CERAMIC INDUSTRY WITH SPECIAL REFERENCE TO POTTERY WORKS

A DISSERTATION
submitted in partial fulfilment
of the requirements for the award of the degree
of
MASTER OF ARCHITECTURE

By

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UNIVERSITY OF ROORKEE
ROORKEE, (U. P.)

July, 1973

CERTIFICATE

CERTIFIED that the dissertation entitled "CERAMIC INDUSTRY, WITH SPECIAL REFERENCE TO POTTERY WORKS" which is being submitted by Shree A.L.CHHATRE in partial fulfilment for the award of the Degree of MASTER OF ARCHITECTURE of the University of Roorkee, is a record of the student's own work carried out by him under my supervision and guidance. The matter embodied in this dissertation has not been submitted for the award of any other Degree or Diploma.

This is further to certify that he has worked for a period of seven months from January 1973 to July 1973 for preparing the dissertation for Master of Architecture at this University.

Roorkee,
July 16th, 1973.

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ACKNOWLEDGEMENT

It is my earnest duty to express deep and heartfelt gratitude to my thesis guide, Shree A.J. Contractor of the Department of Architecture, Roorkee, for the inspiration, encouragement and valuable guidance, given to me during the course of preparing this dissertation.

I would also like to convey sincere thanks to Prof. Rattan Kumar, Prof. R.K.Sahu, Shree R.Jaiswal of the Department of Architecture, Roorkee, for their help and time to time guidance. I must gratefully acknowledge the advice and assistance given by Dr.V.Narsimhan, Shree M.R.Sharma and Shree P.S.Bhandari, Scientists, C.B.R.I., Roorkee. Thanks are also due to Shree N.S.Walkade, of Department of Electrical Engineering, Roorkee for his help. I will be failing in my duty, if I do not acknowledge the facilities extended by Shree S.P.Saxena, Pottery Development Officer, U.P. Govt., Khurja in meacurement of sound pressure level.

Last and the most important, I wish to express sincere appreciation and deep gratitude to Prof.G.M.Mandalia, Head of the Department of Architecture, University of Roorkee, Roorkee without whose assistance and able guidance this dissertation could not have been brought to this level.

Roorkee,
July 1973

A.L. CHHATRE

have been included to give the reader a feeling of working environment and to help the visual presentation of information. It is hoped, that this work will bring relevant material within easy reach of the practising architect.

The author does not claim this to be completely original contribution in all its empassing and the ideas presented can be regarded as an assimilation of data, supplemented by talks with ceramists, potters, building scientists, literature survey and visits to some pottery works such as the Hindustan Sanitary ware and Industries Private Ltd., Bahadurgarh, U.P.Ceramics and Pottery Works, Ghaziabad, Bombay Potteries and Tiles, Bombay, Pottery Development Centre of U.P. Govt.Khurja, Ambica, C-1 and Malhotra Potteries, Khurja.

The author is indebted to those who have been quoted in the dissertation, to those who have contributed to it in the way of ideas or information and to those from whom illustrations have been obtained. To render it more useful, an appendix has been included which gives a 'check-list' for planning of various units and plans of some of the factories surveyed by the author. The glossary of ceramic terms and the sanction formalities are incorporated for clarity and ready reference. It is sincerely hoped that this dissertation will provide a guide line for architects while planning a new industry or in the improvement of existing factories.

CONTENTS

made known by the pottery imported.

1.2 DEVELOPMENT OF POTTERY INDUSTRY IN INDIA

All the ancient Indian ceramic development, with single exception of the Harappan ware, were undated before 1944 A.D. due to lack of scientific excavations. It was Dr. R.E. Mortimer Wheeler who, as the Director General of Archaeology, is credited with the start of scientific excavations.

India is a very vast country with varied climates, geography and topography. The development of pottery during last 3000 years, therefore has not been uniform in the past over the country as a whole and the same is briefly touched under the various periods of history and categorised as follows.[1]

1. Neolithic period - 6000 to 4000 B.C.
2. Chalcolithic period - 3252 to 1500 B.C. } Vedic and Later Vedic
3. Post Harappan Chalcolithic period - 1500 B.C. to 700 B.C.
4. Pre-Mauryan, Mauryan and Post-Mauryan Period (700 to 322 B.C.) (322 B.C. to 300 A.D.)
5. Gupta Period - 320 A.D. to 550 A.D.)
6. Beginning of Christian Era - Around 774 A.D.
7. Muslim Rule - 999 A.D. and onwards.
8. British rule and post-independence.

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1 a) Sastri, N.K.A. and Srinivasachari G., Advanced History of India. 1970

b) Ansari, Z.D., Evolution of Pottery Form and Fabrics in India, Marg, June 1961.

1. Neolithic Period (6000 to 4000 B.C.)

Prior to the introduction of potter's wheel, round bases of pots were first moulded, and then the complete shape of the pot was made by placing it on the convex surface of an inverted bowl. The saucer was turned by one hand and then the shaping of the pot was done by the other. The pottery forms and shapes were found in the earliest layers with no existence of metal, in the excavations at Brahmagiri, Sanganakallu and Nagarjunakonda in the districts of Chitaldurg and Bellary (Mysore) and Guntur (Andhra). The simple pottery forms, hand made and coarse grey in appearance were unglazed and included globular pots with round bases and flaring lips upto 14" size, broad lipped bowls, the spouted pots.

2. Chalcolithic Period (3252 to 1500 B.C.)

During this period people made use of stones as well as copper (chalcos-copper in Greek) and bronze. Initially remains of this phase were restricted to Indus-valley area but the recent excavations have brought to light the fact that besides the Indus Valley, the Deccan, the Malwa, Saurashtra and Punjab were inhabited by the Chalcolithic people, who seem to have survived upto 1000 B.C. The pots from Mohenjodaro, Harappa, Chanhudaro, Rozadi, Rangpur etc. have their profiles of graceful curves. The clay used was uniformly levigated and firing was to some extent uniform to produce a dull red, buff, black and red pottery. Storage jars upto 4'-6" ht., tumblers, beakers, dishes, perforated jars (for steam cooking), bowls etc. were representative of a utilitarian-ware and mostly wheel-made. The aesthetic sense of the Harappans is revealed in the pleasing colour scheme and a skillful combination of geometric and natural forms while painting on pottery. These included the animal motifs, the plant motifs and geometric motifs and thus reveal a close study of their environment.

3. <u>Post-Harappan</u> Chalcolithic Period (1500 to 700 B.C.)

The ceramic remains of this period have been traced in Saurashtra, Malwa, Rajasthan and Deccan. A black and red ware (unglazed) has been found at Ahar in Rajasthan and Navdatoli in Malwa. The range showed cups with short stand base, beakers with burnished surfaces and white colour painting. The firing process was of inverted type which gave the black (inside) and red (on outer bottom) pottery. Besides this there was also the cream-slipped ware. Pots are coated with a thick slip of cream to greenish white colour. These may be called the de-lux ware because of their fineness and delicate geometrical designs. The Navdatoli pottery was made from a coarse clay and was low fired, with elaborate surface treatment by means of thick slip of reddish to pink colour with black decoration. The lotas, channel spouted bowls and storage pots were very common. The ware in the Deccan was found at Jorwe, Nasik, Newasa and was mostly painted. The range includes carinated bowls, burial urns, spouted bowls etc. These were fired to high temperature and from a well levigated clay.

In the second half of the first millenium B.C. , throughout the Gangetic valley, the pottery had highly lustrous steel blue surfaces. Mostly smaller ware, is different from the chalcolithic ware.

It is called as the Northern Black Polished Ware (N.B.P) being slipped and a polished grey. Excavations at Rupar, Hastinapur and Kausambi have brought to light dishes, bowls, knobbed lids, high necked vessels.

4. Pre-Mauryan, Mauryan and Post-Mauryan Period
(700 to 322 B.C. and 322 B.C. to 300 A.D.)

Terra Cotta was the medium of expression for common people and considerable number of objects are found along Indo-Gangetic plains, such as the domestic ware, idols, children toys etc. Decoration was with geometrical and natural motifs, straight lines.

5. Gupta Period (320 to 550 A.D.)

During Gupta period the pottery was mostly the Black and Red type, with elaborate decoration. Excavations at Ahichchhatra,Kumrahar, Vaisali and Kariam in Darbhanga district, Bihar, Rupar, Hastinapur brings to light the use of handis, dipas, bowls and other every-day pots. Decorations were achieved with horizontal lines, animal bird motifs, rosettes etc. Well moulded terra-cotta-plaques and figurines served to decorate house fronts and interiors. Life size sculptures of deities were among the remarkable achievement.

Glazed pottery appears to have been introduced in India during the Muslim period with the exception of appearance of glazed-pottery among the Dravidians of South India. According to the conjecture of some writers, the Persian muslim potters were influenced by work of Chinese p potters in the art of glazing and subsequently developed this art, in India. The glazed pottery originated with glazed tiles around first quarter of 14th century and spread to the production of jars, ornamental wares. The artistic potter was called Kuzagar (Kashigar). The glazed coloured tiles (Persian tiles) were used to adorn domes, palaces forming a durable and almost permanent surface treatment.

The glazed encaustic tiles excelled in colour, and design and were mainly produced in Sind, Multan and Punjab. The tomb of Baha-ul-Hakk at Multan, Tantipara and Lattan mosques at Gaur in Bengal, palace of Raja Man Singh at Gwalior, Lahore fort, Wazir Khan mosque at Lahore are some of the remarkable examples with decorative use of glazed encaustic tiles.

Throughout the periods from Chalcolithic to 18th century A.D., the pottery was mainly utilitarian and for common man with exception of the development of glazed art ware. Some of the forms and shapes have survived to present day and also are being fabricated in some of the modern pottery industries.

8. British Rule and Post-Independence Period

The earliest pottery factory manufacturing glazed vitrified articles was established by M/S Burn and Co., Raniganj in 1860. The first porcelain factory was started in 1860 at Patharaghatta (Bhagalpur district-Bihar) which produced a high-quality table China but closed shortly afterwards. The Bengal potteries Ltd. was established in Calcutta towards the beginning of this century. The first stoneware factory was started at Than (Kathiawar). With growing demand for porcelain and earthenware, other factories soon came into existence and today there are about 500 units (of both smaller and bigger nature) all over India and the total installed capacity of the industry is over 1,00,000 tons/year at present.

Figures 1.2-1 to 1.2-4 indicate the form of pottery during various periods.

1.2.1 Some Idea of Present Production

The group covers a wide variety of products as classified in previous chapter and the following table[2] indicates a steady growth of various products during the last four years.

Table-1

See page-9

2. Govt. of India- Annual Report 1971-72, Directorate General of Technological Development, New Delhi-11.

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6. Beginning of Christian Era (around 774 A.D.)

India developed extensive trade contacts with the western world around this period. As a result, the pottery shows Roman influence which included amphora (cylindrical pot with 2 handles used for importing wine from Rome), rouletted Arreline and red polished ware. The rouletted is a fine black-slipped ware with a decorated pattern, drawing by a machinelike contrivance called a roulette. The Red Polished ware is remarkable for its surface treatment and purity of clay, with a bright red and burnished slip and includes sprinklers, cups, bowls.

7. Muslim Period (after 14th century)

The pottery during this period can be classified under following heads:-

1. Unglazed or terra-cotta pottery,
2. Painted and varnished but unglazed pottery, and
3. Glazed pottery.

The unglazed pottery was mainly specialised at Bhawalpur, Aligarh with designs imprinted or incised over the half-dry surface. The colour was imparted by coloured earths such as ochre, chalk or talc and fixed by firing.

Painted pottery had attained greatest repute at Jullandhur, Hosiarpur, Lucknow and Sarseram. The colour was given after the pottery was fired. It included the idols and statues. The work of potters in the tomb of Shershah at Sarseram (1545 A.D.) stands as a remarkable example.

Thirteenth century marked the beginning of Blue Pottery at Khurja.

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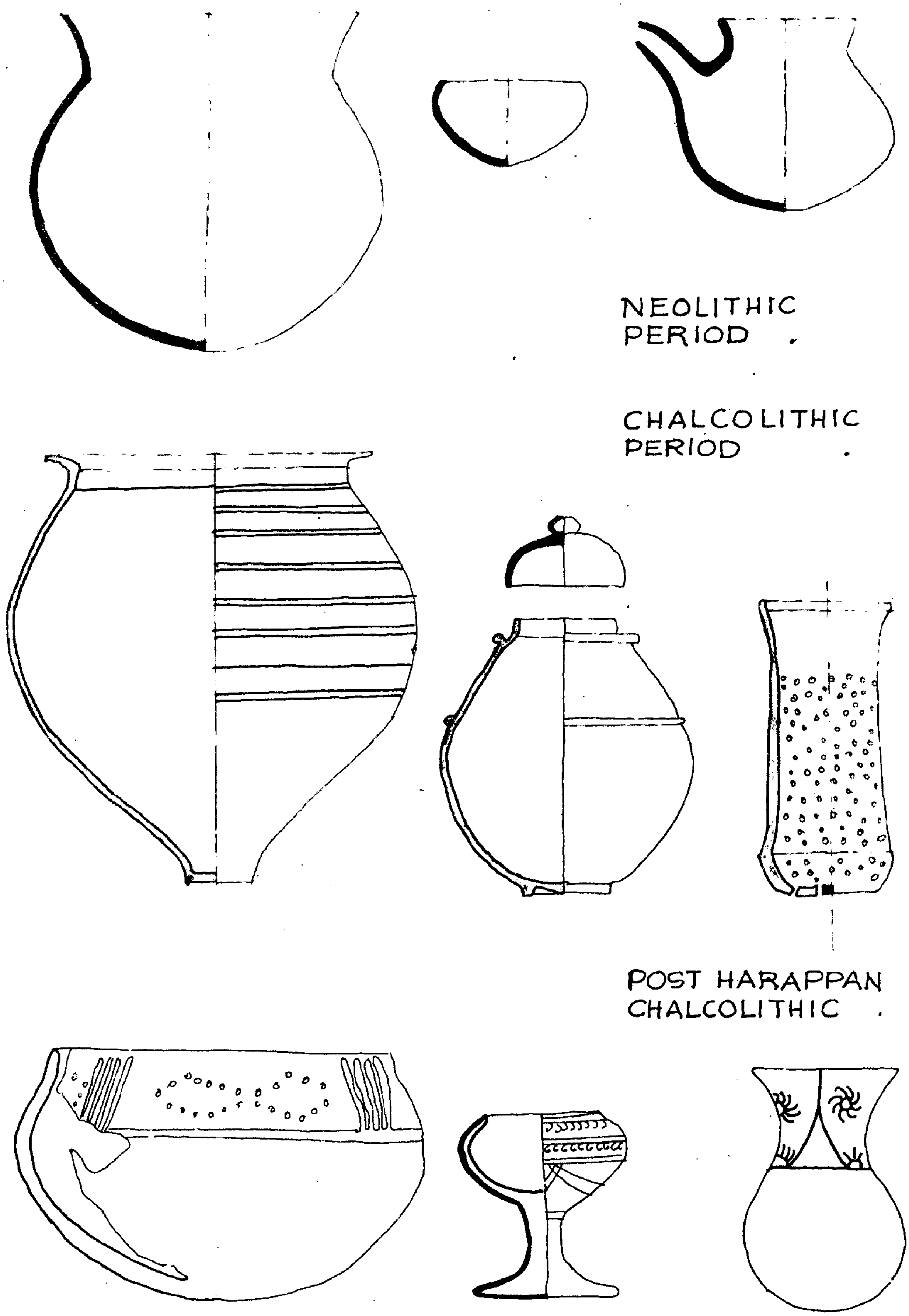
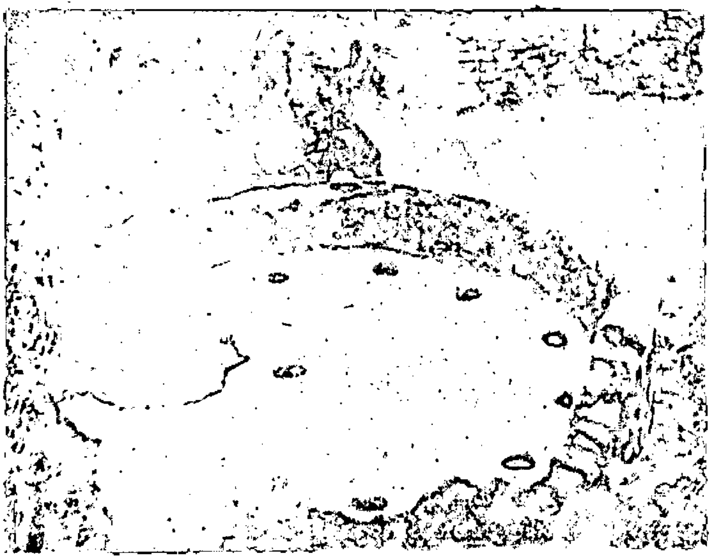


FIG. 1·2-1

: POTTERY IN INDIA : NEOLITHIC, VEDIC, LATER VEDIC .

HISTORICAL DEVELOPMENT.

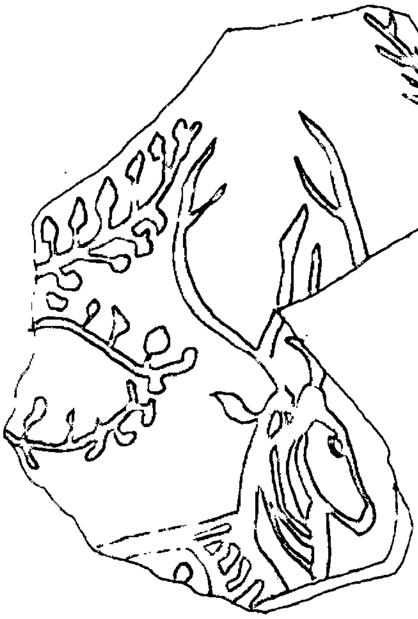
SOAKPIT MADE OF JAR
MOHENJODARO.
→



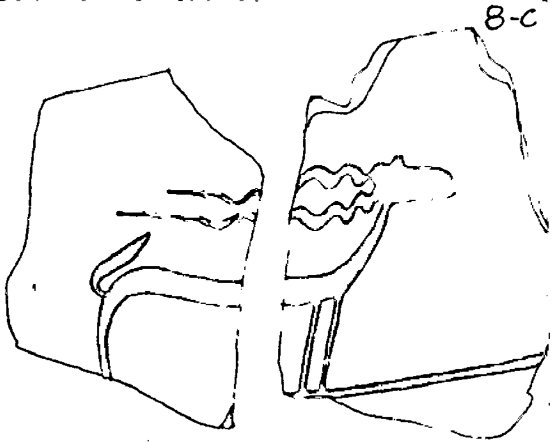
POTTERY KILN
MOHEJODARO.
←

SOURCE: SANKARANAND SWAMI.
HISTORY OF MOHENJODARO & HARAPPA
PP 49 AND 103.

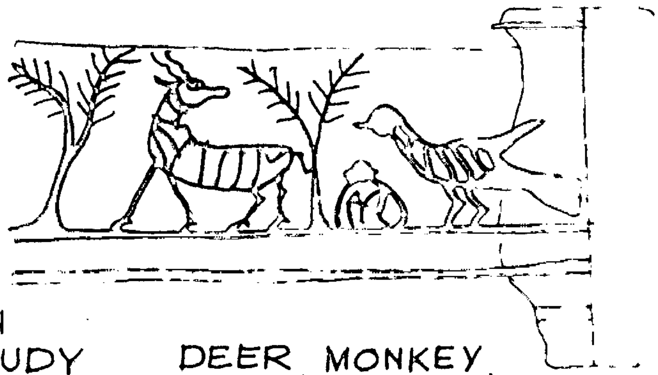
CHAP. I
1.2-A



STAG BELOW A TREE.



REPRESENTATION OF A DEER

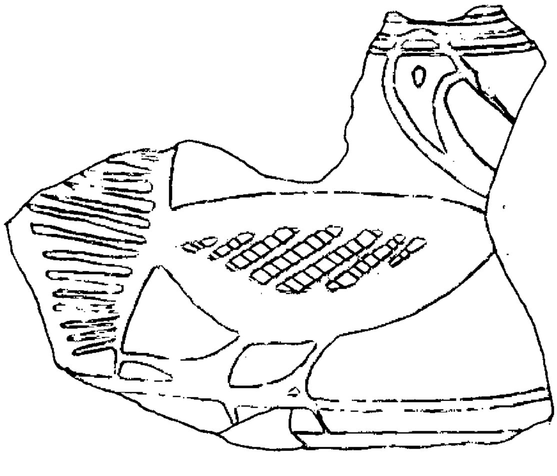


DEER, MONKEY, BIRD MOTIFS.

MOTIFS & DECORATION INDICATE A CLOSE STUDY OF SURROUNDING ENVIRONMENT :

BLACK COLOUR DEÇORATION OVER "REDWARE".

PEAÇOCK



HISSING SNAKES BELOW A TREE.

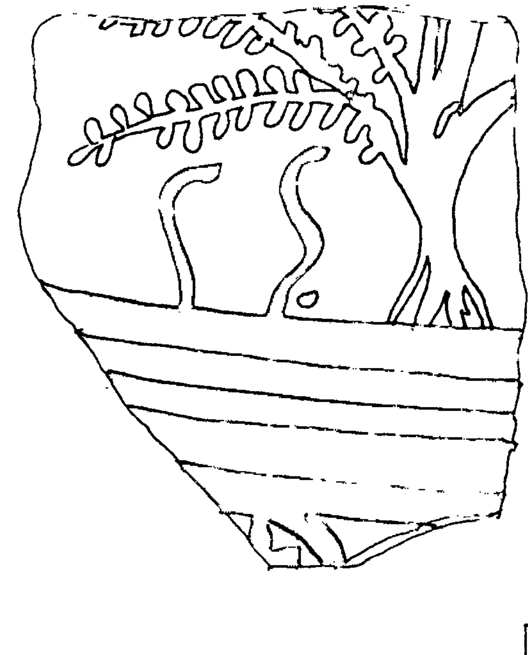
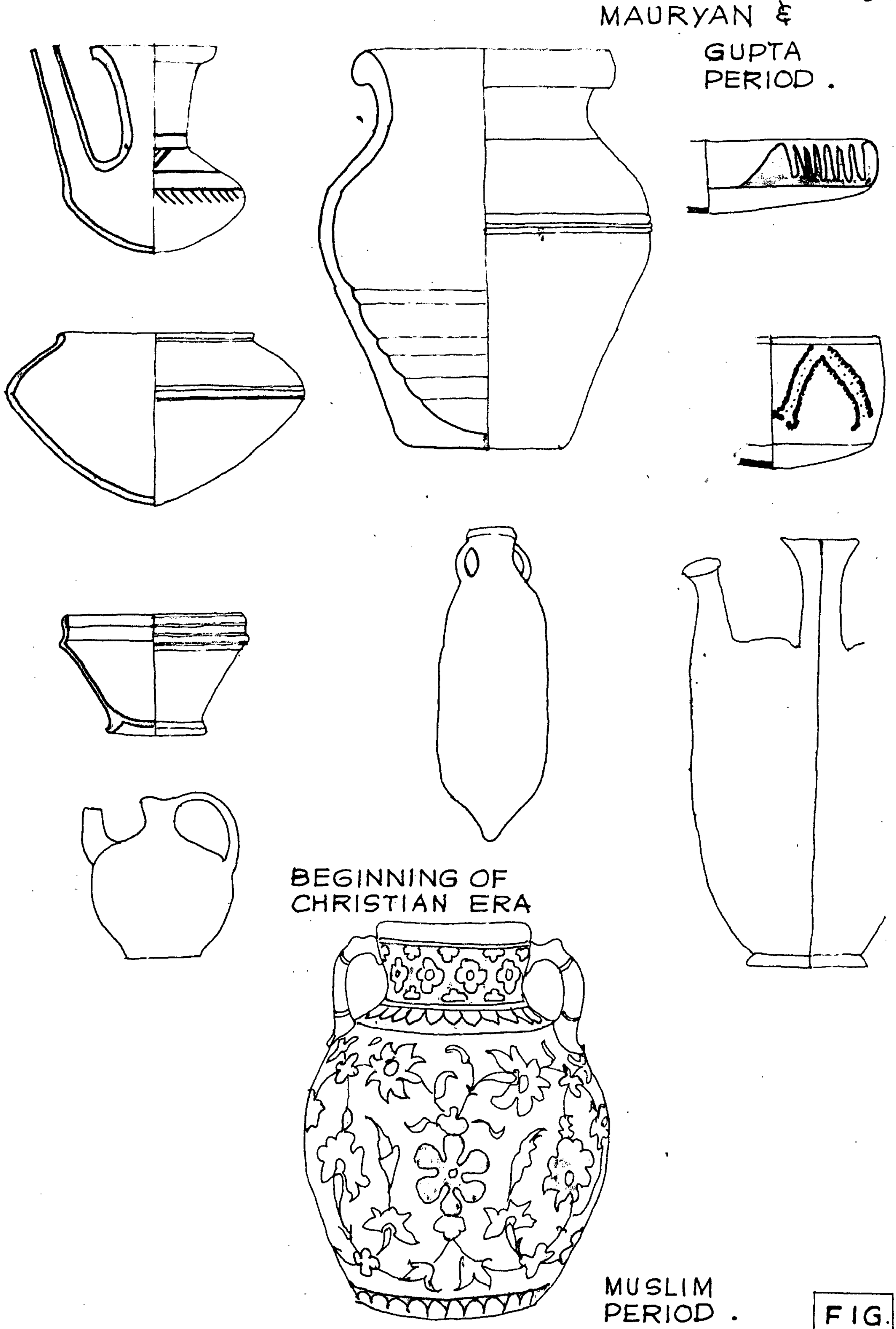


FIG. 1·2-2

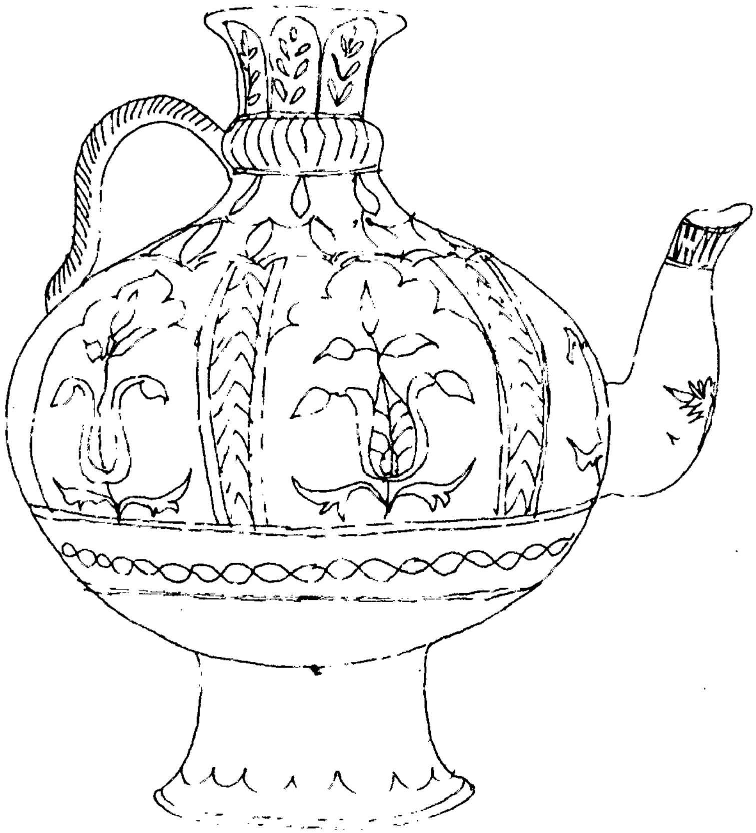
: POTTERY IN INDIA : MOHENJODARO, HARAPPA .

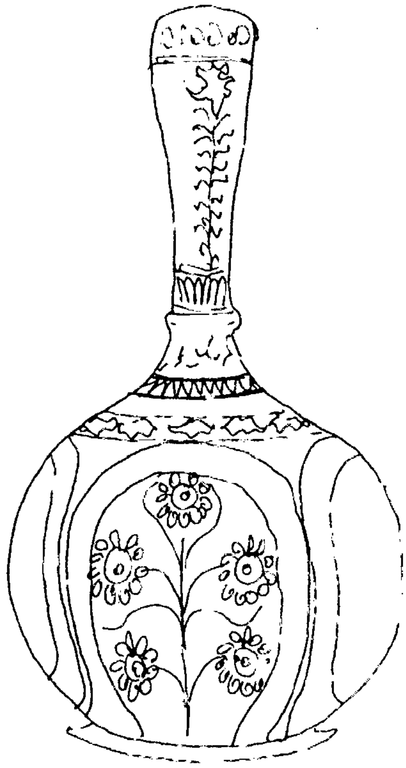


: POTTERY IN INDIA : MAURYA, GUPTA, CHRISTIAN ERA.

