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BANGLADESH

Technical report: Assistance in wall and floor tile production*

Prepared for the Government of Bangladesh
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of E. V. Goonewardena
expert on production of floor and wall tiles

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INTRODUCTION

This terminal report covers the activities and accomplishments of the Expert in Wall and Floor Tile Production - E.V. Goonewardena.

The assignment commenced on 4.7.1985 for a period of one year which was subsequently extended for a further period of six months.

Bangladesh Chemical Industries Corporation (BCIC) in a product diversification attempt of its Bangladesh Insulator and Sanitaryware Factory (BISF) initiated action in the setting up of a turn key Wall and Floor tile production plant with Messrs Pragoinvest of Czechoslovakia (the Contractor) in 1979. The proposed plant was expected to have an annual output of either.

(a) 110,000 sq. meters of 150 mm x 150 mm of glazed wall tiles

or (b) 55,000 sq. meters of 150 mm x 150 mm of glazed wall tiles and 20,000 sq. meters of 100 mm x 100 mm of floor tiles.

Erectional activities of the plant commenced in September 1982 and the installation of machinery was completed in 1984. The commissioning and the guarantee tests commenced in mid - June 1984.

However the commissioning and the guarantees could not be successfully completed, and the production activities of the plant was stalled due mainly to the two tile presses inability to cope up with the expected capacity both in quality and quantity. The Contractor made several attempts as late as October 1984 to prove the guarantees but without success in the press section of the tiles. A further agreement between BISF and Contractor was signed to supply a new press that would fulfil the original Contractual obligations.

This plant with a total capital cost of 2.5 million Sterling Pounds was lying idle at the commencement of the expert's mission.

However with the active participation of the expert, the plant commenced commercial production in July 1986 and in doing so was actively engaged in the following major activities.

In the production of wall tiles

(a) Involved in the installation work of the new tile press.

(b) Development of a suitable wall tile body composition incorporating 94% of indegeneous raw materials; selecting a suitable glaze for the body developed.

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(c) Commissioning of the plant in stages whilst training the staff in the respective sections.

(d) Introduce quality control techniques at various stages of production and introduced decoration techniques of tiles.

In the production of floor tiles

(a) A discarded press was put to good use in manufacture of floor tiles

(b) Initiated the production of floor tiles in this press making use of the green body waste of both insulator and sanitaryware product lines and firing the fabricated tiles in the spare space of the insulator and sanitaryware kilns to produce heavy duty floor tiles of sizes 150 mm x 150 mm and 100 mm x 100 mm.

I. DEVELOPMENT OBJECTIVE

The tile factory was intended to make use of the available facilities in the existing Sanitaryware and Insulator product lines, both of which were operating below the installed capacity. These available facilities were civil works, gas, electricity and water supplies, workshop services, raw materials processing, laboratory services in addition, the use of indegeneous raw materials to develop a new ceramic product involving technological developments; training of personnel in yet another field of ceramic activity; and most of all to contribute towards the saving of foreign exchange through import substitution.

II. IMMEDIATE OBJECTIVES

1. Initiate action towards the commissioning of the tile plant and commence commercial production in the quickest possible time.

2. Contribute to the solution of technological problems in the production of quality wall and floor tiles.

3. Provide the key personnel assigned to the tile production line with the necessary technical skills to take full active part in its trial operations and to ensure its smooth operation after commissioning.

4. Devise stratagies and initiate actions condusive to increase productivity (in terms of both quantity and quality) higher sales and improved financial viability of the plant.

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III. ACTIVITIES

The activities of the expert to fulfill the immediate objectives for the conditions prevailing at the time of drafting the Project Document were:

(a) Be present in the factory during the final stages of the trial runs and the guarantee test to be performed by the turn-key contractor, and carry out a detailed assessment of all aspects of plant performance.

(b) Advise the Company Management of his observations ascertairing either that the plant performs according to the Contract Specifications or recommending steps to be taken by the Contractor to rectify deficiencies prior to official commissioning of the plant.

(c) Provide eventual support to the Company and to the BCIC during negotiations with the Contractor which may be required to fulfill the contract.

(d) Advise on the procurement of testing equipment literature etc. which are deemed necessary to permit a smooth functioning of the quality control function related to tile production line.

(e) Co-operate with local staff in the day to day operation of the production line with a particular view to introducing sound practices of production management, technology, quality control and maintenance.

The above activities could not be commenced since the commissioning of the plant was abondened prior to expert's arrival at the duty station. The situation as the expert found on arrival was outlined in a preliminery report; and to suit the situation a work programme was drawn up with the concurrance of the National Project Director.

The salient points of this work programme were set out as follows:

1. Review the work done on the development on wall and floor tile bodies both by the turn-key contractor and BISF technical staff, and make an in depth study of the chemical compositions of the raw materials.

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2. On the basis of the studies, select bodies for wall and floor tiles maximising indigeneous raw materials and study in detail characteristics such as optimum moisture content and granulation at pressing, bending strength of green tile, dried and fired contraction, water absorption of the fired tile, glaze-body fit to produce tiles of desired quality.

3. Experiment on large scale trials simulating conditions in the existing plant, and to make an in depth study and identify check outs and modifications required.

4. Commence procurement of sufficient raw materials to complete guarantee test followed up by commercial production for a period of at least 6 months.

5. Make initial preparations for the installation of the new tiles press as required by the contractor.

6. Erection of the tiles press.

7. Commissioning and trial runs; check out and modify prepressing operations such as granulation and moisture adjustments needed to achieve the best yields, and the product to have the properties most desired.

