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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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ENVIRONMENTAL CHARACTERISTICS OF THE CLAY BUILDING MATERIALS INDUSTRIES IN AFRICA 1/

by

Zawde Berhane

Ethiopia

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Contents

Synopsis

The paper, after briefly discussing the properties and uses of clay building materials being produced at present in the four sub-regions of Africa (North Africa, West Africa, Central Africa and East Africa) deals with past and present demand and supply of clay building materials in Africa.

The effect of other recently developed building materials such as concrete blocks, ciporex etc. and other construction materials on the clay building materials industries are considered.

The relationship between clay building materials and Portland cement products consumption in the different sub-regions of Africa and developed countries are discussed. Based on these facts future trends in the supply and demand for clay building materials for African countries are forecast.

The statistical data indicate that the demand for clay building materials is high and supply too low. This trend will be higher in the future than it is at present. The paper concludes by pointing out steps to be taken in order to overcome the short-fall in the supply of clay building materials in Africa.

1. Introduction:

Clay is available every where in Africa. Because of this, clay is used as a building material extensively in the four sub-regions of Africa (North Africa, West Africa, Central Africa and East Africa). However, one should keep in mind that all clays are not suitable for brick production(1)*. Clay is used in different shapes, forms and with differing physical and mechanical properties such as "swish", "chicka" etc. "Swish" and "chicka" are mixtures of clay, straw and water. "Swish" is extensively used in West Africa. "Chicka" is the most commonly used building material in Ethiopia. A survey carried out in 1961 showed that about 90 per cent of the houses in Addis Ababa had "chicka" walls.

Sun-dried bricks are mainly used in the sub-regions of Africa where rainfall is not heavy (North Africa, part of Central Africa and part of West Africa). Such unburnt clay building materials do not last long when they are exposed to rainfall because of their high moisture movement when wet, and low resistance to rainfall. When unburnt clay is wet it loses about all its strength. One way of improving the weather resistance of unburnt clay building materials is to fire them. In countries where fuels such as wood or gasoline is scarce and expensive, firing makes burnt clay bricks too expensive. One of the cheapest ways of improving the durability of unburnt clay building materials is stabilization. Stabilized soil blocks can be produced by using stabilizing agents such as lime, Portland cement, bitumen, etc. In addition stabilized soil blocks do not need skilled workers and can be produced with simple machines such as the CINVA RAM+

* Numbers in parentheses relate to references given at the end of this report.

+ For detailed information see "CINVA RAM - Operation Manual", Inter America housing and Planning Center, Bogota, 1957.

Another factor which makes clay building materials expensive in the sub-regions of Africa is lack of infrastructure facilities. Excessive transportation cost makes clay building materials too expensive. For example in West Africa production cost is approximately US$18:- per ton. However, transportation cost is approximately 6 cents per ton per kilometer, which doubles the cost of clay bricks 300 kilometers from the brickwork(2).

The quality and dimensional characteristics of clay bricks produced in developing countries are not satisfactory. The Inter-regional Seminar on the Development of Clay Building Materials in Developing Countries, which was held in Copenhagen in 1968, showed that burnt clay bricks being produced in developing countries have an average compressive strength below 50 kg/cm^2 which might be good enough for rural areas, but for urban construction works the quality should have to be improved. On the other hand, burnt clay bricks produced in developed countries have a compressive strength from 200 to 300 kg/cm^2. It seems that the main causes of such low quality brick production in the developing countries are: (a) lack of qualified staff for proper supervision at the brick works, (b) the use of traditional methods without taking advantage of modern technology such as modern means of producing bricks and proper selection and preparation of raw materials, and (c) lack of governing building codes and specifications in most of the developing countries. Since these topics will be dealt in detail in other papers they are not further treated here.

Statistical data for the four sub-regions of Africa in the use and production of clay building materials are scarce. Lack of statistical data makes it difficult to asses supply and demand and to forecast future needs of clay building materials for Africa. However, some publi-

shed data[1] indicate that clay building materials are the most popular building materials in Africa especially in the rural areas.

Information available for developed countries shows that clay building materials are also popular in such countries. Table I shows the amount of burnt clay bricks used in residential flats in a number of developed countries[2]. It is also reported that residential construction amounts to 48 per cent of total construction in France, 31 per cent in Norway, and 34 per cent in Turkey.

2. Trends in clay building materials consumption in Africa

As it was mentioned earlier statistical data concerning clay building materials in the four sub-regions of Africa are meager. This is specially true when one considers clay bricks. Clay bricks in most African countries are produced by artisians in each village whenever the need arises for such materials. In most of the African countries such products are not usually included in the annual statistical abstracts. Thus one has to try to determine indirectly an approximate consumption figures by using existing relationships for developed countries between the consumption of other building materials such as Portland cement and clay building materials. Other relationships such as between gross national income, development of the building industry as a whole, investiment in the building industry etc. and clay building materials consumption for the developed countries are also used to get an approximate consumption figures of clay building materials. Statistical data for such items as mentioned above are not either complete when one considers the continent of Africa. Thus only a rough estimate of clay building materials consumption and future trends

Table I - Number of flats and per cent of flats constructed of burnt clay bricks in newly constructed residential houses( ).

Country	Year	1957	1958	1959	1960	1961	1962	1963	1964	1965
France	A						402.4	506.2	554.1	572.4
	B						27.2%	26.3%	22.8%	26.6%
Czechoslavakia	A		33.9	45.7	55.3	55.0	58.3	59.0	56.8	58.5
	B		81.7%	78.2%	66.9%	48.7%	40.9%	33.0%	21.1%	20.5%
Norway	A	25.7	25.7	26.0	26.0	26.2	27.8	27.2	28.2	28.1
	B	9.0%	9.0%	4.2%	3.7%	3.4%	2.2%	2.8%	2.0%	1.7%
Turkey	A	36.6	36.6	38.3	34.9	35.9	31.8	32.4	31.2	
	B	47.3%	47.3%	47.5%	47.0%	49.6%	49.6%	53.4%	53.9%	
Bulgaria	A					40.8	43.7	43.9	47.4	45.2
	B					77.3%	77.1%	76.1%	67.7%	63.0%
Yugoslavia	A						10[illegible]	107.6	117.9	117.9
	B							71.1%	63.9%	70.1%
Hungary	A					16.7	13.2	15.9	15.4	19.8
	B					64.9%	47.5%	32.4%	32.3%	33.3%

N.B. A indicates flats in 1000 units and B per cent of flats constructed of bricks

for African countries may be made. Statistical analysis made for a number of developed countries, however, shows that there is a close relationship between demands for clay bricks and cement consumption as indicated in the following pages.

2.1. Trends of brick and cement consumption in developed countries.

Table II shows the per capita products of burnt clay bricks in a number of developed countries, (from 1950 to 1960). The average per capita clay brick production for these countries for 1950 was about 68, whereas the corresponding figure for 1960 was about 112, which shows an increase of about 65 per cent within 10 years.

In Table III the building activity (in thousands of units, by a unit is meant a dwelling) is indicated for some of the countries given in Table II. The average units (in thousands) for the countries given in Table III for 1950 is 320 and for 1960 is 530 indicating a growth of about 66 per cent. It is interesting to note that there is a close relationship between the rates of growth in the per capita clay brick production and the number of dwellings constructed.

The rate of growth in brick production for a number of countries is given in Table IV. The average rate of growth for these countries between 1950 and 1959 was about 9.7 per cent.

These results clearly show that such statistical data are essential for estimating and forecasting future supply and demand.

Table II - Per capita clay brick production in selected countries.

Countries	1950	1953	1955	1956	1957	1958	1959	1960
Belgium	232	252	274	251	268	244	236	247
France (in kg.)	75	73	95	94	98	96	91	90
Italy	31	42	58	59	65	69	73	
Canada	27	29	31	32	29	32	32	26
Germany (FR)	88	105	118	115	109	106	118	117
Holland	118	127	134	136	144	136	136	142
Norway	30	30	32	29	23	24	26	
Austria	82	68	115	121	124	115	124	133
Sweden	51	52	52	46	42	40	44	44
United States	42	37	48	48	39	37	41	39
England	121	146	147	143	134	125	138	143
Yugoslavia	60	40	45	46	50	59	58	66
Albania	11	35	42	43	47	50	80	
Bulgaria	33	58	59	73	64	74	97	
Hungary	85	138	122	122	141	143	167	178
Germany (DR)	74	106	109	110	123	126	136	131
Poland	90	85	95	94	97	97	110	104
Rumania	23	47	39	43	40	46	50	31
USSR	57	88	106	108	121	139	157	164
Czechoslovakia	70	94	113	120	128	130	141	140

Table III - Building activities in various countries
(in thousands of units, a unit = a dwelling)

Countries	1950	1953	1955	1956	1957	1958	1959	1960
Belgium	71	116	210	237	274	292	320	314
France	74	150	216	232	274	276	295	268
Italy	52	121	129	202				
Germany (FR)	360	525	538	561	528	488	555	551
Holland	55	63	62	69	89	90	84	85
Sweden	45	53	58	58	65	63	69	68
United States	1396	1104	1329	1118	1042	1209	1379	1180
England	215	330	329	310	310	281	284	307
Yugoslavia		38	30	37	45	61	61	
Canada	89	97	128	136	117	147	146	
Hungary	25	17	32	26	51	42	47	
Germany (DR)	31	32	33	33	61	63	80	80
Poland	68	79	94	95	122	129	133	
Rumania		46	56	78	78			
USSR	1170	1245	1512	1613	2197	2692	3050	2912
Czechoslovakia	38	39	51	64	64	54	68	78
Norway	22	35	32	27	27	26	27	27

Table IV - **Evaluation of the growth rates of brick production in selected countries.**

Countries	Period	Production of bricks per capita during this period	Growth rate %	Requirements of bricks per dwelling: period	1000 bricks/ dwelling
France	1950-59	75 - 91	2.2	1950-59	44.3 - 12.8
Germany (FR)	1950-50	88 - 118	3.3	1950-59	11.5 - 11.0
Austria	1950-60	82 - 133	5.0	1950-59	
Germany (DR)	1950-59	74 - 136	7.0	1950-59	43.7 - 29.3
Czechoslovakia	1950-60	70 - 140	7.2	1950-59	22.8 - 28.1
Hungary	1950-60	85 - 178	7.7	1950-59	31.8 - 35.3
Rumania	1950-59	23 - 50	9.0	1953-57	17.4 - 9.2
Poland	1950-59	50 - 110	9.2	1950-59	18.2 - 24.2
Italy	1950-59	31 - 73	10.0	1950-59	19.7 - 12.1
USSR	1950-60	57 - 164	11.2	1950-60	8.7 - 12.0
Bulgaria	1950-59	53 - 97	12.8		
Albania	1950-59	11 - 80	24.7		

2.2. Relationship between cement and brick consumption for developed countries.

In a number of its publications( ), ECA has reported logarithimic relationships between cement and clay brick consumption based on the data given in Table V. The relationships for 1950 and 2960, respectively, are as follows:

$$\text{Log. } Y = 1.2707 \log X - 1.2131 \qquad (1950)$$

$$\text{Log. } Y = 0.8270 \log X + 0.1816 \qquad (1960)$$

where Y is the brick consumption in 1000 tons per year and X the cement consumption in 1000 tons per year.
Without the logarithm the equations will look like as follows:

$$Y = X^{1.2707} - A$$

$$Y = X^{0.827} + B \quad \text{where A and B are constants.}$$

The equations indicate that for the same amount of cement consumption, the amount of brick consumed is less for 1960 than that of 1950 one. In other words the effect of technological advancement and development of new building materials such as concrete blocks, ciporex etc., while increasing the cement consumption, tends to replace clay bricks as it can be seen by comparing the two equations. The relative higher increase in cement consumption than that of clay brick, as these new building materials are introduced into the building industry, is understandable.

2.3. Trends of clay brick consumption in the four sub-regions of Africa.

Though statistical data on cement consumption for most of the African countries is available, there is meager information when one considers the clay building materials consumption. This information becomes more scarce when one considers the East African

Table V - Cement and brick consumption in a number of countries.

	Cement (1,000 T)			Bricks (million of pcs)		
	1950	1959	1960	1950	1959	1960
Belgium	2460		3234	2004		2259
France	6376		13173	3143		4088
Italy	5185	14294		1458	3579	
Canada	2874		5195	375		470
West Germany	9557		24012	4123		6222
Holland	1663		3172	1192		1626
Norway	586	1105		98	94	
Austria	1310		2707	568		940
Sweden	1689		2641	357		326
United States	38032		54084	6333		6952
England	112		12672	5921		7279
Yugoslavia	921		2169	977		1234
Albania	15	79		14	125	
Bulgaria	547	1432		237	758	
Hungary	787		1571	796		1776
East Germany	1389		4984	1356		2272
Poland	2364		6339	1235		3100
Rumania	978		2955	371		572
USSR	10164		45270	10204		35100
Czechoslovakia	1630		5127	865		1910

sub-region. For some reason or another some countries in this sub-region do not include clay brick in their annual statistical abstracts. One can get an indirect rough idea, however, about brick consumption in African countries from the data given in Tables VI and VII. Additional information is contained in Table VIII. In Table VIII capacities of brickworks in the different African countries are given. However, here too the data are incomplete.

In Table IX estimated clay brick consumption for 1970, 1980 and 1990 for the four sub-regions are given. The data were received using both the 1950 and 1960 logarithmic equations given on page10. As it was stated earlier estimates made using the 1950 equation gives significantly lower clay brick consumption than the 1960 one. Now the question arises as to which of the two equations gives a better estimate for African conditions. Earlier it was mentioned that new building materials such as concrete blocks, ciporex etc. have been developed extensively and used in the advanced countries. These new materials tend to replace clay bricks while increasing cement consumption. Assuming that these new building materials are not yet fully introduced to Africa, the 1950 equation may give a better forecast for 1970 whereas the 1960 equation might give a closer approximation for 1990 than the 1950 equation. On the other hand, the average of the corresponding figures received using the two equations might give a better approximation for 1980 than that received by using each equation separately. Based on this argument the future clay brick consumption estimates for the four sub-regions are given in Table X.

A look at Table VIII shows that the already established brickworks located in the North Africa sub-region can satisfy the forecasted demand up to 1990, provided that they are used to their full capacities. However, because of excessive transportation expense some of the

Table VI - Trends in cement consumption and rate of growth in the four sbu-regions (1963) (7)

Sub-region	Consumption per capita (kg)	Compound annual rate of growth in % (1953 - 1963)
North Africa	68	7
West Africa	23	8
Central Africa	19	-
East Africa	17	3
Average	32	6
World	110	

Table VII - Population and density by sub-region (1960) (4)

Sub-region	Population (millions)	Density per square kilometer
North Africa	54	9
West Africa	79	9
Central Africa	32	7
East Africa	57	9
T O T A L	222	8

Table VIII Capacity of brickworks in Africa[11].

Country	Capacity t/year	Remarks
1. North Africa		
Algeria	770,000	The capacity includes 160,000 t/year of tiles
Libya	15,000	In 1965 UAR produced about 4,000,000 tons of clay bricks.
Morocco	180,000	
Tunisia	220,000	
Sudan	53,000	
Total	1,238,000	
2. West Africa		
Dahomey	2,000	
Gambia	——	No brickworks in Gambia
Ghana	74,000	
Guinea	82,000	
Haute-Volta	14,000	
Ivory-coast	27,000	
Liberia	10,000	
Mali	12,000	
Mauritania	——	No brickworks in Mauritania
Niger	26,000	
Nigeria	36,000	
Senegal	16,000	
Siera-Leone	——	No brickworks in Siera-Leone
Togo	18,000	
Total	316,000	
3. Central Africa		
Cameroons	25,000	
Congo (Braz.)	16,000	
Congo (K.)	32,000	
Gabon	——	No brickworks in Gabon
ECA	10,000	
Chad	45,000	
Total	128,000	
4. East Africa*		
Ethiopia	25,000	
Somalia	10,000	

Table IX - Forecast of Approximate Clay Brick Consumption of Africa.

Sub-region	Cement consumption in 1000 tons/year				Brick consumption in 1000 tons per year							
					Equation 1950				Equation 1960			
	1960	1970	1980	1990	1960	1970	1980	1990	1960	1970	1980	1990
North Africa	3550	8550	15170	27160	198	602	1250	2640	131	270	436	707
West Africa	1500	4500	11610	27900	66	268	895	2960	63	159	349	760
Central Africa	450	1500	3850	10000	14	66	220	588	24	63	140	309
East Africa	1350	2500	6510	18000	58	111	429	1560	59	98	216	502
Total	6850	17050	37140	83060	336	1047	2794	7748	277	590	1141	2278

Table X - Estimated future clay brick consumption of Africa

Sub-region	Brick consumption in 1000 tons per year			
	1960	1970	1980	1990
North Africa	198	602	843	707
West Africa	66	268	622	760
Central Africa	14	66	180	309
East Africa	58	111	323	502
Total	336	1047	1968	2278

countries in this sub-region have to establish new brick works of their own. This seems specially true for the Sudan and Libya.

On the other hand, the remaining three sub-regions, namely West, Central and East Africa have to start establishing or rather should have started establishing new brickworks in order to satisfy the demand for clay bricks. The capacities of the presently available brick-works located in West and Central Africa seem to satisfy the demand up to about 1970 provided that they are used to their full capacity.

In the West and Central African sub-regions it seems that there are no brickworks in Serra Leone, Mauritania and Gambia. No detail information is available how these countries satisfy their need for clay building materials. It would be adviceable to conduct studies on supply and demand for clay building materials for these countries so that an appropriate recommendation would be made for establishing new brick-works. As it was pointed out earlier it is high time that countries located in these sub-regions should start establishing new brickworks in order to satisfy the demand for such material.

No information is available on the capacities of brickworks located in the sub-region of East Africa. Thus no specific comments could be made on countries located in this sub-region.

The present paper has tried to point out the general situation in the four sub-regions as far as the demand and supply of clay building materials is concerned. Detailed study of each country has to be carried out in order to make conclusive recommendations applicable to a particular country.

2.3: Consumption and availability of mortar materials.

To the knowledge of the writer, no published statistical data is available on production and consumption of materials such as lime and gypsum for the African countries located in the four sub-regions. However, the cement production (using to full capacity presently installed factories) and shortfall for 1970 has been estimated and reported (7) (see Table XI).

Table XI - Estimated production and shortfall of Portland cement for the four sub-regions of Africa.

Sub-region	North Africa	West Africa	Central Africa	East Africa	Total for the four sub-regions
Amount of production (in 1000 tons)	5,200	1,000	1,300	2,100	9,600
Shortfall (in 1000 tons)	3,300	3,500	200	400	7,400
Total for each sub-region	8,500	4,500	1,500	2,500	

West Africa has the highest shortfall (3.5 times its production) and East Africa shows the least shortfall (about 1/5 of its production). Additional information on future demands for Portland cement for the four sub-regions can be seen from Table IX page 15.

4. Conclusions and recommendations

4.1 Recent trends and expected growth of the building activity in Africa indicate that the clay building materials industry production should be increased and improved in quality.

4.2 When one considers African countries by sub-region (North, West, Central and East) brickworks installed only in North Africa have the capacity to satisfy the present (1970) demand for clay building materials. However, if one examines the clay building materials production in each country located in this sub-region, it could be seen that Sudan and Libya are not producing enough.

4.3 The situation in the rest three sub-regions is different from that of North Africa. The full capacities of brick-works located in these sub-regions shortfall of the present (1970) demand for clay building materials.

4.4 Unless immediate steps are taken to establish new brickworks, especially in the above mentioned three sub-regions, the rapid growth in the demand for clay building materials combined with the population explosion will have unfavourable effects on the progress of the building industry and housing schemes of Africa. If the high demand for clay building materials is not counteracted by higher production, clay building materials will be more expensive than what they cost to-day, and thus only few people would be able to build and own houses.

4.5 In order to tackle this acute problem of shortage of clay building materials in Africa, it is suggested that UNIDO in collaboration with the UN Housing, Building and Planning, and ECA should establish a training centre for clay building materials technologists and at the same time should make available expert advisors to those governments who seek for such assistances.

4.6 For rural construction works simpler and cheaper ways of producing clay building materials should be thought for

and introduced to African countries. One way of producing relatively cheaper and at the same time strong enough and durable clay building materials is to use stabilized soils and soil blocks.

4.7 In the urben areas the shortage in the supply of clay building materials could be overcome to a certain extent by introducing the production and use of new building such as concrete blocks ciporex, plastics etc. In some countries where raw materials amd knowhow are available, it might be more economical and cheaper to produce and use such materials in place of clay building materials.

4.8 It is obvious that statistical data are essential for estimating futre supply and demand for any material. The present situation in regard to statistical data on the supply and demand for caly building materials is not satisfactory. Such a condition makes difficult, if not impossible, to make appropriate forecasts of futre demand and supply. In order to lessen this difficulty it is suggested that ECA should approach African countries and inform them the usefulness of such data. If possible a seminar should be organised by ECA in which people dealing with the collection and publishing statistical abstracts from African countries will participate and discuss ways and means of improving statistical information on building materials.

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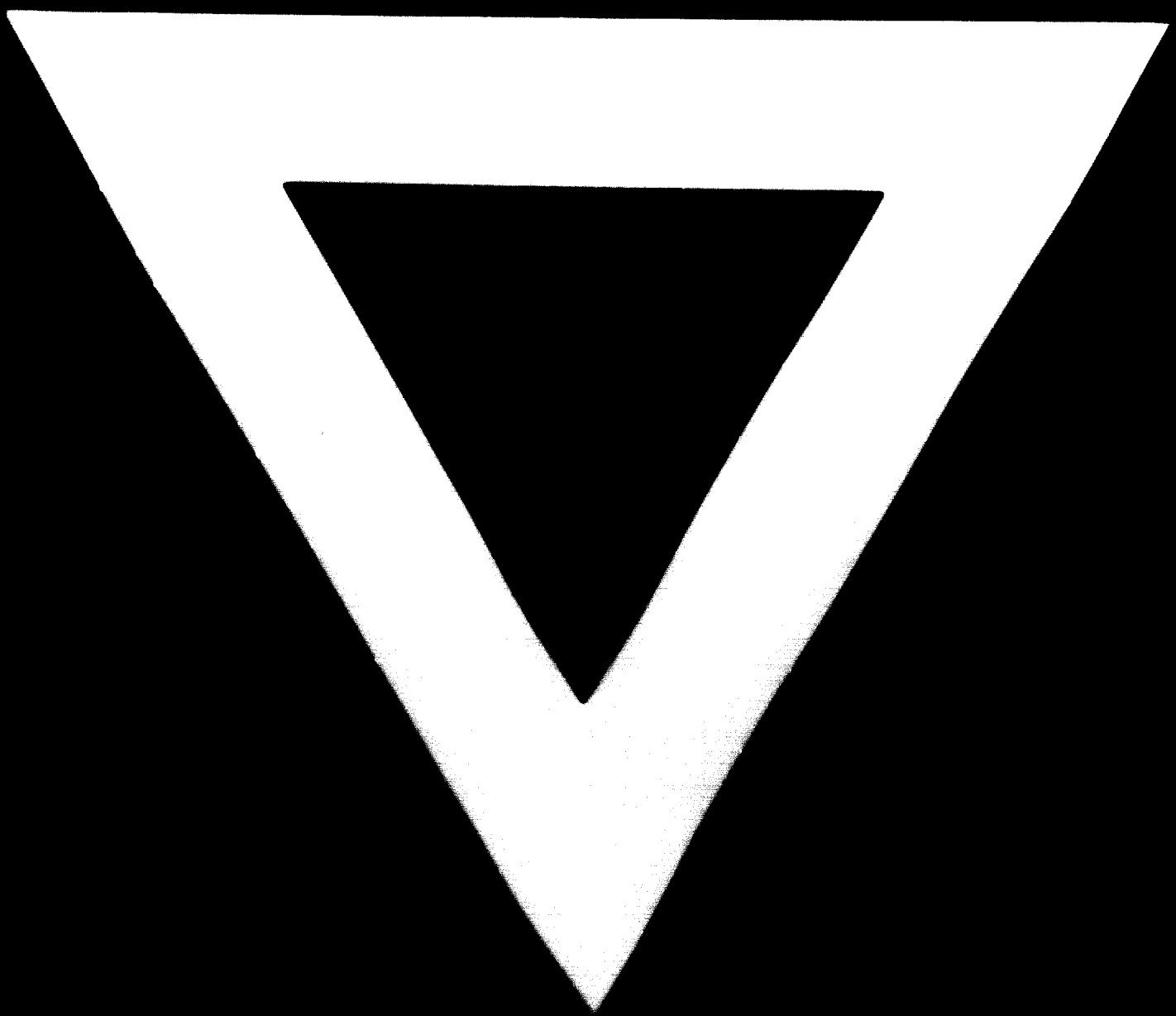

26. 6. 72