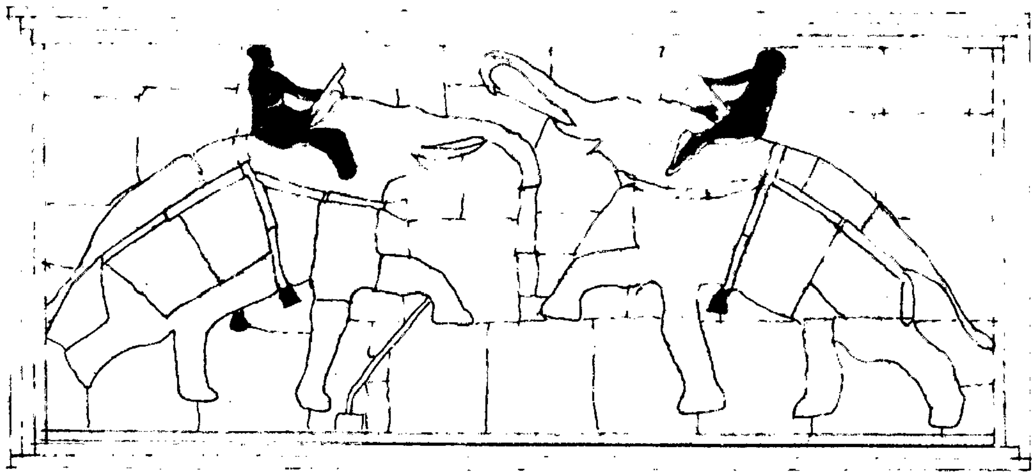
FIG. 1·2-3

GLAZED ARTWARE.





GLAZED TILE MOSAIC
LAHORE FORT; 17TH CENTURY.



: POTTERY IN INDIA : MUSLIM PERIOD:

FIG. 1·2-4

Table No.1

Products	Production in tons during			
	1968	1969	1970	1971
1. Sanitary ware	12,132	12,412	12,762	14,361
2. Insulators L.T.	1,240	1,842	2,259	2,259
H.T.	13,280	13,640	15,433	17,865
3. Crockery	11,417	11,993	17,469	17,700
4. Glazed Tiles	14,080	18,572	19,639	20,642
5. Stone ware pipes	-	19,790	25,542	34,612
6. Stone ware jars	-	7,703	4,728	5,885

1.2.2 Statewise Distribution of Pottery Works manufacturing sanitaryware, crockery, insulators, glazed tiles, stoneware pipes, and jars, chemical procelain.

Table No. 2

State	No. of units[3] (including small scale units)
1. Andhra Pradesh	8
2. Bihar	6
3. Delhi	21
4. Gujrat	22
5. Kerala	11
6. Madhya Pradesh	8
7. Maharashtra	22
8. Mysore	5
9. Orissa	3
10. Punjab and Haryana	21
11. Rajasthan	6
12. Uttar Pradesh	310
13. West Bengal	32
14. Tamilnadu	11
15. Dadra Nagar Haveli	1

3. Indian Industries, Sect.V.Mining Industries, Mineral Products Industries, Reference Book, and Directory, 10th Edition, PP. 23-25, 1971.

1.3 CLASSIFICATION OF CERAMIC PRODUCTS

1.3.1 Definition and Etymology of the word ceramic

Fundamental idea conveyed by the word ceramic is that it is a product obtained through the action of fire on earth materials. It involves the two characteristic elements namely,

i) a product in whose manufacture a high-temperature treatment is involved, and

ii) a product customarily manufactured chiefly from raw materials of earth origin as distinguished from those of an organic and metallic nature.

This broad definition includes now, a variety of products.

At one time the word ceramic was thought to refer only to the art of pottery but the current usage has broadened the term to include all the silicate industries.

The etymology of the term shows that it has been derived from the Greek word 'Keramos', meaning the burnt stuff, but further this word is related to Sanskrit root (कृप - कर्पति - कार्पर) meaning 'to bake'.

'Ceramist' is a person who handles or controls the blending and processing of non-metal, raw materials at high temperature.

'Ceramic artist' is a person who makes art objects of ceramic materials.

'Ceramic Engineer' is a person who controls the scientific production of ceramic ware and conducts research to improve the quality of such products and the methods by which they are made. He studies the geology of earth and modifies the non-metallic substances of earth origin by shaping them and reacting them with high temperature. He is greatly interested in the chemistry and physics of these materials and develops the science of blending on such analysis.

The present day ceramics include a wide range of products which can be classified as follows:-

1.3.2 Classification of Ceramic Products[3]

Structural ceramics:

1. Common brick
2. Paving brick
3. Facing brick
4. Sewer pipes
5. Drain tile
6. Hollow block
7. Terra-cotta
8. Conduits
9. Roofing tiles
10. Flue lining
11. Floor tiles
12. Wall and fire place tiles

Refractories:

13. Fire clay bricks
14. Magnesia bricks
15. Silica bricks
16. Chromite brick
17. Bauxite and diaspor bricks
18. Special refractories

Pottery:

19. Table ware
20. Kitchen ware
21. Art Pottery
22. Sanitary Ware
23. Stone ware
24. Chemical porcelain and stoneware.

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3. Figures 1.3-1 to 1.3-5 bring out the application of ceramics in the above mentioned fields.

Glass Ceramics

25. Household
26. Windows
27. Bottles
28. Lighting
29. Optical glass
30 glazes, enamels, vitrum, artificial stones
31. Quartz glass.

Enamelled metals

32. Household and kitchen
33. Sanitary
34. Chemical
35. Advertizing

Abrasives

36. Silicon carbide
37. Aluminous abrasives

Cements, Limes and Plasters

38. Portland Cement
39. Building, agricultural and chemical lime
40. Calcined gypsum products
41. Magnesia cement,
42. Dental cement.

Insulation (A type of Pottery)

43. Electric insulators
44. Thermal insulators

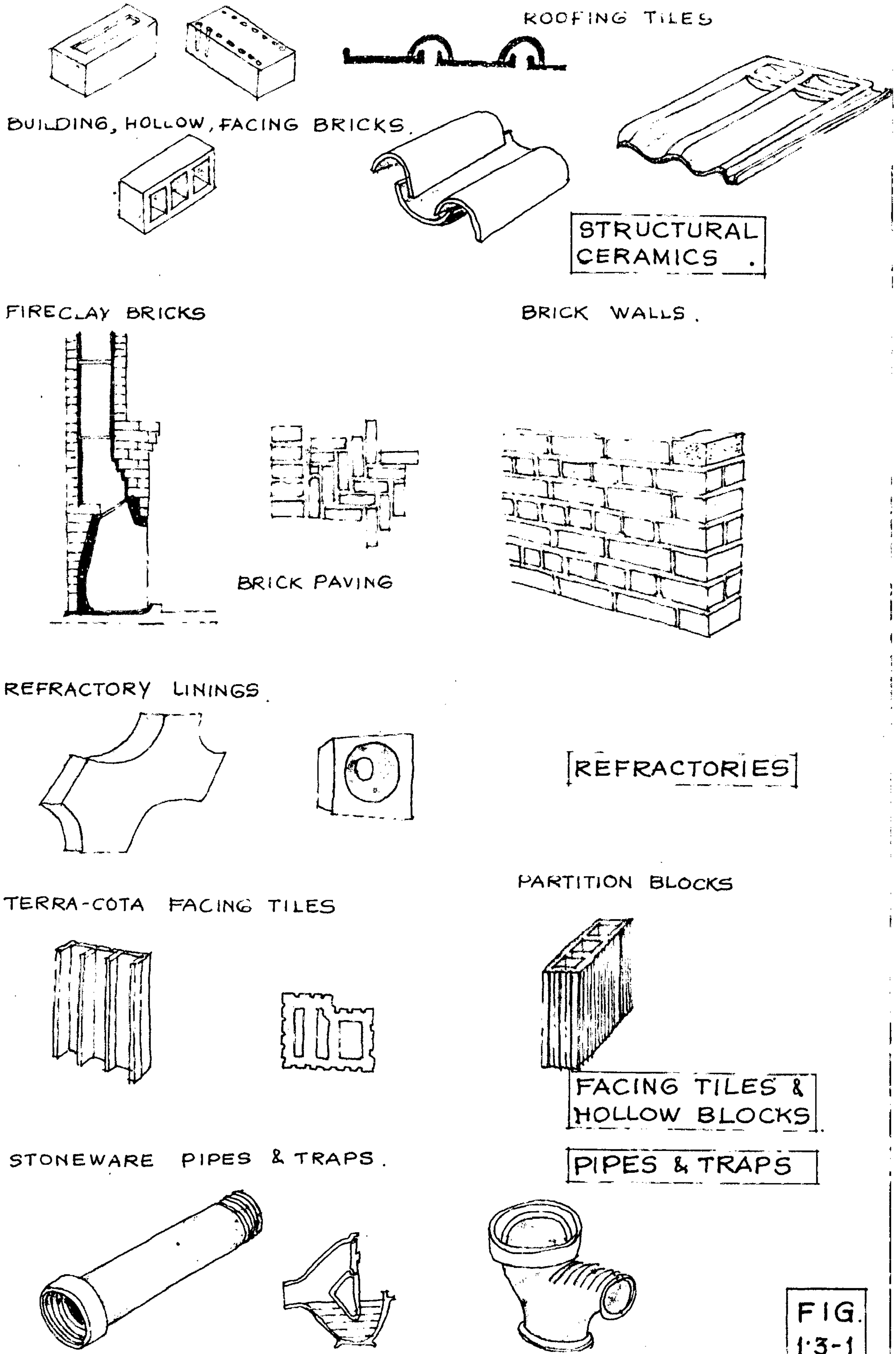
Carbon Ceramics

45. Synthetic diamonds
46. Graphites
47. Cermet

New Ceramics

48. Memory cells
49. Ceramics in space flight
50. Piezoelectric products

Some equivalent words for ceramics, potter and pottery, in other languages, have been included in the appendix II.



: CERAMIC APPLICATIONS :

FIG. 1·3-1

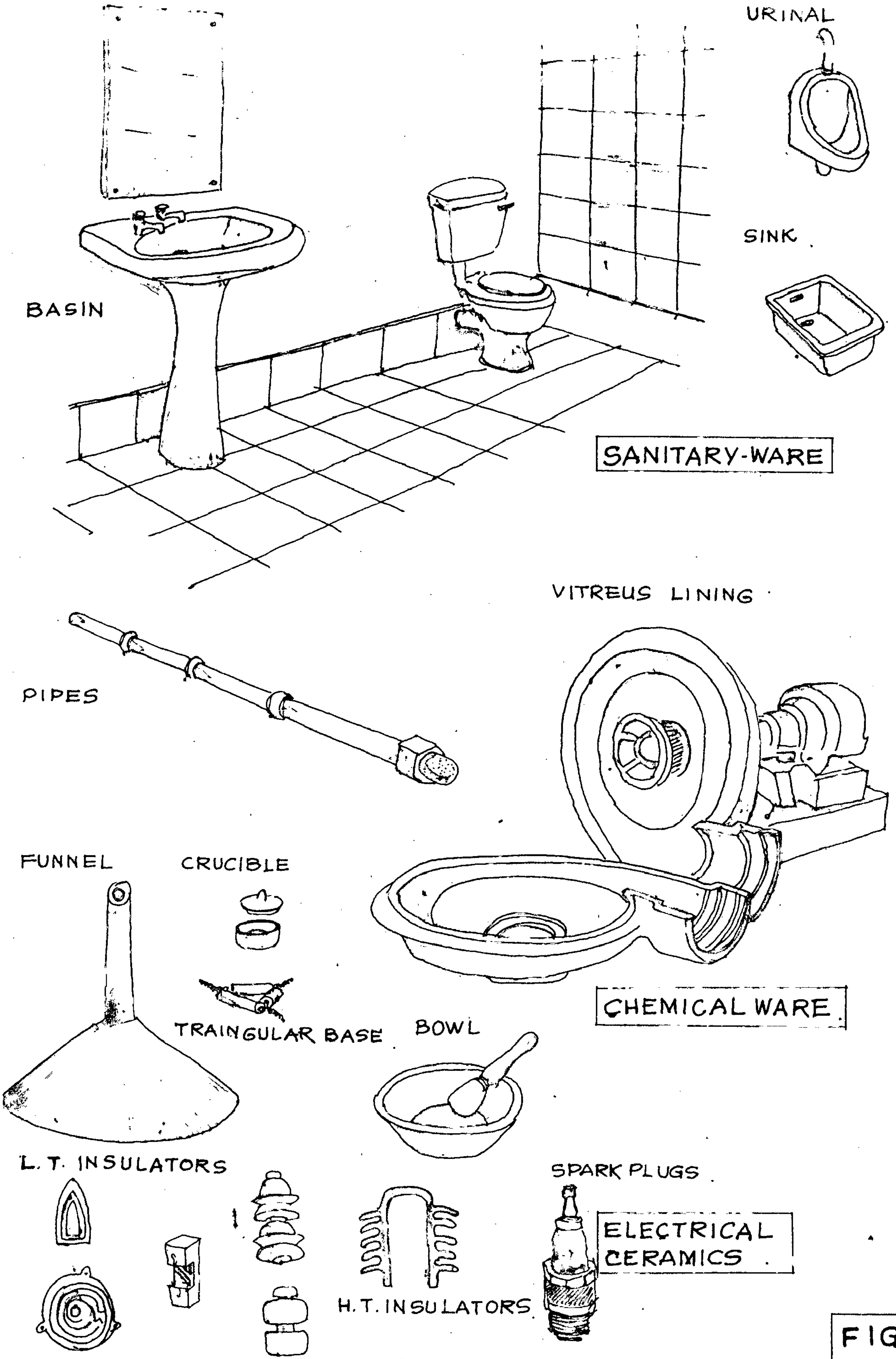


FIG. 1·3-2

: CERAMIC APPLICATIONS :

FIG. 1·3·3

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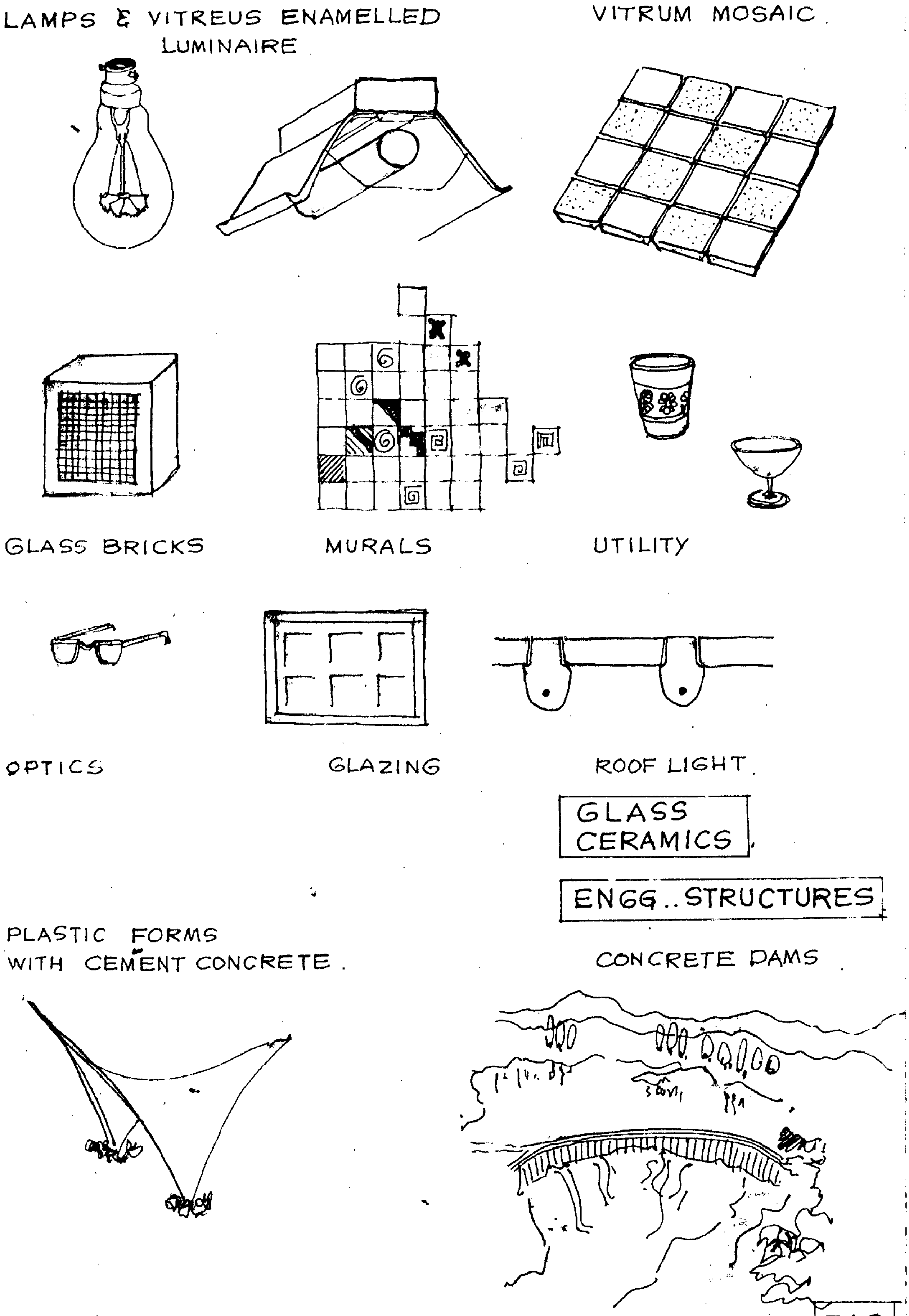

FIG 1·3·4

: CERAMIC APPLICATIONS :

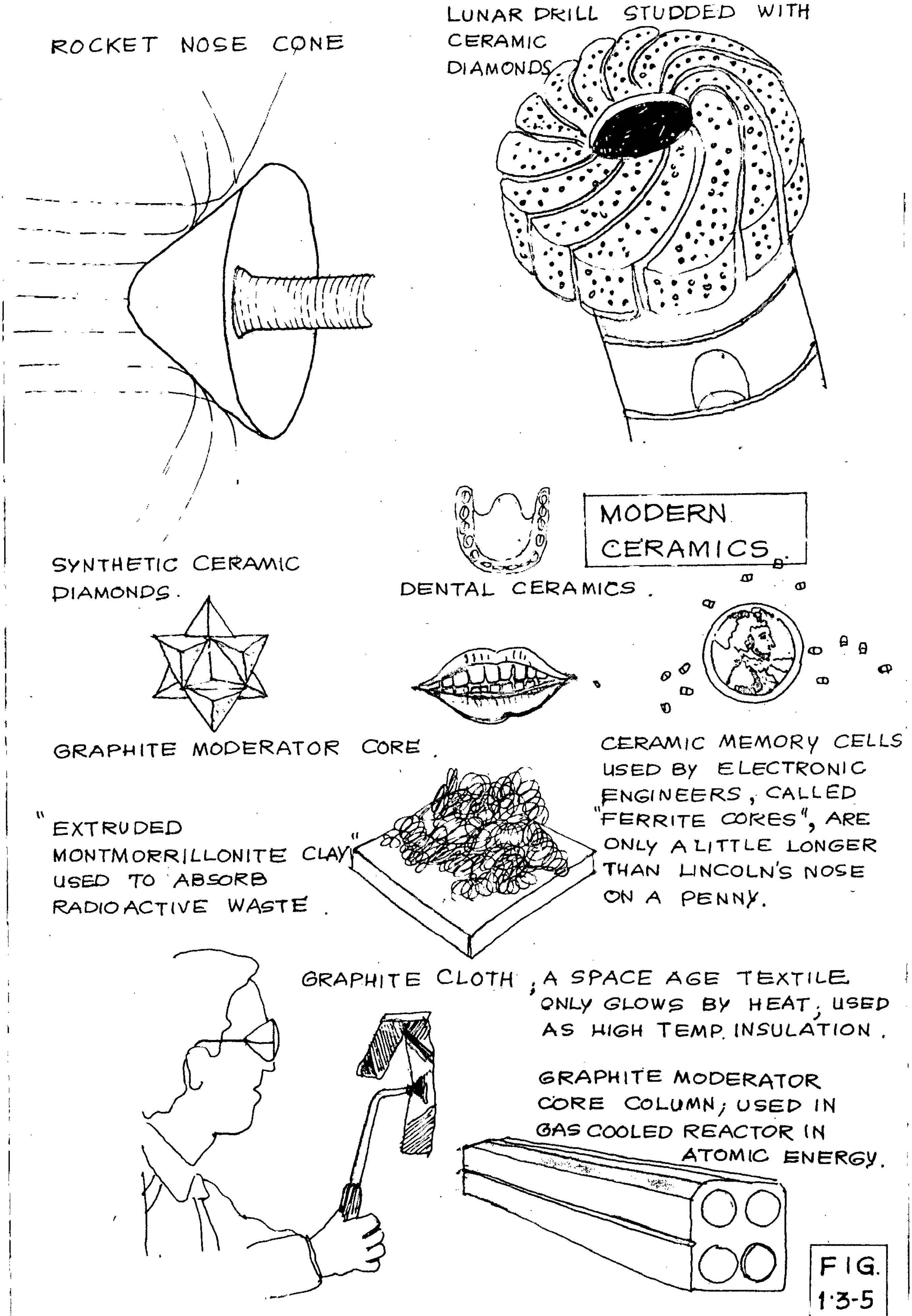

FIG. 1·3·5

: CERAMIC APPLICATIONS :

1.4 PLANNING PARAMETERS

Whenever an architect is entrusted with the design of a building, he is required to do so within a certain framework of act, rules, regulations and byelaws. In the industrial context, apart from the requirements of process, he has to provide minimum standards in terms of height, floor areas related to the number of occupants, safety measures, fire precautions, workers' facilities etc. In the following pages the relevant regulations are listed and so also their effects on planning and design. It is observed that the minimum standards stipulated by 'Indian Factories Act of 1948' and IS:1256-1967 'Code of Practice for Building Byelaws' and 'National Building Code' are not the same and in many important aspects like 'Height of Chimney' there is no reference at all. Likewise the Factories Act makes no mention about the 'Control of Noise' in industries and coverage permissible in relation to plot area.

1.4.1 The Factories Act 1948 (as revised upto 1st March 1972)

Relevant Clauses and effect on Arch.Design and Development.

Chapter	Clause	Effects (as quantified by Factories rules)	Remarks
III Health Sect.11 Cleanliness	1c. Floor becoming wet to the extent of being drained- in course of mnf.process.	Provide a reasonable slope of 1/80th to 1/60th across the floor for quicker drainage.	For cleanli- ness and and safety
	d. Inner walls, sides and top of passages and staircases, partitions and ceiling, i) when painted or varnished ii) white orcolour washed	repainting or revarnish- ing once in every 5 years re-colour or white washing once in every 14 months. durability of surface- coating governed by the above stipulations	For uptodate house keeping and indoor environment
Sect.12 Disposal of waste and effluents	i) Effective disposal of waste and effluents from mnf. process.	No effluents have harmful effects on floor finishes, Ease of cleaning desirable for floors or wall finish- ings.	
		Exhausts of coal fired kilns tend to destroy orchard-blossoms. Location close to orchards to be avoided.	Effect on veget- ation and mango grop.

Chapter	Clause	Effects (as quantified by factories rules)	Remarks
Sect.13 Ventilation and Temperature.	i) Adequate ventilation window area to be min. 1 sft/15 sft of floor area i.e. 7%. Minimum size of door 3'x6'-6"	For optimum ventilation window area should be 15 to 20%. of floor area Orientation to be a compromise between solar and wind direction. kiln located so as to carry winter heat indoors and summer heat away from the building.	For desired air movement, air changes. Affects the orientation of factory buildings.
Sect. 13	ii) Temperature not to cause discomfort and prevent injury to health.	Kilns to have good thermal insulation. Excess heat to be carried to driers by ducts. Floor finish in kiln area to be of heat resisting cement and concrete.	For prevention of injury to workers due to excessive heat Effects on floor area in firing section.
Sect.14 Dust and Fume	i) Dust given off by process leading to schedule of diseases, (silicosis)- adequate precautions to be taken.	Hoods for fettling work with downward ventilation. Use of dust masks for operators in ball mill charging, jaw crushing and loading unloading of intermittant down draught kilns. Examine possibility of Terylene aprons during tolerable period to minimise dust in breathing zone. Lighting-with 'inbuilt reflector-fluorescent tubes'. Access to be provided for frequent cleaning of roof glazing.	To safeguard workers against the dust exposure and the consequent silicosis. Effects of dust on efficiency of lamps and luminaires.

Chapter	Clause	Effects (as quantified by factories rules)	Remarks
Sect.16 Overcrowding	2) Avoidance of over-crowding in any work-room.	Min. of 36sft/person-excluding the space occupied by machinery	Consideration for the maximum number of workers.
		500 cft/person-volume upto max. 14'-0" above floor. Additional height not to be considered for computing min. volume/person.	Future expansion within existing facilities should be considered in light of this.
	Height of workroom	Min. 14' upto the lowest part of roof(R.C.C.)	
		Min. 20' for steel trusses	
Sect.17 Lighting	i) Sufficient lighting by natural, artificial or combination of the two.	More reliance on day light	For efficiency in production, lesser rejections, least eye strain to workers.
	Glazing to be min. 1 sft/15 sft of floor area or 7%.	Area of roof glazing related to the floor area to get desired 'df' as per process (given in Chap. of Lighting)	Types of lamps and luminaires.
	iii) Avoidance of glare	Finishes not to be glossy.	Avoidance of glossy finishes.
		Light sources to be screened by louvres etc.	
Sect. 18 Drinking Water	i) Adequate arrangements for drinking water	1 water centre for every 150 persons upto 500.	As a welfare facility for workers.
	iii) Cooling of water when number of workers exceeds 250.	Over 500, 1 additional water centre for subsequent 500 or part thereof	
	(Cooling from atleast 1st May to 30th Sept.)	Water centre to be atleast 20' away from washing-place, urinal or latrine.	
		Atleast 1 water centre/floor	

Chapter	Clause	Effects (as quantified by factories rules)	Remarks
Section 19 Latrines and Urinals	i) Sufficient latrines and urinals. ii) Adequate lighting and venting. iii) Floors and internal walls to have smooth, impervious finish.	For male and female-separate facilities- at a rate of 1. w.c. upto 50 workers 4 w.c. from 50 to 150 workers 5 w.c. from 150 to 250 workers Over 250 workers, one w.c. for every 50 or part thereof.	Toilet facilities Governed by the number of workers.
	Urinals	Male and Female Not less than 2' in length (or 1 No.) for every 50 workers upto 500 Over 500, 1 for every subsequent 100 Window area 7 percent of floor area or 1 sft /15 sft. White or colour washing to be once in every 4 months and surrounding 4' impervious pavement for toilet blocks floor finishes, dadoes etc.	

Chapter	Clause	Effects (as quantified by factories rules)	Remarks
Sect. 20 Spitoons	Sufficient number of spitoons	Number to the satisfaction of Factory Inspector. G.I.container with conical funnel shaped cover with a disinfectant layer Container with clean dry sand covered with bleaching - Powder and quick lime. Should be easily demountable for frequent cleaning	For good house keeping and a cleaner indoor environment.
Chapter IV Sect.21 Safety	1. Everymoving part, that endangers life, to be fenced with secure fence. For pottery industry the fencing desirable for i) ball mills, and its, ii) driving shaft.	Fence to be of expended metal mesh or m.s. bars. To be given warning colours	Safety of workers and avoidance of injury and accidents.
Sect. 30	1. Grinding machinery to be permanently fixed with its base	Proper footing for machinery in slip house. ball mills, jaw crusher, pan mills.	For foundations of machinery.

Chapter	Clause	Effects (as quantified by factories rules)	Remarks
Sect. 32 Floors, stairs, and means of access.	a) All floors, steps and passages and gang ways to be of sound construction.	Floor finish to be resistant to impact, wear and tear by trolleys, industrial trucks and attack by spilled material.	Type of floor
	b) Access to every place of work.	A minimum 3' space around each machinery.	Minimum space around machinery
Sect. 33 Pits, sumps, openings in floors.	1) All such areas (possible source of danger) to be safeguarded	To be securely covered or fenced m.s. grill or W.I. or r.c.c. covers. G.I. pipe, m.s. bars or r.c. fencing.	Provision of guard-railing.
Sect. 36 Manhole cover.	1) Manhole size of sump, tanks	Size to be min. 16"x12" or 16" dia.	Access manholes
Sect. 38 Precautions in case of fire.	1) Means of escape.	No part of factory to be more than 150' along line of travel from fire escape	Safety provisions against fire.
	2) Exit openable from inside. No fasteners or locking from outside.	Exit to be min. 3'x6'-6"	Means of escape

Chapter	Clause	Effects (as quantified by factories rules)	Remarks
Sect.38 contd.	6(a) Where more than 20 persons are employed on upper floors,	Atleast 1 staircase of min.45" width and of fire resisting materials like	Means of escape
	(b) Storage of inflamable materials to be fire resisting type.	brick wall $\nless$ 4.5 in. concrete $\nless$ 3 in. breeze slabing $\nless$ 3 in.	Fire resisting walls.
	packing material storage.	wood covered with A.C. of $\nless$ 0.25 in. iron or steel	
	(c) No fire escape to be at an angle $> 45^{o}$	Fire exits to be lighted at night. Fire escape to give direct access to ground.	Lighted fire exits at night.
Chapter V Sect.42 Washing facilities	1(a) Adequate facilities	Taps to be at a rate of	Welfare facilities for workers
	(b) Separate for male and female	1 tap upto 20 male/female workers.	Washing facilities governed by number of workers.
	(c) accessible and to be kept clean.	2 taps from 21 to 25 workers 3 taps from 26 to 50 workers	
	a trough with taps or jets at intervals of 2' or	4 taps from 51 to 150 workers 5 taps from 151 to 200 workers	
	Wash basin and tap, taps on stand pipes,	from 201 to 500 workers 5+ 1/50 workers or part thereof.	
	showers controlled by taps.	For over 500 workers 11+ 1/100 workers or part thereof. Water supply to be based on min. 6 gallons/person/day	

Chapter	Clause	Effects (as quantified by factories rules)	Remarks
Sect.46 continued	Canteen	floor and walls to have a smooth impervious finish Colour or white wash to be once a year. Paint and varnish once/3 years. Kitchen walls -1/4 months	Floor finish and colour to canteen walls
Sect. 47 Shelter, rest rooms and lunch rooms	Factory with more than 150 workers provision of rest and shelter, lunch rooms duly enclosed and separated from work areas	Min. area of 128ft/person employed in largest shift. Height - min. of 12 ft. To be separate for male and female. Window area min 7 percent of floor	Provision of shelter, rest room Area/person and height and lighting
Sect. 48 Creches	1. Where more than 50 women workers are employed, creche provision for children (under 6 yrs) of such women. With adjoining open air play-ground suitably shaded and fenced.	Not to be close to noisy areas, and sources of dust, fumes, smell etc. Area of min. 20 sft./child. Min. height of 12'-0" 1 cot or cradle/child 1 chair/woman or equivalent seating space. washing room with dados upto 3 ft., and 1 basin/4 children. 1 latrine for the sole use of children.	Provision of creche for children of women-workers Requirements in terms of area, height toilet, washing room etc.

1.4.2 Relevant Clauses/Sections: IS:1256-1967 Code of Practice for Building Byelaws

7.3 Factories and Industrial Buildings.

Chapter	Clause	Effects fon Arch. design and development	Remarks
(a) Site	Location to be governed by development plan if any	Overrules other considerations for site selection	Selection of site.
	In absence of development plans, factory site shall be approved by local authority	Overall consideration for site selectionis possible	
(c) Means of escape in case of fire	1. Atleast 2 stairways shall be of fire resisting mats.giving direct access to ground.	Any of the following material as per IS:1256-1967 a) brick masonry in lime or cement mortar. b) Teak in combination with iron for beams and posts, c) R.C.C. d) Slates, tiles, bks. or terra-cotta. e) P.C.C. of min. 10 cm. thickness.	Safety precautions against fire. Fire resisting construction.
	2. Staircase width	Min. 1.2 M	Min. stipulations in respect of staircase, width tread, riser etc.
	3. Head room	Min. 2.1 M	
	4. Tread and Riser	Tread-min.25 cm. Riser-max. 18 cm.	
	5. Max. distance from any part to fire staircase.	Max. of 15 M along the line of travel.	
	6. Lighting and Ventilation	Min. 1 M^2/floor height.	
	7. Lobby. landing corridor	Minimum clear width of 1.2M	

Chapter	Clause	Effects fon Arch. design and development.	Remarks
7.3 contd.	8. Hoistway or lift way inside a factory	To be completely enclosed with fire resisting materials	Safety of workers
(d)	Abatement of over-crowding.	min. 3.4 sqm.floor space/person, excluding space occupied by machinery.	For avoiding over crowding.
		Min. breathing space of 14 m^3/ person	Similar to the stipulations of Factories Act.
(e)	Height of work rooms	Min. of 4.5 m. from floor to the lowest point of roof.	Min. Height of work areas.
	Height of Baths/WCS	Min. 2.4 M	
	Height of kitchen	Min. 2.75 m.	
(f)	Percentage of coverage.	Max. coverage to be 3/5th area of site.	Coverage Factory Act makes no mention of this
	Open spaces specified	Front yard 7.5 m Side yard 3.0 m Rear yard 7.5 m	
(g)	Parking regulations- Adequate area within the plot	There should be no obstruction to traffic.	
(k)	No. and location of spitoons.	To the satisfaction of Factory Inspector.	For good house keeping and cleaner indoor environment
6.83	Bathroom and WCS	Bath room-not less than 1.5x1.2 M or 1.8 m^2 WCS- min. 1.1 m^2	FACTORY ACT makes no mention of this.
7.2.1	Areas of parking	Car- 24 m^2; Scooter/motor-cycle- 2.8 m^2; Bicycle- 1.4 m^2	Factories Act makes no mention of this

1.4.3 National Building Code 1971 Part IX: Plumbing Services

Chapter	Clause	Effects on Arch. design and Development (For male)	(For female)	Remarks
5.5.1 Factories	Fitments	For male	For female	
	1) Water Closets	1 for 1-15 persons	1 for 1-12 persons	Differs from Factories Act but tallies with Industrial Society, London's recommendations
		2 for 16-35 persons	2 for 13-25 persons	
		3 for 36-65 persons	3 for 26-40 persons	
		4 for 66-100 persons	4 for 41-57 persons	
		From 101 to 200	5 for 58-77 persons	
		add at a rate of 3%.	6 for 78-100 persons	
		From over 200 persons add at a rate of 2%.	From 101 to 200 add at a rate of 5%. From over 200 persons add at a rate of 4%.	
	2) Ablution taps	1 in each W.C.	1 in each W.C.	-do-
		1 water tap with draining arrangement shall be provided for every 50 persons in the vicinity of W.C. and urinal.	——	
	3) Urinals	Nil upto 6 persons	——	Causes inconvenience.
		1 for 7 to 20 persons		W.C. gets spoiled in absence of a urinal.
		2 for 21 to 45 persons		
		3 for 46 to 70 persons		
		4 for 71 to 100 persons		

Chapter	Clause	Effects on Arch. design and development	Remarks
		From 101 to 200 add at a rate of 3%. From over 200, add at a rate of 2.5%.	
	4. Washing tap with drainage arrangement	1 for every 25 persons or part thereof	Differs from Factories Act
	5. Drinking water fountains	1 for every 100 persons with a minimum of 1/floor	-do-
	6. Showers	As required	Could be 1 for every 25 persons and combined with washing taps.

1.4.4 Industrial Welfare Society: London, 1964

Chapter	Clause	Effects on Arch. design and development		Remarks
Fitments	1. Water closets	1 for 1 to 15	1 for 1 to 10	Similar to National Building Code.
		2 for 16 to 35	2 for 11 to 20	
		3 for 36-65	3 for 21 to 30	
		4 for 66-100	4 for 31 to 45	
		From 101-200 add at rate of 3%.	5 for46 to 60	
			6 for 61 to 75	
		From over 200, add at a rate of 2.5%.	7 for 75 to 90	
			From 91 to 200 add at a rate of 4%.	
			From over 200, add at a rate of 3%.	
	2. Urinals	Nil upto 6	NIL	-do-
		1 for 7 to 20		
		2 for 21 to 45		
		3 for 46 to 70		
		4 for 71 to 100		
		From 101 to 200 add at a rate of 3%.		
		From over 200, add at a rate of 2.5%.		

Chapter	Clause	Effects on Arch. Design and Development		Remarks
Fitments	3. Washing facilities	1 tap for 1 to 10	same as for male	Differs from National Building Code
		2 taps for 11 to 20		
		3 taps for 21 to 40		
		4 taps for 41 to 60		
		5 taps for 61 to 80		
		6 taps for 81 to 100		
		Over 100 add at a rate of 5%.	Over 100 add at a rate of 4%.	
		Over 200 add at a rate of 4%.	Over 200 add at a rate of 3%.	
	4. Drinking Water	drinking water (cooled), - one fountain per floor		No relation to number of persons.

1.4.5 Difference in Minimum Standards: as recommended by various acts/byelaws

Minimum standard with respect to	Factories Act 1948	IS:1256-1967 and Nat.Bldg.Code		Industrial Welfare Society, London 1964	
Height of work room	Min. 20'-0" upto the lowest part of roof for C.I. sheet roofs. 14 ft. for r.c. slab roofs.	Min. 14-10" upto the lowest part of roof			
Drinking water	1 water centre/150 persons upto 1st 500. For more than 500, 1 water centre for every subsequent 500 or part. Min 20 ft. away from toilet or washing place.	1 water centre for every 100 persons with a min. of 1/floor		1 drinking fountain per floor.	
Latrines and urinals	Separate for male and female	Separate for male and female			
		male	female	male	female
	1 W.C. upto 50 male/female workers				
	4 W.C. from 50 to 150 male/female workers	1 for 1 to 15	1 for 1 to 12	1 for 1 to 15	1 for 1 to 10
	5 W.C. from 150 to 250 male/female workers.	2 for 16 to 35	2 for 13 to 25	2 for 16-35	2 for 11 to 20
	Over 250, 1 W.C.for every 50 or part thereof	3 for 36 -65	3 for 26 to 40	3 for 36-65	3 for 21-30
		4 for 66 to 100	4 for 41 to 57	4 for 66-100	4 for 31-45

Minimum standard with respect to	Factories Act 1948	IS:256-1967 and National Bldg Code		Industrial Welfare Society, London 1964	
		Male	Female	Male	Female
Latrines and Urinals continued		from 101-200 add at a rate of 3%. From over 200, add at a rate of 2%.	5 for 58-77 6 for 78-100 From 101 to 200 add at a rate of 5%. From over 200 add at a rate of 4%.	From 101-200 add at a rate of 3%. From over 200 add at a rate of 2.5%.	5 for 46-60 6 for 61-75 7 for 75-90 From 91 to 200 add at a rate of 4%. From over 200, add at a rate of 3%.
Urinals	Min. of 2 ft. length (1 No.)/50 workers upto 500. Over 500, 1/every subsequent 100 Same basis for female workers if separately provided.	NIL upto 6 1 for 7 to 20 2 for 21 to 45 3 for 46 to 70 4 for 71 to 100 From 101 to 200, add at a rate of 3%. From over 200, add at a rate of 2.5%.		Nil upto 1 for 7 to 20 2 for 21 to 45 3 for 46 to 70 4 for 71 to 100 From 101 to 200, add at a rate of 3%. From over 200, add at a rate of 2.5%.	
Welfare Washing facilities	1 tap upto 20 persons 2 taps for 21 to 25 persons 3 taps for 26 to 50 persons 4 taps for 51 to 150 persons. 5 for 151 to 200 persons.	1 tap for every 25 persons or part thereof Same basis for female		1 tap for 1 to 10 2 taps for 11 to 20 3 taps for 21 to 40 4 taps for 41 to 60 5 taps for 61 to 8D 6 taps for 81 to 100 Over 100%, add at a rate of 5%.	

Minimum standard with respect to	Factories Act 1948	IS:3256-1967 and Nat. Bldg Code	Industrial Welfare Soc. London 1964
Washing facilities	for 201 to 500, 5+1/50 workers or part thereof for over 500, 11+1/100 workers or part thereof Same basis for female		Over 200 add at a rate of 4%. Same basis for female
SAFETY			
Precautions in case of fire	Where more than 20 worker are on upper floor, atleast one staircase of fire resisting materials to be provided. Min. width- 3'-9"	Atleast 2 staircases to be of fine resisting materials min. staircase width -4ft. Head room - 7 ft. Tread 10" Riser max.7"	—
	Max. distance from fire escape to any part (along the line of travel)15 ft.	Max. distance from fine escape to any part (along line of travel) 50 ft.	
	Angle of fine escape not to be more than 45°.	Lobby, passage leading to fire escape -4 ft.	
	Exit to open from outside with no fasteners on outside.	Exit to open from inside with no fasteners on outside.	
	Exit size- min. 3' x 6'-6"	Exit size- min. 4'x7'-0"	
Noise Control	No mention	Ear protection recommended over 85 db in 600 to 1200 cps(Hz)	
Lighting	1 sft./15 sft. of floor area.	Lighting recommended for various processes by IS:6060 of 1971.	

1.4.6 Height of Chimney

Since the Factory Act makes no reference about the chimney height, a brief text about the materials for chimney construction, formulae for finding the height and diameter have been included for guidance. However, it is a field of mechanical engineers and his advice should be sought for its design. Chimney is constructed to create a natural draught where no draught fans or blowers are used and discharges the products of combustion at such a height that they will not be a nuisance to the surrounding community. With coal fuel, introduction of aero-cyclones for soot collection is highly desirable to minimise the nuisance.

Principal points to be observed in design of a chimney are as follows:-

i) Height must give the desired draught.

ii) Cross sectional area must be sufficient for boiler load served.

iii) Foundation must be designed to support the load.

iv) Chimney must resist the max. wind pressure.

v) It must have resistance to weathering, action of heat, rain etc.

vi) It must have good internal lining of fire clay bricks to protect the material and prevent excessive loss of heat through radiation.

vii) Aesthetics of chimney design must be given due consideration as it is an eye catching feature seen from a long distance and fromany direction.

Materials of Construction

There are three principal materials used namely,

(a) Steel,
(b) Brick
(c) Concrete.

Steel chimney is the cheapest of all and most easily erected, but it requires regular maintenance by way of painting and internal fire brick lining. It should be braced at two-third of its height by steel ropes. Chances of leakage are less because of lesser number of joints.

The brick chimney lasts longer than the steel one and stands weathering better. It has uniform internal diameter with tapering outer wall. The internal lining of fire bricks should have annular space between the lining and outer wall to allow for its expansion so that external wall remains unaffected. The chimney section can be square or circular. Chances of leakage are more with numerous joints.

Concrete chimneys with reinforcement are strong and almost air-tight for any leakage. The concrete permits casting to the desired external shape and provides scope in the design aesthetics of chimneys. It must have internal fire brick lining.

Design of Chimney

Some formulae commonly used are enumerated below. They are based on the fact that air and flue gas expand in volume with increase of temperature, so that the higher the temperature, the less they weight per cubic foot.

Formula No.1[1]

Formula for resulting natural draught is

$$D = 0.52 x H x P \left(\frac{1}{T_o} - \frac{1}{T_c}\right)$$

where,

D = draught pressure, in.of water,

H = Height of chimney, ft.

P = atmospheric pressure

T_o = absolute temperature of outside air, deg. F.

T_o = absolute temperature of chimney gas, deg. F.

Note: Absolute temperature is Fahrenheit temp + 460.

For Height of Chimney FORMULA NO.2[2] (mks units)

$$h = 353\left(\frac{1}{T_1} - \frac{W+1}{W} x \frac{1}{T}\right) \text{ mm of water}$$

where,

H = Height of chimney in meters,

T_1 = temperature of outside air in ^oK.

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1. Higgins Alex. 'Draught and its Control, Chapter 16, Boiler Room Questions and Answers, McGraw Hill Book Co. Inc.New York- pp.67-71-1945.
2. Pandya, N.C. and Shah, C.S. Draught. Chapter VI Elements of Heat Engines, 6th Ed. Charopar Book Stall, Tulsi Sadan, St.Rd. Anand (W.R.) 1967, pp.202-225.

T = average temp. of chimney gases in °K

w = amount of air supplied per kg of fuel

h = draught measured in mm of water column.

For diameter of chimney

$$A = \frac{Q}{KV} \text{ and } A = \frac{\pi}{4} x D^2$$

where,

A = cross sectional area of chimney,

Q = volume of flue gases handled in cum./sec.

K = coefficient of velocity (K=0.3 to 0.5)

D = diameter in meters.

Formula 3[3] (FPS units)
For Height of Chimney

$$h = 4.244H\left(\frac{1}{T_a} - \frac{w+1}{w\ T_f}\right)$$

where, H = Height of chimney in feet, above fire grate to produce draught,

h = draught required, expressed in inches of water

T_a = absolute temp. of outside air in °K.

T_f = mean temp. of flue gases in °K

w = weight of air actually used per lb. of fuel.

For Diameter of Chimney

$$A = \frac{Q}{K\sqrt{H_f}} = \frac{\pi}{4}D^2$$

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3. Dey, N.C. Natural and Artificial Draught, Chap.X, Heat Engines and Applied Thermodynamics, Asia Publishing House, Bombay, 1964, pp.262-274.

where D = diameter of chimney,

A = sectional area of chimney in sft.

Q = volume of gases passing through chimney in cusecs.

H_f = height of flue gases equivalent to draught pressure of h inches of water.

$K = 8.025\sqrt{1 - \frac{h_f}{H_f}}$ (generally between 1.5 to 2)

h_f = feet head of flue gases due to friction.

These formulae provide some basic idea as to the size of chimney, its height and the draught. However, for detailed reference use of the books cited in the foot-note given on the previous page is suggested.

1.4.7 Summary

It can be observed from the foregoing tabulation that the minimum standards in terms of facilities, heights, lighting, noise etc. are not the same as stipulated by Factories Act, IS Code. In Indian context, the Factories Act of 1948 as revised upto 1/3/1972 is not comprehensive enough and makes no reference to important aspects like coverage, open spaces, height of chimney, noise abatement, colour-application related to betterment of environment etc.

IS:1256-1967 Code of Practice for Building- byelaws and the National Building Code differ in many respects with the Indian Factories Act of 1948.

It is suggested therefore that there has to be better coordination between the two authorities to come to some common conclusions and to make the Factories Act of 1948 more comprehensive and uptodate.These recommendations would then provide a good frame work(For architects and engineers to work within). At the moment, the Factories Act stipulations, although inadequate, over-rule the IS recommendations as the latter is not the controlling authority. It is learnt that the Indian Standard Institution is trying its level best to pursue the local authorities of cities all over India for adoptation of the better IS Standards and it has met with encouraging response from a number of authorities. However, a more rigorous and integrated approach is necessary.

1.5 PROCESS DETAILS AND DIAGRAMS

A thorough knowledge of various processes is essential for architects who plan new factories or improve upon the existing ones. The evolution of hand-forming process dates back to as far as 7000 B.C. A chronological list of ceramic processes is enclosed in the Appendix VI to include the earliest processes to the latest and modern ones.

The future envisages a revolution in terms of replacement by automatic processes and modern equipment, modern types of kilns with controlled firing. All the factors must get their requisite share at the planning stage itself.

1.5.1 Details of Process for a Pottery Works

Raw Materials

China clay, ball clay felspar, quartz for the 'body' of the ware, and in addition barium carbonate, calcium carbonate, zinc oxide and tin oxide frit etc. for the glaze of the wave, and flint balls for a ball mill and granite stones for the ball mill lining.

Out of these, only the flint-balls, raw felspar and raw quartz are stored on open platforms, while the rest stored in covered sheds.

The Process itself: (Figs. 1.5-1 to 1.5-7)

Raw felspar and quartz are calcined in a furnace which makes them brittle and thus easily crushable. They are washed clean with water, dried in shed on sloping platforms to drain away the water and subsequently by natural evaporation. These are then crushed to 1 cc. size. The crushed materials are then ground dry in a separate ball mill to the required fineness and stored under shed. A battery of ball mills is installed on a platform. Generally 4 to 5 ball mills are run turn by turn so that repairs etc. could be attended to without the work being hampered. A ball mill with accessories occupies about 8'-0"x4'-0" (2.4mx1.2m) and requires a circulation space on all four sides. Generally another platform is provided over the ball mills and is used for feeding the raw materials to the ball mills through 'feed-holes' with a water pipe and a drawoff point over each ball mill to add required quantity of water. Raw materials are weighed and added to the ball mill with water and the mill set for rolling after closing its month. The intimate, slurry like body-mixture formed therein is called 'SLIP'.

After the necessary period of milling, the slip is run out into a 'blunger' (accommodated within the platform height provided for ball mills) having twice the capacity of a ball mill and the slip is thinned to required consistency by addition of more water. (China clay is generally added in the blunger). The thinned slip is then passed through a 'vibrating sieve' and the 'magnetised channel into an 'agitator', having three times the capacity than that of a blunger. Generally the agitators are in duplicate so that whilst one is being filled, the other one is connected to the filter press. The slip from the agitator is drawn into chambers of the filter press, wherein the 'body' is retained in the cloth chambers and water is expelled, which flows into a retaining tank-generally there are two such tanks, excess water pumped to the storage while the remaining slip is again passed to the blunger.

The 'body cakes' from the filter press are then stacked on a table-platform situated between the filter press and the de-airing pug mill. These cakes are fed into the de-airing pug mill, which delivers the de-aired 'clay rolls' at the other end. These clay rolls are-

(a) sliced into thin bats for making saucers and

(b) used as such for making cups, mugs etc.

(c) The body cakes from the filter press are directly used for making 'casting slip', in a blunger located in the casting section. Kettles, sugar pots, milk pots, spouts, lids, handles (and the sanitary ware) are made by the casting process by using the plaster of paris moulds. Kettles etc. are finished here and their parts joined.

(d) Saucers, plates and shallow ware is formed by jiggering operation, and finished by fettling etc.

Finished ware of all types, is then placed on wheeled racks and sent into the warm air dryers. When 'bone-dry', the racks are wheeled into a small 'blowing chamber', where the dust is removed by hand blower, the dust being drawn up a chimney by a small exhaust fan. Man operating must use a dustmask. The further operation is the underglaze decoration- done in separate spray chambers, where the colour shades may be 'spray-gunned'. Underglaze stamps or borderlines are done by hand on small wheels. Once decorated in this way, the articles are carried by 'wheeled racks' to 'dipping-booths' where they are actually dipped into a 'glaze-slip', finished at the bottom and again stacked on wheeled racks and carried to the loading site of the kiln. (The 'glaze slip' is prepared in a separate ball mill in the glazing department, and reduced to the required consistency in a small blunger, sieved through a magnetised channel and then taken to the 'dipping booths'. In many factories, the biscuiting of the ware is avoided but instead the 'green-dipping is resorted to. Biscuiting means the firing of ware to a lower temperature in a separate kiln prior to glazing). The racks with 'glazed-ware' are reloaded onto the 'cars' in the compartments of the 'fire clay' furniture. 'Cars refer to the kiln cars' and the furniture refers to the refractory racks, saggers, supports, setters etc. specially designed to accommodate/ support the articles to be fired. These cars ,loaded,pass through passing gate- an exact cross section of the kiln- to ensure that the loading is perfectly done and ensures a smooth movement of cars within the kiln.

The bigger factories prefer a 'tunnel kiln', oil fired, with a 24 hours continuous operation; whilst the smaller concerns resort to the coal fired down draught kiln- a periodic type, not requiring a continuous 'feed' of articles for firing. The tunnel kiln is like a railway tunnel with a rail track running through its length. Wheeled cars, with steel chassis, and fire clay racks are used to carry the ware through the kilns.

It is roughly divided into three parts, 1/3rd part- preheating zone, middle 1/3rd part- firing zone (heated by oil burners on either side) and the last 1/3rd part-cooling zone. The cars enter through the preheating zone-side, get fired and leave by the end of cooling zone- the other end. The loaded cars are on the outside railway line and are transferred to the tunnel line by a 'transfer-bridge' which runs on a short rail-line at right angles to the mainlines. Similarly the 'fired cars' are transferred to the outer line by another transfer bridge at the other end.

The tunnel kiln, being a continuous type remains fully packed with the green-glazed wares and when a car is pushed or pulled into it, a car comes out (duly fixed) from the other end. The fired and cooled articles are taken to the inspection and sorting departments. For the down draught periodic kilns-coal fired, the glazed ware is filled in the saggers and loaded in the kiln. The duration of the total operation from start to finish' is about 6/7 days.

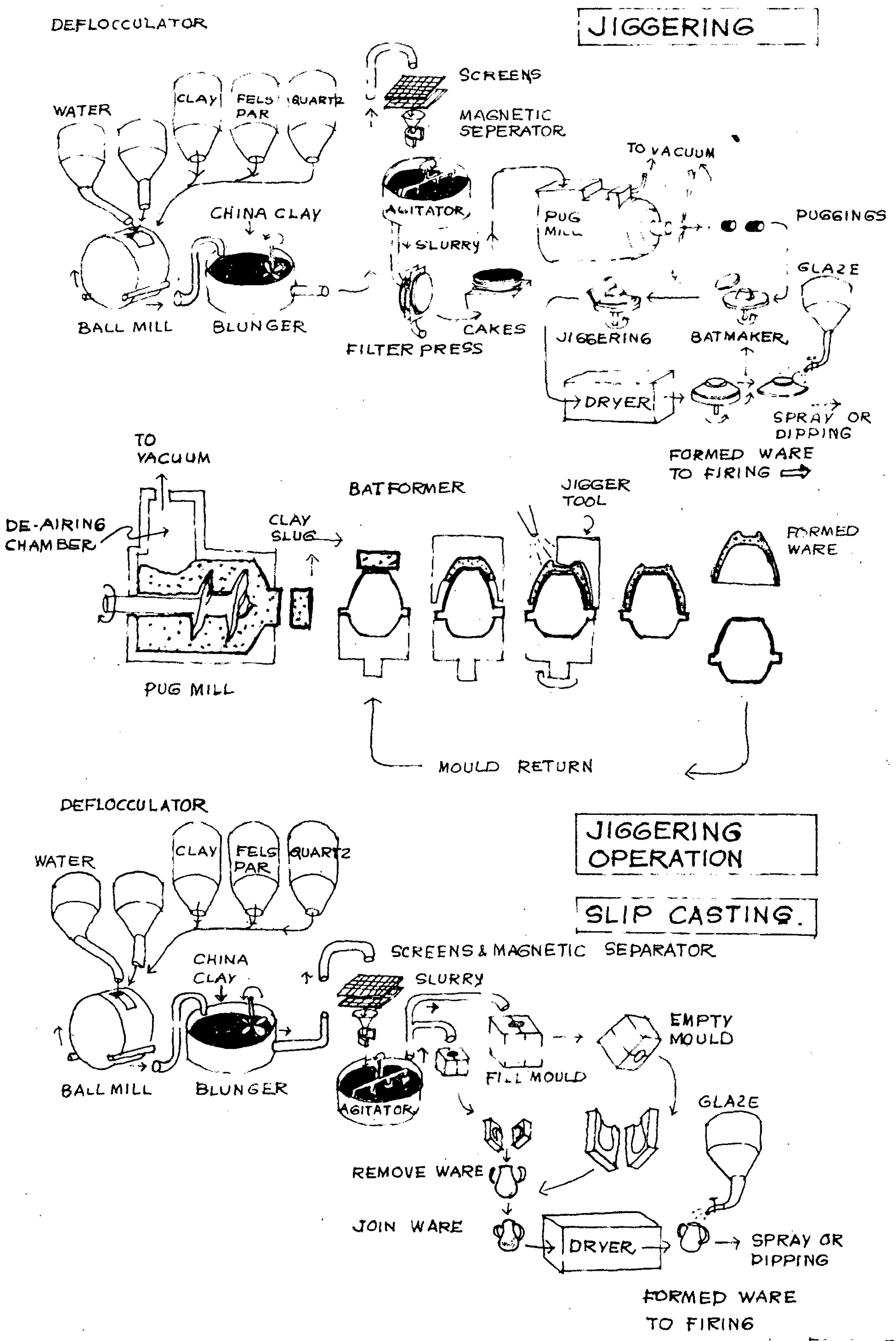
The fired ware is taken to the inspection and sorting departments. It is dressed, sorted out and packed or stacked in warehouse. Packing material is the rice-husk, jute, string and cardboard cartons or wooden crates. 'Fire-precautions' are necessary here. (when there is the overglaze decoration, the fired ware is decorated and fired again in small electric kilns at lower temperatures to fuse the decoration with glaze. Hereafter the packing/sorting is similar to the above.

1.5.2 Schedule of Machinery: Pottery Industry

Department: Slip House.