8. Commence raising the temperature of the biscuit kiln and glost kiln to their operating temperatures. Effect adjustments in the kilns to produce desired properties of the tiles.

9. Studies on the glazing line operation; rate of glaze fall, adjustment on glaze viscosity, litre weight etc for proper glaze take up.

10. Vary operating conditions of the firing schedule of the kilns where necessary.

11. Operate the plant as an entire unit.

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The above work plan was expected to be completed during the mission time of the expert and was drawn up on the premise that the new tile press which was on order on the expert's arrival, will be erected and commissioned by the end of January 1986. However the erection of the tile press was completed only in May 1986, requiring the extension of the mission time by a further six months.

IV. ACHIEVEMENTS OF IMMEDIATE OBJECTIVES

The achievements of the immediate objectives could be broadly divided into two main areas. Firstly the achievements prior to the installation of the new tiles press and achievements thereafter which cover the commissioning of machinery and commencement of commercial production.

Achievements prior to the installation of the new tiles press consist mainly of the laboratory and pilot plant level of studies on wall tiles the details of which are given below.

1. Having studied the body development work that have been already completed both by the Contractor and BISF, three body compositions were selected with a view of maximising local raw materials.

   The chemical analyses of all materials used are given in the annexes of this report.

   The body compositions were formulated as given below:

Materials/Body	WT-2	WT-3	WT-4
Bijoypur Clay	50	50	48
Bijoypur (Calcined)	10	10	10
Red Clay	10	10	10
Limestone	16	16	16
Dolomite	05	05	05
Pitchers	05	05	05
Ball Clay (English)	04	-	-
Ball Clay (Indian)	-	04	06
	100	100	100

.../...

The chemical composition of these three bodies are as follows:

Composition	WT-2	WT-3	WT-4
Loss on ignition	14.29	14.32	14.45
SiO_2	53.70	53.59	53.29 (63.44)
Al_2O_3	17.50	17.62	17.80 (21.19)
CaO	10.15	10.14	10.14 (12.07)
Fe_2O_3	1.26	1.28	1.28 (1.52)
MgO	1.47	1.47	1.46 (1.74)
	98.37	98.42	98.42

* Within brackets is the composition of the fired body used for commissioning the plant

Studies with these bodies were done on laboratory scale with respect to milling, drying, granulation, adjustment of moisture content, ageing of granules. The pressing of tiles were conducted in the existing press. The pressed tiles were further dried in the laboratory drier and fired in the laboratory kiln.

The tests and the results at various stages of this investigation are indicated below:

1. Grinding of the material is conducted such that the rest on the sieve No. 120 (aperture size 63 micron) is less than 2%.

2. Particle size distribution of the granulated material is such that
   - Rest on Sieve No. 20 - Less than 20%
   - Between Sieve No. 40 and 20 - 35 - 45%
   - Between Sieve No. 80 and 40 - 25 - 35%
   - Passing through Sieve No. 80 - Less than 10%.

3. Moisture content of the process dust is between 6.5 and 7.5%.

4. Green Strength of the tile - 11 - 12 kg/cm^2.

5. Tiles fired at 1150°C on a fast fired schedule; reaching the maximum temperature in 13 hours, did not experience any, rejects.

6. Fired strength of the tile was between - 100 - 110 kg/cm^2.

7. Porosity and water absorption was between - 18 - 20%.

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8. Fired contraction 0.07%

This low contraction was viewed to be a break through on account of two factors - (a) To combat the variation of temperature expected in the process kiln.

(b) To stick to strict size tolerances.

In view of these satisfactory results, the studies were extended to a pilot plant level and have had similar results.

It should be mentioned that, to do the tests on pilot plant level, the experimental filter press which was lying idle since erection of the plant was commissioned by the expert. The Sheepbridge press which was not functioning was put into operation and was used for the fabrication of the tiles.

The edge runner mill in the process plant was utilized for the granulation of the material.

In view of the fact that Calcination of Bijoypur Clay was thought to be a cumbersome arrangement contrary to the earlier belief, it necessitated to develop further bodies eleminating calcined clay and a new body was developed, eleminating Calcined Bijoypur Clay.

The composition of this body was

	WT-5
Bijoypur Clay	48
Red Clay	10
Limestone	16
Dolomite	05
Pitchers	15
Ball Clay (Indian)	6
	100

The properties of this body compared very well with the earlier bodies developed and in addition had improved fired strength.

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The two available glazes one of English origin and the other of Japanese origin were tested out with the body. The english glaze fired at 1050°C matched well with the body, and satisfied both the Harkort and Autoclave tests.

Having done further trials with the body and glaze, the raw materials requirement for the impending guarantee tests, and commercial production were evaluated. On the basis of this information the procurement of raw materials commenced.

It should be mentioned that instead of importing the prepared glaze it was found cheaper to import only the frit and accordingly only the frit was imported. The glaze prepared with this frit matched successfully with the body satisfying both Harkort and Autoclare tests.

FLOOR TILE PRODUCTION

In view of the fact that there were unexpected delays in the arrival of the new tiles press, the expert concentrated on the production of floor tiles and printing of wall tiles.

It should be mentioned at the outset that the production of floor tiles in the wall tiles plant is discouraged, since the firing of floor tiles involves a higher temperatures than those required for wall tiles. This frequent change in the firing schedule of the kiln to cater for floor tiles would eventually result in the shortening of the life span of the bisque kiln. Further the glost kiln of the wall tiles plant also will have corresponding shut downs with the above mentioned adverse effect.

A market survey carried out by BISF, indicate that the demand in the country for floor tiles are quite low, and this low demand does not warrent a product line at the expanse of wall tiles productions.

Further on the enquiries already at hand from various sources outside the country, there are good indications that an export market for wall tiles exist and this avenue need to be further developed.

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In view of these factors it was recommended that the spare space, both in the insulator kiln and sanitaryware kiln is made use of for the firing of floor tiles. The fabrications of the tiles is possible to be done in the Sheepbridge press.

In this respect it was thought best to make use of the green waste both from the Insulator and Sanitaryware product lines. This approach would make the price of the floor tiles cheaper and will be in a position to compete with the much prevalent terrazzo floor tiles, as had been pointed out by the findings of the market survey. This proposal will have the following advantages.

1. Sanitaryware green waste along with the sweepings will be effectively used in the body composition for floor tiles, making the body cheaper.

2. Insulator green waste similarly could be used for the body making the body cheaper. It is estimated that the loss of green body waste from the Sanitaryware and Insulator product lines is about 15%.

3. Unutilised space of both insulator kiln and sanitaryware kiln could be made use of without any extra expense on firing.

4. This proposal would increase the productivity of the plant.

5. The floor tile production could be done continuously with the use of the 2nd silo, and the sheepbridge press without any hindrance to the regular production wall tiles.

6. Lastly this arrangement will avoid any possible contamination in the alternate processing of wall and floor tile bodies since the processing has to be done in the same slip house.

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The use of both the insulator green body waste and sanitaryware green body waste was amply demostrated by the production of 8,000 pcs. of 150 mm x 150 mm x 85 mm floor tiles. These tiles fired in the insulator kiln had the desired properties of heavy duty acid resistance floor tiles of porcelain type. Further experiments to produce floor tiles of 100 mm x 100 mm x 55 mm tiles were done and the tiles were produced using the same press, the body and fired in the insulator kiln. The conclusions of this excersise is that floor tiles of 150 mm x 150 mm and 100 mm x 100 mm of various thicknesses were possible to be manufactured making use of the waste bodies of both insulator and sanitaryware production lines, without a hindrance to the continuity of production of wall tiles.

The period immediately prior to the arrival of the new tile press, the expert was actively engaged with the BISF staff on the preliminery arrangements for the smooth installation of the press. The visiting erection engineer was expected to stay in Bangladesh only for a period of 3 weeks. The preliminery works included, the civil engineering work on the foundations, the mechanical engineering works such as the fabrication of the overhead platform, charger hopper; electrical engineering works such as the power supply and the other auxillary services such as water, compressed air, lighting etc.

A detail programme was drawn up to effect the erection of the press in the shortest possible time.

The erection of the press was completed in mid-May 1986.

Before embarking on achievements accomplished on the technological aspects in respect of the guarantee test of the new tiles press and of production of wall tiles on commercial scale it is relevant to outline the flow diagram of the plant.

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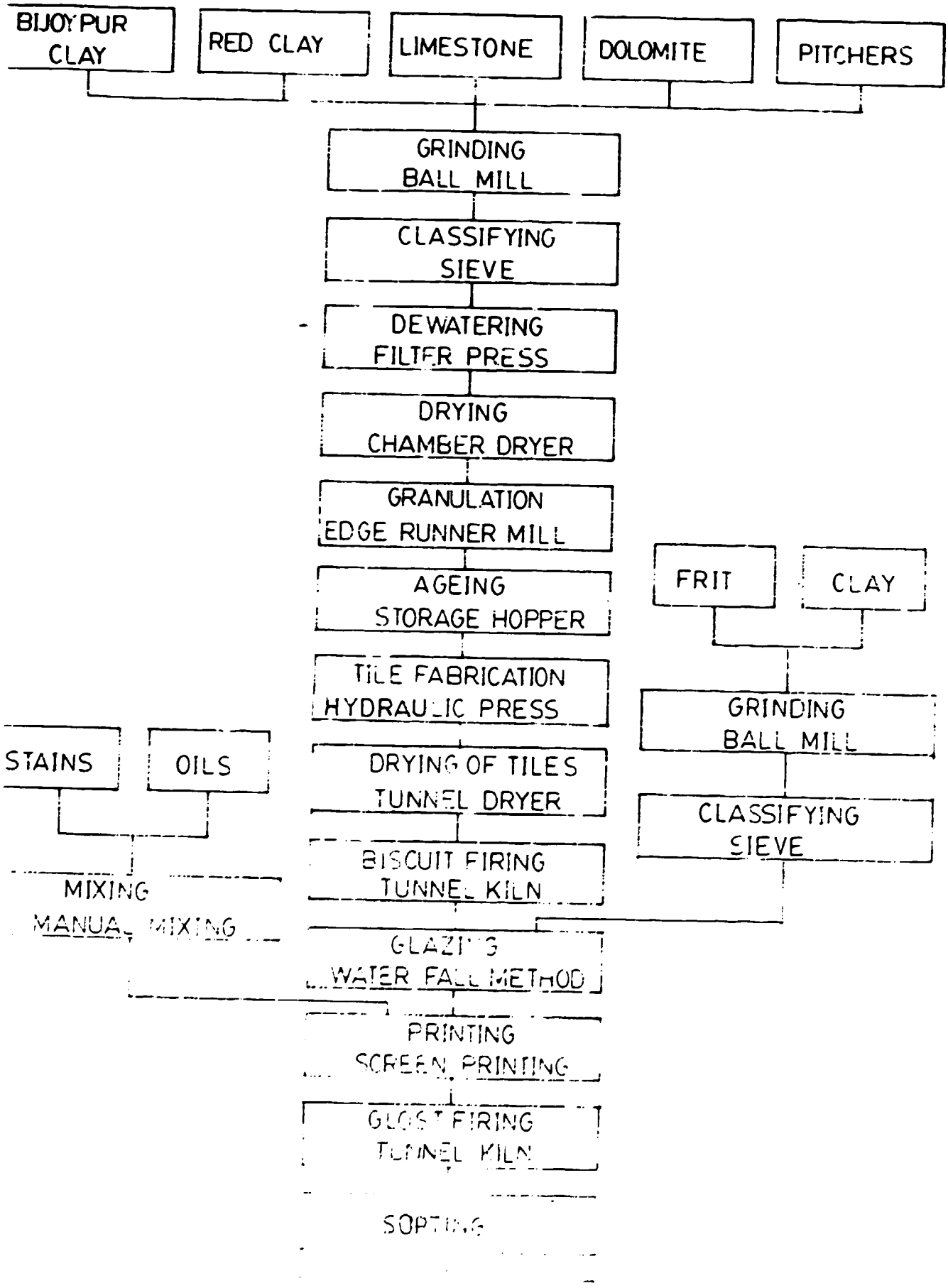
FLOW CHART- WALL TILES PRODUCTION



As had been explained before, the erection of the tiles press was the main obstacle for the commencement of commercial production of wall tiles. Having completed this task a programme was drawn up for the production activities to be started.

Before the commencement of any production activity, the entire plant was cleaned up to make sure that there will be no possibility of any contamination; and to ensure that sufficient raw materials were available for the continuity in production.

Based on the body composition established during the first phase of the expert's mission large scale body preparation commenced.

The batch composition of the tile body was as follows:

Bijoypur Clay	-	1800 kg.
Red Clay	-	350 kg.
Limestone	-	560 kg.
Dolomite	-	175 kg.
Pitchers NCl	-	525 kg.
Ball Clay	-	210 kg.

Initially the hard materials pitchers, dolomite and limestone together with a 50% percent of Bijoypur Clay component was milled for 5 hours (in the ball Mill of 7' dia x 7' length capacity), with 3000 litres of water the rest of the Bijoypur Clay, Red Clay and Ball Clay was added with another 1000 litres of water and milled for a further 5 hours.

This way the residue on the 250 (63 micron aperture) mesh screen of the resultant slurry was maintained below 1.5%.

The slip so prepared had a litre weight of 1350 gms. and contained(54% M.C.).

The slip was dewatered in a fitter press, and the pressed cakes had an average moisture content of 24%.

The filter pressed cakes were further dewatered in the chamber drier, which was heated with steam. The drier temperature was adjusted at 80-85°C and the period of drying was maintained at 20-22 hours. The average moisture content of the of the dried cakes were around 7%.

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The granulation in the edge runner mill as studied previously needed careful control of the moisture content of material fed, to achieve the desired granulometric analysis, most suited for pressing devoid of problems. The chamber drying did not produce a uniformly dried clay cakes; the center deck of the drier car was more dried than the top and bottom decks.

To achieve uniformity of moisture content of granules from the edge runner, mixed feeding of materials from the drier cars was practiced.

The granules so prepared were stored in the hopper for at least 3 days for ageing, thereby achieved homogenity in the moisture content of the granules. This way sufficient material was always stored at all times both for adequate ageing and for continuity in production.

The commissioning and trial guarantees of the new tiles press were conducted with this body material.

The basis of the guarantee performance of the press as evaluated by the expert was agreed both by BISF and the Contractor,

Output of glazed Wall Tiles per annum as per the contract	110,000 M^2
Assuming a 5% loss in glost firing; the biscuit tile output	115,790 M^2
Assuming a 10% loss in biscuit-firing; the green tile output	128,655 M^2
No. of working days as per the contract	300 M^2
Hence the daily output of green tiles per day (in a single shift)	429 M^2
Assuming the working hours of the shift with allowances for die cleaning and other adjustments to be 6.7 hours	
The required output of green tiles per hour	64 M^2
Hence the output of tiles per minute	1.06 M^2

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At the rate of 44.4 tiles of 150 mm x 150 mm per M^2, the no. of tiles required per minute	48 Nos.
At the rate of 4 tiles per punch the no. of punches per minute	12

It should be mentioned that the new press satisfactorily proved the guaratees.

The pressure at which the tiles are fabricated is maintained at 290 bar and the green strength of the tile was between 12-13 kg/cm^2 with the moisture content of granules between 5.5 - 6.5%.

The thickness of the pressed tiles were maintained at 6.5.mm weight of the green tile is maintained around 285 gms

Tile Setting

Dimension of the kiln car length is	1300 mm
the breadth	360 mm
and the loading height	600 mm

With this arrangement there were two possibilities of setting in the biscuit kiln.

1. 14 stacks of 80 tiles per stack (1120 pcs.)
2. 14 stack of 40 tiles per stack in the top tier and 6 stacks of 30 tiles per stack in the bottom tier. (840 pcs.) in two tiers.

Due to the irregularities in the manual setting the formerly mentioned placing was opted out. Further a warpage of the tile was experienced in the former method and the 2nd method of setting was preffered.

Drying

The tile cars are dried in a tunnel drier in which the moisture content in the tile is reduced below 2%. It is worth mentioning that there were no damages in the drying process, and no contraction during drying.

Note: Unlike in the previous biscuit firings by the Contractor the shade of the tile is uniform. In the earlier firings the centre of the tile was of a different shade in comparison to the rest of the surface of the tile indicating non-uniformity in firing. This was eradicated with the body developed.

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Biscuit Firing

Biscuit firing was done in the tunnel kiln muffled type gas fired of 44.2 meters long.

The firing curve is given in the ANNEXURE VI and the pushing time of the car is 90 minutes.

The damages in the biscuit firing was maintained below 3%. However a slight curveture of the tile was experienced in the firing which was overcome by the face to face setting of the tiles.

The properties of the fired tiles were as follows:

1) Fired strength 120 kg/sq.cm.
2) Water absorption - 19 - 20%
3) Contraction - 0.07%
4) Weight of the fired tile - 230 gms.

These properties satisfied the Japanese Industrial Standards for glazed tiles.

Glazing

Glazing was done by the waterfall method.

During the preliminery commissioning of the plant by the contractor, the glaze on the edges and the back of the tile was not effectively removed after the tile passes through the fall, with the result that quality of the finished tile was marred and also there were losses both of the tiles and saggers due to sticking.

This was rectified by proper cleaning devices and the adjustments required both in the conveyor and the glaze, thereby the losses in this aspect was completely eleminated.

Glost Firing

Glost firing was done in the tunnel kiln muffled type gas fired of 44.2 meters long.

The firing curve is given in the ANNEXURE VII and pushing time of the car is 60 minutes.

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The rejects in the glost fire was around 10%.

The breakdown of the rejects was as follows:

1. Colour spot - spot appearing on the surface.
2. Glaze Scar - Body exposed by being not covered with glaze.
3. Pinhole - Small hole appearing on face of glaze.
4. Boss - Protruding on the face of glaze made by an adhering material.
5. Warp - Convex warp concave warp
6. Edge Crack - Crack produced at the edge of face

Decoration

In view of the fact that there exists a very heavy demand for decorated tiles, the glazing line was equipped with two screen printing machines on which two colours systems could be introduced on a white or coloured tile.

The manufacture of various designed screens were introduced with the already available equipment at the Bangladesh Small and Cottage Industries Corporation. This excercise was done druing the first phase of the expert's mission.

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V. UTILIZATION OF THE PROJECT RESULTS

1. The tile plant with an installed capacity of 110,000 sq. meters per year which was lying idle since its installation in 1984, commenced commercial production. The estimated production target of 300,000 sq. feet for the year 1986/1987 could very comfortably be achieved. For the period from 1st Aug. 1986 to October 1986 (3 months) a production of 85,000 Square Feet of tiles was achieved, inspite of the teething problems in a new plant.

2. Production of floor tiles was successfully achieved making use of the insulator green body waste and sanitaryware green body waste, making use of the Sheepbridge press which was lying idle. The floor tiles were fired in the insulator and sanitaryware spare space, with a view of devising stratagies and actions conducive to increased production and improved financial viability of the plant.

3. Wall tile bodies with 96% local raw materials were developed with a view of maximising profits, without hindrance to the quality of the finished product.

4. Ensured sufficient production of tiles both floor and wall tiles to feed the consumer demand, and thereby halted the drain of foreign exchange in the import of these items.

5. Instroduced production of screen printed tiles and also the production of the screens required for various designs.

6. Imparted technology on the production of wall and floor tiles and introduced a sound system of production management, quality control and maintenance.

7. The small scale filter press was commissioned which was used for the studies on pilot plant level in wall tile body development, and this could now be used for any future studies.

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VI. FINDINGS

1. Bangladesh raw materials such as Bijoypur Clay, red clay, limestone and Dolomite constitute a very satisfactory combination for the formulation of a lime siliceous type wall tile body, which produce the desired properties of wall tiles in respect of size tolerance, strength and colour.

2. Availability of local expertise in the production of screens used in textile industry which could be extended to be used for the ceramic industry.

3. A large quantity of waste materials could be gainfully utilized in the manufacture of floor tiles. For this purpose the unutilized capacity in the sanitaryware and insulator plant could be gainfully used.

4. The local demand for floor tiles does not warrant a separate production line for floor tiles but with the use of the available presses the demand could be met.

VII. RECOMMENDATIONS

1. Initially spare dies for manufacture of tiles to be purchased abroad for continuity in production.

2. Dies required for the production line of tiles are expensive and need frequent changes to maintain quality standards. The technology of developing them locally need to be introduced. There by much needed foreign exchange could be saved and the products could be diversified both size wise and design wise.

3. Saggers - Manufacture of saggers to be introduced locally. Since the temperatures required for such firing of bodies as cordierite is already available in the insulator kiln the avenues of producing soggers should be explored.

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4. Commence production of 100 mm x 100 mm tiles.

5. Initiate manufacture of other shapes such as one-round Edge, 2-round edge tiles both for 150 mm x 150 mm tiles and 100 mm x 100 mm tiles.

6. To procure sufficient spare parts for the two Sheepbridge presses, to enable them to be operated continuously.

7. Production of coloured floor tiles.

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VIII. PRODUCT UTILIZATION CAPACITY - Wall Tiles

Although the installed capacity of the plant is 110,000 sq. meters of 150 mm x 150 mm glazed wall tiles per year, having studied the constraints in production, only about 75,000 sq. meters per year appears to be a more realistic figure.

The above figure is based on the following production analysis in the various stages of manufacture. Also indicated are the pre-requisites to achieve the above production figure.

The output from the glost kiln is limited;and is the bottle neck in the production line. Hence the product utilization capacity was evaluated based on the output of the glost kiln.

Capacity of the glost kiln for 150 mm x 150 mm pipe tiles

Output of tiles/glost kiln car = 420 pcs.
No. of cars possible to be fired/day = 24 Nos.
(ie). One kiln car is taken out of the kiln every hour.
Therefore the output of tiles from the glost kiln per day

$$= 420 \frac{\text{pcs.}}{\text{car}} \times 24 \frac{\text{cars}}{\text{day}}$$

$$= 10{,}080 \text{ pcs/day}$$

$$= 226 \text{ sq. meters/day (At } 44.44 \text{ pcs per sq. meter)}$$

Assuming 10% reject in the glost kiln

The output of saleable tiles = 203 sq. meters/day.

Assuming a steady supply of cars to the kiln throughout the year.

The annual production $= 203 \frac{m^2}{\text{day}} \times 365 \frac{\text{days}}{\text{year}}$

$$= 74{,}000 \text{ sq. meters}$$

To achieve this output of tiles, the following pre requisites need to be fulfilled.

The total No. of glazed tile cars required for the glost kiln per week is = 24 cars/day x 7 days/week

$$= 168 \text{ cars/week.}$$

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Additional 10 glazed the cars are always kept available for emergencies

Hence the grand total for the week.

= 178 cars/week.

Requirement of Cars for glost setting

Assuming a 6 day week for the glazing operation.
The No. of tile cars required to be glazed

per week = 178

Hence per day the cars required = $\frac{178}{6}$

= 30 cars

This means 6 extra cars will be required to be glazed every day (in excess of the cars required to feed the kiln).

Hence the no. of cars in accumulation at the end of the week (ie) Thursday is = 6 cars/day x 6 days = 36 cars

The no. of cars in the glost kiln at any given time = 34 cars.

Therefore the total no. of cars required for the glost kiln operation:

(i) No. of cars required inside kiln at any given time - ---------- 34

(ii) No. of cars outside the kiln (end of glazing week) ---------- 36

Hence the total requirement of cars for the glost kiln

Total -------- 70

Biscuit Firing Capacities and Requirement

The speed of the kiln is regulated at the rate of one car every 90 minutes.

Therefore the no. of green tile cars required per day

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$$= \frac{24 \text{ hrs/day} \times 60 \text{ mts/hour}}{90 \text{ mts/car}}$$

$$= 16 \text{ cars/day.}$$

No. of tiles loaded in each car = 840 tiles.

Therefore the total green tiles required each day

$$= 840 \frac{\text{tiles}}{\text{car}} \times 16 \frac{\text{cars}}{\text{day}}$$

$$= 13,440 \text{ tiles/day}$$

$$= 302 \text{ sq. meters/day.}$$

Assuming a 10% loss in bisque firing.

The output of biscuit tiles/day

$$= 302 \times \frac{90}{100} \text{ sq.meters}$$

$$= 272 \text{ sq.meters}$$

Since the biscuit tile requirement is only 226 sq.meters/day the biscuit firing capacity is adequate.

Press Section

Capacity and Production requirement

At the rate of punches/mt. in press	-	12
and the no. of tiles/punch	-	4
No. tiles/mt.	-	48 pcs.

As shown previously at this pressing rate the output from the press section/day = 429 sq. meters.

Since the green tile requirement is only 302 sq.meters, the press section capacity is adequate.

Granulation Section

Capacity and Production requirement

The required output of material per day is for 302 sq. meters of tiles.

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At the rate of 285 gm/tile and 44.44 pcs/sq. meter.

The quantity of material required per day

= 302 day x 44.44 x 285 gms

= 3825 kg.

Assuming a 2% loss of material in the press section the requirement of material.

per day = $3825 \times \frac{102}{100}$

= 3900 kg/day

= 3.9 tons/day

This weight include 6% of water in the granules.

Capacity and Requirement in ageing and Storage of Granules

The required capacity of the storage Sile is 3.9 tons/day x 3 days (ageing)

= 11.7 tons

Approximately 12 tons

The capacity of one hopper = 12 tons and the required storage and ageing could be achieved.

Filter Pressing - Requirements and Capacities

Output required from the filter press

= 3900 kg of material at 6.0% moisture content.

= 3666 kg dry material

No. of cakes/filter press	-	60
No. of filter presses	-	2
Total No. of cakes	-	120
Pressing Cycle	-	2½ hours.
Weight of each cake	-	20 kg at 22% M.C.

Hence the dry weight of material handled in a single operation of both filter presses

= 120 x 20 x $\frac{78}{100}$ kg. = 1872 kg.

Since only 3 hours will be taken to complete pressing cycle (inclusive of cleaning and unloading of cakes), with 2 pressings per day the required output could be achieved

1872 x 2 kg. = 3744 kg.

Requirements and Capacities

Milling Section

Altough the ball mill at present processes only 3620 kg per milling operation, it has a capacity of 4100 kg.

Hence for this capacity the batch composition:

Bijoypur Clay	:	2039 Kg.
Red Clay	:	396 Kg.
Limestone	:	634 Kg.
Dolomite	:	198 Kg.
Pitchers	:	595 Kg.
Ball Clay	:	238 Kg.
		4100 Kg.

This output from the ball mill satisfies the requirement.

Glaze Requirement and Capacity

The No. of biscuit tiles required to be glazed

is - 30 cars x 420 pcs.

= 12,600 pcs.

Glaze take up by each tile pcs = 20 gms.

The glaze requirement = 252 Kg.

10% Loss is expected in the raw glaze.

Hence the glaze requirement = 277 Kg. glaze

The Ball Mill available for glaze preparation can handle material up to 300 Kg. per milling operation; hence the requirement is easily achieved.

.../...

It should be mentioned that the above capacity utilization of the plant was worked out for 150 mm x 150 mm wall tiles, but a similar evaluation for 100 mm x 100 mm wall tiles could be derived.

ANNEXE I

CHEMICAL COMPOSITIONS

1. White Bijoypur Clay

	Raw	Fired
LO_1	6.93	-
SiO_2	71.40	76.71
Al_2O_3	19.00	20.41
TiO_2	1.04	1.11
Fe_2O_3	0.82	0.88
CaO	-	-
MgO	0.26	0.28
K_2O	0.53	0.57
Na_2O	0.08	0.08

ANNEXE II

Red Clay

	Raw	Fired
LOI	6.70	-
SiO_2	63.90	69.31
Al_2O_3	16.78	18.19
TiO_2	0.65	0.70
Fe_2O_3	6.67	7.23
CaO	1.04	1.12
MgO	0.42	0.46
K_2O	2.51	2.72
Na_2O	0.25	0.27

ANNEXE III

WBB - Ball Clay

	Raw	Fired
LOI	13.18	
SiO_2	50.95	58.95
Al_2O_3	31.22	36.12
TiO_2	0.52	0.60
Fe_2O_3	1.19	1.38
CaO	0.55	0.64
MgO	Trace	-
K_2O	1.80	2.08
Na_2O	0.20	0.23

ANNEXE IV

Limestone

	Raw	Fired
LOI	42.50	-
SiO_2	0.53	0.92
Al_2O_3	0.77	1.34
TiO_2	0.10	0.17
Fe_2O_3	0.29	0.50
CaO	54.74	95.20
MgO	0.81	1.42
K_2O	0.05	0.09
Na_2O	0.15	0.26

Dolomite

LOI	43.50	-
SiO_2	5.35	9.69
CaO	29.66	53.74
MgO	20.18	36.56

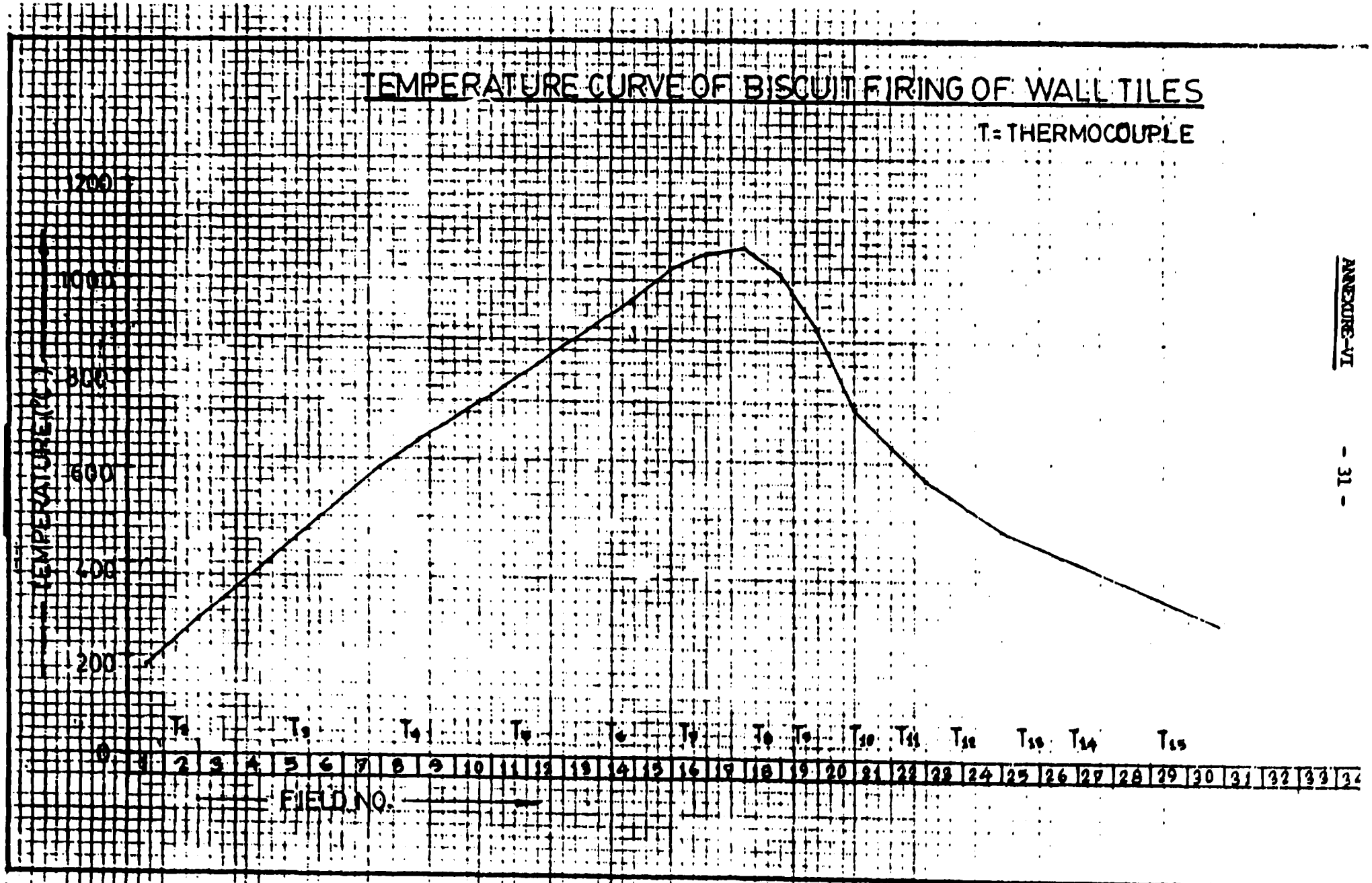
ANNEXE V

HCl Pitchers

	Raw	Fired
LOI	2.39	-
SiO_2	73.80	75.61
Al_2O_3	16.78	17.19
TiO_2	0.25	0.26
Fe_2O_3	0.35	0.36
CaO	0.54	0.55
MgO	0.07	0.07

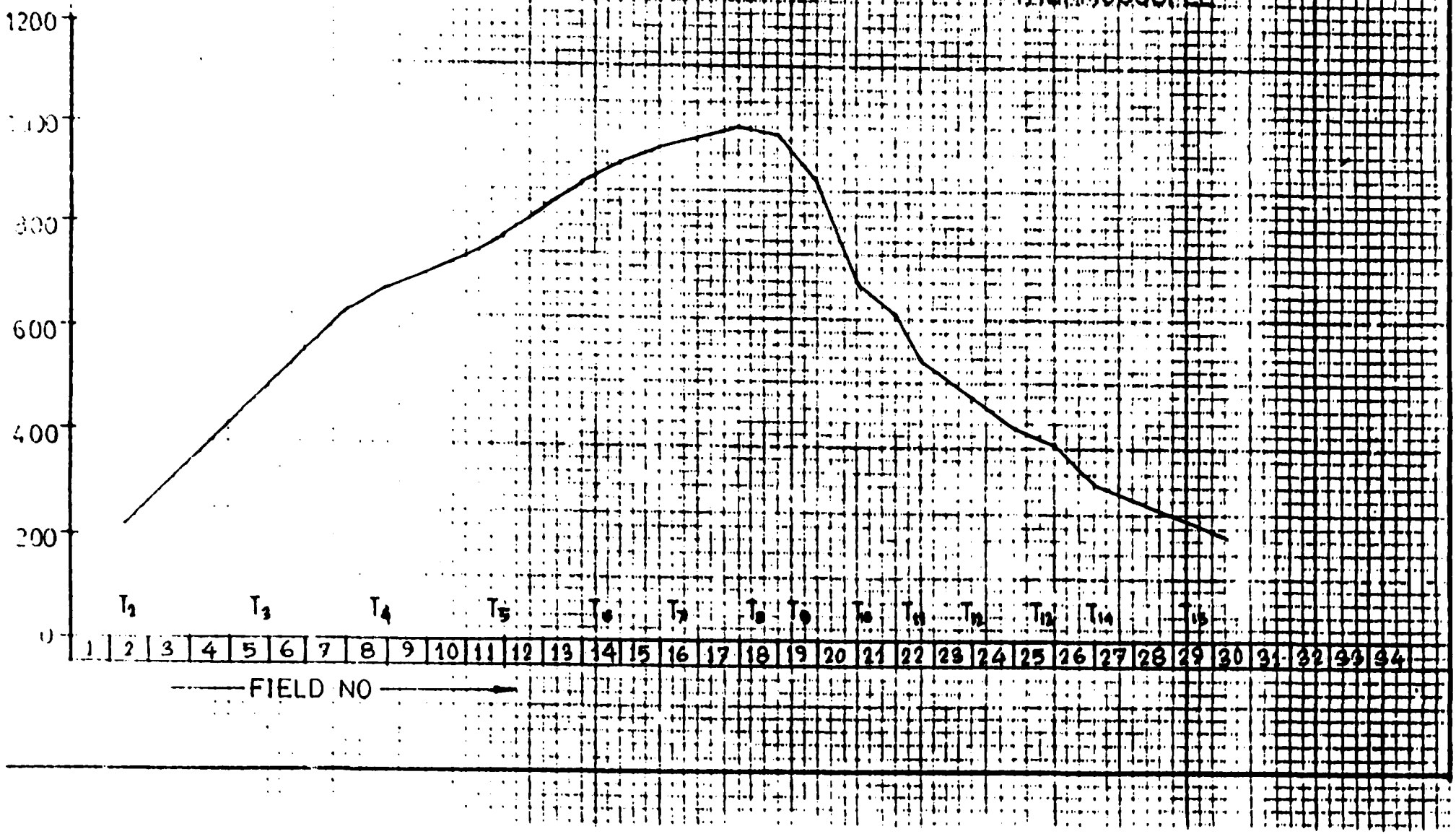
TEMPERATURE CURVE OF BISCUIT FIRING OF WALL TILES

T = THERMOCOUPLE



TEMPERATURE CURVE OF GLOST FIRING OF WALL TILES

T = THERMOCOUPLE



ANNEXURE VIII

In accordance with UNIDO requirements and those required by the BISF and BCIC the following progress reports were submitted at the mentioned dates.

A Tripartite Review Meeting was held, in May 1985 minutes of these meeting are available.

1.	Preliminery Report	18th August 1985
2.	Progress Report No.2	6th November 1985
3.	Progress Report No.3	10th December 1985
4.	Progress Report No.4	8th January 1986
5.	Progress Report No.5	31st March 1986
6.	Progress Report No.6	30th June 1986
7.	Progress Report No.7	10th August 1986
8.	Progress Report No.8	13th October 1986