American Research Center in Egypt
Egyptian Antiquities Project

"Conservation and Display of Roman Mosaics
Kom el-Dikka, Alexandria"

3rd Progress Report
Completion Report for Shelter Construction

submitted by Dr Wojciech Kołątaj, the Project Director
November 5, 1998

This report was prepared for
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under USAID Grant No. 263-0000-G-00-3089-00

CONTENTS

Dr. Wojciech Kołątaj

1. INTRODUCTION:

This Report covers designing and construction work carried out under the ARCE/EAP Grant during the third phase of the Project lasting from July 21 till October 31, 1998. Process of mosaics conservation as well as partial reconstruction of walls of the house *alpha* and construction of casing walls are not dealt with in present Report.
Shelter construction is already advanced in ca. 95 %.

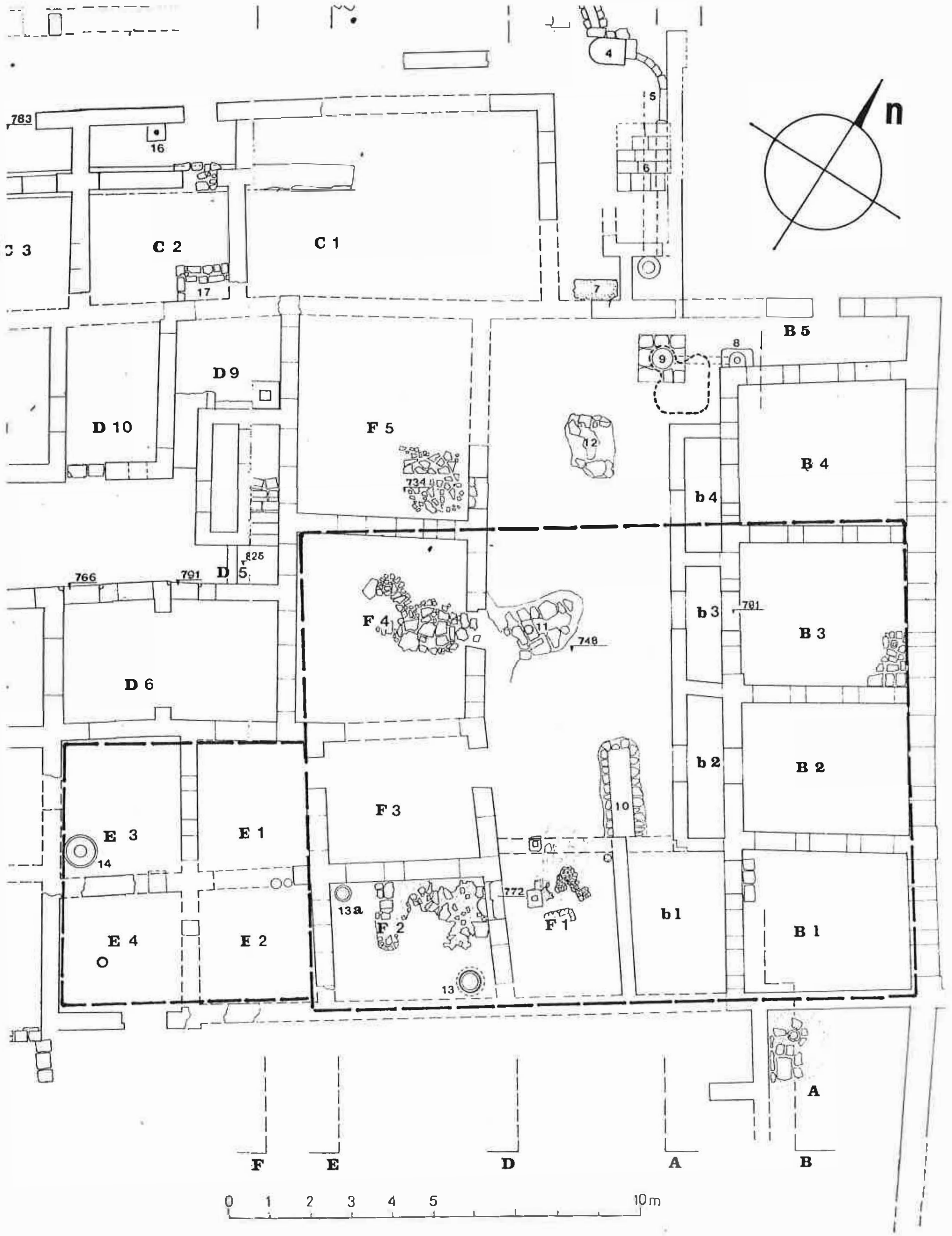
I would like to point out that all the photographs illustrating both present and previous Reports were made by Dr. Edwin Brock - photographer of the Project.

2. CONDITIONS FOR DESIGNING:

Present Project aims at preservation and exhibition of floor mosaics belonging to an Early Roman house situated on the south-eastern edge of the Kom el-Dikka site. Mosaic are located some 6,5 m above the sea level, i.e. ca 9 m below the level of the nearby Saphia Zaghloul street. Modern sewage system is laid much higher than the mosaic level and therefore can not be used for draining rain-water. This situation is also aggravated by the fact that floors of the Early Roman house are placed some 1,7 m below ground level of the surrounding relics of Byzantine buildings (houses B, F and D). (**Plan No 1**).
Fragment of the house Alpha excavated in 1972-1973 consists of four rooms adjoining paved courtyard. All rooms are embellished with mosaic floors featuring different designs and techniques. Walls of the house built in *opus quadratum* technique (blocks 0,50 x 0,50 x 1,00 m) were apparently dismantled following the earthquake in AD 365. (**Phot. 1, 2**). Following the provisional protection of the mosaics, the excavated trenches were filled in 1974. As a result of current research conducted under the EAP Grant it has been established that the mosaic in the main room of the house (*alpha-3)* extends well to the west, below foundations of the nearby Byzantine building. The western wall of this later building is now dismantled and the whole extent of the mosaic revealed. (For results of archaeological work see: **2nd Progress Report**).

This new discovery had an essential impact on overall design of the planned shelter. The initial design was modified and improved to meet new requirements.

Apart from the three mosaic floors preserved in *situ* it is planned to exhibit two more mosaics transferred from another locations: one from the southern, inaccessible part of the House *alpha* and yet another one from the Early Roman Villa discovered in the area of the Theatre.



763
16
C 3
C 2
17
C 1
4
5
6
7
B 5
8
9
D 9
D 10
F 5
734
12
B 4
b 4
825
766
791
D 5
F 4
11
748
b 3
701
B 3
D 6
10
b 2
B 2
E 3
14
E 1
F 3
772
13a
F 2
F 1
b 1
B 1
E 4
E 2
13
A
F
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A
B
0 1 2 3 4 5 10 m
n

PLAN 1

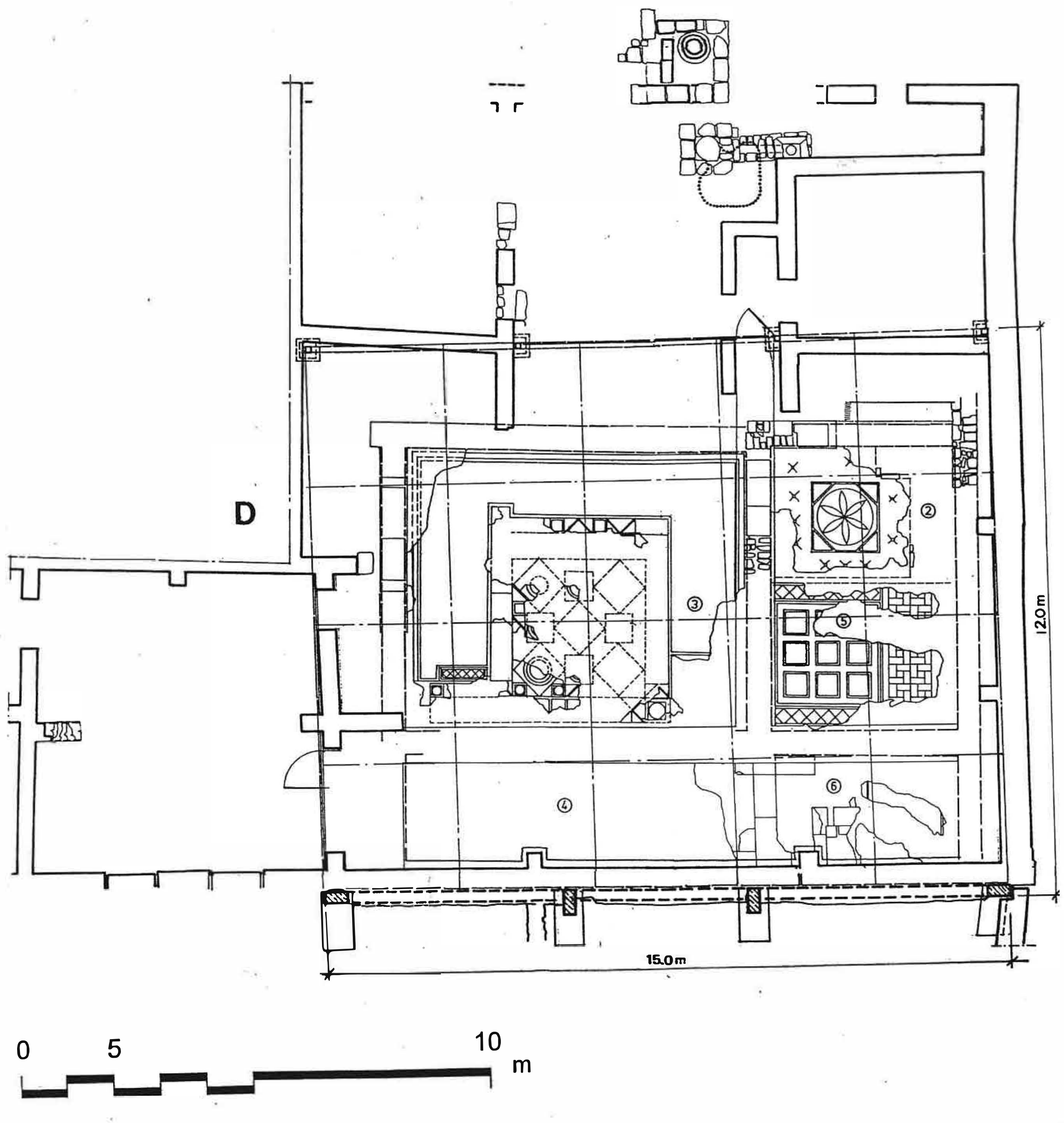
3. SHELTER DESIGN UPDATING:

Shelter measuring ca 15 x 12 m was designed to protect a group of Early Roman mosaics against external atmospheric conditions. Both the roof supporting structure and glass walls of the shelter are not structurally coupled with earlier relics of the Byzantine buildings. The shelter has been built, as if inserted between the existing walls either original or restored.
Specification of steel sections and corrugated sheet iron available on the market as well as some structural requirements implied a basic structural module of 3 x 3 m to be applied. This module enables almost perfect adjustment of the shelter to the existing ancient relics.(**Plan No 2**)
Gabled roof rests from the north on pillars and steel beam, and from the south on pillars and reinforced concrete beam. This differentiation results from the necessity to combine two functional features in a single architectonic unit: roof supporting structure and retaining wall supporting the slope from the south. Pitched roof refers closely to antique tradition, nevertheless no attempt was made to imitate it. Roofing was designed as covered with corrugated sheet iron in natural colour of weathered limestone and not the traditional roof-tiles.
Roof does not adjoins directly the Byzantine walls; it is separated by a strip of glass panels or beams of independent supporting structure. Roof has no eaves, its surface passes directly into glass walls surfaces, thus giving an overall box effect.
The height of the shelter comprised between level of the mosaics and the ceiling amounts to 4,90 m. The mosaics are, however sunk in relation to the ground level and the level of the foot-bridge. This feature creates visual effect of overall height conforming better to the standards of ancient house. Absence of visible internal supports and flat, white ceiling enables to avoid any visual interference with existing architectural relics.
Substantial difference of levels between mosaics and foundations of the surrounding Byzantine structures (ca. 1,60 m) caused the surrounding soil profile to be dangerously exposed. This situation called for either partial reconstruction of walls of the Early Roman House *alpha* or construction of casing walls. Both these methods were applied according to local requirements.

4. STRUCTURE OF THE SHELTER

As it had been mentioned already, the shelter was designed to adjust to existing walls of the Byzantine buildings. Their preserved height determines the least possible height of the shelter. In places where Byzantine walls were preserved in lower courses only, new walls made of security glass panels (1,0 x 2,50 m) will be introduced.

The roof supporting structure consists of reinforced concrete beam placed on four reinforced concrete pillars measuring 0,26 x 0,50 m, and 5 m tall. At the same time, those pillars make also an important fragment of retaining wall. Both outer pillars were set with their longer side attaching the Byzantine walls. Intermediate pillars were built perpendicularly to the said wall in order to counteract the pressure of the escarpment. (**Phot. 3, 4; Attachment: draw. No 1 and calculations**)



PLAN 2

- Reinforced footings of the pillars were shaped as a platforms some 0,30 - 0,40 m thick, measuring 1,20 x 0,60 m. This type of construction protects the whole structure against tilting caused by escarpment. The footing reaches some 0,40 - 0,50 m below level of mosaics. The retaining wall widening an existing Byzantine wall from the south was built of limestone blocks joined with lime-cement mortar (1:2:5). Both structures were separated and insulated with two-layered polystyrene foil. **(Phot. 5, 6)**

- Southern concrete beam measuring 0,26 x 0,35 m was reinforced in tensile working cross-sections with steel fabric Q_R 3600 kg/cm^2 2 x ϕ20 + 2x ϕ 16, and in other non loading sections: 2x ϕ 16. Shackles (ϕ 6) set every 25 cm were used. **(Phot. 7, 8, 9, 10)**

- Northern beam was made of channel bars 2x [140 welded on top of steel pillars [140. Outer pillars were made of welded channel bars 2x [140, middle pillars were additionally filled with concrete. Foundations of the rigidly fixed pillars were made of concrete in shape of truncated pyramid,(base: 0,80 x 0,80 m, upper surface: 0,40 x 0,40 m, height: 0,80 - 0,75 m.). In order to enable dismantling, pillars were wrapped with triple folded foil coated with lubricant. Concrete foundations were laid below footing of the Byzantine walls, in the filling layers. **(Phot. 11, 12, 13, 14)**

- Tracing and levelling of both constructions was made by means of teodolite surveying with mean accuracy of $\pm$ 0,5 cm.

- Roof structure based on 3 x 3 m module was made of truss-girders 12 m long, constructed of welded steel 2 x L 50 x 50 x 5 according to computer made calculations. Trusses (h_{max} = 1,2 m; h_{min} = 0,6 m) were fixed in 3 m distances along the E-W axis. Halves of the prefabricated trusses were reassembled and welded on site at the ceiling level and moved to prescribed positions. **(Attachment: draw. No 2 and calculations). Phot. 15, 16.**

- Vertical braces at the ends of trusses and in the level of roof ridge were made of channel bars [60. Horizontal braces in outer northern and southern modules in the plane of upper bands was made of channels [60. Purlins spaced at 1 m were made of channels [80 bolted to angle bars welded in turn to top flanges.

- Roof is covered with corrugated sheet iron (sheets: 6 x 1 m, 0,5 cm thick). Sheets will be coated with creamish stoving varnish and bolted every 0,5 m in lines set 3 m apart. (**Phot. 17, 18**), *19, 20.)*

- Thermal insulation made of Styrofoam panels 2,5 cm thick is to be fixed to the bottom of purlins.

- Following the raining season and verification of possible leaks, wire netting carrying the ceiling will be attached to 4 x 4 cm angle bars welded to the bottom flange of the trusses. Ceiling will be made as a two-coat lime-cement plaster work finished with smoothed gypsum coating and divided into four large panels.

- Roof gable walls will be made of smoked glass (plates 8 mm thick and 1 m long) in conformity with basic division of panel glass walls. Buttings of trusses from the south and north will be screened with a strip of corrugated sheet iron. Gutters are to be fixed on both roof edges: the northern one sloping towards the east and southern sloping towards the west.

5. PANEL GLASS WALLS

- Adjoining rooms E1, E2, E3 and E4 of the Byzantine building will be adopted as a entrance vestibule (ca 36 sq. m) leading to the shelter. Vestibule will be arranged as a garden patio embellished with palm tree and equipped with benches. Ivy or other climbers will be introduced on northern wall of the Building D. Panel glass wall (6 x 3,5 m) with the main entrance to the shelter will close the vestibule from the east.(**Attachment: draw. No 3**). Western glass wall of the shelter will incorporate relics of Byzantine wall dividing houses E and F. For constructional reasons the glass wall will be divided by a horizontal steel frame □ 60 x 60 set at the level of 2,5 m above the ground.

- Interior of the shelter will be naturally lighted up from north and west through glass walls, and from the east through an elongated window positioned between wall coping of the Byzantine building B and the ceiling. There will be no windows in any form from the south.

- Mid section of the northern wall (measuring 6 x 3,5 m) will be divided by horizontal bar fixed at the level of 2,5 m above the ground and vertical bar placed 1 m off the room B3 of the Byzantine building. Exit from the shelter will be located between the wall of this room and the bar. All segments of the glass wall will be executed in security glass 1 cm thick fixed on top and at the bottom with no vertical couplings.

- Several glass panels above the horizontal frame will be made hinged along vertical axis, this feature ensures better ventilation of the shelter. Lower edges of the panels will be equipped with drips. Overall surface of those windows will be determined experimentally following the completion of roof and ceiling. Their surface could be enlarged if necessary.

- Glass panels will be assembled following completion of conservation work in January-February 1999. All necessary materials had been purchased already.

6. FOOT-BRIDGE CONSTRUCTION:

The foot-bridge placed ca. 1 m above level of the mosaics enables visitors to take pictures and at the same time protects mosaics against possible damage. It is traced along angular line joining the entrance and the exit and positioned directly over the walls making southern and eastern limit of the *triclinium*. The level of the foot-bridge is 3 steps lower than the entrance platform and the exit.

The foot-bridge will be built as a wooden floor fixed to steel sections I 160. Width of the bridge enables undisturbed traffic of visitors in a single file. The shape of railing is not decided as yet; it could be made of jute ropes. Fixed railing (wood or iron) could conflict with neutral character of the interior.

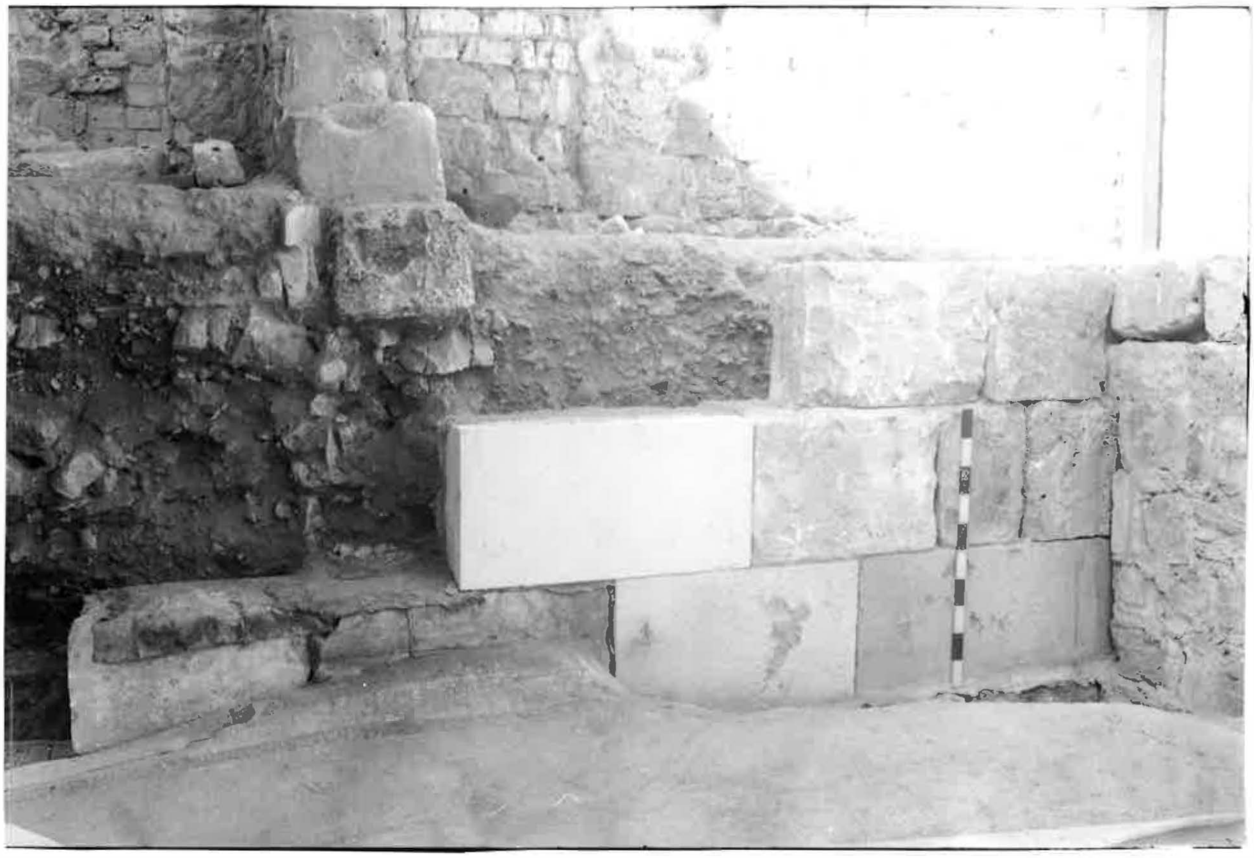
7. DRAINING SYSTEM:

It was decided to solve the problem of draining by re-using Byzantine sewage system. The rain-water from the southern part of the roof will be drained off directly to the ancient sewage system while the water from the northern part will be drained off to the nearby wells and underground cistern.
Ancient sewage system running along the R4 street has already been partially cleared and successfully used for draining. Both wells reach subsoil water table. In case of overflow, the cistern will be used as a stand-by reservoir.
Given the relatively limited dimensions of the roof combined with good soil permeability and grass overgrowing surrounding slopes, the whole area will be sufficiently protected against inundation.

Photographs

Edwin Brock

1, 2

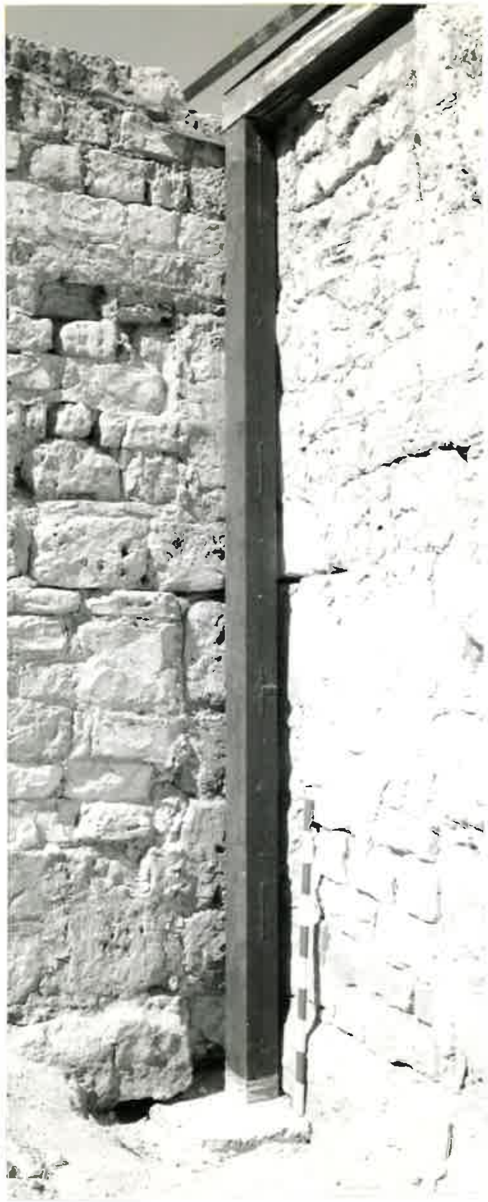
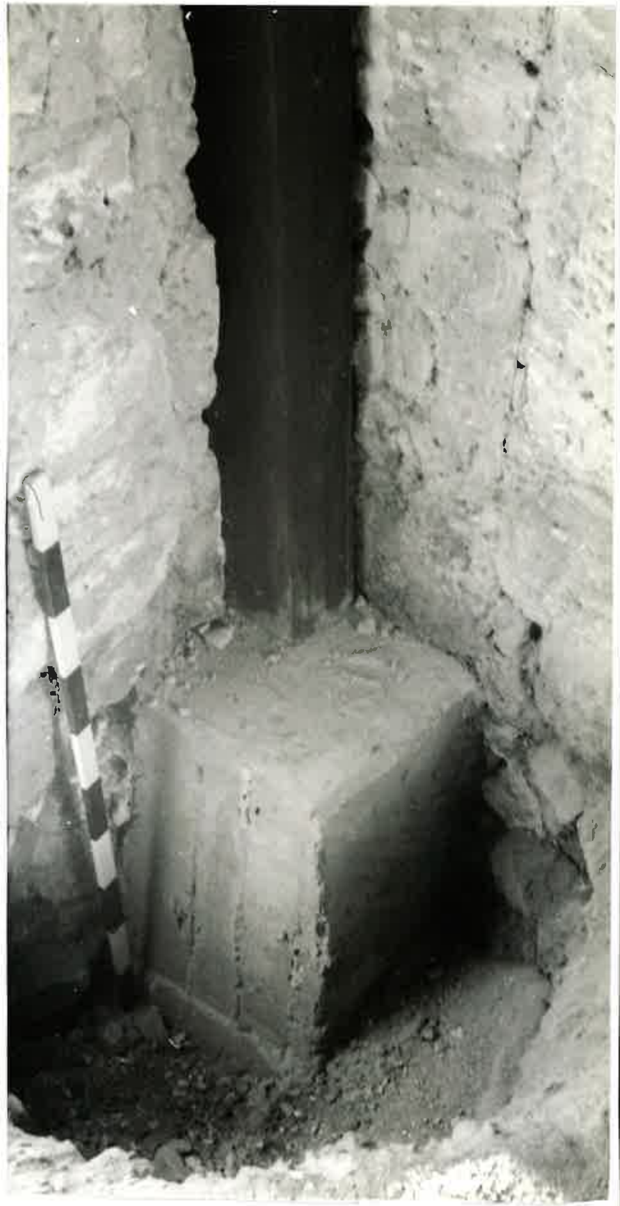


3, 4

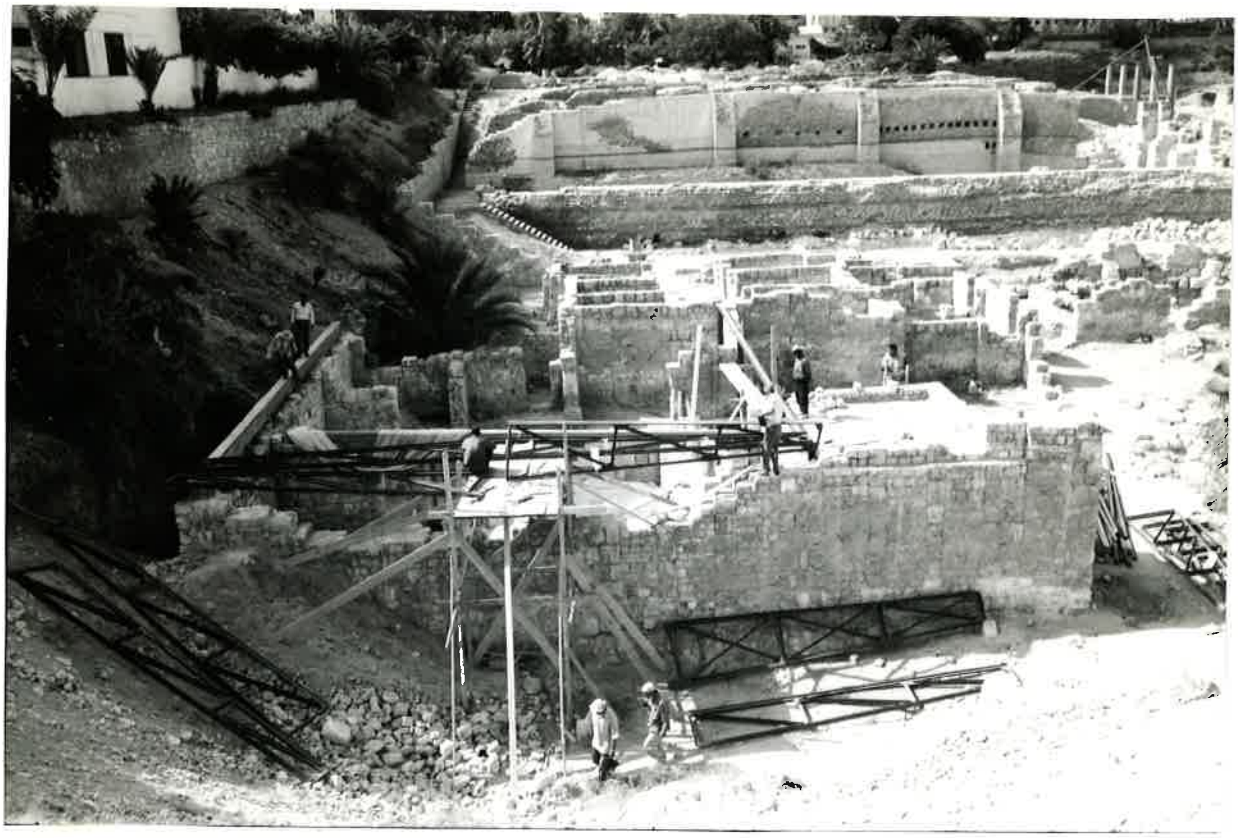
5, 6

7、8



11، 12، 13، 14



17, 18

19, 20

ATTACHMENT #1

(Roof supporting structure drawings and calculations)

Loading

Cover = 10 X 3 = 30 Kg./m´

Purlins = 5 X 3 = 15 Kg./m´

Bracing = 5 X 3 = 15 Kg./m´

O.W. = 75 Kg./m´

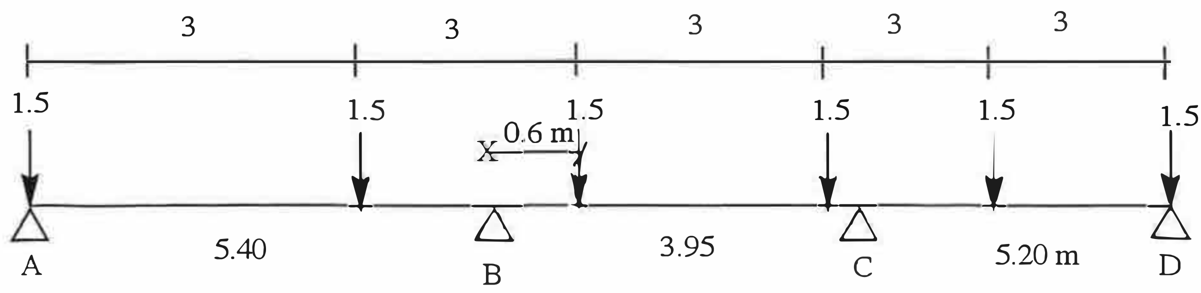
Plaster & Stell net = 50 Kg./m´

L.L. = 50 Kg./m´

W = 30 + 15 + 15 + 75 + 50 + 50 = 235 Kg./m´

for weld = 15 Kg./m´

Total = 250 Kg/m´



Own wt. = 0.25 x 0.5 x 2.5 = 0.3 t/m'

$$M_{Bmax} = \frac{2\,(3)\,(\overline{5.4}^2 - \overline{3}^2) \qquad (3.95 + 5.2)}{5.4\,[\,4\,(5.4 + 3.95)\,(3.95 + 5.2) - \overline{3.95}^2]} \times 1.5$$

$$+ \frac{0.6\,(3.95 - 0.6)\,[2\,(\,3.95 + 5.2)\,(\,2 \times 3.95 - 0.6) - 3.95\,(3.95 + 0.6)]}{3.95\,[4\,(5.4 + 3.95)\,(3.95 + 5.2) - \overline{3.95}^2]} \times 1.5$$

$$+ \frac{3{:}6\,(3.95 - 3.6)\,[2\,(\,3.95 + 5.2)\,(\,2 \times 3.95 - 3.6) - 3.95\,(3.95 + 3.6)]}{3.95\,[4\,(5.4 + 3.95)\,(3.95 + 5.2) - \overline{3.95}^2]} \times 1.5$$

$$+ \frac{2\,(0.3\,)(5.4)^3\,(5.4 + 5.2)}{2\,[4\,(5.4 + 3.95)\,(3.95 + 5.2) - \overline{3.95}^2]}$$

$$+ \frac{0.3\,(3.95 + 2 \times 5.2) \times \overline{3.95}^2}{4\,[4\,(5.4 + 3.95)\,(3.95 + 5.2) - \overline{3.95}^2]}$$

$$= \quad 2.42 \quad t.\ m.$$

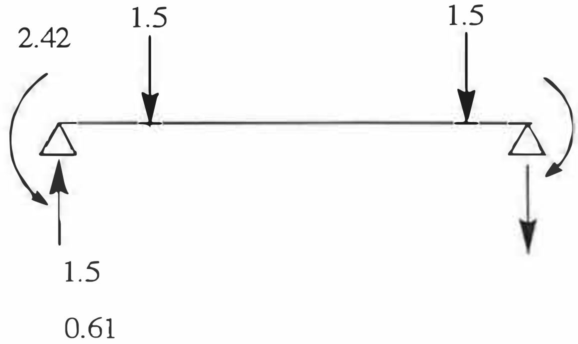
$f_c = 65 \qquad k_1 = 0.295 \qquad k_2 = 1208$

$$d = 0.295 \sqrt{\frac{2.42 \times 10^5}{25}} = 29.02 \quad cm.$$

$h = 35$ cm.

$$As = \frac{2.42 \times 10^5}{1208 \times 30} = 6.67 \ cm^2$$

$Q_{max} = 2.1$



$$q = \frac{2.1 \times 10^3}{25 \times 25} = 3.36 < 6 \quad kg/cm^2$$

O. K.

A-A
2∅16
2∅16 + 2∅20
B-B
15.0 m
L = 4.4 m
L = 7.85 m
L = 6.0 m
L = 2.4 m
7.5 m
L = 4.8 m
L = 4.45 m
L = 7.35 m
L = 5.7 m

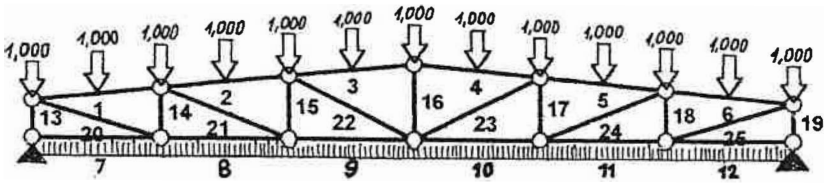
ATTACHMENT # 2

(Roof supporting structure drawings and calculations)

girders

Different schemes of truss girders and different types of loads were considered.

All relevant computer calculations were made at the Department of Structural Analysis and Mechanics of Materials of the Warsaw Institute of Technology.



800 kN/m

NOŚNOŚĆ PRĘTÓW: T.I rzędu

Obciążenia obl.: Ciężar wł.+A

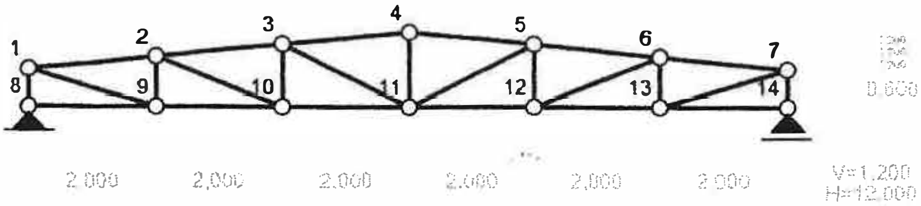
Przekrój:	Pręt:	Warunek nośności:	Wykorzystanie:
1	7	Stan graniczny użytkowania	72,2%
	8	Nośność (Stateczność) przy zginaniu	84,9%
	9	Nośność (Stateczność) przy zginaniu	90,9%
	10	Nośność (Stateczność) przy zginaniu	87,6%
	11	Nośność (Stateczność) przy zginaniu	84,9%
	12	Stan graniczny użytkowania	72,2%
	13	Nośność na ściskanie	10,5%
	14	Nośność na ściskanie	6,5%
	15	Nośność na ściskanie	1,4%
	16	Nośność na rozciąganie	3,3%
	17	Nośność na ściskanie	1,4%
	18	Nośność na ściskanie	6,5%
	19	Nośność na ściskanie	10,5%
	20	Nośność (Stateczność) przy zginaniu	26,2%
	21	Nośność (Stateczność) przy zginaniu	10,4%
	22	Nośność przy ściskaniu ze zginaniem	13,8%
	23	Nośność przy ściskaniu ze zginaniem	13,8%
	24	Nośność (Stateczność) przy zginaniu	10,4%
	25	Nośność (Stateczność) przy zginaniu	26,2%
	1	Nośność przy ściskaniu ze zginaniem	61,7%
	2	Nośność przy ściskaniu ze zginaniem	74,9%
	3	Nośność przy ściskaniu ze zginaniem	71,1%
	4	Nośność przy ściskaniu ze zginaniem	71,1%
	5	Nośność przy ściskaniu ze zginaniem	74,9%
	6	Nośność przy ściskaniu ze zginaniem	61,7%

NOŚNOŚĆ NA ZGINANIE (54): T.I rzędu

Obciążenia obl.: Ciężar wł.+A

Pręt:	x/L:	φL:	Mx:	Mrx:	My:	Mry:	N/Nr:	SW:
1	0,500	1,000	0,000	1,931	0,538	3,379	0,140	0,299
2	0,500	1,000	0,000	1,931	0,538	3,379	0,179	0,338
3	0,500	1,000	0,000	1,931	0,538	3,379	0,168	0,327
4	0,500	1,000	0,000	1,931	0,538	3,379	0,168	0,327
5	0,500	1,000	0,000	1,931	0,538	3,379	0,179	0,338
6	0,500	1,000	0,000	1,931	0,538	3,379	0,140	0,299
7	0,500	1,000	0,000	0,962	0,424	0,669	0,000	0,634
8	0,500	1,000	0,000	0,962	0,424	0,669	0,215	0,849
9	0,500	1,000	0,000	0,962	0,424	0,669	0,275	0,909
10	0,500	1,000	0,000	0,962	0,424	0,669	0,242	0,876
11	0,500	1,000	0,000	0,962	0,424	0,669	0,215	0,849
12	0,500	1,000	0,000	0,962	0,424	0,669	0,000	0,634
20	0,500	1,000	0,000	0,941	0,025	0,669	0,224	0,262
21	0,500	1,000	0,000	0,926	0,026	0,669	0,065	0,104
22	0,500	1,000	0,000	0,908	0,027	0,669	0,022	0,063
23	0,500	1,000	0,000	0,908	0,027	0,669	0,022	0,063
24	0,500	1,000	0,000	0,926	0,026	0,669	0,065	0,104
25	0,500	1,000	0,000	0,941	0,025	0,669	0,224	0,262

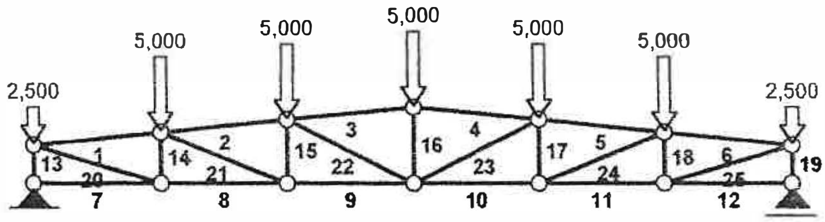
SCHEMAT STATYCZNY: *NR 2*



PRĘTY UKŁADU: Typy prętów: 11 - przegub-przegub

Pręt:	Typ:	A:	B:	Lx[m]:	Ly[m]:	L[m]:	Red.EJ:	Przekrój:
1	11	1	2	2,000	0,200	2,010	1,000	1 2 L 50x50x5
2	11	2	3	2,000	0,200	2,010	1,000	1 2 L 50x50x5
3	11	3	4	2,000	0,200	2,010	1,000	1 2 L 50x50x5
4	11	4	5	2,000	-0,200	2,010	1,000	1 2 L 50x50x5
5	11	5	6	2,000	-0,200	2,010	1,000	1 2 L 50x50x5
6	11	6	7	2,000	-0,200	2,010	1,000	1 2 L 50x50x5
7	11	8	9	2,000	0,000	2,000	1,000	2 L 50x50x5
8	11	9	10	2,000	0,000	2,000	1,000	2 L 50x50x5
9	11	10	11	2,000	0,000	2,000	1,000	2 L 50x50x5
10	11	11	12	2,000	0,000	2,000	1,000	2 L 50x50x5
11	11	12	13	2,000	0,000	2,000	1,000	2 L 50x50x5
12	11	13	14	2,000	0,000	2,000	1,000	2 L 50x50x5
13	11	8	1	0,000	0,600	0,600	1,000	2 L 50x50x5
14	11	9	2	0,000	0,800	0,800	1,000	2 L 50x50x5
15	11	10	3	0,000	1,000	1,000	1,000	2 L 50x50x5
16	11	11	4	0,000	1,200	1,200	1,000	2 L 50x50x5
17	11	12	5	0,000	1,000	1,000	1,000	2 L 50x50x5
18	11	13	6	0,000	0,800	0,800	1,000	2 L 50x50x5
19	11	14	7	0,000	0,600	0,600	1,000	2 L 50x50x5
20	11	1	9	2,000	-0,600	2,088	1,000	2 L 50x50x5
21	11	2	10	2,000	-0,800	2,154	1,000	2 L 50x50x5
22	11	3	11	2,000	-1,000	2,236	1,000	2 L 50x50x5
23	11	11	5	2,000	1,000	2,236	1,000	2 L 50x50x5
24	11	12	6	2,000	0,800	2,154	1,000	2 L 50x50x5
25	11	13	7	2,000	0,600	2,088	1,000	2 L 50x50x5

OBCIĄŻENIA [kN]:



W Y N I K I

SIŁY PRZEKROJOWE: T.I rzędu

Pręt:	x/L:	x[m]:	M[kNm]:	Q[kN]:	N[kN]:
1	0,00	0,000	0,000	0,000	-31,406
	1,00	2,010	0,000	0,000	-31,406
2	0,00	0,000	0,000	0,000	-40,200
	1,00	2,010	0,000	0,000	-40,200

3	0,00	0,000	0,000	0,000	-37,687
	1,00	2,010	0,000	0,000	-37,687
4	0,00	0,000	0,000	0,000	-37,687
	1,00	2,010	0,000	0,000	-37,687
5	0,00	0,000	0,000	0,000	-40,200
	1,00	2,010	0,000	0,000	-40,200
6	0,00	0,000	0,000	0,000	-31,406
	1,00	2,010	0,000	0,000	-31,406
7	0,00	0,000	0,000	0,000	-0,000
	1,00	2,000	0,000	0,000	-0,000
8	0,00	0,000	0,000	0,000	31,250
	1,00	2,000	0,000	0,000	31,250
9	0,00	0,000	0,000	0,000	40,000
	1,00	2,000	0,000	0,000	40,000
10	0,00	0,000	0,000	0,000	40,000
	1,00	2,000	0,000	0,000	40,000
11	0,00	0,000	0,000	0,000	31,250
	1,00	2,000	0,000	0,000	31,250
12	0,00	0,000	0,000	0,000	-0,000
	1,00	2,000	0,000	0,000	-0,000
13	0,00	0,000	0,000	0,000	-15,000
	1,00	0,600	0,000	0,000	-15,000
14	0,00	0,000	0,000	0,000	-9,375
	1,00	0,800	0,000	0,000	-9,375
15	0,00	0,000	0,000	0,000	-3,500
	1,00	1,000	0,000	0,000	-3,500
16	0,00	0,000	0,000	0,000	2,500
	1,00	1,200	0,000	0,000	2,500
17	0,00	0,000	0,000	0,000	-3,500
	1,00	1,000	0,000	0,000	-3,500
18	0,00	0,000	0,000	0,000	-9,375
	1,00	0,800	0,000	0,000	-9,375
19	0,00	0,000	0,000	0,000	-15,000
	1,00	0,600	0,000	0,000	-15,000
20	0,00	0,000	0,000	0,000	32,626
	1,00	2,088	0,000	0,000	32,626
21	0,00	0,000	0,000	0,000	9,424
	1,00	2,154	0,000	0,000	9,424
22	0,00	0,000	0,000	0,000	-2,795
	1,00	2,236	0,000	0,000	-2,795
23	0,00	0,000	0,000	0,000	-2,795
	1,00	2,236	0,000	0,000	-2,795
24	0,00	0,000	0,000	0,000	9,424
	1,00	2,154	0,000	0,000	9,424
25	0,00	0,000	0,000	0,000	32,626
	1,00	2,088	0,000	0,000	32,626

* = Wartości ekstremalne

NOŚNOŚĆ PRĘTÓW: T.I rzedu

Przekój:	Pręt:	Warunek nośności:	Wykorzystanie:
1	1	Nośność na ściskanie (39)	56,9%
	2	Nośność na ściskanie (39)	72,9%
	3	Nośność na ściskanie (39)	68,3%
	4	Nośność na ściskanie (39)	68,3%
	5	Nośność na ściskanie (39)	72,9%
	6	Nośność na ściskanie (39)	56,9%
2	7	Nośność na rozciąganie (32)	0,0%
	8	Nośność na rozciąganie (32)	34,4%
	9	Nośność na rozciąganie (32)	44,0%
	10	Nośność na rozciąganie (32)	44,0%
	11	Nośność na rozciąganie (32)	34,4%
	12	Nośność na rozciąganie (32)	0,0%
	13	Nośność na ściskanie (39)	20,0%

14	Nośność na ściskanie (39)	15,8%
15	Nośność na ściskanie (39)	7,5%
16	Nośność na rozciąganie (32)	2,7%
17	Nośność na ściskanie (39)	7,5%
18	Nośność na ściskanie (39)	15,8%
19	Nośność na ściskanie (39)	20,0%
20	Nośność na rozciąganie (32)	35,9%
21	Nośność na rozciąganie (32)	10,4%
22	Nośność na ściskanie (39)	21,5%
23	Nośność na ściskanie (39)	21,5%
24	Nośność na rozciąganie (32)	10,4%
25	Nośność na rozciąganie (32)	35,9%

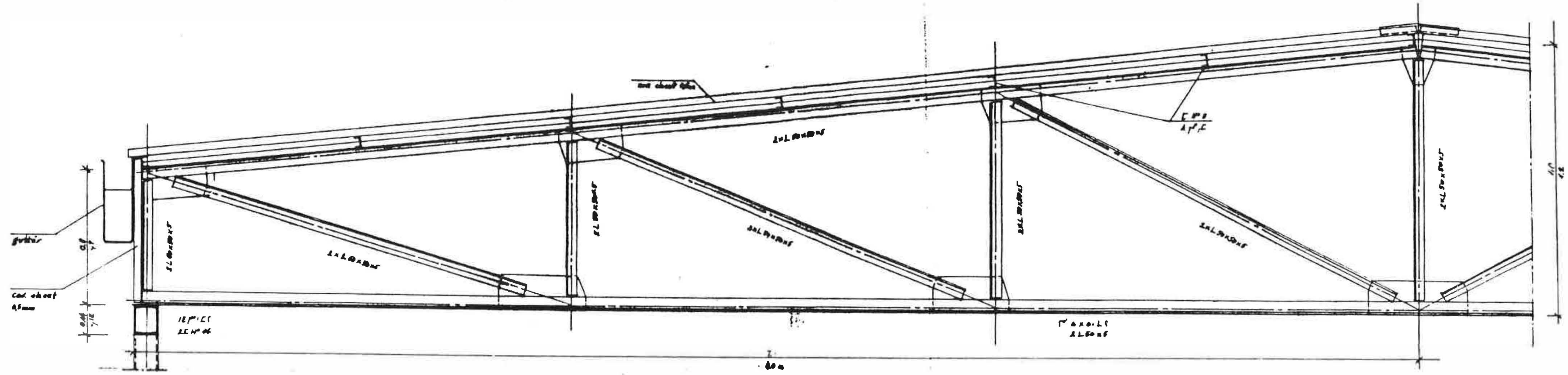
NOŚNOŚĆ NA ROZCIĄGANIE (32): T.I rzędu

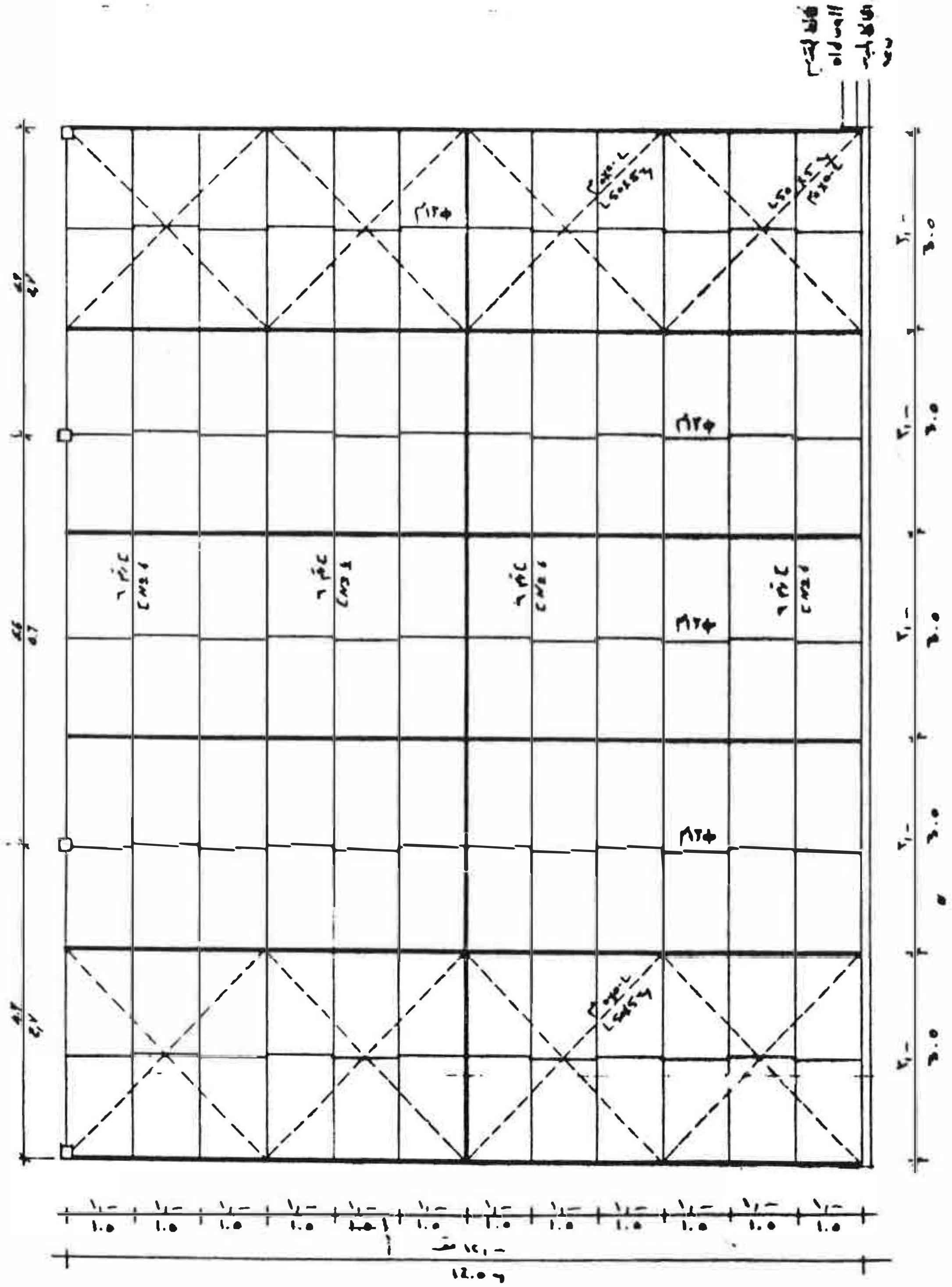
Pręt:		A[cm2]:	Aψ[cm2]:	N[kN]:	Nrt[kN]:	SW:
1	Zam.mimośrod.	9,60	8,46	-31,406	148,077	0,212
2	Zam.mimośrod.	9,60	8,46	-40,200	148,077	0,271
3	Zam.mimośrod.	9,60	8,46	-37,687	148,077	0,255
4	Zam.mimośrod.	9,60	8,46	-37,687	148,077	0,255
5	Zam.mimośrod.	9,60	8,46	-40,200	148,077	0,271
6	Zam.mimośrod.	9,60	8,46	-31,406	148,077	0,212
7	Zam.mimośrod.	4,80	4,23	-0,000	90,962	0,000
8	Zam.mimośrod.	4,80	4,23	31,250	90,962	0,344
9	Zam.mimośrod.	4,80	4,23	40,000	90,962	0,440
10	Zam.mimośrod.	4,80	4,23	40,000	90,962	0,440
11	Zam.mimośrod.	4,80	4,23	31,250	90,962	0,344
12	Zam.mimośrod.	4,80	4,23	-0,000	90,962	0,000
13	Zam.mimośrod.	4,80	4,23	-15,000	90,962	0,165
14	Zam.mimośrod.	4,80	4,23	-9,375	90,962	0,103
15	Zam.mimośrod.	4,80	4,23	-3,500	90,962	0,038
16	Zam.mimośrod.	4,80	4,23	2,500	90,962	0,027
17	Zam.mimośrod.	4,80	4,23	-3,500	90,962	0,038
18	Zam.mimośrod.	4,80	4,23	-9,375	90,962	0,103
19	Zam.mimośrod.	4,80	4,23	-15,000	90,962	0,165
20	Zam.mimośrod.	4,80	4,23	32,626	90,962	0,359
21	Zam.mimośrod.	4,80	4,23	9,424	90,962	0,104
22	Zam.mimośrod.	4,80	4,23	-2,795	90,962	0,031
23	Zam.mimośrod.	4,80	4,23	-2,795	90,962	0,031
24	Zam.mimośrod.	4,80	4,23	9,424	90,962	0,104
25	Zam.mimośrod.	4,80	4,23	32,626	90,962	0,359

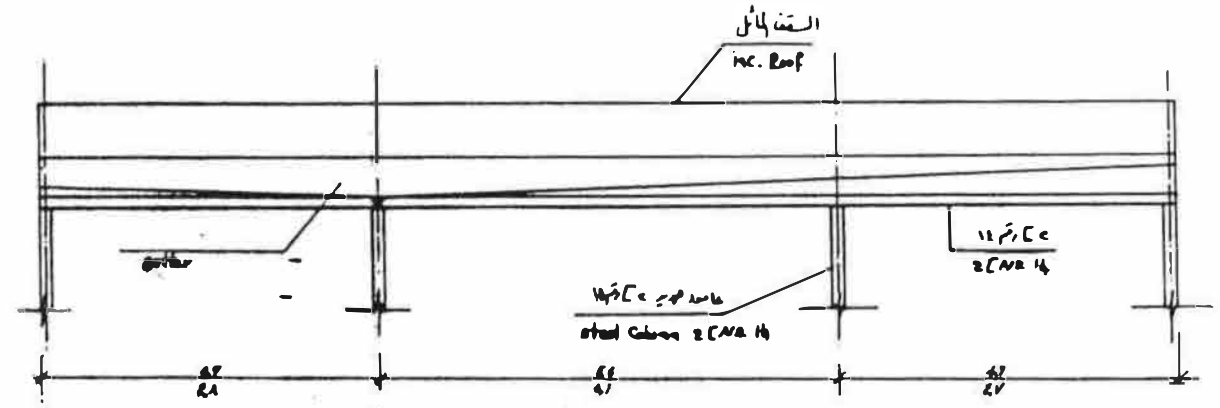
NOŚNOŚĆ NA ŚCISKANIE (39): T.I rzędu

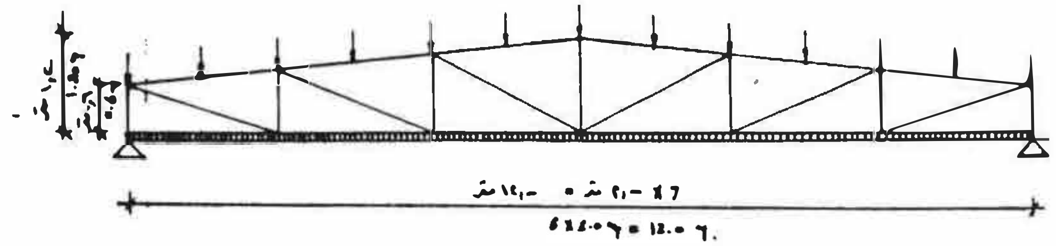
Pręt:	lwx:	lwy:	$\bar{\lambda}$:	φ:	ψ:	N[kN]:	Nrc[kN]:	SW:
1	2,010	2,010	1,426	0,366	0,897	-31,406	150,696	0,569
2	2,010	2,010	1,426	0,366	0,897	-40,200	150,696	0,729
3	2,010	2,010	1,426	0,366	0,897	-37,687	150,696	0,683
4	2,010	2,010	1,426	0,366	0,897	-37,687	150,696	0,683
5	2,010	2,010	1,426	0,366	0,897	-40,200	150,696	0,729
6	2,010	2,010	1,426	0,366	0,897	-31,406	150,696	0,569
13	0,600	0,600	0,730	0,725	1,000	-15,000	103,200	0,200
14	0,800	0,800	0,974	0,576	1,000	-9,375	103,200	0,158
15	1,000	1,000	1,217	0,451	1,000	-3,500	103,200	0,075
17	1,000	1,000	1,217	0,451	1,000	-3,500	103,200	0,075
18	0,800	0,800	0,974	0,576	1,000	-9,375	103,200	0,158
19	0,600	0,600	0,730	0,725	1,000	-15,000	103,200	0,200
22	2,236	2,236	2,722	0,126	1,000	-2,795	103,200	0,215
23	2,236	2,236	2,722	0,126	1,000	-2,795	103,200	0,215

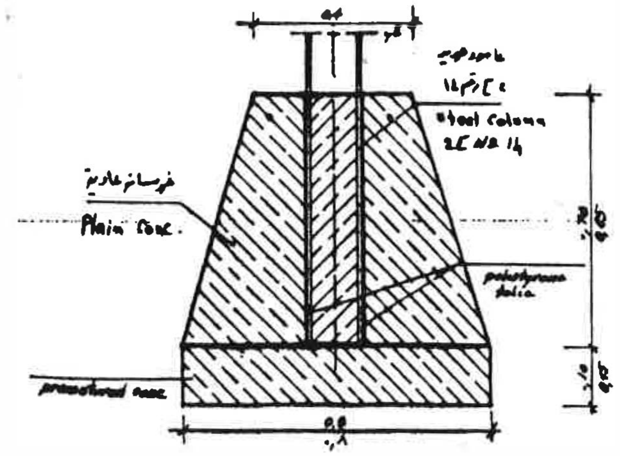
$\bar{\lambda}$ - miarodajna smukłość względna (λ/λ_p)

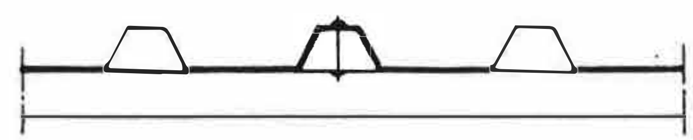








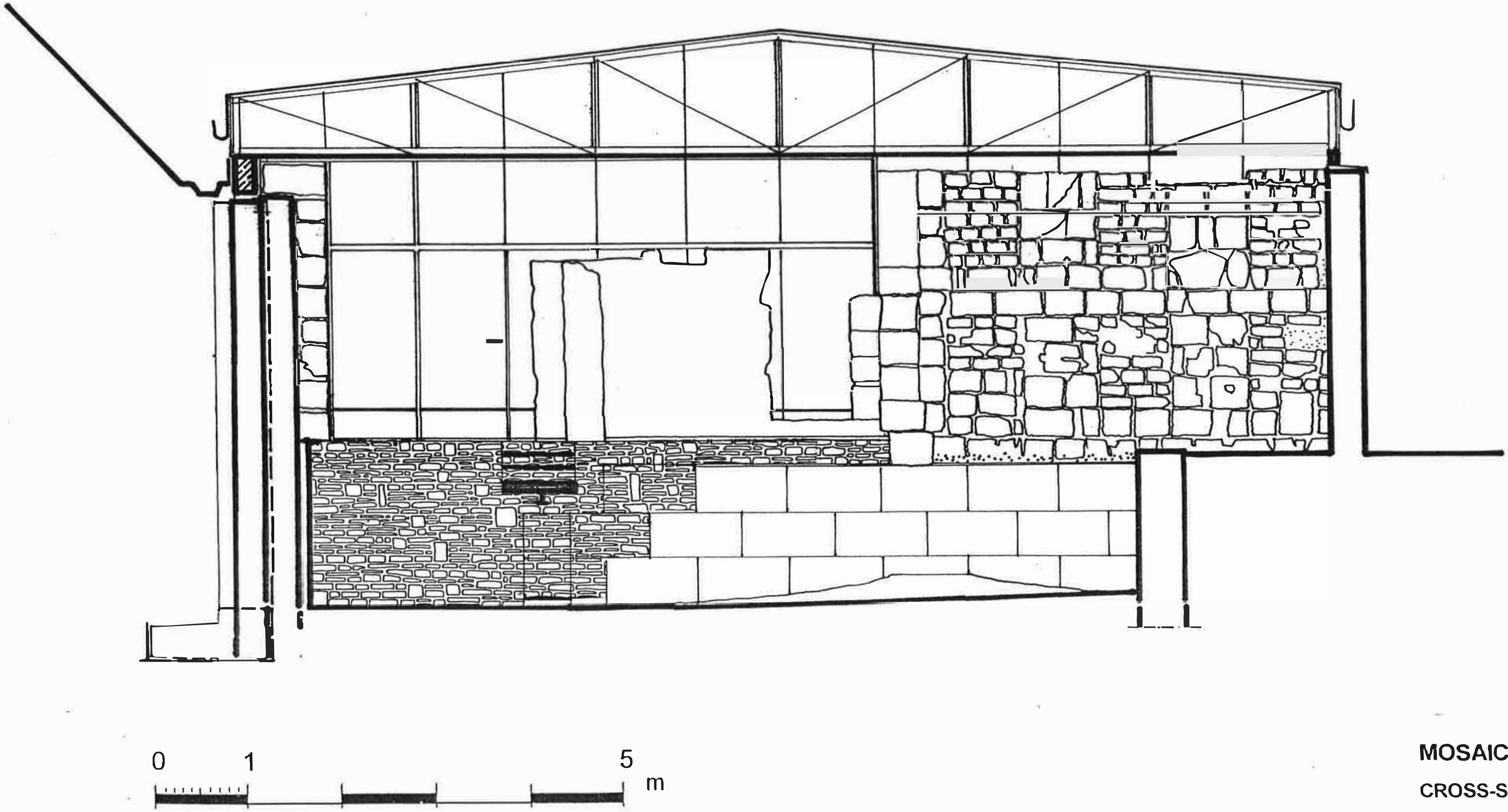




- Plates thick. = 0.5 cm.
- all Joints by welding

- سمك الالواح المثبتة ٠٫٥ سم
- جميع الوصلات تتم باللحام

ATTACHMENT # 3



MOSAICS SHELTER

CROSS-SECTION N-S