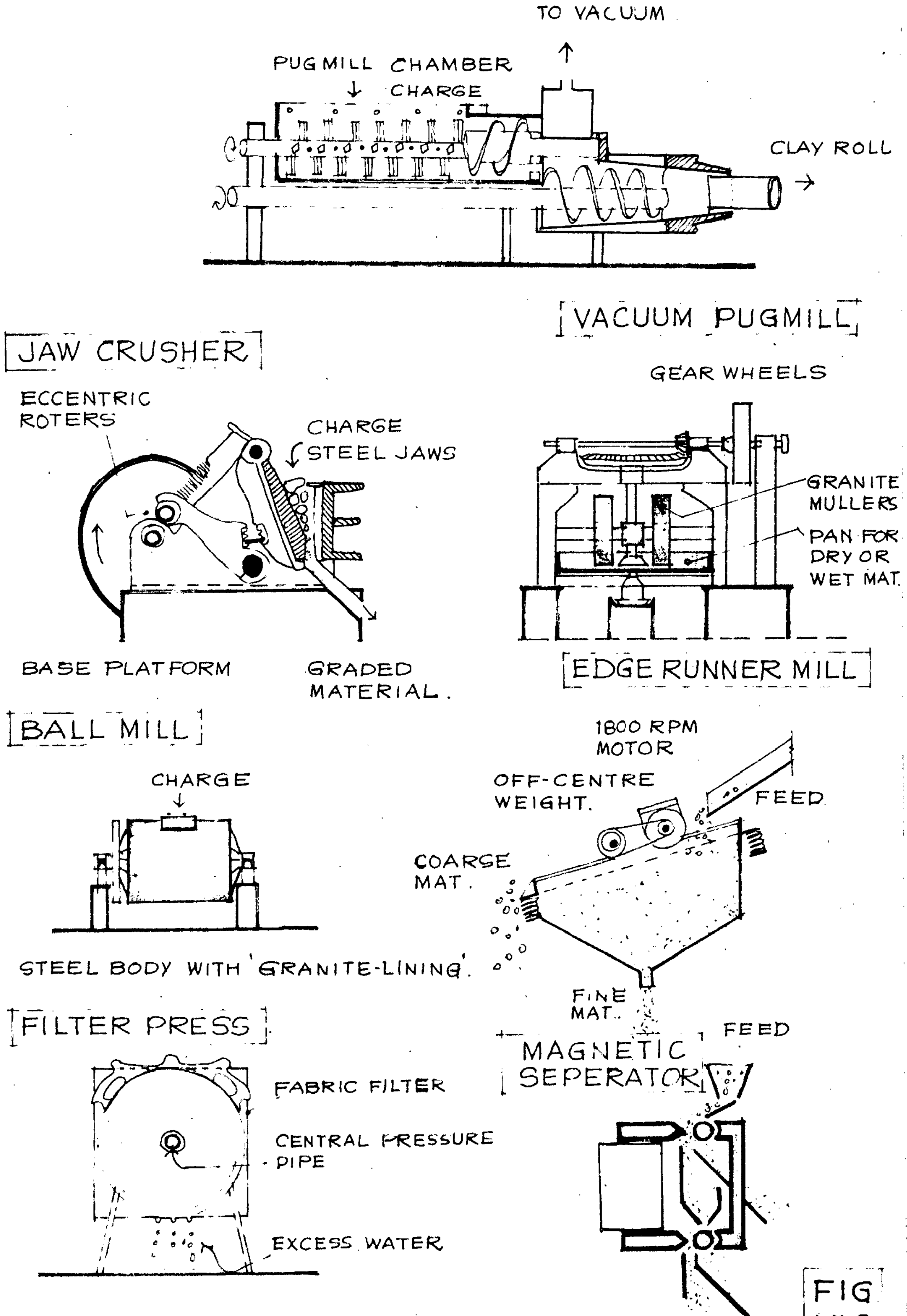
Machine/equipment	Approx. size. L(or Ø)	B	H
Weighing bridge	4'-0"	4'-0"	3 ft.
Jaw crusher	4'-6"	3 ft.	4 ft.
Conical grinder	6"-10"	4-6 ft.Ø	-
Washing machine	6 to 15 ft.	4 to 6 ft.Ø	-
Ball mill	3 to 6 ft	2ft to 8ftØ	-
Edge runner mill	4 to 10 ft.Ø	-	3 to 4 ft.
Blunger	5 to 6 ft.Ø	-	5 to 6 ft.
Pumps	varying sizes as per H.P.		
Sieve (vibrating)	3 to 6 ft.	3 to 6 ft	3 to 4 ft.
Magnetic separator	4 to 6 ft.	1 to 1½ ft	-

Machine/Equipment	Approximate size L (or θ)	B	H
Agitator	4 to 6 ft.θ	-	4 to 6 ft.
Filter press	8 to 15 ft.	3 to 4 ft.	3 to 4 ft.
De-airing pug-mill	5 to 18 ft.	3 ft.	3 to 4 ft.
MAKING DEPARTMENT			
Bat making machine	2 ft.	2 ft.	2 ½ ft.
Throwing	2 ft.	2 ft.	2½ ft.
Jiggering	4 to 6 ft.	3 to 4 ft.	2 ft to 3 ft.
Casting tables	3 to 4 ft wide		1 to 2 ft.
Wheels for finishing of wares, grinding wheels	2 to 4 ft.	2 to 4 ft.	2½ ft.
Spraying cubicals	4 to 5 ft.	4 to 5 ft.	7 ft.
DRYING AND FIRING SECTION			
Dryers' (for wheeled racks)	20 to 80 ft.	6 to 20 ft.	8 ft.
Tunnel kiln	100 to 405 ft.	10 ft.	8 to 10 ft.
Down draught type	6 to 30 ft.θ	8 f	8 to 10 ft.
Electric kiln for decoration (after glaze)	8 ft.	8 ft.	8 ft.
Wheeled racks	5 ft.	2½ to 3 ft.	4 ft.
Kiln cars and transfer cars	As per tunnel kiln section.		



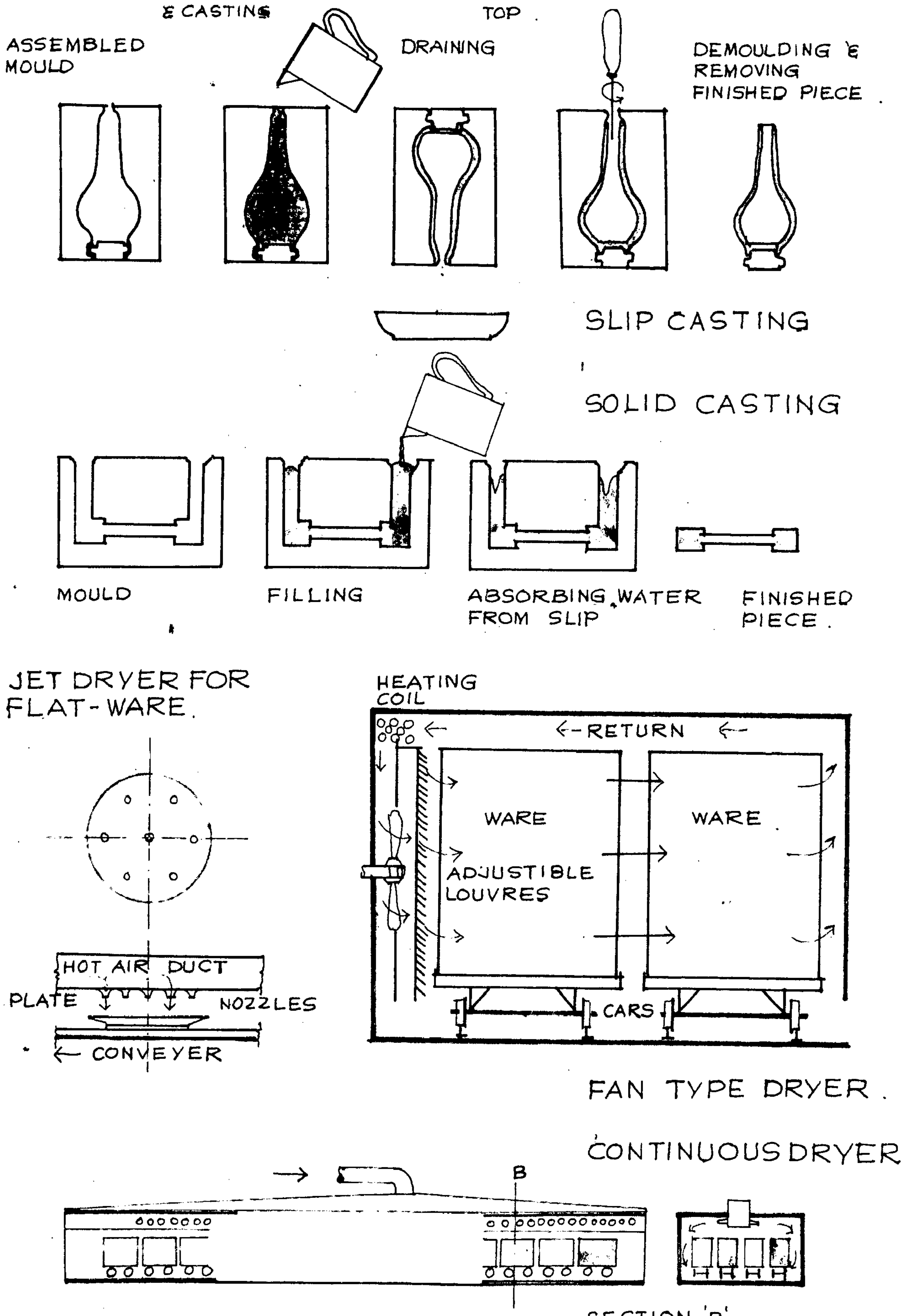
: SIMPLIFIED FLOW DIAGRAMS :

FIG 1·5-1



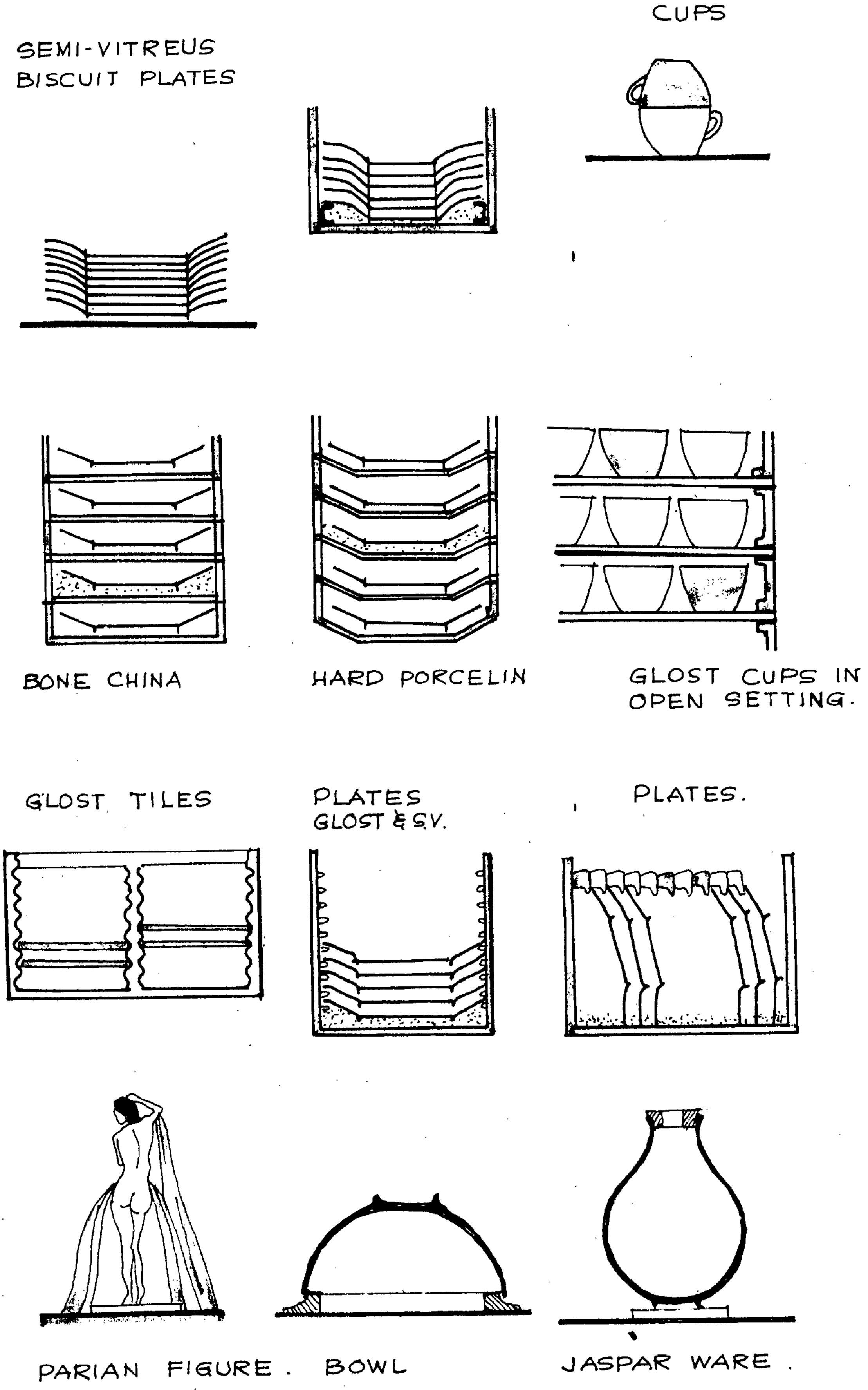
: MACHINERY – SLIP·HOUSE

FIG 1·5-2



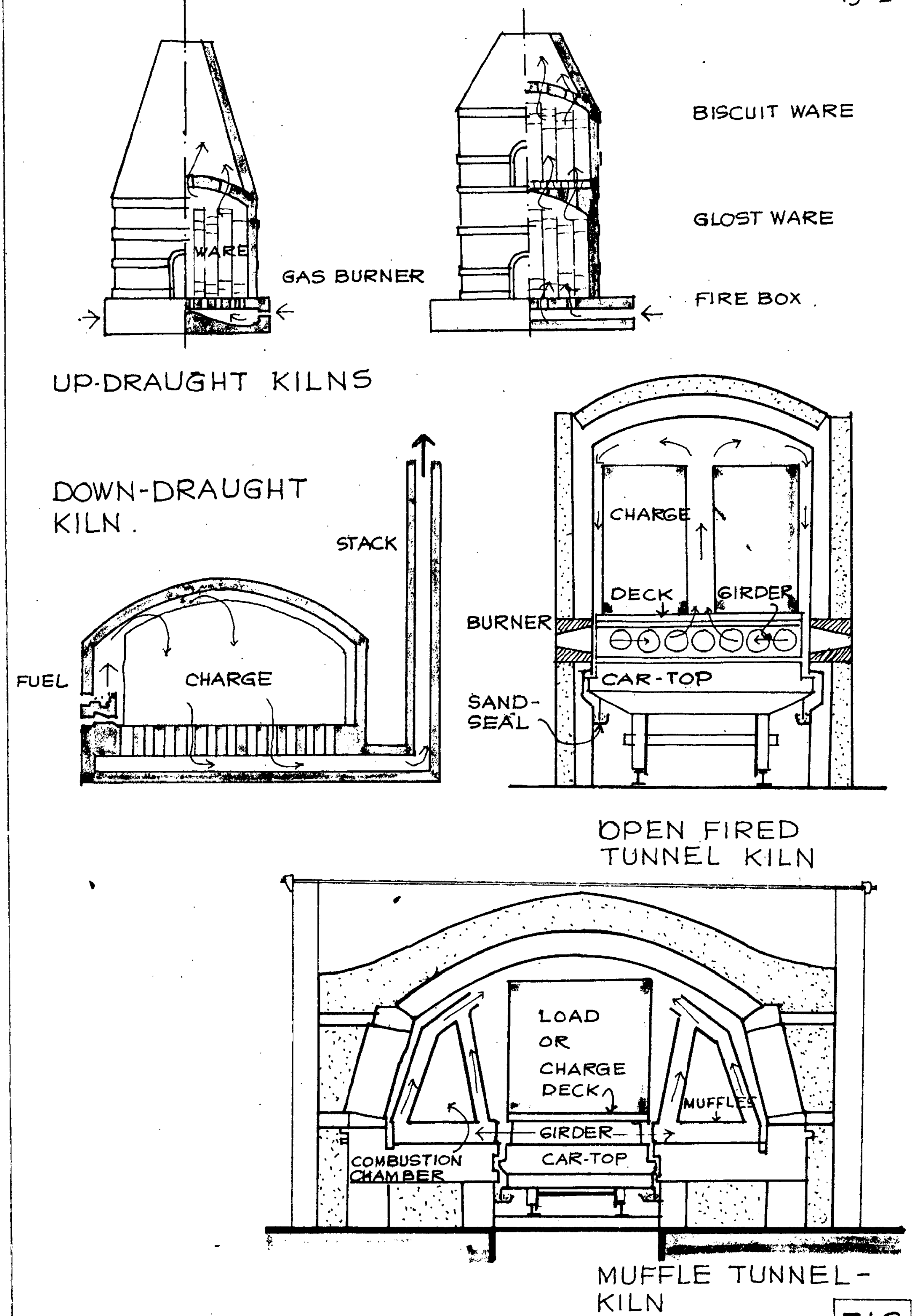
: CASTING & DRYING :

FIG. 1·5-3



: SETTING METHODS :

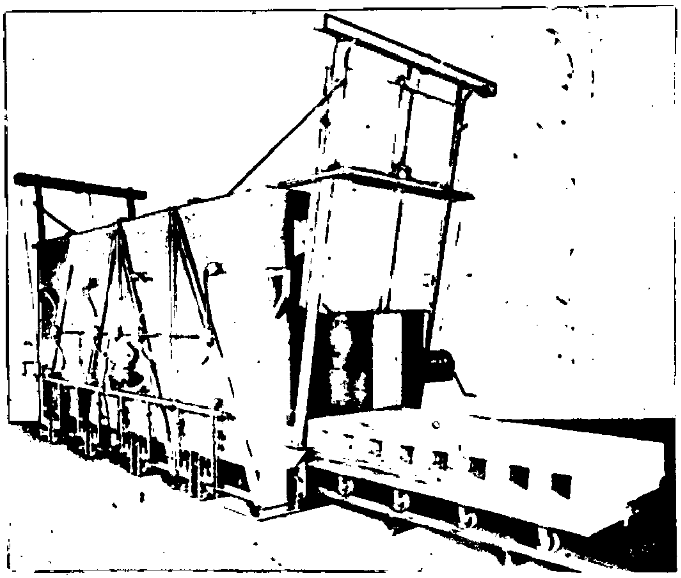
FIG. 1-5-4



: KILN TYPES :

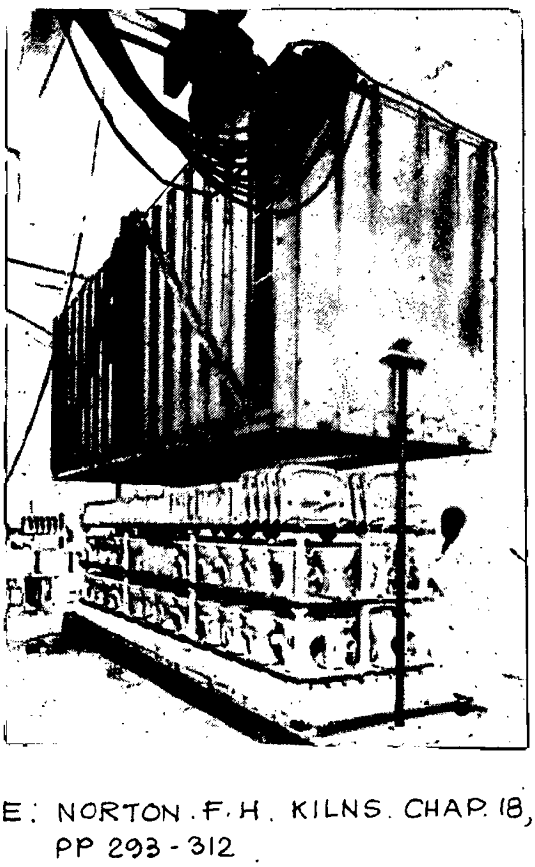
FIG. 1·5-5

AN ERA TO COME
MODERN KILNS



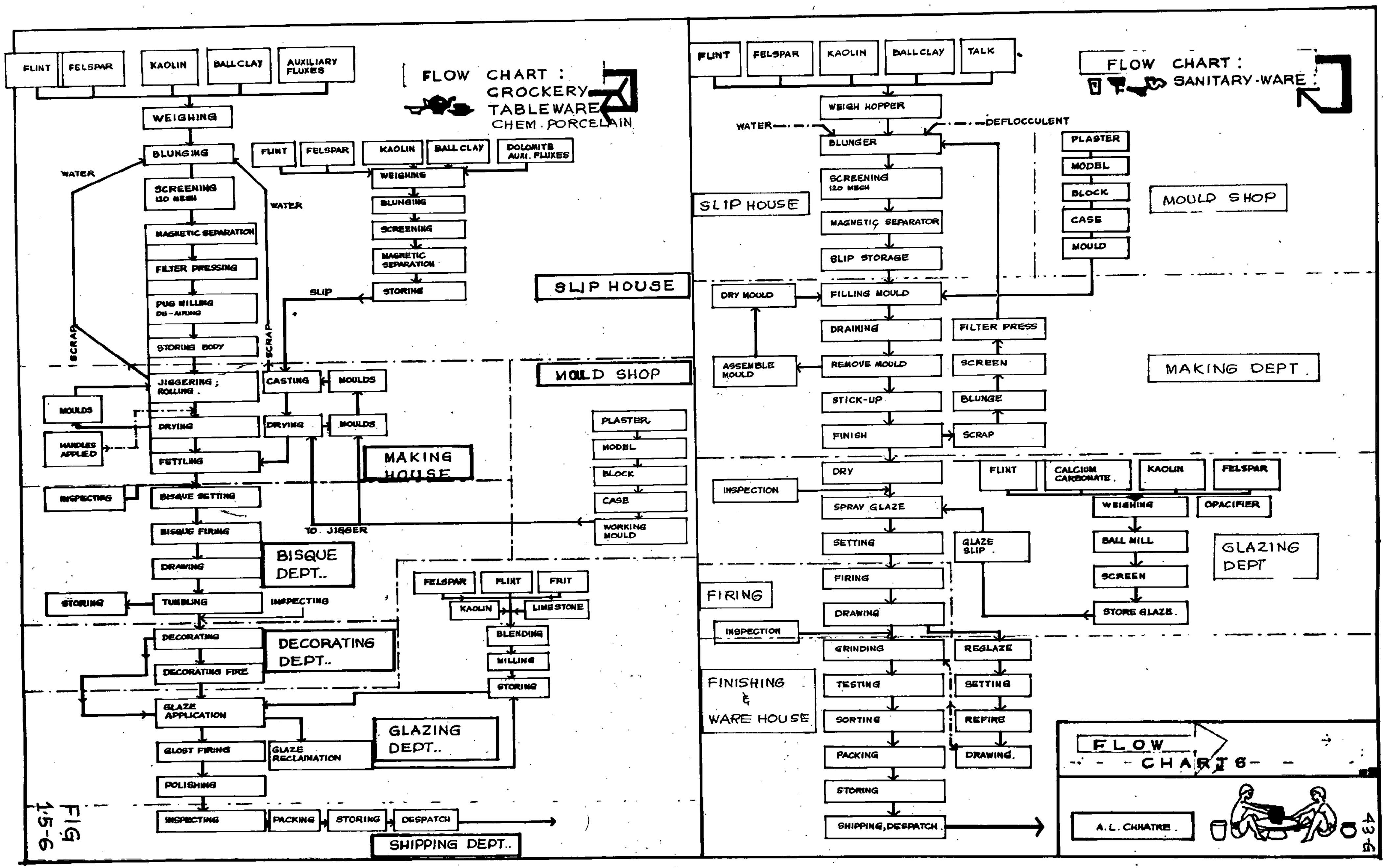
A SHUTTLE KILN

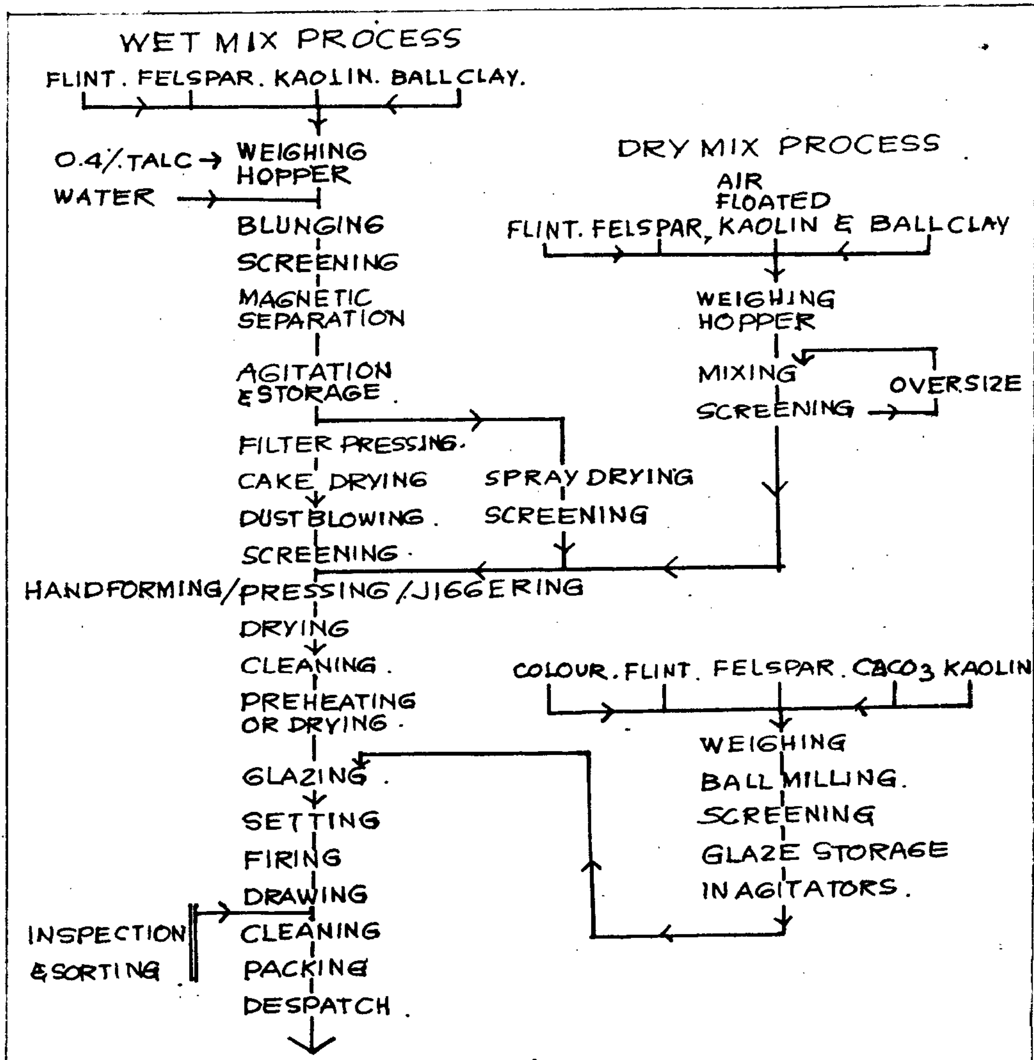
A CIRCULAR
TUNNEL KILN



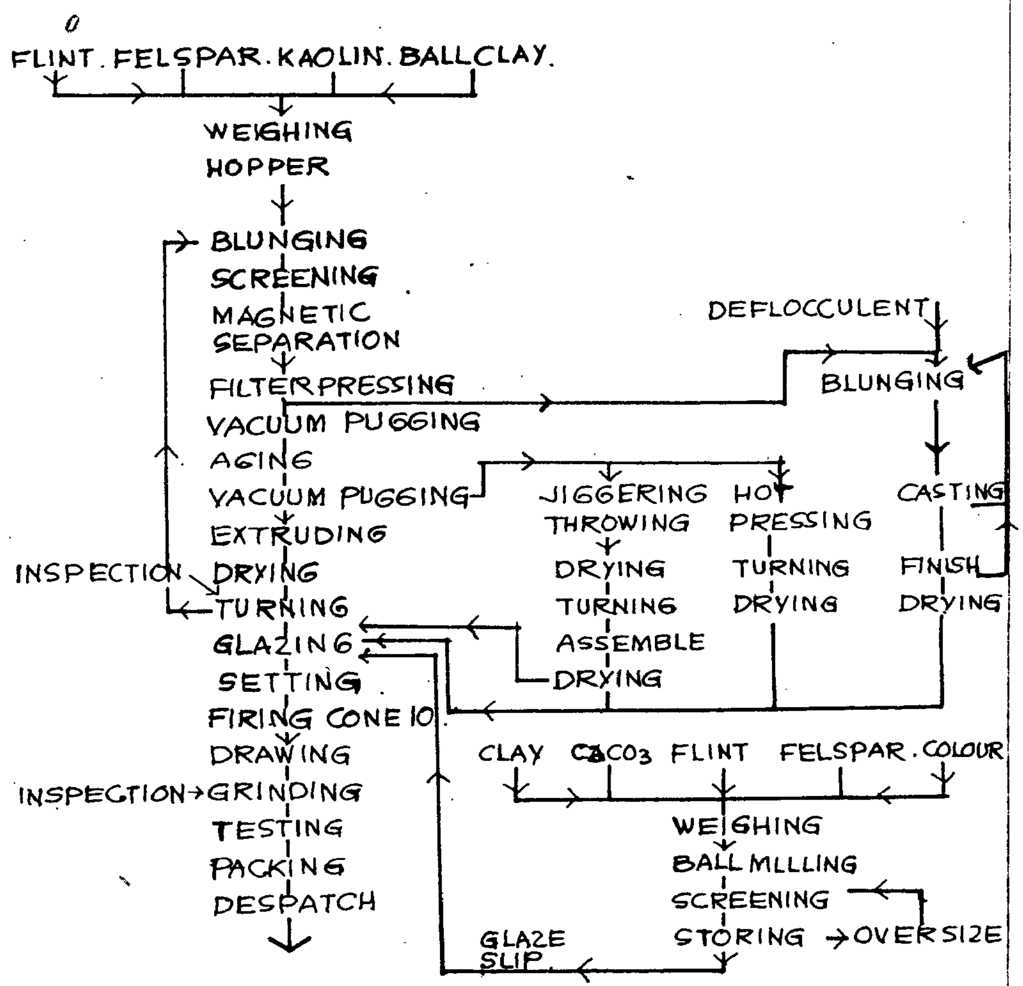
AN ELECTRIC ELEVATOR
KILN .

SOURCE: NORTON . F. H. KILNS. CHAP. 18, FINE CERAMICS.
PP 293 - 312 .


FLOW CHART : CROCKERY TABLEWARE CHEM. PORCELAIN
FLINT
FELSPAR
KAOLIN
BALLCLAY
AUXILIARY FLUXES
WEIGHING
BLUNGING
WATER
SCREENING 120 MESH
MAGNETIC SEPARATION
FILTER PRESSING
PUG MILLING DE-AIRING
STORING BODY
SCRAP
JIGGERING ; ROLLING .
MOULDS
DRYING
HANDLES APPLIED
FETTLING
INSPECTING
BISQUE SETTING
BISQUE FIRING
DRAWING
TUMBLING
STORING
INSPECTING
DECORATING
DECORATING FIRE
GLAZE APPLICATION
GLOST FIRING
GLAZE RECLAMATION
POLISHING
INSPECTING
PACKING
STORING
DESPATCH
SHIPPING DEPT..
FLINT
FELSPAR
KAOLIN
BALL CLAY
DOLOMITE AUXI. FLUXES
WEIGHING
BLUNGING
SCREENING
MAGNETIC SEPARATION
STORING
SLIP
CASTING
MOULDS
DRYING
MOULDS
MAKING HOUSE
SLIP HOUSE
MOULD SHOP
PLASTER
MODEL
BLOCK
CASE
WORKING MOULD
TO JIGGER
BISQUE DEPT..
DECORATING DEPT..
FELSPAR
FLINT
FRIT
KAOLIN
LIMESTONE
BLENDING
MILLING
STORING
GLAZING DEPT..
FIG 1.5-6
FLOW CHART : SANITARY-WARE
FLINT
FELSPAR
KAOLIN
BALLCLAY
TALK
WEIGH HOPPER
WATER
DEFLOCCULENT
BLUNGER
SCREENING 120 MESH
MAGNETIC SEPARATOR
SLIP STORAGE
SLIP HOUSE
PLASTER
MODEL
BLOCK
CASE
MOULD
MOULD SHOP
DRY MOULD
FILLING MOULD
DRAINING
REMOVE MOULD
ASSEMBLE MOULD
STICK-UP
FINISH
FILTER PRESS
SCREEN
BLUNGE
SCRAP
MAKING DEPT.
DRY
INSPECTION
SPRAY GLAZE
SETTING
GLAZE SLIP
FLINT
CALCIUM CARBONATE.
KAOLIN
FELSPAR
WEIGHING
OPACIFIER
BALL MILL
SCREEN
STORE GLAZE.
GLAZING DEPT
FIRING
FIRING
DRAWING
INSPECTION
GRINDING
TESTING
SORTING
PACKING
STORING
SHIPPING, DESPATCH
REGLAZE
SETTING
REFIRE
DRAWING.
FINISHING & WARE HOUSE
FLOW CHARTS
A.L. CHHATRE.
43-G



FLOW DIAGRAM
LOW TENSION INSULATORS



FLOW DIAGRAM
HIGH TENSION INSULATORS

FIG. 1.5-7

CHAPTER II

PHYSICAL PLANNING

2.1 PHYSICAL PLANNING CONSIDERATIONS

Architects who undertake the design of factories are faced with considerations quite different, in many respects, from those to which they are accustomed in relation to usual practices and literature. In industrial context, it is the function which is the predominent factor and the architect is required for providing a suitable envelope, corelating the functioning of units in a sequence and creating an environment conducive to work and production along with care of the workers. He should work in close collaboration with specialists like ceramic, structural, mechanical and electrical Engineers so that the working of plant is satisfactory from all the angles. With the change in social attitudes, working conditions for employees form an important consideration in terms of physical environment and facilities, and in providing these, architect assumes a new responsibility. Planning can be resolved into two major divisions, namely the i) site planning and ii) the planning of buildings. Site planning has not been included in the scope of this dissertation, however the factors affecting the selection of site and the relevant checklist are included in the appendix V and III respectively as guide lines.

2.1.1 Planning of Factory Buildings

A manufacturing plant can be physically divided into six major activities and requires, Various kinds of facilities in terms of buildings and equipment. The six major divisions are:

1. Administration area and security,
2. Manufacturing area (production area)
3. Ancillary facilities required for the production.
4. Welfare facilities,
5. Special requirements,
6. Miscellaneous requirements.

These broad divisions can be further subdivided into other requirements and have been tabulated to render the 'reference at a glance' easy. (page 46)

2.1.2 Basis for Planning

The factors mentioned below provide necessary basis for the general planning approach.

1. Function

Purpose of a factory building is essentially the production of goods. It must house the manufacturing equipment, its operational staff which in turn enables that equipment to function efficiently.

2. Straight line production

refers to various departments for successive operations located in such a way as to effect a simple and direct production flow, so that the cross flow of materials will be reduced to a minimum. There should be no crossing or retracing of the production line with consequent congestion.

3. Flexibility

A departmental layout sufficiently elastic to permit

Table 3

Physical Requirements of a Pottery Industry

Administrative area	Manufacturing area	Ancillary facilities	Welfare facilities	Special requirements	Miscellaneous
• Entrance hall with display	• Raw material bins and unloading plateform	• Testing laboratory for raw materials and clay slip	• Toilets	• Plaster of production unit specially for sanitary ware	• landscape elements like water pools hedges, shelter-belt trees lawns etc.
• Waiting	• Slip house.	• Electrical and mechanical maintenance workshops.	• first aid boxes	• Research laboratory including product design section.	• Street furniture like poles,litter bins, dust bins, road signs.
• Toilets.	• Making dept. (casting, jiggering pressing etc)	• Allied storage spaces	• Health facilities including checking	• Guest rooms.	• seggregation of vehicular and pedestrian traffic within factory premises
• Director's room	• Moulding dept.	• Boiler house with compressors for warm air	• wash rooms	• Training Centre.	
• Joint director's room.	• Drying dept.	• Oil storage tanks.	• drinking water.	• Housing for workers.	
• Production manager room.	• Finishing,dept.	• Oil pressurised tanks with blowers.	• rest and shelter rooms	• Housing for staff.	
• Chief Chemist's room	• Firing dept.including fire clay materials.	• Instrumentation room	• creche.		
• Sales representative room.	• Decorating dept.	• Water reservoir	• Spitoons		
• General office and storage.	• Sorting and Inspection dept.	• Elect.substation and standby generator.	• Canteen		
• Library cum conference room.	• Rooms for excise staff and office	• Garages and their maintenance workshops	• recreation rooms		
• Entry checkpost	• Packing dept.	• Cabins for staff of various depts	• union room		
• Time office	• Ware-housing	• Maintenance for Civil works and bldgs.(Wksp)	• rationshop		
• Checkpost for entry of raw materials and exit of finished products	• Despatch and loading platform				
• Residence of chowkidars.					
• Parking space					

rearrangement in accordance with changes in production-methods or expansion of departments without disorganising the existing scheme, is indispensable.

4. Column Spacing

Interior column spacing should be as far apart as economically possible, to allow for free location of machines and cause the least interference with the transportation of materials.

5. Properly located facilities

Staircases, locker rooms, toilets, washrooms, rest-rooms, toilets, washrooms, rest-rooms, drinking-water fountains, creche, canteen etc. located where they best serve the purpose and do not interfere with the flow of production.

6. Floor finish and the envelope

Clear ceiling heights adequate for the work performed, walls and roofs strong enough for loads and thermal performance; floor finishes best suited to the process.

7. Conducive Environment

To be provided by adequate lighting and ventilation, colourful surrounding, appropriate finishes, dust free air, acoustics etc. with due consideration for the oranta-tion.

8. Physical and psychological communication

The walls of the main work areas to be free of enclosures by storage or staff cabins, so as to establish physical and psychological communication through openings with outside. These openings will act not only as visual rest centres and provide acoustic absorption when open, but also promote the air movement so necessary for any pottery works.

2.1.3 Production Capacity

In practice this capacity is decided by taking into consideration the demand for the proposed product, available financial resources, development in phases, economic feasibility and the final target of production i.e. the future expansion etc.

Based on these complex considerations, the architect is briefed about the total development. It is once again stressed that a factory design is not a one-man job but a team work of experts like ceramic engineer, structural and mechanical engineer, illumination engineer etc. and the better the coordination by architect the better would be the end product.

The ceramic engineer works out the number and types of machinery and equipment needed, the number of workers all related to the production in terms of a certain predetermined tonnage/day. Working, backwards and analysing the requirements of various raw materials, their storage etc. can be found out. Architect should classify this information into various departments of the production area and list out the schedule of machinery, equipment, the number of workers, ancillary and related areas for each of the departments. It may be mentioned here that in the main production area, there are no watertight compartments but areas are alloted for specific types of work. It is the sequence and co-relation of one department to another that will ultimately lead to an efficient production line.

Actual size of every department is ultimately related to the production capacity but some amount of future expansion should be inbuilt in the plan itself. Areas required by various machinery and equipment in various departments have been given and so also their sequence. This approach would provide sufficient guide lines for architects while planning a pottery industry.

2.1.4 Production area and the sequence of operations

Having thoroughly discussed and illustrated the process it was concluded that following would be the sequence of various departments in the production line:

i) Raw material intake

ii) Slip house,

iii) Making department and moulds department.

iv) Drying department

v) Finishing department

vi)	Glazing department	OR	vi)	underglaze decoration
vii)	Firing Department		vii)	Glazing
viii)	Decorating department and decoration fire		viii)	Firing including seggers and fire clay marticles
ix)	Inspection and sorting		ix)	Inspection and sorting
x)	Packing		x)	Packing
xi)	Warehousing		xi)	Warehousing
xii)	Despatch		xii)	Despatch.

This sequence of operation is applicable irrespective of the method of forming the 'ware' whether it is by casting, pressing, jiggering or extrusion.

i) Raw Materials Intake and Storage

Storage bins or spaces are required for following 'body' materials. Quartz, felspar, flint balls, granite-stone, fire clay, china clay, ball clay, plaster of paris. Glazing materials like calcium carbonate, barium carbonate, zinc and tin oxides, colouring pigments are supplied in bags and hence require racked storage.

The different types of clays and the plaster of paris must have a covered storage space while others may or may not have a cover at the top. However, for undisturbed handling throughout the year, a covered space is suggested for all the materials.

A very important factor is that for storage of clays, there should be atleast 4 months storage capacity as there is almost no supply of clay during monsoon.

As explained in detail in the chapter on 'Handling of Materials' there should be a minimum handling in order to

i) prevent mixing with other materials and dirt,

ii) save the useful man hours.

It is suggested that the trucks should unload directly into storage bins which would have a sloping floor and a controlled outlet. Whenever material is required, it is removed through this outlet into a trolley, which in turn is taken to weighing bridge and finally emptied into the container of the gantry which delivers the same to the concerned ball mill. This process would minimise double handling and save time. Depending on site conditions, the storage bins should preferably be placed along western side of the unit so that the area most affected by solar radiation is not used for human occupation.

ii) Slip House

This is the most important department as the raw material is processed into clay or clay slip ready for being used in the making department. There are a number of machines in this section as listed below. (Factory act stipulates a min. of 0.90 M space on all sides of machinery)

Table No.4

Machinery and Space Requirement

Machinery	Space required L B and Ht
a) Weighing bridge	3mx3mx2.45m
b) Jaw crusher	3.5mx3mx2.4m
c) Dry grinder (edge runner mill)	3.6mx3.6mx2.4m
d) Ball mill	3.6mx3.6xmx2.4m
e) Blunger	3mx3mx1m
f) Pumps	as per H.P.
g) Vibrating Sieve	2.5x2.5x2.4m
h) Magnetic separator	portable or fixed
i) Agitator	3.8mx3.8mx3m
j) filter press	5mx4mx2.4m
k) De-airing pug mill	4.5x3Mx2.4m
l) Kneading roller	3.6mx3.6mx2.4m
m) Batting machine	3mx3mx2.4m
n) Retaining tanks	3mx1.8mx1.8m

When machinery is placed side by side they could have common space between them. There should be a minimum of 2m clear space by one longer side of jaw crusher, filter press and the de-airing pug mill so that the trolley can move more freely for transporting the materials to and from these machines. Some layouts are suggested as in figs. 2.1-1 and 2.1-2) wherein the sequence of operations, area for movement of trolleys, etc. are taken into account. All storage racks to be of timber and just placed on floor so that they could be shifted and adjusted to the required position. Height should not exceed 1.8 m for ease of handling. Iron racks should be avoided to prevent contamination with clay giving rise subsequently to stains over the fired ware. Slip house being noisy should be separated from the making department by a wall upto the ceiling to prevent the noise-transfer. The door openings should have either sliding shutters or roller types as the swing of wide door shutters occupies quite a space.

iii) Making Department

The processed clay from 'slip-house' is shaped in this department either by casting, pressing, or jiggering. Casting, jiggering and pressing though from a part of making department, they should be treated as different sections and areas allotted to them should be separate for each. This suggestion is given because the clay required is of different nature in each case, work planes are not the same. Casting section depends upon the type

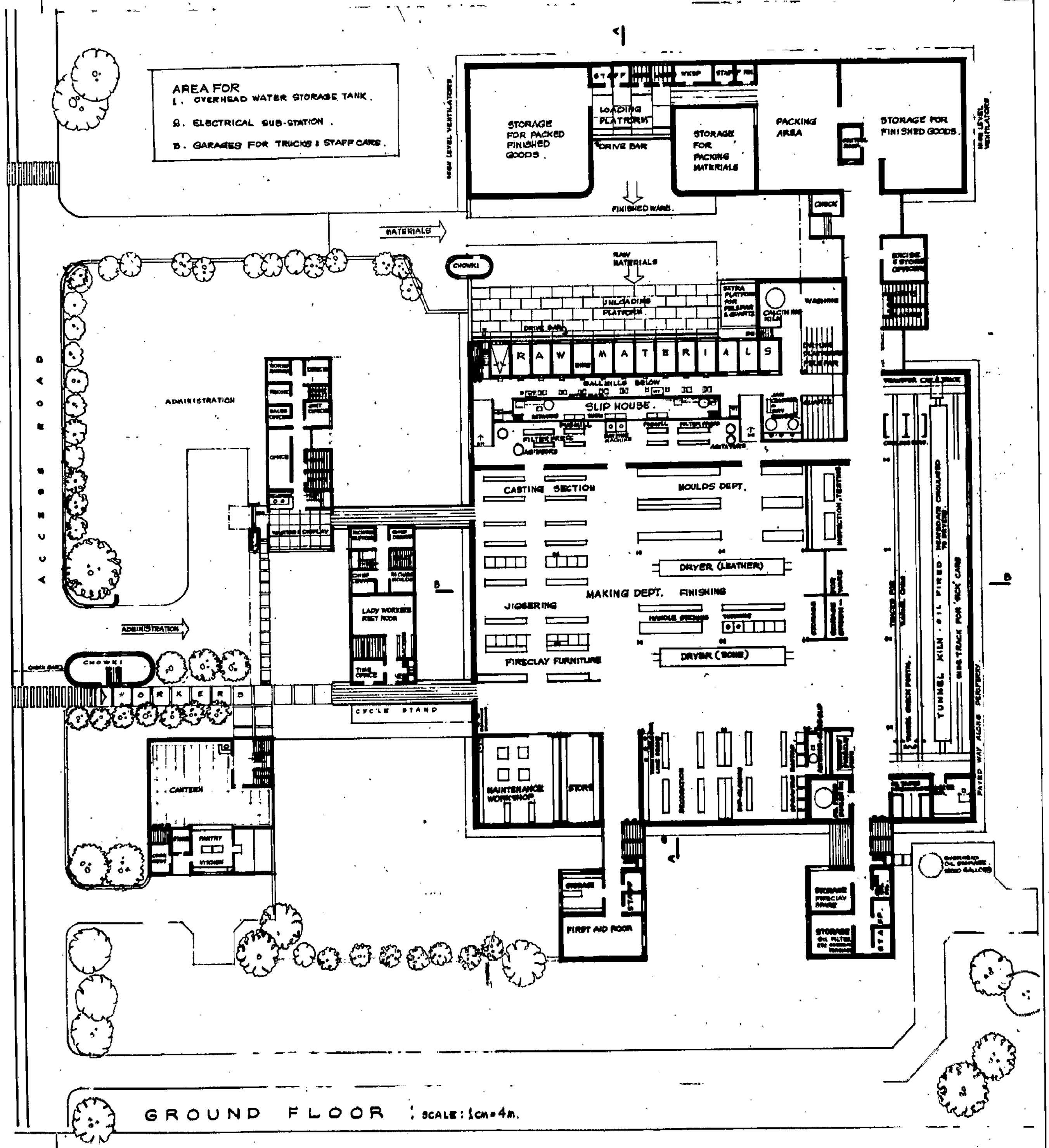
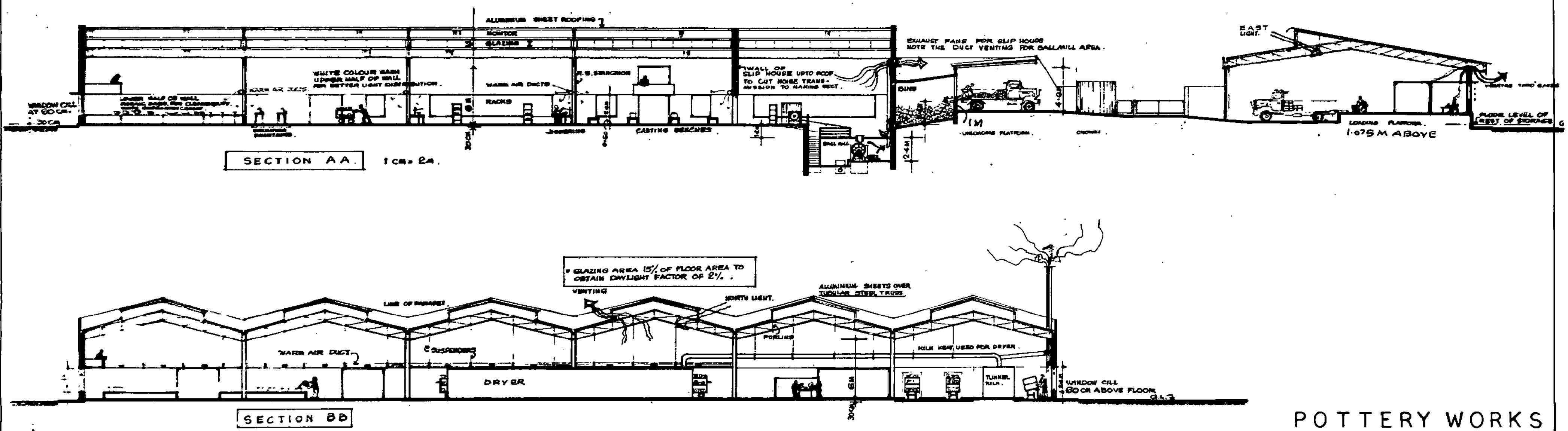

AREA FOR
1. OVERHEAD WATER STORAGE TANK.
2. ELECTRICAL SUB-STATION.
3. GARAGES FOR TRUCKS & STAFF CARS.
STORAGE FOR PACKED FINISHED GOODS.
LOADING PLATFORM
DRIVE BAR
STORAGE FOR PACKING MATERIALS
PACKING AREA
STORAGE FOR FINISHED GOODS.
FINISHED WARE.
MATERIALS
RAW MATERIALS
CHOWKI
UNLOADING PLATFORM.
CALCIN KILN
WASHING
DRIVE BAR
R A W M A T E R I A L S
BALL MILLS BELOW
SLIP HOUSE.
FILTER PRESS
AGITATORS
ADMINISTRATION
CASTING SECTION
MOULDS DEPT.
INSPECTION, TESTING
DRYER (LEATHER)
MAKING DEPT.
FINISHING
JIGGERING
FIRECLAY FURNITURE
DRYER (BONE)
TUNNEL KILN - OIL FIRED
ACCESS ROAD
ADMINISTRATION
LADY WORKERS REST ROOM
TIME OFFICE
CHOWKI
W O R K E R S
CYCLE STAND
CANTEEN
PANTRY
KITCHEN
MAINTENANCE WORKSHOP
STORE
FIRST AID ROOM
STORAGE FIRECLAY SPARE
PAVED WAY ALONG PERIPHERY
GROUND FLOOR ; SCALE: 1cm=4m.

FIG. 2.1-1a

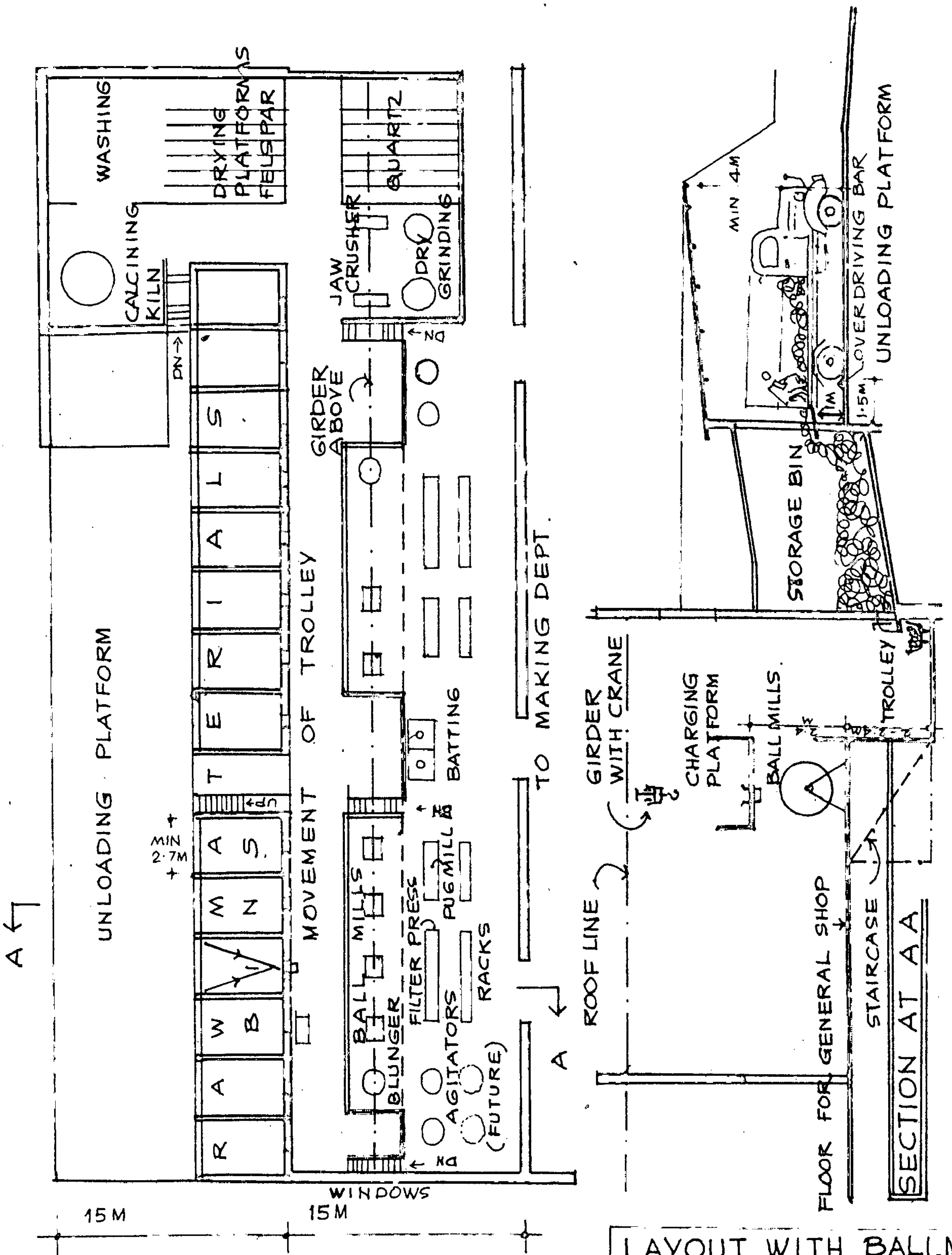


POTTERY WORKS

A. L. CHHATRE.
M. ARCH. 2.

FIG. 2.1-1b

52-B



LAYOUT WITH BALLMILLS AT FLOOR LEVEL WITH GENERAL SHOP FLOOR

FIG 2.1-2

: SLIP-HOUSE :

of product i.e. if fabrication of ware is mainly by casting as in the case of sanitary ware, the slip has to be constantly agitated before actual casting. For larger areas, an agitator within this section is desirable and this becomes a source of noise. This should be enclosed by accustic partitions to help the otherwise quiet making department. For such casting as of sanitary ware, there should be an overhead system of p.v.c. slip lines with draw off flexible extensions for casting into moulds. A certain degree of flexibility should be inbuilt in the plan itself by i) providing casting benches just placed on floor, ii) No floor drains to carry back the excessive and drained off slip, but can be taken, instead by p.v.c. containers. The slip lines should be run at about 2.4m above floor so that they do not interfere with the general working of plant. Casting benches of wood, should be of max. 0.60 m height above floor so that the placing of heavy moulds is easier and so is the casting. Where 'slip casting' is unnecessary as for the kettles, pots, handles etc., it is brought over the casting benches in p.v.c. containers and here also these benches should be max. 0.60 m above floor. This is useful because the worker can lift the slip filled container to about 1M above floor. In both the cases their layout should be such that it allows for removal of the released moulds to dryers.Conveyer casting has been dealt with in detail in the handling of materials.

Jiggering section includes the jigger jolleyes, the throwing and hand shapping etc. Jigger jolley occupies a space of 5'x3'x2½' and atleast 1m space (1.5x1x0.75m) must be left clear for the worker to operate on the lever side.

Throwing wheels demand that the operator sits on the same plane (refer fig 2.2.8 for photograph) as that of wheel so that when the clay lump is thrown, he can shape it with effective force. Small insulators are also formed in this way. This sitting space must be provided on the table itself on which the throwing wheel rotates. Its height should not exceed 0.60 m above floor for safety reasons. Pressing is done by screw presses and space required is similar as in the case of jigger jolley. For all these sections, the location is logically adjacent to the slip house with casting section the nearest of all so that slip-carrying is reduced to a minimum. The ancillary department is that of mould making. This should be so located as to have a direct link with making department. This is particularly important in respect of sanitary ware as the mould is quite large and a constant supply is required. For smaller items like crockery, chemical porcelain, moulds are smaller and the mould-making department is nothing but a storage space for moulds. The smaller establishments just purchase the moulds, use them and sell them back to cement industries after the absorption capacity of moulds is lost. Bigger concerns must have their own mould making department so that the design of the ware can be changed to stand better in the competition, rather than going in for standard designs. Provision of wash and tea rooms close to the making department is an important factor based on author's observation as follows. In the pottery works surveyed by the author it was observed that during making of ware, workers take a cup of tea almost once in every 1 to $1^{1}/2$ hour at the place of their work and in doing so consume some amount of free silica present in these departments. This must be discouraged by providing a tea room close by so that the worker takes his tea in this room and prevents early symtoms of silicosis. This would not reflect on his efficiency as the payment to worker should be related to the number of pieces formed by him. (A certain minimum and incentives for subsequent production).

Supervisory staff should be located between the making and the administrative departments separated from both as this system has following advantages (fig.2.1-1). i) walls are kept free for openings, ii) future expansion is possible in any direction, iii) Supervisory staff of moulding, casting, jiggering sections when placed together establish better rapport and can jointly solve problems rather than in isolation, (iv) certain facilities like reading, tea or rest rooms can be shared by all, (v) Double storeyed development is possible within the single height of main work areas and observation galleries at first floor permit a better view of the making department as such. All the three sections must also be corelated to the next section of leather drying. In case of sanitary ware, the casting and leather drying system is combined in conveyor system, while for other ware, the formed ware has to be carried for leather drying .

(iv) Leather Dryer

This dryer consists of a tunnel of 40'-50' length (12m to 15m) 6'-8' wide and 6'-8' in height. Towards one end of the tunnel, there should be a provision of blower room. Compressed and warm air is blown and pressed into the ducts carrying the same to the dryer. This flow of warm air should be in a direction opposite to that of travel of ware. The dryer tunnel should be so located that it is close to the making department and at the same time capable of taking advantage of waste heat from kiln area. In case of tunnel kiln, a continuous supply for the dryers is available, but in the case of intermittent kilns, this warm air supply should be augmented by provision of boiler. A boiler room provision can also be used for warming of indoor air during winter season.

(v) Finishing

Finishing or fettling operations are the most dangerous source of dust which rises to the breathing zone of the operatives. Hence this must be carried out in specially ventilated booths. At present these facilities for such precautions do not exist. It is suggested that booths of approx. 1.2mx1mx2m be used. These could be placed isolated or along a wall. Best location will be between the two columns so that it divides the fettling area from its adjacent area. This is applicable in respect of sanitary ware industry as well as crockery, chemical ware and insulators.

Sticking of handles to various pots is done after leather drying. Present practice in most of the factories is by way of floor squatting. This has the advantage in lesser damage by way of fall from a height and that it requires no furniture.

Although squatting for a longer time is a matter of habit, it is inconvenient. It is suggested that workers should be given low height (40 cm. high) stools.

Bone drying

Considerations are similar to that for leather drying. Its logical location is next to finishing department, whence the articles are carried over wheeled racks to the bone dryer. Once they come out of this dry-er they should be taken to the decoration or glazing depending on overglaze or underglaze decoration.

vi and viii) Glazing and Decoration

In case of sanitary ware the glazing should be spray-glazed in the specially built and ventilated cubicals. Size of these is 1.2mx1mx2m and must have atleast 1m space for operatives to work on (workside) workside followed with a wooden storage rack, for keeping the ware to be fettled and fettled ones. For smaller items, there should be a combination of spray glazing and 'dip-glazing'. The dip glazing requires a wooden bench of 0.60m height and width and atleast 1.2M working space. These being wooden worktables, can be adjusted to any place and pose no planning problem. The 'glaze-slip' should be prepared in slip house, blunged and brought to the agitator near glazing section wherein it is further agitated before being used. This agitator is likely to be a source of noise and hence should be enclosed with partition. This section must have space to accommodate the colour-pot mill and storage of ~~pri~~ pigmenting chemicals.

Decoration section should have arrangement of worktables of 75 cm. ht. and 2 or 3 wheels for the line decoration. These tables provide adequate storage for brushes, pallets, 'cut print stencils' . The entire area must be daylighted for correct colour identification and perception.

vii) Firing Section

This section has two possibilities.

i) Tunnel kiln,

ii) Down draught kilns.

Tunnel kilns being very long (150' to 405'x2.4M x2.4M)
45Mx122M
the length of the firing section is governed by its size. A 15m wide bay can take care of a tunnel kiln+ 2 tracks for kiln cars and a bye-pass for sick cars.

Other requirements are the oil-pressurising chambers and instrumentation room. At the two ends of the kiln there must be atleast 4.5m to 6 m space for accommodating the transfer track. A 3mx3m space is minimum for two oil tanks and a compressor and air blower. Instrumentation room shou should be completely enclosed by partitions to keep off the excessive heat of the kiln.Oil is stored in an elevated reservoir outside the builtup area and it is pumped up from oil tankers and goes by gravity to the two oil tanks for being pressed into kiln.

A tunnel kiln consumes about 2.5 tons of oil/day. Hence the reservoir must have adequate capacity (A 15 days supply stock of 40 tons divided in two parts.). Whatever the type of kiln there should be storage space close-by for i) saggers or fire clay furniture, ii) Greenware storage, and (iii) unloading of fired ware. With the down draught kilns, storage of coal and the quick removal of the burnt ash are important considerations. Both these contribute to the dirt and dust and spoil the floor. A good-housekeeping and quick removal of ash to disposal area appears to be the only solution.

The new factories should not go in for these latter type of kilns in view of the following: i) uncontrolled firing, ii) shortage of coal, iii) Nuisance value of coal and (iv) Air pollution and effect on fruit-crops.
In modern context there are a variety of kilns both electrically and oil fired ones and of different capacities to suit medium and large scale production. Henceforth, a new enterprise should think in terms of kilns with controlled firing which reduce the wastage to 3%. and

which keep the factory interior more clean and hygienic.

ix) Inspection and Sorting

The cooled fired ware is inspected, sorted out and some is rejected. The fired ware is unloaded on racks, sorted out on a work table 1.8mx1m and classified ware is kept on another rack, for being taken away to packing department. At this stage, the product, being stronger, could be handled on a powered trolley for faster removal and avoid manual lifting of heavy loads.

(x,xi and xii) Packing, Ware-housing and Despatch

Before the product is packed, it is weighed and checked by excise inspector. Therefore, on way to this section, there must be provision for i) weigh bridge-big enough for trolley, ii) Room and office for excise inspector. The working of this section should have following sequence, a) temporary storage, b) packing (storage of packing material, and a small workshop for packing cases, palletization, crates etc.) , c) warehousing, and d) loading platform. Temporary storage should have enough racks and space between them for movement of trolley. Storage of packing material should be of fire-resisting materials in view of its combustible nature. Actual packing can be done on 75 cm. high work tables or by squatting,out of which the former is recommended as it causes less inconvenience. For very large concerns, palletising of packing could be considered- this has been dealt in handling of materials and products. Loading platform should be 43 in.high so that the truck platform comes more or less in the same plain and the loading becomes easier and faster. There should be a cover over this area at 13'-0" (4 m) above ground level to ensure uniterrupted loading throughout the year. The most important consideration while locating the warehouse is that the control for checking in of raw materials and checking out of finished ware should be at one point for ease of management and security. (Fig.2.1-1a)

2.1.5 Ancillary Accommodation

1) Testing Laboratory

This laboratory tests the raw materials, clay slip, plastic clay, glazes, pigments, fired ware. Its location has relation to every stage of production and should therefore be close to the making department. Location close to sliphouse should be avoided as it is a noisy area and would therefore the distract the attention of chemists and laboratory must have acid resistant floor finish.

2) Electric Substation and Standby Generator

Location of this station is as directed by the electrical supply authority and as such architect can do very little in this respect, except maintain its basic aesthetics in keeping with the general design.

3) Maintenance Workshops

Location to be close to the making department so as to quickly attend to the fault and prevent loss of production.

2.1.6 Some Special Requirements

Beyond the usual requirements of a pottery industry few special requirements are given for consideration of large scale manufacturers while some are applicable to small scale and large scale concerns.

i) Guest Rooms

Most of the pottery works are so located that for visitors, suppliers, dealers, inspectors etc. there are no lodging facilities nearby and are therefore put to great inconvenience. It is suggested that atleast four guest rooms for larger concerns and two guest rooms for smaller ones should be provided to overcome this inconvenience. (Sugar Industry in India as a rule has a provision for guest rooms).

ii) Plaster of Paris Unit

For larger establishments especially the sanitary ware industry, should have its own plaster of paris production unit required for making of moulds. 'Sanitaryware-moulds' being very large, consume a large quantity of plaster of paris. Moulds after losing absorption capacity are of no use and are then sold to cement industries as raw materials. For a steady supply of moulds, a plaster of paris making-unit is highly desirable. Any surplus material is purchased by smaller units in the region.

iii) Research Centre

This is indispensable in our modern world in order to keep abreast of the latest developments in the industry, create new designs and patterns, for technological advancement exploring new material processes and also to attend the day-today problems factory problems.

iv) Training Centre

This is needed as a social welfare centre to train the workers in the art of casting, jiggering, kiln work, setting, glazing etc. so as to keep a constant supply of trained personnel for this industry like apprenticeship programmes in other industries.

2.1.7 Some Idea of Production and Machinery

For a 4-ton Plant Capacity Manufacturing,

a) 800 teapots, and sugar pots
   5000 cups
   5000 saucers
   (per day)
   or

b) 300 clits + 3500 L.T. insulators/day   or

c) Half of each of a and b.

SLIP HOUSE

i) One jaw crusher- jaw 6in.x12in.
   1 ton/hour (of 3/4" size) 9 to 10 H.P.

ii) 1 pan mill-with granite mullers
   - 9"x24" wheels, pan 4'x1'
   1/3 ton/hour of 2o mesh .   5 H.P.

(i and ii: one motor 18 H.P.)

iii) 5 ball mills-silex stone lining-
   4½'x4' size.
   1/2 ton size/ Ball mill/day. 6 H.P. each.
   4 for body 1 for glaze + 1 agitator.

iv) one blunger 5' dia.x7' deep.
   Fan 20"dia. - 1 ton capacity of body slip - 5 H.P.

v) 1/18"dia. vibrating sieve   1/2 H.P.

vi) Electromagnet working on 110-220 volts. D.C.

vii) Retaining tank/agitator   5 H.P.
10'x6'x6'

viii) Hydraulic pressure pump
4 H.P. - 350 gallons/hr.

ix) 1 filter press- 40 chambers of 32"dia.
3/4 ton in 1½ hr.

x) One number deairing pug mill   1Ton/hr.   5 H.P.

If shaft driving is used then 1 motor of 20 H.P. with belt and driving shaft.

MAKING DEPARTMENT

1.12 jigger jolleys   - each 1/2 H.P.

2. 10 wheels   - each 1/2 H.P.

3. 4 wheels for finishing each 1/2 H.P.

4. One 15 H.P. motor to run the machines.

SAGGER SECTION

1. One roller mill for mixing fire clay and grog
1/4 ton/hr.   5 H.P.

2. 1 Blunger - 1/2 ton/hr. 2 H.P.

3. 1 Pug mill- 1 ton/hr.   5 H.P.

4. 1 jigger jolley- 1/2 H.P.

5. One motor of   10 H.P.

MOULDING DEPARTMENT

1. One pan mill-steel millers. 24"x9"
pan 4' dia. x 12".   1/3 ton/hr.   5 H.P.

2. Calcining Kiln for gypsum.

3. One motor 5 H.P.

4. One mesh- 90 No.

FIRING DEPARTMENT

1. 1 no. calcining kiln for quartz/felspar.

2. 3 down draught type kilns.
   each 223.7 sq.ft. + ht. of 10'-0" or a tunnel kiln.

Main Raw Materials required.

1.	Ball clay	55 tons p.m.
2.	Felspar	30 tons.
3.	Quartz.	30 tons.
4.	$CaCO_3$	1 ton
5.	Fireclay	25 tons
6.	Gypsum	3 tons
7.	Coal or	45 tons
8.	Oil	60 tons

2.1.8 Summary

The foregoing discussion gives some guide lines in respect of correlation and sequence of operations so as to achieve efficiency in production. Administrative requirements are only enumerated and no special consideration is involved except that the plan should provide for future expansion. A double storeyed development is considered reasonable and logical for administrative units wherein the rooms such as library-cum-conference, could be on first floor so as to be quiet and less disturbed. Security staff should be provided housing on the site itself so that a round-the-clock vigil can be ensured. Some idea of production capacity and related requirement of machinery has been given . On the basis of space requirement of machinery and equipment as elaborated in the foregoing text, planning standards could be formulated.

2.2 HANDLING OF MATERIALS AND PRODUCTS

Material handling emerged as a technology during Second World War when the acute shortage of manpower mooted the development of mechanical handling in industry. This was due to the enormous quantities of surplus pallets and other handling equipment thrown by the armed forces at the end of hostilities.

It might be defined as the movement of every thing- 'the picking up and setting down, moving in horizontal or vertical planes, (or even a combination of the two) of materials or commodities whether in bulk or unit, in their raw, semi-finished or finished state'. Scientific materials handling is now recognised as a vital factor in end-cost of all products and services. It is therefore essential that every new factory should be so designed that the structure and layout do not inhibit the application of the most efficient handling method compatible with the work to be peßformed. 'Handling-considerations' do not apply only to workshops but are equally important in respect of raw materials, finished products storage, transport, reception and despatch bays.

It is important to note that none of the 'stages of production' can be divided into water tight compartments. Smooth flow of materials and products in and out of the building are the 'key words' for a modernfactory.

2.2.1 Advantages of Effective Materials Handling

The various advantages are as follows:

1. Increase in productivity from existing plants and full

use of installed capacity.

2. Increased volume handled with no'manpower increase'
3. Upgrading of jobs.
4. Delays reduced.
5. More time spent on manufacturing.
6. Reduction in fatigue by eliminating heavy-manual handling and transporting.
7. Reduction in accidents and personal injury due to manual handling.
8. Time saved by faster handling (fig.2.2-1)

2.2.2 Nature of the Handling.

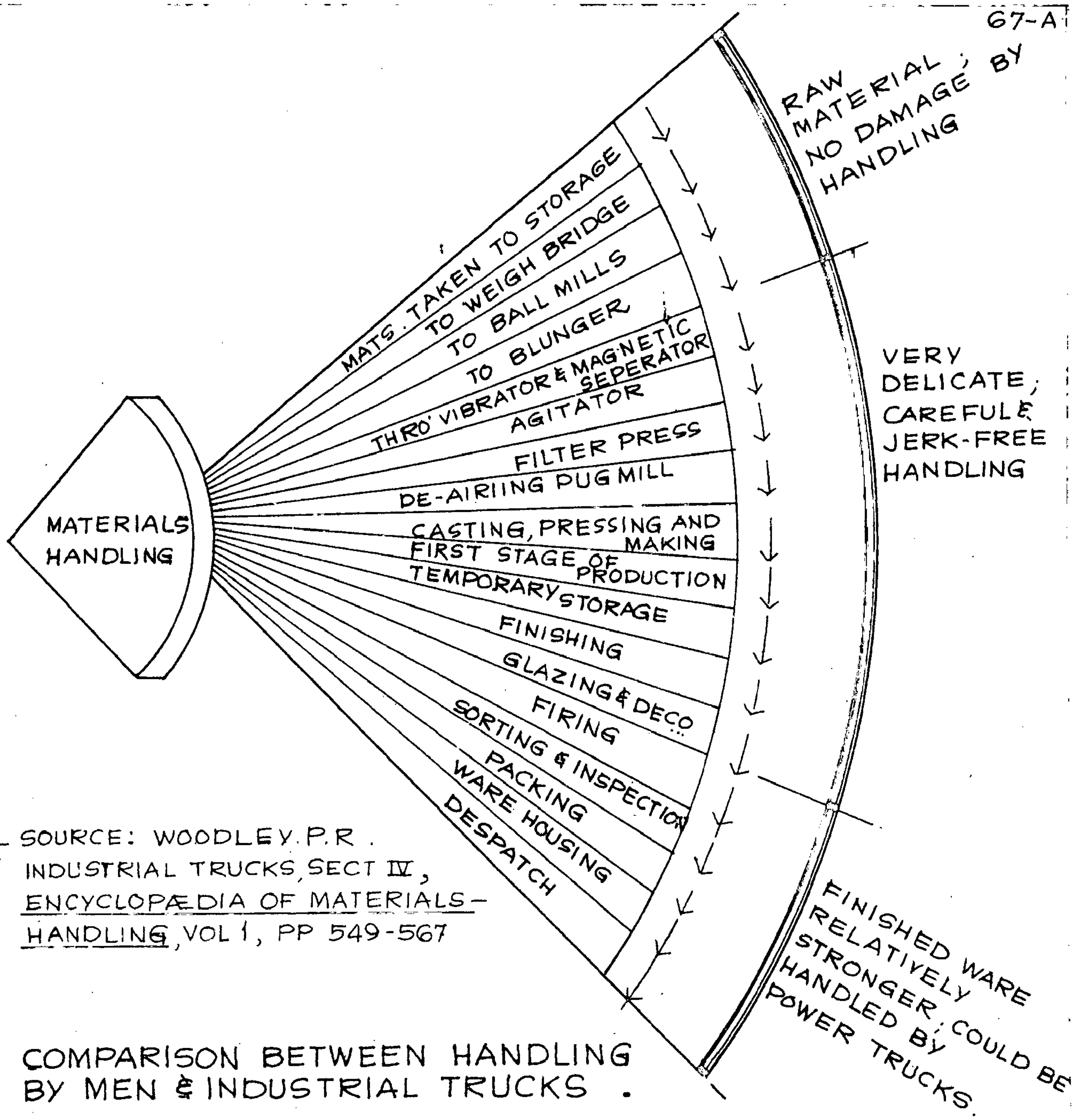
A detailed study of various processes and flow diagrams (as given in Chapter 1) reveals that the handling could be generally divided into three stages of production.

i) Handling of raw materials,

ii) Handling of products during formation,

iii) Handling of finished products including packing, ware-housing and despatch.

A further study of the process would bring out the difference in the strength of products in these three stages, i.e. in the first stage of production, only raw materials are being handled and that these materials are not breakable. In the second stage, the product, in the form of a greenware, is extremely delicate and must be very carefully handled to avoid damage. In the final stage, the product is a 'fired-ware' and, hence, relatively stronger than the second stage product. These stages give a guideline



SOURCE: WOODLEY. P.R. INDUSTRIAL TRUCKS, SECT IV, ENCYCLOPÆDIA OF MATERIALS-HANDLING, VOL 1, PP 549-567

COMPARISON BETWEEN HANDLING BY MEN & INDUSTRIAL TRUCKS.

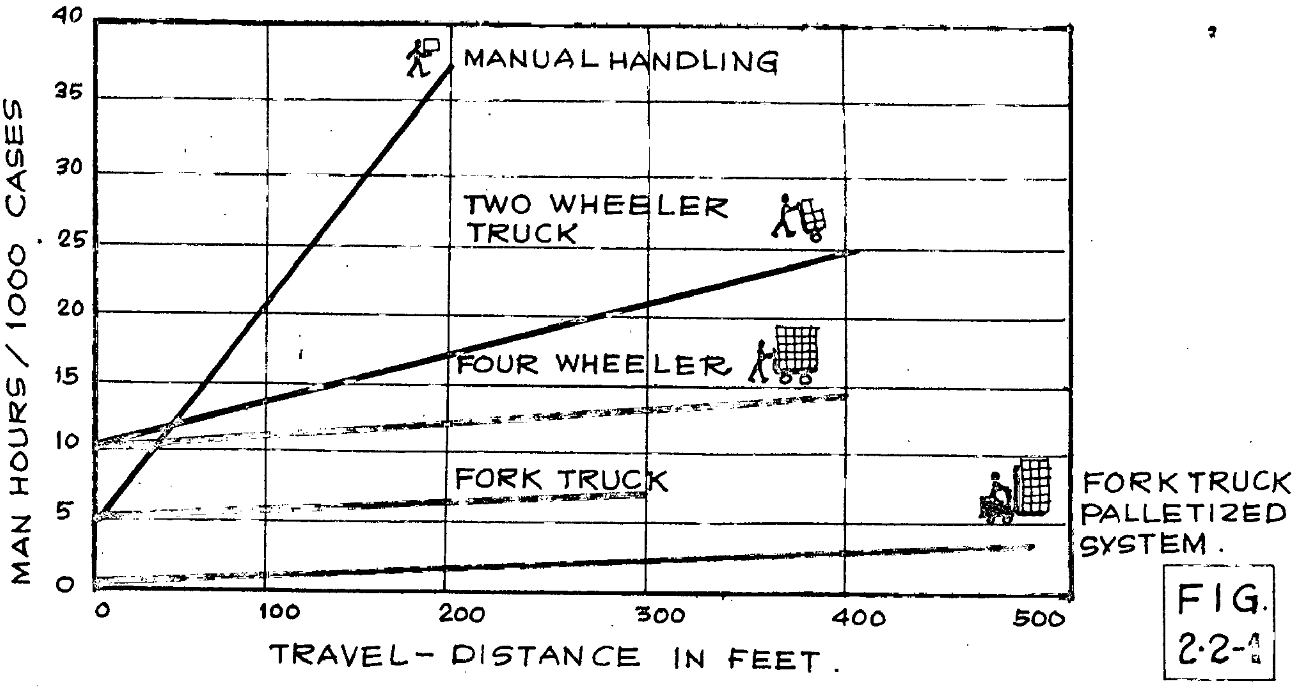


FIG. 2.2-1

as to the extent of mechanised handling applicable during each of the three stages.

2.2.3 i) Handling of Raw Materials

As already mentioned, the principal raw- materials are the china and ball clays, felspar, quartz and the glazing materials such as the zinc and tin oxide, barium and calcium carbonate, frit etc. The materials are brought in by railway wagons or truck transport of which the latter is the most commonly used transport for incoming of raw materials or outgoing finished product. With the increase in the number of vehicles on road in the transport network, road transport is going to be more and more used. One more point in favour is that the material is only handled once and not twice or thrice as in the case of railway wagons, thus lessening the possibility of mixing of other materials.

In context of 'pottery works' it is extremely important to note that during the months of monsoon, the clays are not quarried and hence not brought in the factory. An adequate storage area with capacity to hold atleast '4 months' clay stock is desirable. In a number of factories, as observed, the raw materials are stored on a raised (1' above ground level) platform wherefrom they are taken to the slip house for weighing and charging into ball mills. The position of ball mills with respect to G.L. has a considerable effect on raw material handling.

i) Ball mills at floor level.

ii) Ball mills on a raised platform, | Fig.2.2-2
iii) Ball mills below the floor level. |

In the first case, the charging platform goes to a height of 2.4 m above floor and the material (weighed and filled in bags) is raised to this height by a lifting chain and pulleys moving along the platform over an I section (refer figure). If this trolley moving over the I section is 'powered', handling of materials becomes easier and smoother. The charging operation/ball mill occurs once or twice a day as 4 hours or 8 hours is the running time set for ball mills for a thorough grinding of materials.

In the second case, the charging platform is considerably higher but a similar arrangement as in first case could hold good and the blunger or the mixing tank is accommodated in the height of raised platform. Generally, 1 blunger between 2 ball mills is usually placed. This helps for the gravitational flow of the 'blunger-contents' (slip) to the agitator. In first case the blunger being below the floor, its contents have to be pumped to the agitator.

In the third case, where the ball mill is below the floor level, the charging platform is in the same level with that of general floor level and thus the material can be charged into the ball mills without being raised and no raising arrangements are necessary. However, this advantage is to some extent lost because the slip from slip storage has to be pumped and raised to blunger 2.4 m above. 'The gravitational flow' is out of question because of -ve level difference which was taken advantage of in second case. Further the workers in the basement area are deprived of visual rest-centres in the form of windows and lot of absorption area will have to be provided to avoid excessive reverberation of sound from the bal blank surfaces around the ball mills.

Unloading of raw materials

Raw materials are brought in by the trucks or by railway wagons. If railway is close to the site, the contents of wagon are emptied on a platform-specially built to avoid mixing of other materials with it. As and when required, this can be taken to sliphouse. With the trucks, the storage bins should be so arranged that the contents are emptied directly into the bins instead of on a platform and being subsequently carried to storage bins. In many factories the practice is to unload the material on a platform and then to carry it manually or by wheeled racks into the storage bins. This involves a double handling and wastage of man hours for the subsequent transfer of material. Loading time of trucks with 180 cft capacity is enumerated to give some idea of time involved in double handling.

i) clay	-20 minutes,
ii) Quartz	-35 minutes,
iii) felspar	- 35 minutes,
iv) Quartz or felspar	- 30 minutes (if of max. 2" size)
v) Bags of chemicals or glazing mats.	- 75 minutes (for 200 bags)

However, the time taken for subsequent loading of bins will be much more than above because the above time requirement is when truck stands close to the material being loaded.

The arrangement suggested is that the truck backs up to the storage bin, opens the rear plank onto the parapet of bin and material is unloaded directly into the bin. Further with sloping floor and a controlled outlet, material can be taken directly into a waiting trolley and taken for weighing and filling into the container wherefrom it will be raised to the charging platform.

For deciding the height of parapet (table 5), a survey of about trucks was done to include both the old and new trucks and the loaded and empty trucks. Second precaution necessary is prevention of overdriving of trucks and the damage to the bin walls. This can be prevented by the 'over driving bar' at floor as shown in the fig. .2-1.2 The distance of rear wheels to the rear end governs this position of bar but this varies with the truck and horse power. In the most commonly used trucks with 121 H.P. having a minimum overhang this is 5'-0" or 1.5 M. and a bar at 1.5M from the bin wall will overcome the majority cases and would cause no obstruction for trucks with bigger overhang. This observation is based on 1 hour survey on Hardwar road and at Naya Bazar Street, Old Delhi, where during 1 hour, 12 out of 15 and 33 out of 40 trucks were 121 H.P. respectively.

Table 5 - Height of Truck Platform

Regn. No.	Truck	Loaded/ unloaded	Height of truckplat-eform
1. USV 6225	Mercedes	Loaded	42½" or
2. USV 6625	Mercedes	Unloaded	43"
3. UPS 7060	Bedford	Unloaded	43"
4. USV 6216	Tata	loaded	42"
5. HRA 7831	Tata	Unloaded	44"
6. UPU 9465	Leyland	Loaded	41"
7. HRA 7205	Tata	Loaded	40"
8. USV 5325	Mercedes	Unloaded	43½"
9. PND 3025	Tata	Loaded	42"

Place Hardwar road near Canal at Roorkee

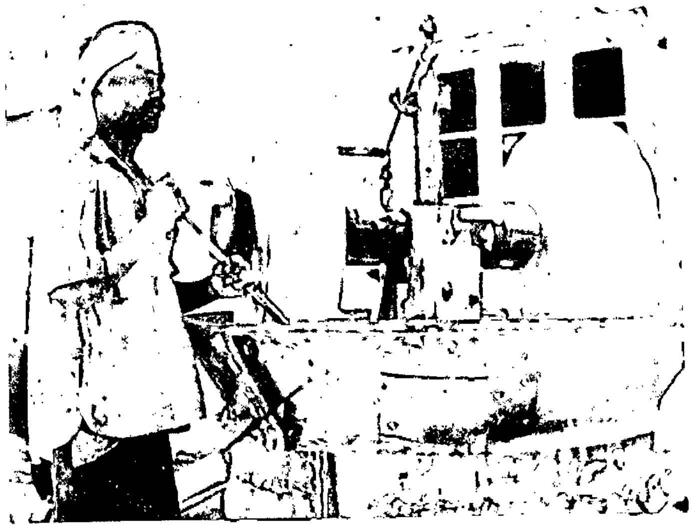
Time 4.30 P.M. to 5.30 P.M. on 11.4.1973.

Therefore 1 M or 39" to 40" height of parapet with a rubber lining at top, is suggested.

Drying Platforms for Calcined Quartz and Felspar

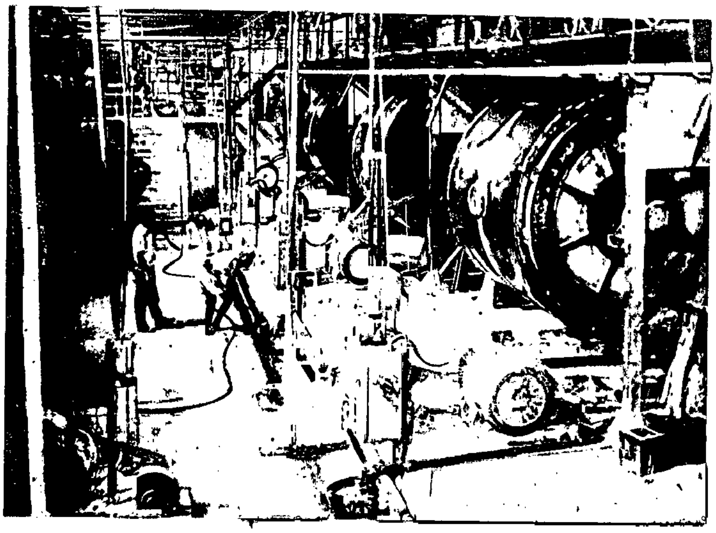
To render the above materials brittle and more easily crushable, these are calcined (heated) in kilns and washed before being crushed in jaw crushers. Once washed, these have to be spread over a drying platform to remove the water, which partly drains off andpartly gets evaporated. During monsoon, the evaporation is almost absent and a warm air flow is essential to eliminate water completely. For this purpose arrangement as shown in fig.2.2-2 is suggested.

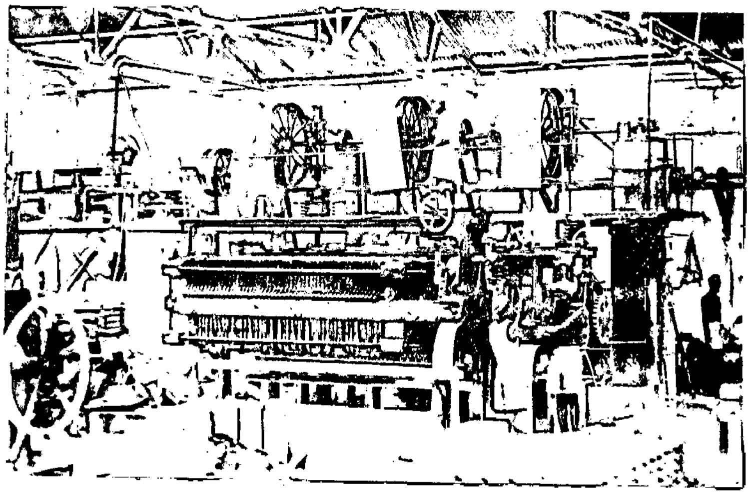
HANDLING OF RAW MATERIALS



PAN MILL OR EDGE RUNNER MILL. ←

A BATTERY OF BALL MILLS →



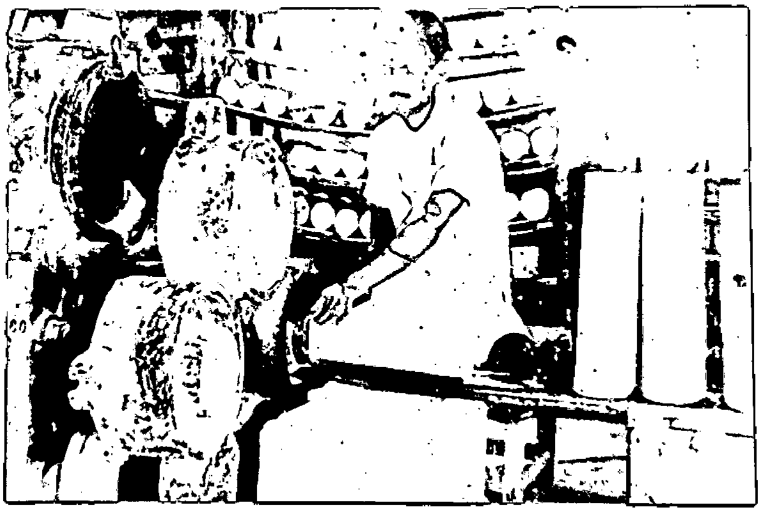


FILTER PRESS IN SLIP HOUSE. ←

SOURCE: RESPECTIVELY,

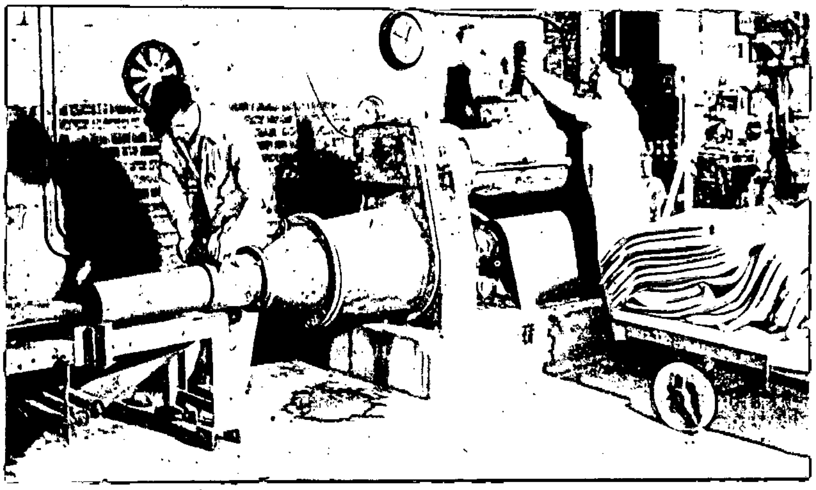
- OFFICE OF THE CHIEF ADVISOR OF FACTORIES (O.C.A.F.) GOVT. OF INDIA, SILICOSIS IN THE POTTERY & CERAMIC INDUSTRY, REPORT NO. 11, PICT. NO 1.
- HINDUSTHAN SANITARY-WARE (HSI) BULLETIN, THE DECADE THAT WAS. P.P. 8. 1971-72.
- C.S.I.R. CERAMICS POTTERY, WEALTH OF INDIA, PP. 87.

HANDLING OF RAW MATERIALS



DEAIRING PUG MILL
←

FILTER PRESS CAKES BEING FED TO PUGMILL, CLAY ROLLS EMERGING OUT.
→



THROWING & HAND FORMING.
←

SOURCE. (RESPECTIVE).
- CSIR, op-cit, PP 90.
- NORTON. F.H. BONE CHINA, CHAP. 22, OP-cit, P.P. 348.
- O.C.A.F., op-cit, PICT. NO. 5.

A platform laid to slope with channels having a perforated tile drain bottom is recommended. This serves two purposes.

i) Drains off water from washed material,

ii) Being connected to air main, it effectively helps evaporation with air current spread all over the area of material, through the perforated tile drain.

2.2.4 (ii) Handling of product during formation.

Various stages can be enumerated as

i) Making, ii) Drying and finishing and iii) glazing and iv) firing.

It has been seen that the raw materials having undergone the processes of grinding, blunging, agitating are in the form of a slurry 'called' CLAY-SLIP'. The slip is passed through a filter press and the filter cakes are further subjected to de-airing in pug-mill and the emergent clay rolls are temporarily stored over a wooden rack. At this stage the clay is ready for various 'making-processes'.

i) roll 'as it is' used for Jiggering and Throwing

ii) rolls once again mixed f with water and blunged to form 'clay slip' for casting process.

This jiggering process is used for preparation of cups, saucers, plates etc. The following are the handling operations (with correct sequence a skilled worker with an assistant can make about 600 pieces/day in a shift of 8 working hours)

a. clay supply in the form of cut 'Bats' for plates and saucers and in roll form for cups

b. supply of empty moulds

c. carrying away the jiggered pieces.

From now on, the ware being formed is delicate and demands careful and jerk free handling.

Explanation (Fig.2.2-3)

For smaller units where the manual handling is done, the sequence of operations is as follows,

a) mould A_1 placed on wheel,
b) jigger lever operated
c) clay lump thrown in mould,
d) excess clay back to clay storage, and
e) mould placed at A_1' with jiggered ware.

} 1 piece ready

For second piece operations are repeated and A_2 goes to A_2' At the end of A_5, the plank A is empty and before A_5 goes to A_5', the helper replaces plank A with another plank of 5 empty moulds and carries the plank A' for open air drying. To avoid delays, generally 2 such A planks are placed with about 10 empty moulds, each plank being replaced with empty moulds and simultaneous carrying away of A' plank for drying.

(A'5-mould'unit happens to be easy for manual handling)

As far as possible the removing of moulds etc. should be done from the other side of the platform (opposite to the operative) so that during his movements he does not inadvertently damage or disturb the moulds etc. being brought from the rear side.

However with bigger units the jiggered ware is carried to dryers over wheeled racks. Capacity of a wheeled

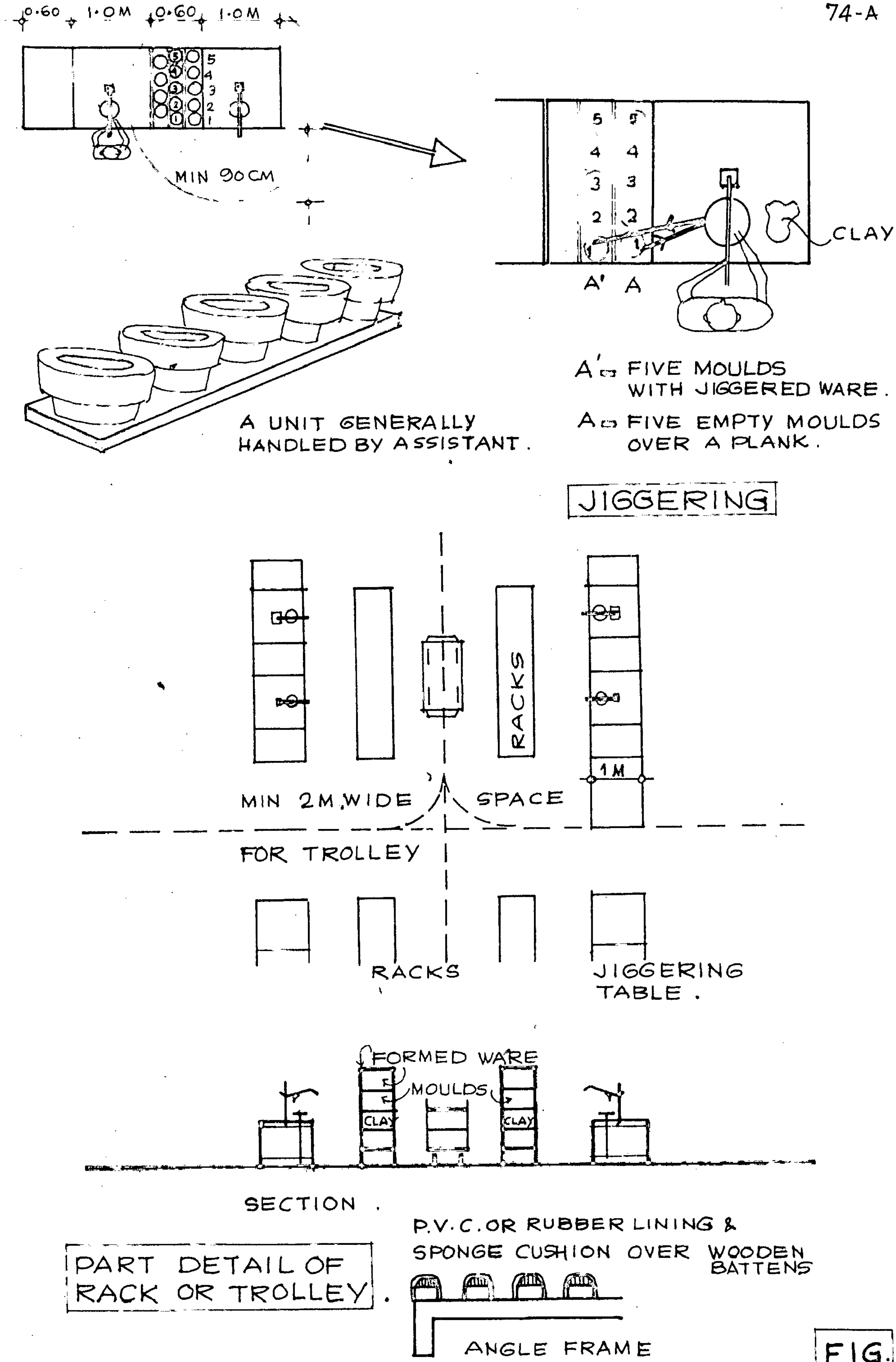


FIG. 2·2-3

: HANDLING-PRODUCT IN FORMATION :

JIGGER JOLLEYING ←

↑ CASTING OF POTS

↑ CLEANING AND STICKING OF HANDLES.

↑ GLAZING BY DIPPING

SOURCES (RESPECTIVE)
- OCAF, OP-cit, PICT NOS. 6, 10, 9.
- CSIR, OP-cit, PP 90 (FOR CASTING)

CHAP II
2·2-C

rack is very large and as such a different system is suggested.

Operative himself picks up empty mould plank from top rack and replaces the plank with jiggered ware. In this way, inspite of a feedback from near side there is no risk of any damage to the articles or ware being formed.

Throwing

It is a process by which jars, some types of insulators etc. are formed. Considerations for handling of materials and products are similar to that for the jiggering process. It differs in following respects:

i) Thrower sits on the table itself for hand shaping of ware.

ii) Height of this should not exceed 2'-6"(0.75 M) for safety reasons and ease of climbing.

iii) once he seats himself in position he cannot be expected to get up and take away the formed ware, himself.

iv) sufficient area for seating of operative and for storage of formed ware.

Casting

Sanitaryware, pitchers, kettles, cup handles etc. are formed by this process and as such the 'clay slip' is the material being handled which is used for filling up of plaster of paris moulds. Once a layer is formed along the inner surface of mould, excess slip is drained off and taken for reuse while the moulds are opened to release the ware. For smaller articles like kettles, pitchers etc. clay slip is brought in by plastic containers, agitated and filled into the moulds by plastic jugs. The points given on the next page need consideration:

i) Height of casting benches should not exceed 0.60M (2'-0") for ease of hand-casting,

ii) Storage of empty moulds,

iii) storage of formed ware.

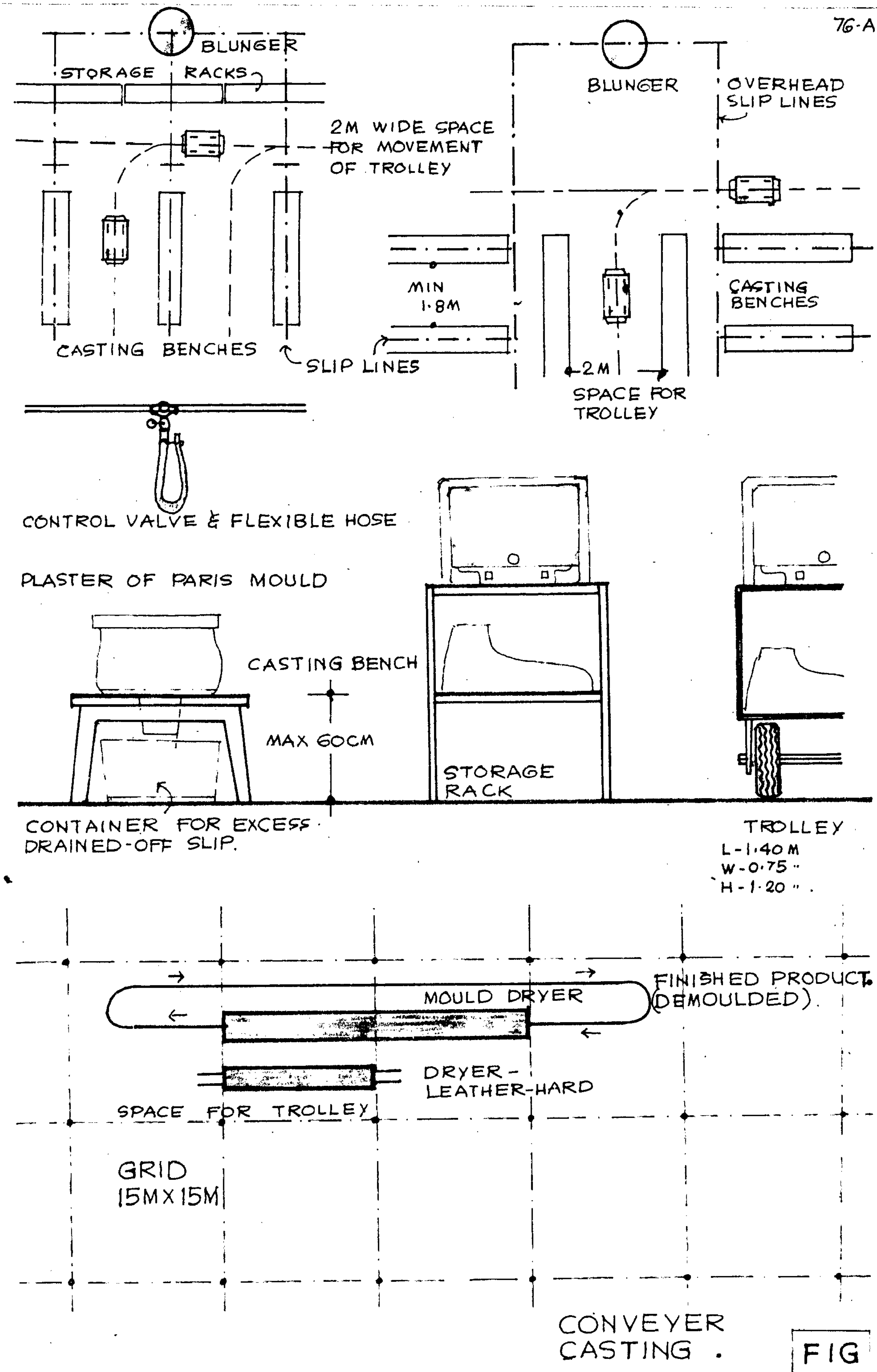
iv) casting and releasing of moulds being skilled work is done by the same person.

v) carrying back the 'excess and drained off slip' for reuse.

vi) use of plastic buckets and jugs to avoid contact with iron.

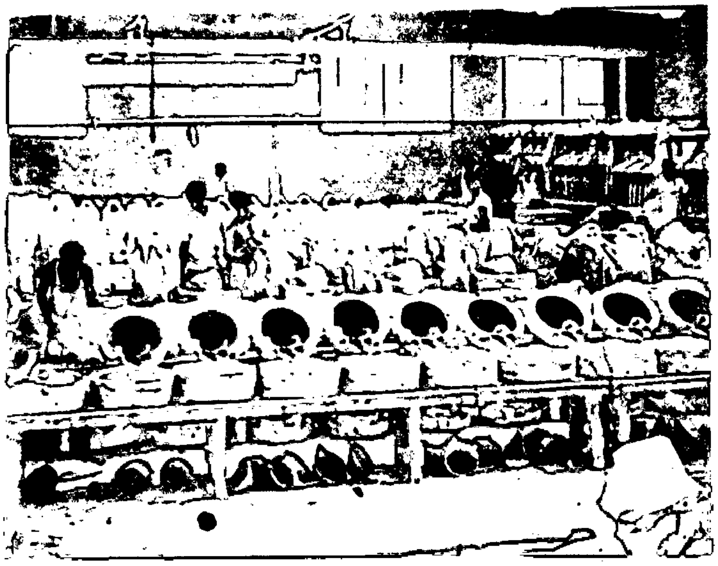
Casting of Sanitary Ware(Fig. 2.2-4)

The articles being of larger size, casting by jugs is most inadequate. The 'slip' is conveyed from the slip house agitators and pumps through overhead P.V.C. pipes above casting benches with flexible 'draw-off' branches at intervals . The P.V.C. slip line is suspended by clamps etc. at 2.4 M above floor. Once the ware is released, it is stored on racks with 'rubber lined sponge cushioning' for soft-supporting the newly formed ware. These are subsequently taken to dryers by placing over wheeled racks. Sufficient (2M) space must be left between the storage racks for the free movement of wheeled racks. Casting benches should not be more than 2'-0' (.60 M) in height and should be kept free on floor so as to provide flexibility in their arrangement. This is particularly necessary as it allows provision for change, adoption of new techniques of handling.



: HANDLING-PRODUCT IN FORMATION:

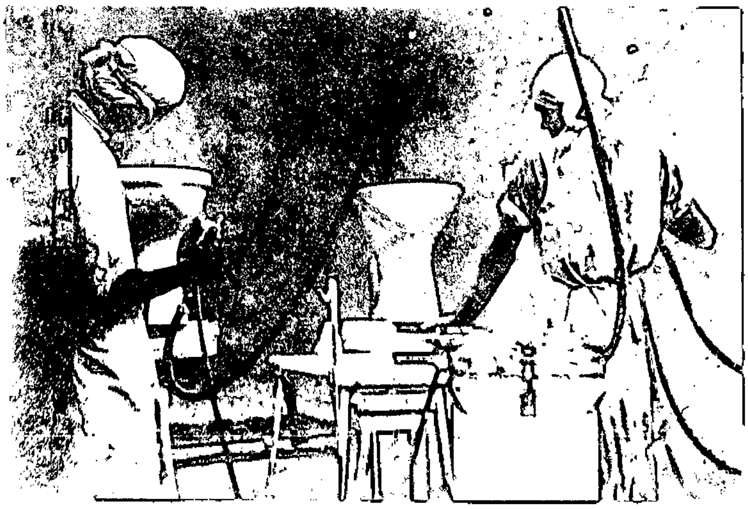
FIG 2·2-4



HANDLING OF PRODUCT DURING FORMATION

CASTING OF SANITARY WARE ←

FINISHING IN FETTLING HOODS →



SPRAY GLAZING ←

SOURCE :
- HSI BULLETIN, op.cit, PP. 9 .

CHAP II
2.2-D

Drying

For dryer tunnel, there has to be atleast 2 to 2.5M space on one side for movement of dryer cars.

Similar dryer is used for various articles and processes of making the clay-ware.

Adoption of new techniques must allow for conveyer casting system specially for the sanitaryware. This requires space for

i) mould dryer about 30M long x 2.4M x 2.4M

ii) conveyer casting bench-overall length about 45 M.

iii) Dryer for the ware.

Mould dryer is required because the mould being large, does not dry quickly and the production goes down unless a continuous supply of dry moulds is ensured. This system occupies a space of about 15 M in one direction. A grid of 15Mx15M provides flexibility for orienting the conveyer-casting system along either axis.

Pressing

This is a process for making of some types of making of some types of porcelain insulators like cleats, fuses, etc. Raw material consists of dry mix obtained by drying the filter cakes to about 12% water, disintegrating in a dust blower and finally the screening. The dry mix is brought in plastic containers and pressed in the dye of hand toggle and screw presses to form the insulators. Semi-automatic hydraulic presses should be be considered as a new alternative to screw presses.

Finishing

The ware once passed through dryers is ready for finishing. The polishing, fettling etc. should be carried out in enclosures to avoid the resulting dust-nuisance. This has been already dealt in detail under the topic of 'Dust-Control' and hence only mention is made here.

Glazing

The finished ware can be finished either by the 'dip glazing' or spray glazing, the latter must be carried out in cubicals to avoid spread of the spray dots and to promote exhaust ventilation. Larger items like sanitary-ware is spray-glazed while smaller articles are dip glazed.

Firing

i) Tunnel kiln, ii) Downdraught kiln.

Tunnel Kiln

The glazed greenware is transferred from wheeled racks to kiln cars duly set on the appropriate fire clay furniture. The kiln cars should pass through a check-gate (an exact cross section of tunnel kiln) to ensure its smooth travel in the kiln. The transfer cars push them into the kiln. The tunnel kiln being a continuously fired type, following consideration is desirable:

i) Minimum 2 tracks by the side of tunnel kiln to accommodate a number of cars ready for being loaded with green and glazed ware.

ii) Manufacturing of ware is generally during the day shift and to meet the demand of a tunnel kiln, the day shift must prepare enough ware so as to be sufficient for night shift.

iii) Thus by the end of day's work, one of the tracks with kiln cars should be kept ready, duly set with green-glazed ware, for the night-feed.

iv) An additional short side track is recommended near both ends of kiln to remove the sick or defective kiln cars. In the absence of this side track a sick car will provide great obstruction.

v) As a fired ware car comes out at a rate of 1 car/hour, a small enclosure on tracks at the fired end side is recommended to accommodate the just arrived and very hot kiln car. The enclosure should be provided with exhaust ventilation and the excessive heat thus removed should be utilised for dryers. If this precaution is not taken, the excessive heat given off by hot car would cause a great discomfort in kiln section.

vi) A sufficient area for storage of the green-glazed ware and the fire clay furniture.

vii) Storage of fire resisting materials for fuel-(the furnace oil).

(ii) Down draught kiln

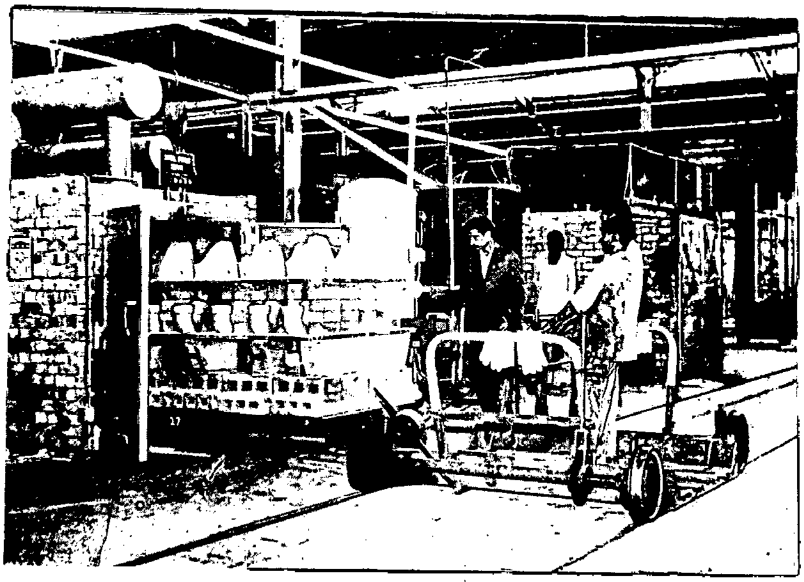
This is a non-continuous type of kiln while, one firing operation complete from loading to unloading is of about 6 days. Material and product handling should have following considerations,

i) sagger storage for settling of greenglazed ware,

ii) storage for coal-used as a fuel.

A SET KILN CAR ENTERING THE TUNNEL KILN . NOTE THE PASSING-GATE ←

FIRED WARE TO BE TAKEN TO TRANSFER CAR .



FIRED & COOLED WARE BEING INSPECTED & SORTED OUT .

FORMED WARE .

SOURCE : RESPECTIVE .

- NORTON F.H. KILNS, op-cit, PP 306 .
- H.S.I , op-cit, PP. 10, 5 .

CHAP II 2.2- E

iii) Persons engaged in loading/unloading of saggers should wear a respiratory mask in view of the dust nuisance.

iv) This type of kiln is only suggested for smaller units and future expansion must make a provision for a tunnel kiln.

v) Immediate removal of coal-ash to the point of disposal to minimise dust nuisance indoors.

2.2.5 (iii) Handling of Finished Goods

The material after being fired is relatively stronger and adoption of industrial trucks can be considered as worthwhile. Once out of the kiln, it is inspected and sorted out. Edges in respect of sanitary ware,need to be protected and this could be done by 'paper gum taping' the edges.

Ware Housing

Ware housing of goods is a feature of every type of industrial building. Even in the smallest of production units consideration must be given to the storage of raw materials, handling and storage of finished goods. Production and despatch rates can never be balanced, since goods have to be accumulated at the various stages in the production cycle. Storage facilities are therefore necessary during the whole process of manufacture.

Warehousing comprises the following functions:-

i) Receipt of goods,

ii) Safe storage of goods at the time required and in correct sequence, having regard to the order in which they were received.

iii) A control system that will enable these functions to be performed.

Mechanical Handling

Whether storage is short term or long term , it is essential that provision is made for rapid movement of materials and ease of handling. Excess handling of goods may prove dangerous in view of their brittle nature and it adds to the cost and not value. Goods may be stacked by hand to a height of some 7'-8' (2.1 to 2.4M) Mechanical means of lifting enable this height to be increased upwards upto 16' (5M) compact packing requires less volume of storage and the height is almost fully exploited because of mechanical handling.

The design of ware house is affected or governed by the following factors.

1. Method of storage which can be
   - a. simple stacking,
   - b. Racking, use of fixed racks,
   - c. Palletisation,
   - d. Inter-locking type (specially for sanitary ware)
2. Method of Handling
   - a. Manual handling,
   - b. conveyer,
   - c. Manually operated wheeled racks,
   - d. Forklift.
   - e. Tow trucks

3. Method of Packing

   a. export type,

   b. local

   c. distant cities.

4. Method of receipts or despatch including checking, loading and unloading.

Storage by Stacking and Racking

Storage height is limited by a man's reach- say upto 6'-7' (2.1M). Slotted angle racking or wooden racking can be tailored to suit the goods. Space between the racks is governed by the system of handling.

The storage of goods on pallets is suitable for warehousing most types of products. The advantage of palletising is obviously greater where it is possible to load goods straight from the packing line onto pallets and then to storage.

In essence a pallet is a portable platform of appropriate size and strength. Fragile or irregularly shaped goods require special pallets called post and box pallets.

In the scheme of palletisation the following procedure must be adopted:

i) select a suitable type of pallet depending on nature of material.

ii) Select suitable handling equipment.

iii) Depending on (i) and (ii) layout of racks, height, spacing, gangway widths can be determined.

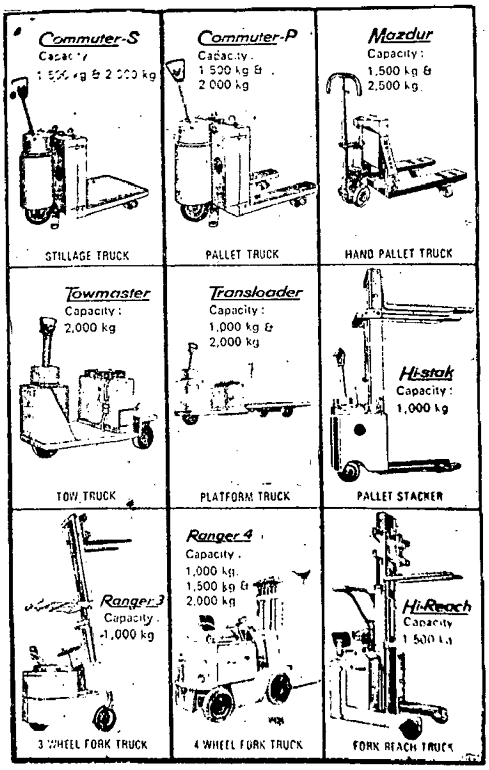
(In western context, palletised service is adopted to a no. of pottery works)

HANDLING OF FORMED WARE.

INTER LOCK TYPE STACKING.
NOTE THE COMPACT NATURE OF STACKING.
←

TYPICAL USE OF FORK-LIFT TRUCKS

MECHANISED HANDLING.
→



RANGE OF INDUSTRIAL TRUCKS IN INDIAN CONTEXT.
←

SOURCE (RESPECTIVE)
- HSI BULLETIN, OP-CIT, PP 10.
- GODREJ CATLOG, INDUSTRIAL TRUCKS, FORK LIFT TRUCKS.
- MACNEILL & BARRY CATALOG, MATERIALS HANDLING EQUIPMENT.

Types of Industrial Trucks (Fig.2.2-5-7)

There is a wide variety of industrial trucks of Indian manufacture such as Fork lift, towtrucks, pallet trucks, platform trucks, pallet stracker, stillage trucks etc. of different carrying capacities. Forklift truck take its name from the pair of forks used for lifting the load. The forks vary in width and length to suit the load being carried with generally an extendable mast. (common height of the mast is 8'(2.4m) and extends to give a lifting height of 12'-14'(3.6m to 4.2m).

The height and width of door openings is determined by the height of mast (including the free lift) for its free movement within the concerned departments. A 3M height and width is satisfactory for ease of turning etc. The width of the gangway must depend on the size of the pallet and the turning circle of the truck chosen. Gangways are generally 11'-0"(3.3M) but may be reduced to 7'-8' (2.1M to 2.4M) with fork-reach trucks. Maximum five pallets depth along walls and ten for free standing pallets is permissible. For entirely free movement a stanchion free area is the best but this has to be weighed against the increased cost of single span and inconvenience due to stanchions.In American practice a 40'x50' (12Mx15M) grid is commonly employed. As already dealt in detail under the chapter of flooring, due consideration is necessary for the weight and friction of the concerned industrial trucks.

STANDARD DIMENSIONS

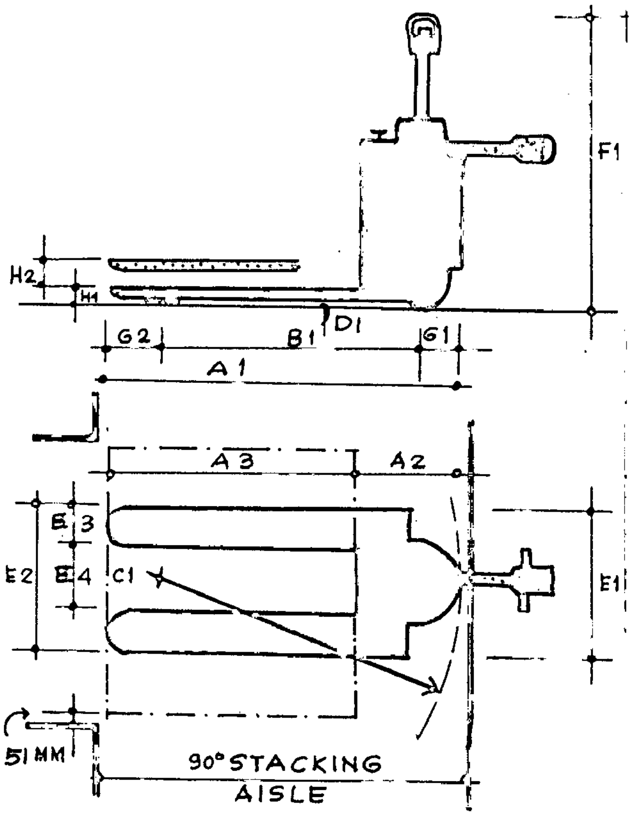
	INCHES	mm
A1 - OVERALL LENGTH	54 3/4	1391
A2 - POWER-UNIT "	18 3/4	476
A3 - FORK — "	36	914
B1 - WHEELBASE	40 5/8	1032
C1 - TURNING RADIUS	48	1219
D1 - UNDER-CLEARANCE	1	25
E1 - WIDTH-POWER UNIT	28	711
E2 - " OVER FORKS	22	559
E3 - " OF FORK	6 1/2	165
E4 - " BET. "	9	229
F1 - OVERALL HEIGHT	53	1346
G1 REAR OVERHANG	6 1/2	165
G2 FRONT "	7 5/8	194
H1 HEIGHT OF FORKS	3 3/8	86
" " LIFT	4 1/2	114

CAPACITY

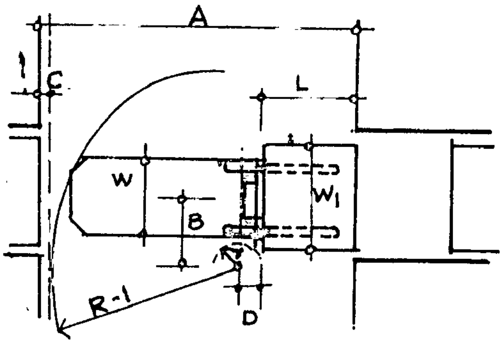
1500 KG EVENLY DISTRIBUTED

SPEED

3 MPH AVERAGE



PEDESTRIAN ELECTRIC PALLET TRUCK.



A MIN. AISLE WIDTH FOR RIGHT ANGLE STACKING

B HALF TRUCK OVERALL WIDTH W PLUS INSIDE TURNING RADIUS r.

C OPERATING CLEARANCE 2"-3".

D DISTANCE FROM FACE OF LOAD TO CENTRE OF DRIVE AXLE.

R1 OUTSIDE TURNING RADIUS

L LENGTH OF LOAD

W1 WIDTH " ".

WHEN W1 IS NOT MORE THAN 2B,

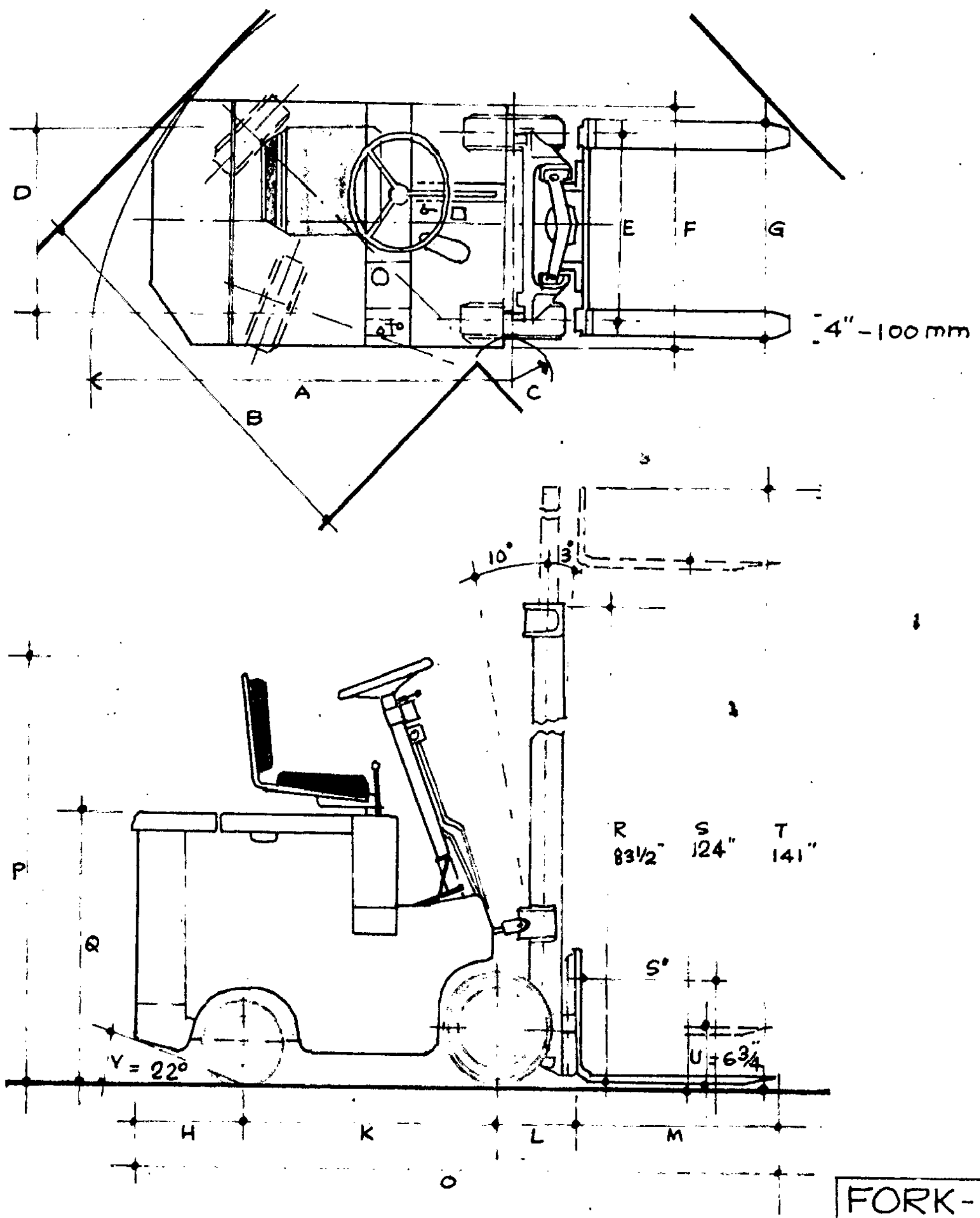
$$A = R1 + D + L + C .$$

MIN. RIGHT ANGLE STACK AISLE FOR FORK TRUCKS (REAR STEERING WHEELS)

SOURCE : WOODLEY. P.R; DETERMINING OPERATING SPACE FOR INDUSTRIAL TRUCKS; ENCYCLOPAEDIA OF MATERIALS HANDLING, VOL 1; PP. 635-642.

FIG. 2·2-5

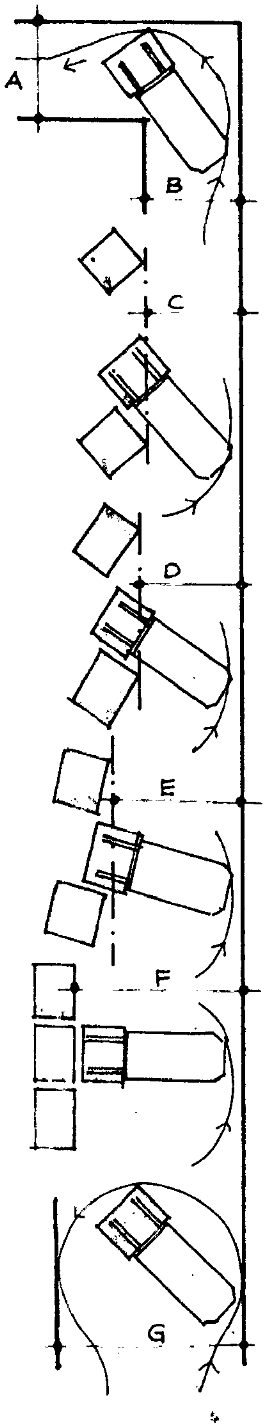
: INDUSTRIAL TRUCKS : DATA :



FORK-LIFT TRUCK

DIMENSIONS		INCHES	mm
A	OUTSIDE TURNING RADIUS	62	1575
B	MIN. INTERSECTING AISLE	57 1/8	1450
C	INSIDE TURNING RADIUS	6 1/4	160
D	REAR TREAD	25 3/16	650
E	FRONT "	26 1/4	665
F	OVERALL WIDTH	34 7/8	885
G	MAX. LATERAL SPREAD	30	760
H	C/L OF STEER WHEELS TO REAR OF TRUCK	15 3/4	400
K	WHEEL BASE	37	940
L	C/L OF DRIVE WHEELS TO FACE OF FORKS	12 1/2	310
M	STANDARD FORK LENGTH	30	760
N	OVERALL LENGTH LESS FORKS	65 1/4	1650
O	" " - -	95 1/4	2410
P	O.A. HEIGHT HAND STEERING WHEEL	62 1/4	1580

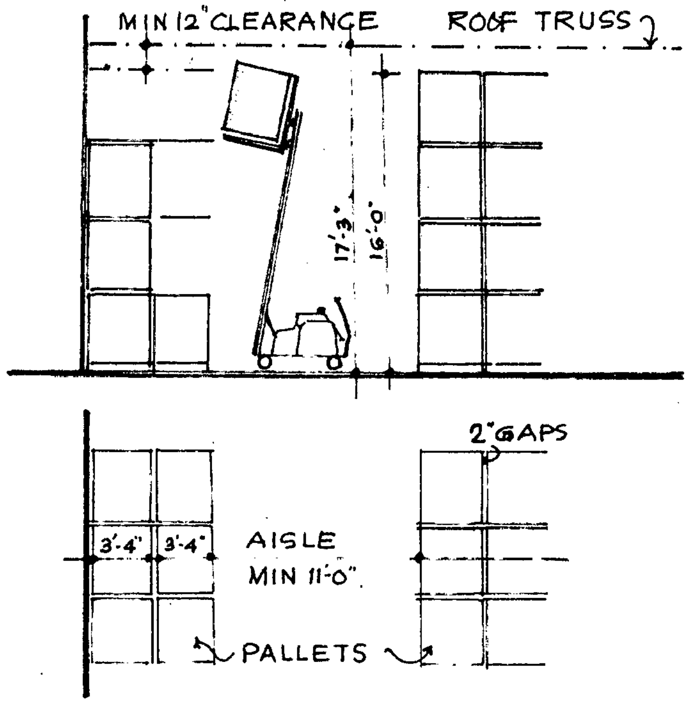
FIG. 2.2-6



PASSAGE WIDTH	SIZE OF PALLET IN INCHES 48"x 40"	40"x 32"
A	78"	69
B	81	81
C	88	84
D	108	102
E	125	117
F	145	135
G	162	154

DATA ON OPERATING SPACE IN SIX POSITIONS .

SOURCE : WOODLEY. P.R. op-cit, PP. 635-642.



SOURCE :
WOODLEY. P.R, op-cit, PP. 635-642.

: INDUSTRIAL TRUCKS - DATA :

FIG. 2·2-7

Packing and Despatch

The packing is resolved into (i) Export packing, (ii) Local supply, (iii) Distant cities.

Export packing for sanitaryware is done by placing the ware in a polythene bag held in a wooden crate with sponge cushions at intervals on all faces including the bottom. For smaller ware, it is in cardboard cartons packed in wooden carton with hay or paper foil filling. Local supply is by wrapping of ware into dried rice hay and tied with ropes. For smaller items it is in cardboard cartons and hay packing and distant city supply is in wooden cases while sanitary ware is tied in gunny bags with rice hay packing. It is recommended that the enclosure for storing the packing materials should be of fire resisting materials in view of the combustible nature of the packing materials. For despatch , the loading platform should have a height of 43" with a overdriving bar at 1.5M from its face. A covered loading platform is suggested for undisturbed loading during all the seasons. The truck height with load comes to 11'-0" and hence, roof should be about 13'-0" (3.9M) above the ground level. (Fig. 2.1-1b)

2.2.6 Summary

The foregoing discussion brings out attention and which has effect on planning. While in western countries the methods are becoming increasingly sophisticated, Indian pottery industry should aim at striking a golden mean between total mechanization and total manual handling in view of the following:-

i) Any system of mechanised handling should be in relation to the stage of production i.e. for raw materials, mechanical handling by a power gantry is suggested while during formation stage only manually handled wheeled racks should be considered. During final stage of products (after firing) use of industrial trucks like pallet or stillage trucks or transloader truck is suggested. For warehouse use of fork trucks is suggested specially because it exploits fully the storage areas.

ii) Certain processes of hand or sponge finishing done most efficiently by the human-sensory system should not be replaced by mechanised ways of finishing.

iii) The entire factory should have 'SINGLE LEVEL PLANNING' to facilitate the easy movement of wheeled racks or industrial trucks.

iv) All storage racks and wheeled racks should have soft cushioning as suggested.

v) No storage racks should be fixed to floor so as to provide flexibility and new arrangements should a new handling method be employed in future.

vi) A minimum of 2M space should be left between storage racks for free movement of wheeled racks.

vii) Door openings in warehouse and kiln area to be atleast 3Mx3M for adoption of industrial truck handling. Doors should be sliding or roller type otherwise swing area of wider door openings waste a lot of space.

viii) Single handling should be resorted to where possible.

CHAPTER-III

ENVIRONMENT AND ORIENTATION

3.1 GENERAL

Basically a factory building is a shell to protect and run a process. But the process needs workers who are increasingly demanding better conditions. Good management practice now has its constituents as the provision of pleasant and efficient working conditions. Over the last few decades, changing social attitudes, hygienic requirements, mental satisfaction and psychological aspects have emphasised the fact that workers have got to be considered.

Good and efficient work demands good conditions in offices, factories and institutions. In factories, one of the essentials will be to provide a working environment which is optimal both for work and satisfaction rather than marginally acceptable. It is created by the space within the building, its envelope and the equipment, the process and the people concerned. The main constituents for the physical environment are as follows:-

(i) Dust free and hygienic atmosphere, (ii) Noise control, and reduction, (iii) Lighting (daylight and artificial), (iv) Colour, (v) Safety, (vi) Smoke and fire, (vii) Pollution, (viii) Ecological balance etc.

It is however not possible to include all the above factors in this thesis and the scope is restricted to include Noise Control, Dust Control, Lighting and Colour. Creation of a conducive environment, leading to efficiency, is actually a team work of many experts. The aim should be the achiefement of a well-lit, dust free and ventilated, colourful, acoustically well designed factory.

3.2 NOISE CONTROL

Noise is often defined as unwanted sound. The degree of 'unwantedness' is however a physiological and psychological question and may range from moderate annoyance to various degrees of permanent hearing loss and, will furthermore be rated to differently by different observers. It is generally recognised that the overall efficiency of human beings is considerably higher when they are less irritated or annoyed by the surroundings. Also a certain degree of quietness is a desirable quality in itself. Control of noise is therefore important from all points of view, as it affects the very efficiency of man.

High noise levels are prevalent in industrial buildings. The amount of noise depends on the type of machines installed and industrial operations carried on and also the way the power is applied and transmitted. The harmful effects of excessive noise have been well recognised and it has been shown that such noise produces physiological and psychological effects on industrial workers, for example, annoyance, fatigue and loss of hearing. 'Noise-control is very pertinent to POTTERY INDUSTRY because the NOISE-TOLERANCE is particularly reduced with lack of oxygen and with action of fumes or DUSTS interfering with oxygen-consumption and person is from 20 cps to 20,000 cps (Hertz)

SOUND: It is a vibration, generated by physical motion, that imparts a to and fro movement in the air. If the wave motion is within the audible frequency range, it will be perceived as sound when it impinges upon the eardrum and its associated hearing parts.

FREQUENCY: The oscillation of the air causes alternate compression and rarefactions of molecules and this rate of oscillations is called the 'frequency' of vibrations, which for sound waves is measured in cycles per second (cps) or Hertz(Hz).

WAVELENGTH: Sound travels through a certain distance during a cycle or vibration and this distance is called 'wavelength'

Frequency x wavelength = velocity

$(f) \times (\lambda) = C$

The velocity of sound in AIR = 1130 ft/sec. at N.T.P.

in WATER= 5000 ft/sec.

in SOLIDS = >10,000 ft/sec.

The wavelength has a wide range from 0.113 ft. to 70.63 ft.

POWER: Rate at which the sound energy is spent is called the acoustical power and measured in watts.

SOUND INTENSITY: It is the average amount of acoustic power flowing through a unit area in a specified direction at a given point in the sound field and is measured in watts/square cm or SQM.

PITCH: It is that aspect of auditory sensation in terms of which sounds may be arranged on a scale extending from 'low' to 'high' as a musical scale.

TIMBRE: Sonorous quality of any instrument, or of a voice.

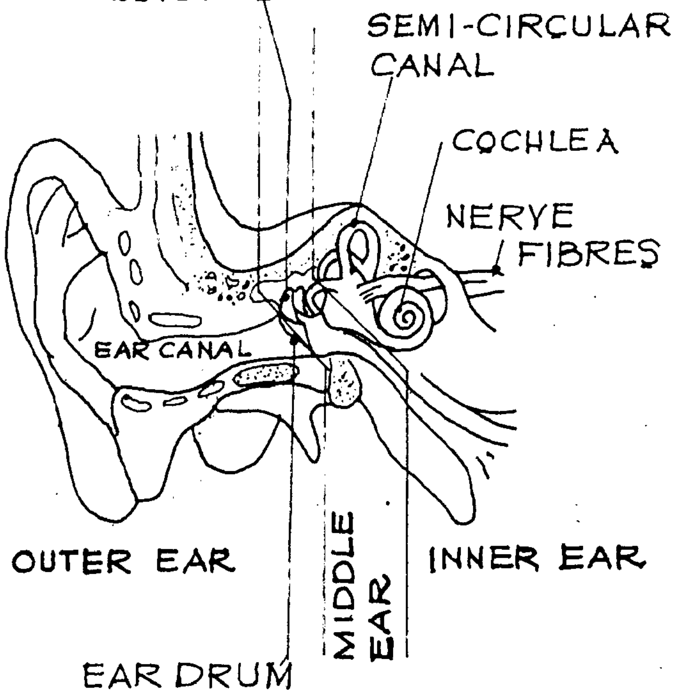
ANNOYANCE: The widespread dislike of certain sounds. The sound causing annoyance will vary from one person to another. An individual may be truely annoyed by a stimulus which is neutral to other people.

LOUDNESS AND LOUDNESS LEVEL: (Fig.3.2.1 and 2) and Table 6.

Loudness is the intensive characteristic of auditory response. It is measured in SONE and is defined as the loudness of pure tone of 1000 cps at 40 dB above the threshold of hearing of a normal auditor. Loudness level is measured in PHONS and at 1000 cps, the pressure level in dB and loudness levels in phons coincide. We judge sound as to its loudness which appears to increase with increase in sound pressure. A pure tone at 1000 cps and 50 dB may be much louder than a 200 cps/50 dB and even more at 10,000 cps/50 dB because our ears are more sensitive to frequencies between 1000 to 5000 cps. It requires an increase in sound level to make higher or lower frequencies seem as much loud as tone at 1000 cps/50 dB.

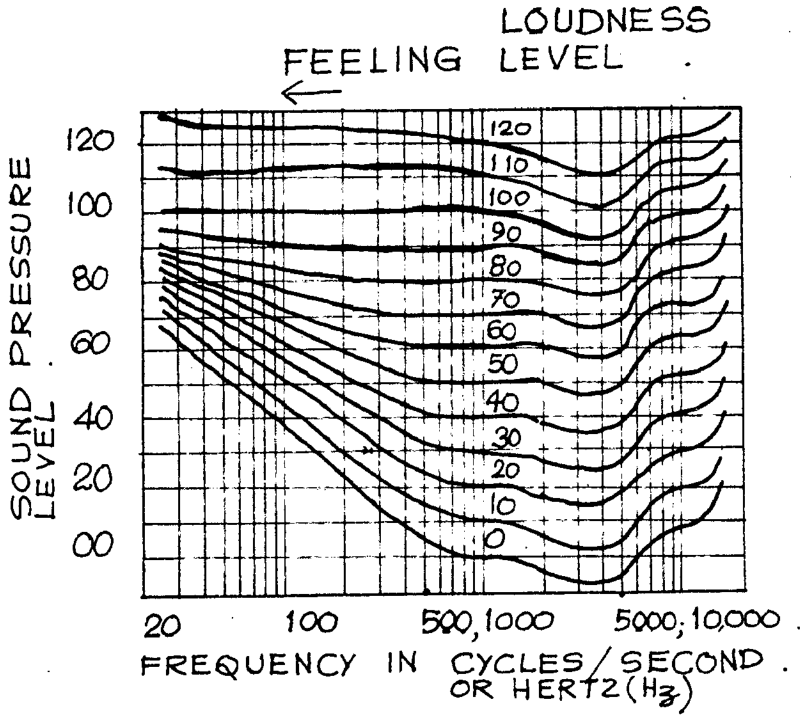
MEASUREMENT OF NOISE: It is usually measured and expressed in terms of sound pressure level (SPL). If P is the pressure of a sound wave, then its SPL is expressed in decibels as,

$$SPL = 20 \log_{10} \frac{P}{P_r} \text{ dB}$$



SECTION THROUGH HUMAN EAR.

SOURCE: BROACH. J.T, PSYCHOACOUSTICS & NOISE CRITERIA, ACOUSTIC NOISE MEASUREMENT, PAGE 22, 22-42.



EQUAL LOUDNESS CONTOURS.

SOURCE: KINZE & SHARP, FUNDAMENTALS OF ARCH. ACOUSTICS, ENVIRONMENTAL TECHNOLOGIES IN ARCH., PAGE 323, 318-350.

: HEARING & HUMAN RESPONSE.

FIG 3·2·1

where Pr (0.0002 dyne/sq.cm.) is the reference pressure and also the lowest sound pressure that an average human ear can perceive. The decibel is a convenient unit to state the SPL and the noise reduction achieved by acoustical treatment. The distribution of noise energy over the audio range i.e. its spectral distribution is of great importance in noise-reduction. Frequency grouping commonly used for octave bands may generally be 37.5-75,75-150, 150-300, 300-600, 600-1200, 1200-2400, 2400-4800, 4800-9600 cps (Hz). These band levels are essential for estimating damage risk, loudness level and speech interference level. An equivalent sound pressure level when added to an existing sound pressure level the resultant SPL is increased by 3 dB, example, 50 dB + 50 dB = 53 dB of sound pressure level.

Table No.6[2]

Relation between loudness, in sones and loudness level in phons.

L.L. phons.	L sones	LL phons	L sones
20	0.250	65	5.66
25	0.354	70	8.00
30	0.500	75	11.30
35	0.707	80	16.00
40	1.000	85	22.60
45	1.410	90	32.00
50	2.000	95	45.30
55	2.83	100	64.00
60	4.00	105	90.50
		110	128.00
		115	181.00
		120	256.00

2. ISO recommendation R-131, Expression of the physical and subjective magnitudes of sound or noise, Ist edition 1959, pp.7

3.2.2 SOURCES OF INDUSTRIAL NOISE

These can be classified into following groups:

1. IMPACT: Noise caused by the impact is the most intense and widespread of all industrial noises. It is normally coupled with resonant response of the structural members connected to the impacting surface. In pottery industry such noise is very rare.

2. FRICTION: Most of the noise due to friction is produced in such processes as sawing, grinding and sanding. Friction also occurs at the cutting edge on lathes and badly lubricated bearings. It is very unpleasant in character.

3. RECIPROCATION: Where a machine vibrates or reciprocates, the moving surface will radiate noise directly.

4. AIR TURBULENCE: Noise may be generated by rapid variation in air pressure caused by turbulence from high velocity air, steam or gases. (for example exhaust noise)

5. OTHER NOISES: In addition, there are other noises as well such as whining noise from turbines, humming noise from transformers, noise of driving belts as they pass over joints at the drums of driving shaft, noise of pressure pumps in action etc.

3.2.3 Subjective and Harmful Effects of Noise

Excessive noise is harmful to the factory workers in following ways.

i) Annoyance resulting in lack of concentration due to distraction, (ii) Inducement of fatigue may lead to accidents and to decreased output. This is especially so where the job demands mental concentration and vigilance. (iii) Interference with speech communication level (SIL) results making difficult the intelligible communication even at a distance of 1 M from the source (Generally above 55 dB). In areas where the SIL is above 70 dB, even the raised voice communication becomes very difficult and troublesome, (iv) Industrial deafness, at first only temporary (Temporary threshold shift TTS) but gradually becoming permanent (Permanent Threshold Shift PTS). It is found that where an octave band level of continuous noise between frequencies 150-9600 c/s exceeds 85 dB the risk of damage to hearing exists. The time of exposure to such noise is very important. , (v) Noise of operation if rythematic is less distracting, (vi) Noise levels above 75 dB result in contraction of blood veins leading to heart trouble[2], (vii) Psychosomatic diseases originating from noise-action may include outbursts of rheumatism, gynaecological complications and mild neurosis. (viii) High noise levels tend to excite the nerve system and upset the normal temperament, create weakness of muscles and may lead to lever diseases and ulcers.

Range of Noise Levels in some industries[3]

Industry		SPL in dB (mean levels)
Machine tools	-	85
Leather Industry	-	88
Heavy electricals	-	90
Rail coach	-	90

2. