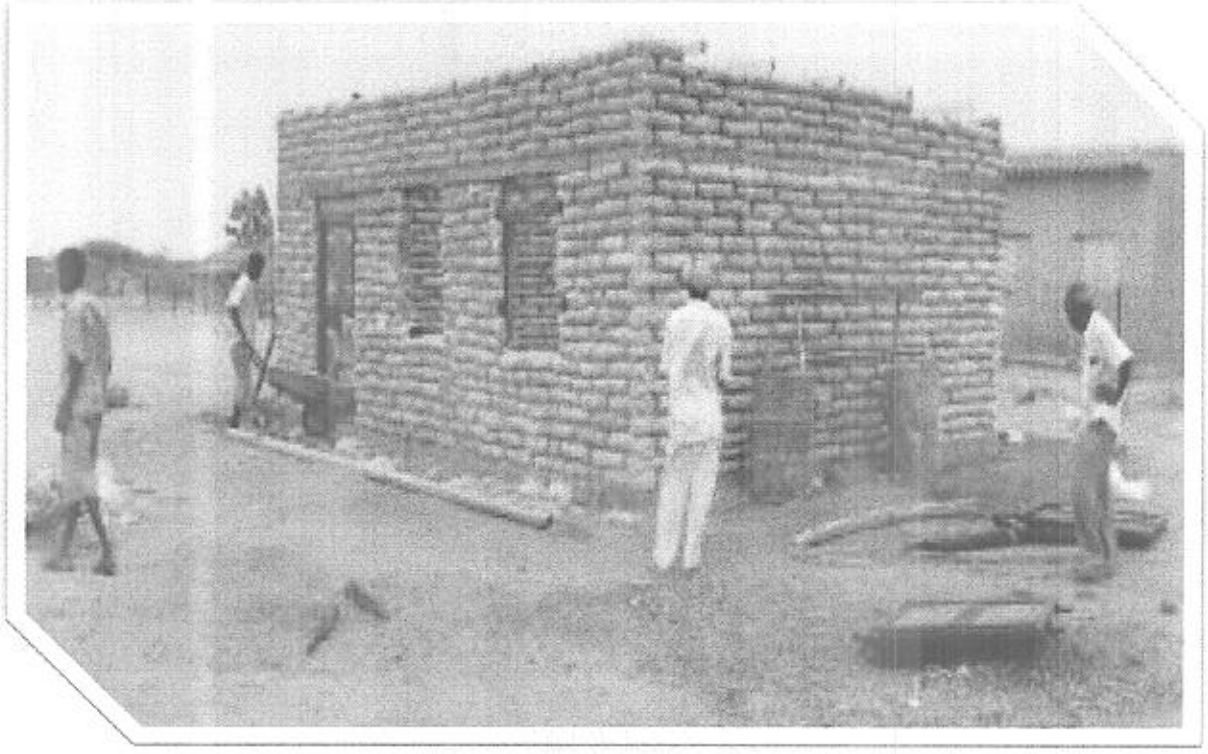


د. حائط نزعت منه أكياس البلاستيك وجرى ملأ الخطوط بين المداميك

11.1.2 نماذج لبعض المبانى

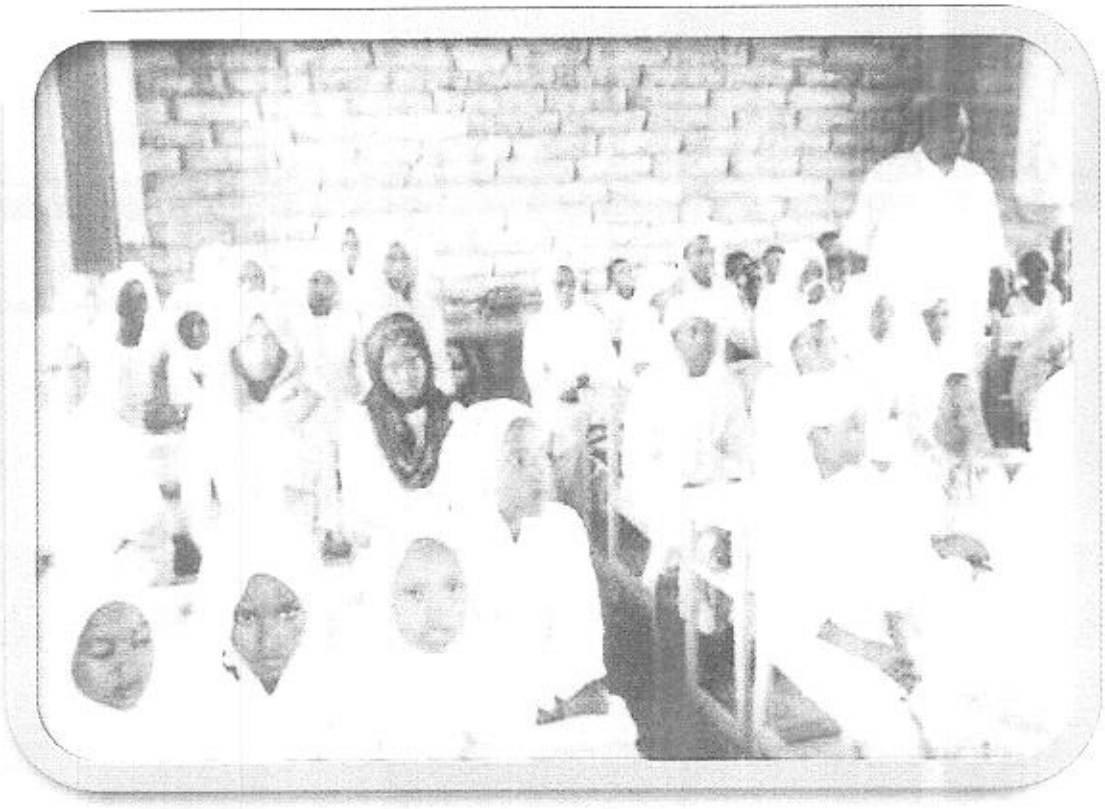


أ. ميز المعلمات بقرية اللقورى شرق كادوقلى ــ المبنى فى مرحلته الأخيرة.

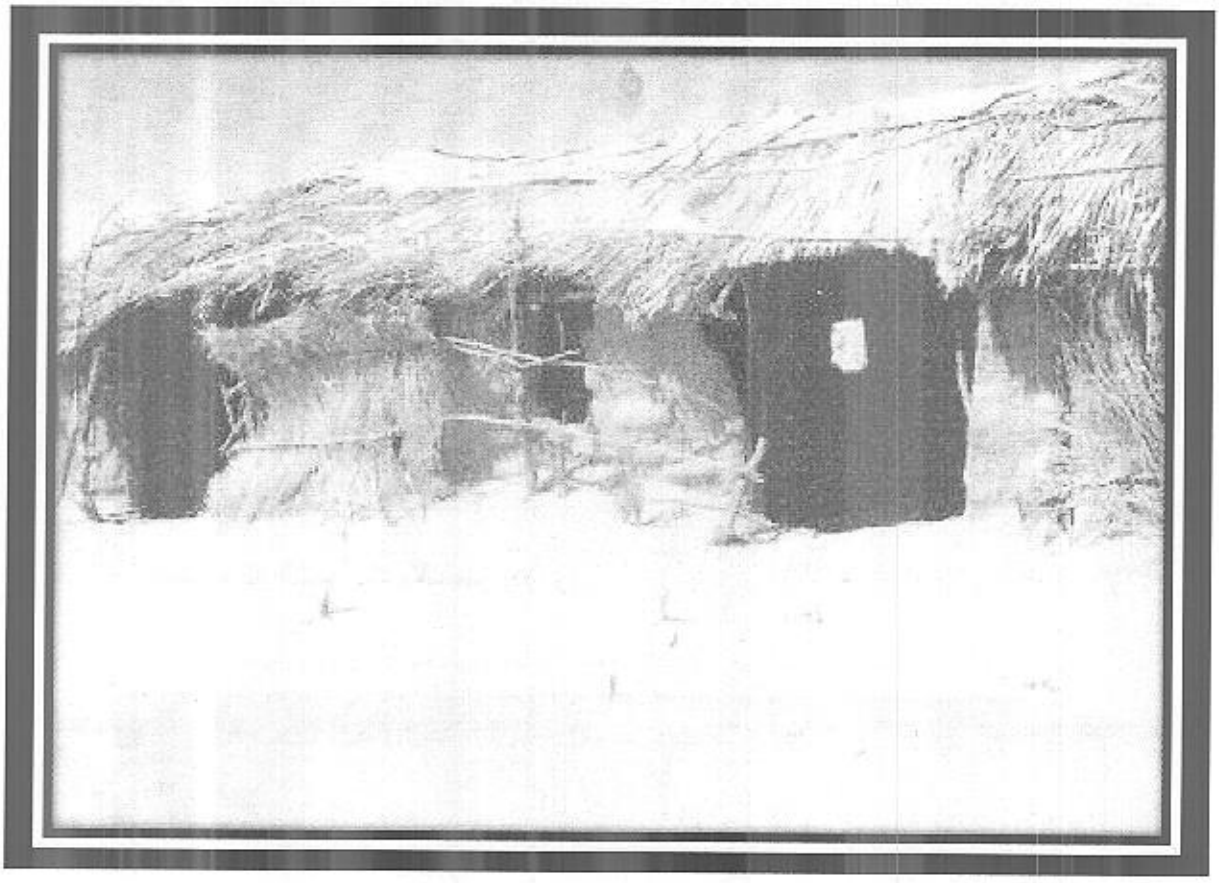


ب. فصل مدرسة بود جبر ــ ريفى الدويم فى مرحلة وضع السقف

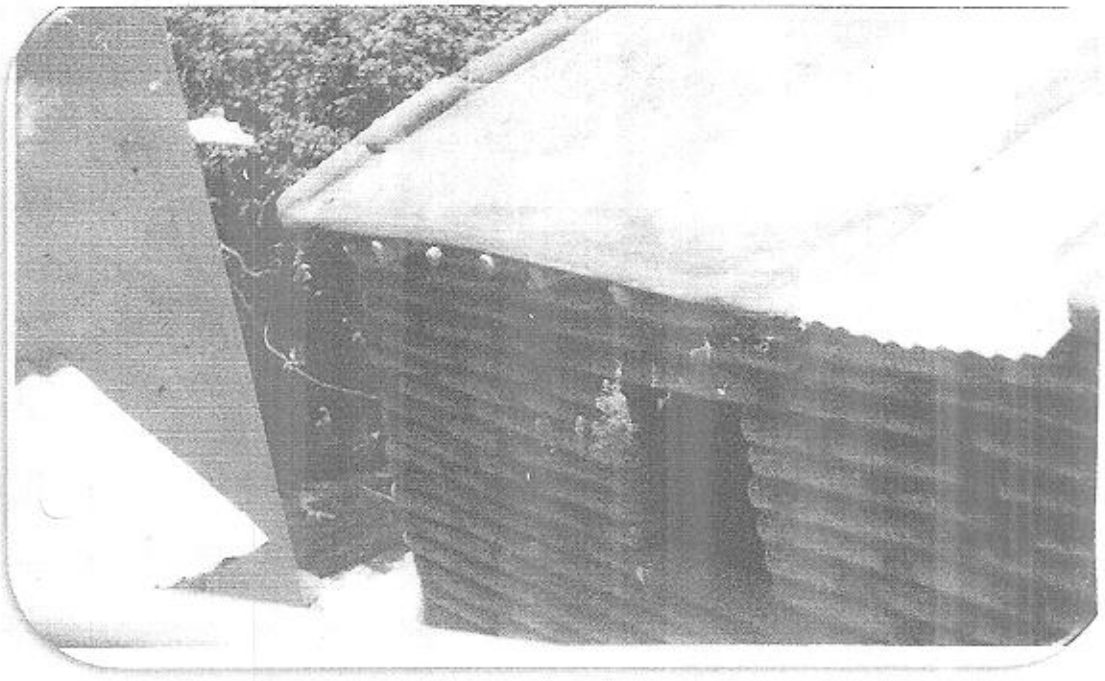
ج. إكتمل الفصل وبه التلميذات والمعلم يدرس



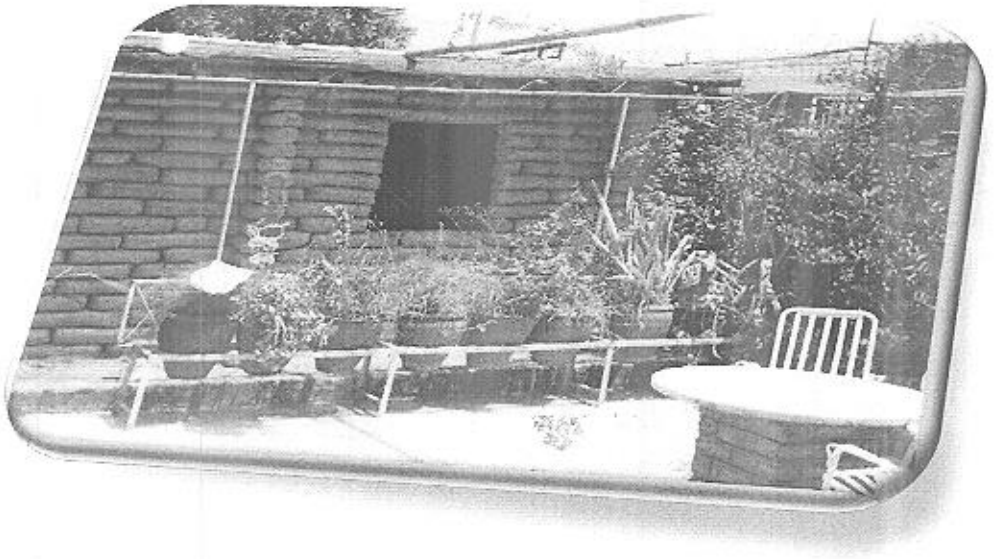
د. بُنى هذا الفصل بمبادرة ودعم من منظمة بلان سودان ــ برنامج ريفى الدويم ــ ومعه تم بناء ثلاثة فصول أخرى "كما جاء ذكر أماكنها من قبل" كما جرى تدريب عدد من البنايين. بلغت تكلفة الفصل أربعة عشر ألف جنيه، فى الوقت الذى كانت فيه تقديرات مهندس محلية الدويم ثمانية وعشرون ألف جنيه.



ه. الفصل القديم مبنى من المواد المحلية



و. كرنك وجراج بمنزل بروفسير محمد عثمان السمانى



ز. إضافة لما جاء ذكره، تم بناء نماذج أخرى شملت:

- مطعم بالرياض
- مبنى بالحديقة الدولية
- مكتب استقبال لبلان سودان
- منزل بالصالحة ــ أمدرمان
- مركزين للتنمية الريفية كما جاء ذكرهما من قبل، أحدهما بالصالحة قرب الدمازين، والآخر بالدبيبات بجنوب كردفان.

سمات مصاحبة

الحاجة للتقنية فى مجالات كثيرة:

- للاسكان منخفض التكلفة {حضرى وريفى}.
- البنيات التحتية، اقتصادية، خدمية، تنموية.
- لحالات ذات خصوصية كالابدال لاستخدامات الكتلة الحيوية فى الأماكن المتصحرة وتلك إلى تعانى من الحرائق.
- وفى تقنيات قابلة للتطوير كحصاد المياه.

تطبيق التقنية:

سهلة التطبيق للميزات الآتية:

- توفر المواد المستخدمة: رمل، جير، أسمنت، أكياس البلاستيك وأوتاد الخشب.
- سهولة عملية البناء: التدريب ليوم — ويومين يكفى.
- مصدر دخل لفقراء المدن والريف، إذ أن أجر العمل فيها يمثل ثلث التكلفة.

خلاصة:

أن التقنية: أصيلة، متينة، صديقة للبيئة، منخفضة التكلفة، تقبل الديكور وتصل لكل الاستخدامات، فى كل السودان، وأخريات كثر

نأمل أن تتحقق التقنية الميزات أعلاه

الملاحق

ملحق رقم (3)
شهادة من بلان سودان

Plan Sudan
Block No.7
House No. 177
Riyadh, Khartoum,
Sudan.

+(249) 11 225968
+(249) 11 227041
E-mail: plansudan@sudanmail.net
:sudan.co@plan-international.org

To Whom It May Concern

Dear Sir/ Madame,

This is to confirm that Professor Mohamed Osman Al Samani from the Environmental and Development Services consultancy firm has collaborated with Plan International Sudan and has promoted community based and environment friendly construction materials and design. Professor Al Samani has contributed technically and designed innovative methods in construction by developing and constructing four classrooms in Um Rimta locality through the usage of locally available construction material such as lime mixed with sand and a small amount of cement. The four classrooms located in the following villages:

1. Wad Jabor
2. Al Shigag
3. Al Gadisia
4. Abu Nowara

The innovation contributed to the technical capacity building of the local community construction workers, reduced the cost of the classrooms by more than 50 % (12,000 SDG compared to 25,000 SDG) by the usage of the locally available construction materials (lime and sand). These classrooms are currently functioning and used by the basic school pupils (boys and girls) and have contributed to child enrollment, retention and performance.

Yours Sincerely,

Donald McPhee
Country Director, Plan Sudan

ملحق رقم (4)
شهادة من دكتور عثمان الخير

Khartoum 25th December 2011

CERTIFICATE

I have had the chance to get to know closely, and deal with, the building technology innovated by Prof. M. O. Sammani, named Plastic Earth Bricks.

To start with, I am not surprised that somebody from outside the engineering realm probes to come up with solutions for engineering questions. On the contrary, this has arisen as a responsible response of a keen person engaged in rural development where he could feel the shear need for producing practical solutions.

This invention builds on the much desired advantages of the material earth, availability, workability, thermal behaviour, low cost, etc. etc. it has similarity with Nadir Khalil's earth bag technology which uses coiled earth (sansges) in cloth 'tubes'. I have also I had the chance to study that technology and follow the implementation of an experimental unit in Khartoum. I truly believe that Sammani version is more appropriated to our situation. The replacement of cloth with plastic bags in one improvement.

The technology leaves room for some improvement also. These are issues of proper earth selection for example, adaptation to roofs construction and some engineering or architectural modifications that may take place.

Nonetheless, I find the achievement so far realized by Prof Sammani so valuable that I intend to apply and promote this technique where it fits. I surely stand ready to give my full support and explanation whenever needed.

OSMAN M. ELKHEIR
Ph D, Arch-Director, Newtech Consulting Group
Co-Chairman ARC. PEACE International
00 249 9 1234 7097

ملحق رقم (5)
دراسة جيلوجية هندسية لمواقع الجير بمحلية النهود

S/C – Kon

(6)

En Nahud Cooperative Credit Project

GEOLOGICAL OCCURRENCE AND ENGINEERING PROPERTIES OF LOCAL MATERIALS FOR THE CONSTRUCTION OF WATER STORAGE TANKS

June, 1996

Environment and Development Services (EDS),
El Shark Hotel - Sharia El Gamhoriya,
P.O. Box 10408,
Khartoum / SUDAN.

1. INTRODUCTION :

1.1. Background :

The area investigated lies entirely in En Nahud Province of Western Kordofan State, bounded by latitudes 12^{0} 00' - 13^{0} 30'N and longitudes 27^{0} 30' - 28^{0} 15'E (Map Fig.1).

The area forms the SW corner of the thirsty triangle of Mazrub-Sodiri-Nahud. The area is underlain mainly by the Basement Complex rocks which are known to be water devoid. Intensive geophysical surveys coupled with hammer drilling indicated the presence of saline ground waters in some localities. The area is extensively covered by sand dunes and surface drainage systems are ill-developed.

Average annual rainfall varies from 300mm in the South to around 150mm in the North. Average annual evaporation reaches 2,500mm forming an annual water deficit of more than 2,000mm. The majority of rainfall either evaporates or infiltrates through the sandy soils. A small part of the rains is collected in clay depressions along interdunal hollows or along inland drainage systems. Such waters are short lived.

Historically rain water stored in Tebeldi trees used to be the main source of water for domestic supply in Hammar area. It was reported that up to 900,000 M^{3}

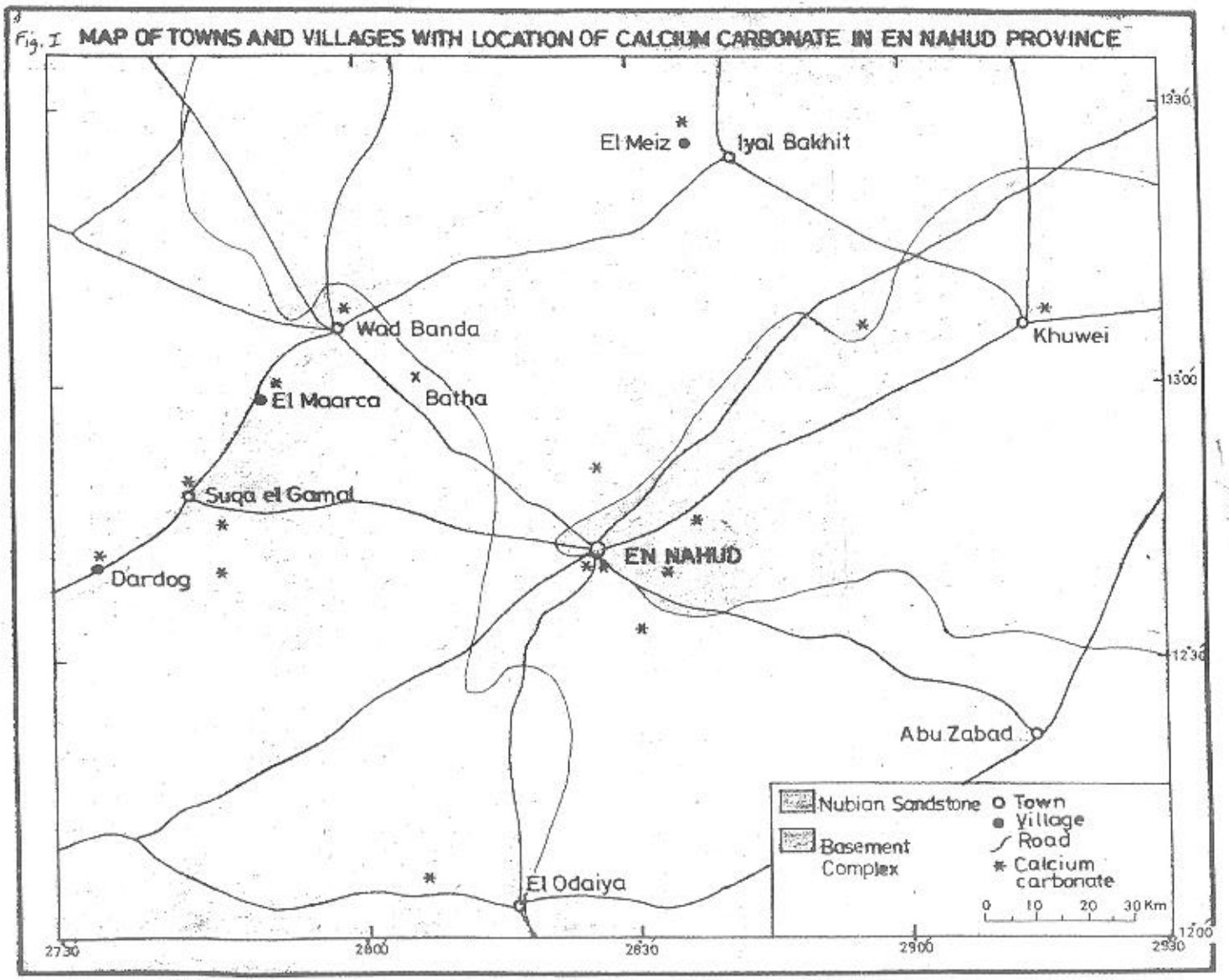


Fig. I MAP OF TOWNS AND VILLAGES WITH LOCATION OF CALCIUM CARBONATE IN EN NAHUD PROVINCE
El Meiz
Iyal Bakhit
Wad Banda
Khuwei
El Maarca
Batha
Suqa el Gamal
EN NAHUD
Dardog
Abu Zabad
El Odaiya
Nubian Sandstone
Basement Complex
Town
Village
Road
Calcium carbonate
0 10 20 30 Km
13°30'
13°00'
12°30'
12°00'
27°30
28°00
28°30
29°00
29°30

used to be stored annually. Due to ecological changes Tebeldi trees are drastically diminishing.

En Nahud Co-operative Credit Project (ENCCP) is exerting substantial efforts towards solving the domestic water supply problems. One of the solutions adopted by the project is supporting communities through availing credit to build concrete water storage tanks, with the purpose of storing rain-waters or tankered waters from the far existing water-yards.

The construction materials in use, at present, are cement, steel, sands and gravels and fired bricks. The practice is faced by many problems such as high costs and the importation of cement and steel to the area. Added to that the environmental problems resulting from tree cutting for brick-firing.

Calcium carbonate, locally known as Geer, had been widely used during the colonial period in the construction of government buildings in Nahud town. Water storage tanks 2 x 2 x 1.5m capacity and with a wall thickness of 30cm were built of Geer and sand in Wad Banda. They date back to the time of Darfur Pacification Campaign of 1916, built to store water for the army.

1.2. Study Objectives :

Environment and Development Services (EDS) having as one of its concerns the promotion of domestic water

supplies, finds investigating the use of Geer and other local building materials in the construction of water storage tanks, an ideal solution to the water problems of the project area for the following reasons :-

a) Availability of Geer and other building materials as stones, sands, gravels and clays in many places in the area.

b) The high costs and unavailability of imported materials, cement and steel.

c) Reduction of environmental hazards of tree cuttings for brick-making.

d) Promotion of the activity as a participative and community based technology.

1.3. Study Terms of Reference (TOR) :

The proposed project activities were phased into 3 stages, each emanating from the other, and all make the project proposal. The 3 phases are : i) investigation of the occurrence and engineering properties of local construction materials, ii) selection of two villages for piloting proto-type tanks, and, iii) Once the proto-types prove successful, mobilization of the project communities for construction of storage tanks at the needy villages.

The TOR for Phase I, the subject of this report, can be summarized into :-

a) Mapping of construction materials in the area with more emphasis on the Geer.

b) Sampling of locally used materials, if any, including the existing tanks at Wad Banda, for laboratory analysis, to verify their engineering properties and their suitability for the construction of water storage tanks.

c) Design of two prototype tanks to be constructed as pilot projects using local materials.

1.4. Study Team :

The study team was composed of two consultants :

- Dr. A.S. Daoud : Geologist.
- Mohamed E. Siddig : Civil Engineer.

2. GEOLOGIC OCCURRENCE :

2.1. Field Investigations:

To investigate the availability, occurrence, and use of local construction materials, the geologist spent two weeks in the field. The major centres of En Nahud, Odaiya, Suqa El Gamal, Wad Banda, Iyal Bakheit, Khuwei and their rural villages were visited. More emphasis was put on Geer, and samples, including Wad Banda tanks, were collected for laboratory analysis.

At the earlier stages of the field survey the following initial criteria was applied to indicate the presence of Geer :-

i) Occurrence of thick covers of Acacia Nubica trees, especially true when the material occurs at a depth of 1-1.5 meters.

ii) Presence of gray clay soils, mostly in interdunal hollows, when the depth to material is not more than 1 meter.

iii) Presence of white fragments and kanker around mice holes, which holds well, when the depth to material is less than 0.5 meters.

2.2. Material Investigated :

The construction materials investigated included Geer or calcium carbonate, stones, sands and gravels.

2.2.1. Calcium Carbonate (Geer) :

The most important finding of the field survey is the identification of the locally known Mungur-Mungur or calcium carbonate, which is the raw material for the manufacture of cement and lime. The geologic conditions and its reaction with diluted hydrochloric acid indicate its calcium carbonate nature.

The occurrence of calcium carbonate in the area, takes one of three forms :-

i) As compacted and relatively hard material, known locally as Mungur-Mungur.

ii) A powder form, separately occurring, or mixed with Mungur-Mungur.

iii) A very hard fragmentary form (Kanker) always found mixed with the powder type.

Compositionally, there are no differences between the three forms, all are calcium carbonate. The material

is neither a lime-stone nor a marble which is the crystalline form. Some varieties of the compacted form are similar to lime-stone but the processes of diagenisis and lithification were not complete.

The material is a lacustrine deposit, probably of Quaternary age, deposited in continental lakes prior to sand dune invasion. It is not known whether the material was deposited in a huge lake covering the whole region or in isolated small lakes distributed all over the area. The occurrence of the material, in the form of Kanker nodules, was reported from all over the Bara-Umm RuWaba-Renk trough, forming the transitional zone between the superficial deposits and the Umm RuWaba sediments. Within the project area investigations revealed the following results from the sites visited :-

a) En Nahud :

In Nahud town the material is found in Ban Gadeed, Abu Sitta, and Geddal, occurring in compact or powder forms. Around Nahud it occurs extensively in Iyal Zubeir in a compact form and at a depth of 20cm. in a layer of 85-100cm. thick underlain by a 15cm. layer of powder rich kanker fragments. The formation is underlain by a 10cm. thick layer of grey silt followed by a yellowish sand layer. Powder form rich in kanker fragments occurs in Rahad El Silik, while powder and compact forms occur extensively in Hillat Ismail.

b) El Odaiya :

No Mungur-Mungur or free powder forms were reported to occur in Odaiya town. In Higgeirat village, east of Odaiya, a white material with kanker nodules was tapped at a depth of 3.5m. in a newly constructed hafir. In Umm Khashmein village, west of Odaiya, a powder form layer of 50cm. thick occurs at a depth of 50cm. below ground surface.

c) Suqa El Gamal :

In Suqa El Gamal town, Mungur-Mungur is found at the depth of 75cm. and extends for 50 to 70cm. downwards. In Dardog, Gulla, and Sallam villages a compacted form occurs.

d) Wad Banda :

In Wad Banda town the powder form occurs extensively below 50 to 70cm. and extends for a thickness of more than 50cm. In El Maarka village, south of Wad Banda, compact form occurs at a depth of 75 to 100cm., and extends for more than 1 meter thick, followed by a layer of white sand with yellowish pebbles. In El Batha, near Wad Banda, both the compact and powder forms occur extensively and are exposed on the surface.

e) Iyal Bakheit :

Along the road from Nahud to Iyal Bakheit the compact form of the material occurs in Koreina village. No occurrence of the material was reported at the town, but a compact form was noticed in El Meiz village north of the town.

f) El Khuwei :

In Khuwei both the compact and powder occur extensively and are exposed at the Wadi bed within the town. Both compact and powder forms were reported to occur at El Khuwei rural villages.

2.2.2. Other Building Materials :

The most important building materials, other than the Geer, include building stones, gravels and clays.

a) Building Stones :

The building stones available in the area are the rocks of the Basement Complex, Nubian Sandstones, and lateritic stones.

= Rocks of the Basement Complex exposed in the area are mainly granitic rocks. Granitic and gneissic rocks are widely spread in the rural areas of El Odaiya. Higgeirat granites are very massif, with smooth tops and sides and widely spaced joints. Granitic rocks of Umm Khashmein are characterized by closely spaced joints and fractures. Quarrying of such rocks to obtain reasonable dimensions for building is an easy job. Granitic rocks with closely spaced joints and fractures cropping out east of Iyal Bakheit are extensively used as building stones.

= Rocks of the Nubian Sandstone Formation include mudstones, ferrugenous sandstones, pebbly sandstones and conglomerates. Nubian outcrops are widely spread in the area. Large Nubian

outcrops occur east of Nahud. Jebel Heidoub is composed mainly of mudstones, coloured in shades of deep purple to white, and capped by a thin bed of ferrugerous sandstones. The jointed mudstone blocks can easily be Quarried and shaped in addition to their durability. The jointed mudstones of Jebel Heidoub are extensively used as building stones. Sandstones and gravels are Quarried at Jebel Kirum NW of Nahud. Outcrops of Nubian rocks occur in the rural areas of Suqa El Gamal and Wad Banda.

Lateritic rocks are durable, impervious and easy for quarrying. They are widely spread and extensively used as building stones in Odaiya and Fula areas.

b) Sands, Gravels and Clays :

Fine to medium well sorted sands are available throughout the area forming sand dunes and/or sand sheets. Sands and gravels are available along the upper parts of the seasonal water courses or as outwash around the Basement and Nubian outcrops.

In every rainy season a layer of clay rich soil is deposited in natural fulas, hafirs and interdunal hollows. In El Beida, south of Nahud, clay rich soils were deposited in large depressions. In many localities clay material is found under a thin sand cover. More than 3 meters thick clay layers dominate El Odaiya area.

In recent years manufacturing of bricks is becoming wide spread in the area. In Nahud animal dungs are added to the clayey soils and soaked for few days. High Quality bricks are manufactured from the clay deposits of El Beida. The major constraints facing red brick manufacturing is the scarcity of water and fire-wood.

3. ENGINEERING PROPERTIES OF GEER :

3.1. Laboratory Tests :

To determine the engineering properties of Geer, laboratory tests were conducted in the Building and Road Research Institute (BRRI) of the University of Khartoum. The tests include grain size distribution, volume change (shrinkage), setting time, solubility, lime reactivity, and trial mix tests. The following results were obtained :-

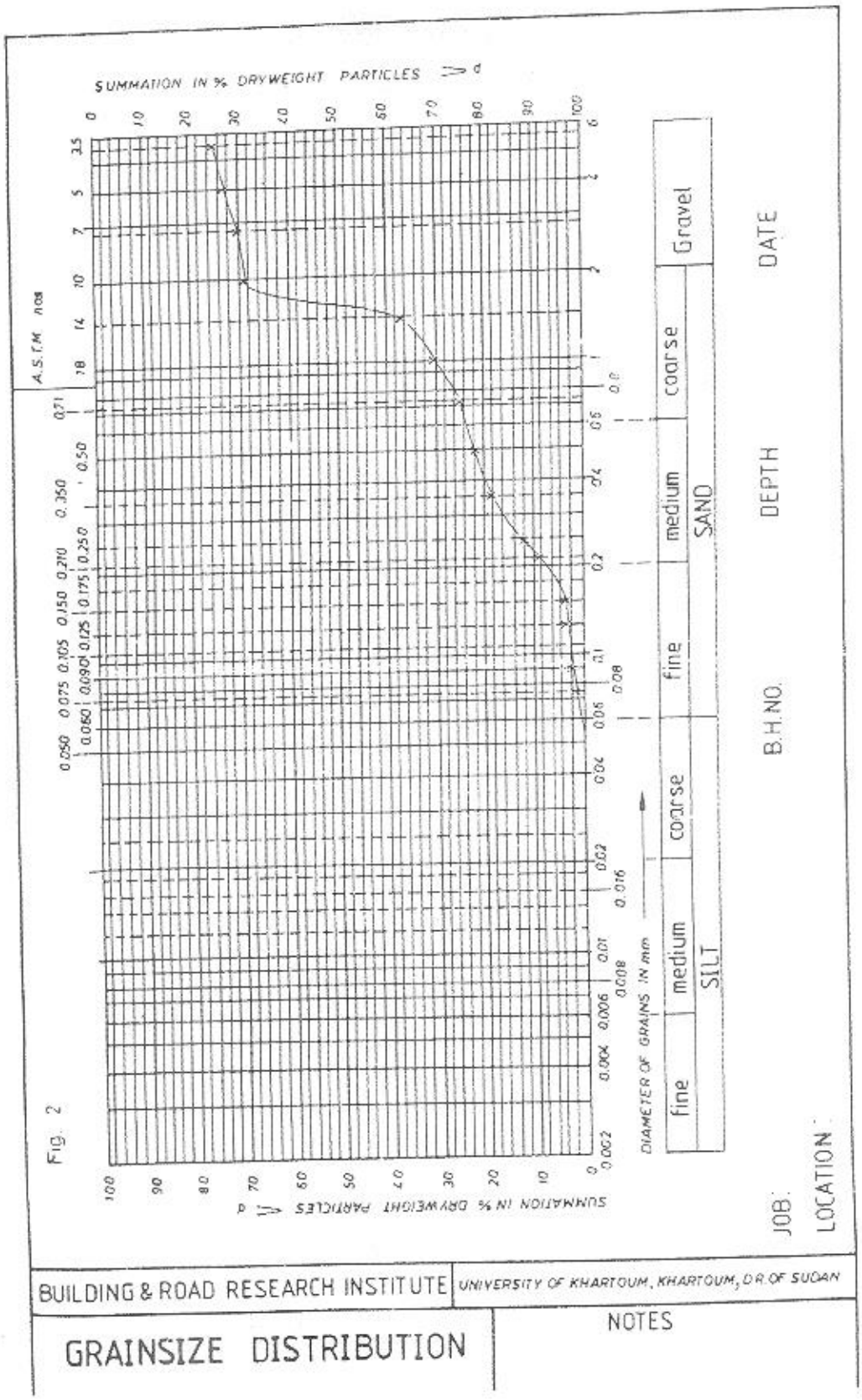
3.1.1. Grain Size Analysis (Fineness):

This was conducted on the powder form of the material and the following are obtained (Table 1 and Fig.2):

Diameter size greater than that of gravel	= 24%
Diameter size of gravel	= 7%
Diameter size of sand (coarse, medium and fine)	= 69%
Total	= 100%

3.1.2. Volume Change (Shrinkage) :

Total volume		= 15.00 cm^3
Decrease in volume		= 0.4 cm^3
Volume change	= $\frac{0.4 \times 100}{15.00}$	= 2.67%


SUMMATION IN % DRYWEIGHT PARTICLES
A.S.T.M. nos
SUMMATION IN % DRYWEIGHT PARTICLES
DIAMETER OF GRAINS IN mm
fine
medium
coarse
fine
medium
coarse
Gravel
SAND
SILT
Fig. 2
JOB:
LOCATION:
B.H.NO.
DEPTH
DATE
BUILDING & ROAD RESEARCH INSTITUTE
UNIVERSITY OF KHARTOUM, KHARTOUM, D.R. OF SUDAN
GRAINSIZE DISTRIBUTION
NOTES

3.1.3. Setting Time :

Consistency (water content)	= 35%
Initial setting time	4 hrs 37 min.
Final setting time	8 hrs 57 min.

3.1.4. Solubility :

The material is soluble in Water, but the solubility decreases when :

i) The material is compact.
ii) The water current is weak.

All the above tests were carried on the powder form of the material.

3.1.5. The Burning Test :

The burning test to produce lime was carried out on the compact form. The test gave the following reaction :-

$CaCo_3$ Heat $CaO + CO_2$

The maximum temperature	= 950 °C
Weight before burning	= 2019.48 gm.
Weight after burning	= 1178.31 "
Loss by ignition	= 841.17 "
Lime produced	= 58.95%
Loss by ignition	= 41.05%
Lime purity	= 94.74%
% of impurities	= 5.26%

3.1.6. Lime Reactivity Test :

When 600 ml. of water was added to 150 gms. of CaO the temperature change with time was recorded. The maximum temperature of 98°C was reached after six minutes only. Hence the lime is very reactive and the CaO completely reacted with water to form $Ca(OH)_2$.

$$CaO + H_2O \longrightarrow Ca(OH)_2 + Heat.$$

Time (minutes)	Temperature (°C)
0	37
2	39
4	84
6	98
8	96
10	96
12	95
14	93
16	92
18	90
20	88
22	87
24	85
26	84
28	84
30	80

3.1.7. Trial Mix Tests :

The following tests of strength and volume change were conducted on mixes of lime with cement and the powder form with cement.

3.1.7.1. Strength of Pure Lime :

Strength 1.2 tons = 2.34 Kg/cm^2 = 0.23 N/mm^2

3.1.7.2. Cement + Lime in the Ratio 1:2

Strength 2.8 tons = 56.89 Kg/cm^2 = 5.56 N/mm^2

Volume change = 1.78%

3.1.7.3. Cement + Lime in the Ratio 1:4

Strength = 1.7 tons = 33.77Kg/cm^2 = 3.31 N/mm^2

Volume change = 2.5%

3.1.7.4. Strength of Pure Powder Form :

0.18 tons = 3.68 Kg/cm^2 = 0.36 N/mm^2

3.1.7.5. Cement + Powder form in the Ratio 1:2

Strength 3.3 tons = 66.21 Kg/cm^2 = 6.5 N/mm^2

Volume change = 1.43%

3.1.7.6. Cement + Powder form in the Ratio 1:4

Strength = 1.4 tons = 30.77 Kg/cm^2 = 3.02 N/mm^2

3.1.8. Strengths of Pure Cement :

3.1.8.1. Cement from China :

Strength after 3 days = 180 Kg/cm^2

Strength after 28 days = 305 Kg/cm^2

Strength after 7 days(70% of 28 days) = 213.5 Kg/cm^2

3.1.8.2. Atbara Cement :

Strength after 3 days = 290 Kg/cm^2

Strength after 28 days = 320 Kg/cm^2

Strength after 7 days(70% of 28 days) = 224 Kg/cm^2

3.1.8.3. Sea Bulk Cement :

Strength after 3 days = 317 Kg/cm^2

Strength after 28 days = 485 Kg/cm^2

Strength after 7 days(70% of 28 days) = 339.5 Kg/cm^2

3.1.8.4. Rabak Cement :

Strength after 3 days = 205 Kg/cm^2

Strength after 28 days = 470 Kg/cm^2

Strength after 7 days(70% of 28 days) = 329.0 Kg/cm^2

3.1.9. Comments on the Results :

Reference to laboratory tests, the following comments can be made :-

- Although gravel sizes constitute 24% of the powder form, it can be easily crushed to the fine sand size.
- Volume change (Shrinkage) being as low as less than 3% can further be reduced when mixed with sand for mortering.
- The setting of 4 to 9 hours is considered reasonable.
- The material, $CaCO_3$, is soluble in water and should be prevented from direct water contact by cement plastering.
- Lime purity of 95% is high and contains no harmful ingredients as sulphur, iron, etc..
- The strength of the powder form (3.68 Kg/cm^2) is higher than that of lime (2.34 Kg/cm^2) and it is advisable to use the powder form without burning.
- The powder form when mixed with cement in the ratio of 4:1 gave a volume change of less than 2% and a strength of 31 Kg/cm^2, indicating its suitability for constructional purposes.

3.2. Water Storage Tanks :

3.2.1. Design Criteria :

In designing the proto-type tanks the following criteria were adopted :-

- The circular base tank is geometrically considered more strong and pressure resistant.
- Depth of the tank should suit the loose sandy formation.
- The tank capacity should suit minimal surface run off (sheet flow) and water stored should be silt free; and with minimal evaporation losses.
- Tank capacity is to meet domestic requirements for at least one family, for a period of 3 months.
- Availability of local construction materials such as building stones, $CaCO_3$, sand, etc..

3.2.2. Design Features :

The design features comprise the storage tank, filter and roof, (Fig. 3.1 - 3.2).

Tank :

- Circular shape 3.6 - 2.1m. I.D., 4 meters deep and 0.5m. above ground level.
- Masonary walls 0.35m. thick build from stones and lime mortar 1:5 mix, soaked for 7 days.
- Internal plastering of walls with Portland cement (1:4) of 1cm. thick, and base plastering 2cm. thick.
- Wall fixed stairs for cleaning.

Filter :

- Rectangular in shape, 1m. deep, 1.5m. wide, 7.5-35m. long; wall thickness of 0.35 meters, with masonary base.
- Filled with well rounded clean coarse aggregates and fine sand.
- Collection channel to catch sheet flow.
- Sliding gate to avoid high silted water and to provide the required amounts.
- P.V.C. inlet pipe 4" Ø .

Thatch matting Roof :

- Made from local materials : timber, straw, etc.. covered internally with polyethelene sheets to prevent surface contamination and water evaporation.

To avoid surface contamination during water hauling a suction pump can be used to draw water. To ensure complete dewatering a hole of 4" Ø and length of 50cm. can be made at the tank base to accommodate the pump filter. The suction pump can be produced locally in Nahud workshops.

3.2.3. Construction Costs :

= Based on commercial prices of local and imported materials, labour costs, tentative costs for a 10 M^3 and 30 M^3 capacity tanks costs are given in Table 2.1 and 2.2. It is to be noted that the cost per M^3 storage decreases drastically as the total capacity increases.

= The community can contribute by labour provision This will reduce the cost by one third.

Table 2.1. : Cost estimate for 10 M^3 Tank.

Item	Description	Unit	Quantity	Unit Cost Ls.	Total Cost Ls.
A	Hand Excavation:				
A1	For storage tank	M^3	31	3,000	93,000
A2	For Filter	M^3	7	2,000	14,000
B	Masonary in 1:4 Lime Mortar :				
B1	For storage tank 0.35m.	M^2	44	5,000	220,000
B2	For Filter 0.35m.	M^2	24	5,000	120,000
C	Plastering in 1:4 cement, 0.01m thick. :				
C1	For storage tank	M^2	36	2,000	72,000
C2	For Filter	M^2	20	2,000	40,000
D	Filter Media Supply and Place :				
D1	Coarse aggregate 1 - 3"	M^3	2	6,000	12,000
D2	Fine clean sand	M^3	1.5	2,000	3,000
E	Sliding Gate 0.8 x 0.6(m) x 3mm.	No.	1	7,000	7,000
F					
F1	P.V.C. Pipe 4" Ø	M.	1.5	2,000	3,000
F2	P.V.C. elbow 90°	No.	1	10,000	10,000
G	Thatch matting roof 3m. diam. 1m. height	No.	1	25,000	25,000
I	Building stone	M^3	25	3,000	75,000
J	Building sand	M^3	10	1,500	15,000
K	Lime	Tin	80	1,500	120,000
L	Cement	Sack	4	10,000	40,000
M	15mm. Ø bars	No.	1	6,000	6,000
	Total				975,000

= The use of hydrated lime as mortar reduces the total cost by almost one third. The use of powder form without burning will again reduce the cost by at least 10%.

3.3. Conclusions and Recommendations :

- The compact form of Mungur-Mungur is extensively used as a building stone because of its durability and easiness to shape. The powder form, mixed with animal dungs, is extensively used as a plastering material to protect walls from the erosive action of heavy rains.

- The compact form is burned to produced hydrated lime which is also used for tanning leather.

- Water storage tanks were built from Mungur-Mungur as building stones, using mud as mortar and plastered with cement.

- Water storage tanks built using sandstones and lime mortar at Wad Banda in 1916 are still persisting.

- Building materials as stones, clays, gravel and sand are available throughout the project area.

- Calcium carbonate materials proved to be suitable for constructional purposes. They can be used as mortar or mixed with cement for plastering.

- The powder form should be used without burning. This will reduce the cost and environmental hazards.

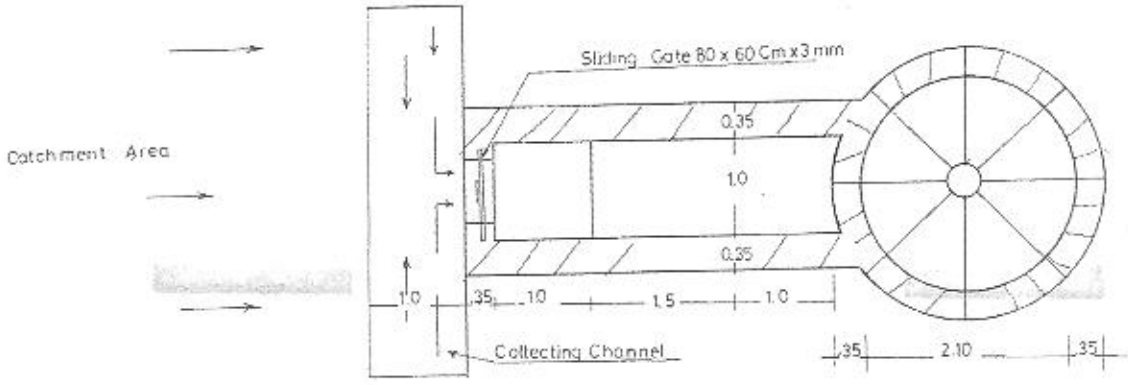
- The present practise of using corrugated iron sheets as a tank cover reflects more heat and increases evaporation. The proposed thatched roof with an internal polythene membarance is more cheaper and highly efficient.

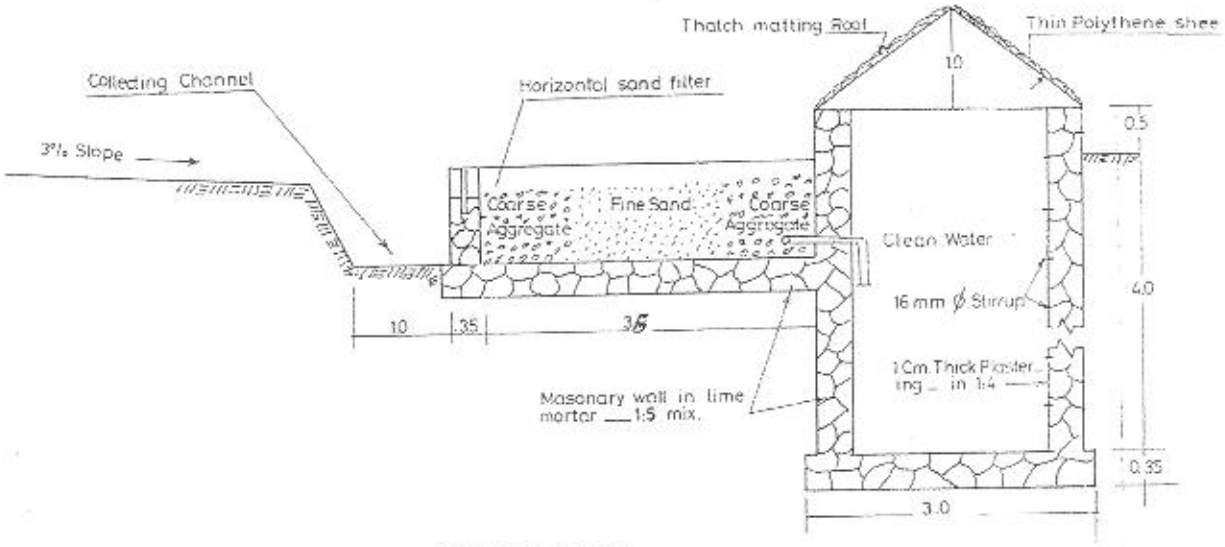
- The proposed designs are tentative designs and need to be improved based on piloting results. A series of tanks can be tied to a specific catchment area and with some kind of watershed management.

- Finally, the implementation of such tanks shall promote community benefits including, availing water during the dry period, creation of job opportunities, checking population out-migration, and ensure better utilization of available natural resources.

Fig.. 3-1 CIRCULAR MASONARY UNDER GROUND TANK

CAPACITY=10m³ SCALE:- 1:50





ENG. Mohd El Mahdi

ENG. Abdalla Hassan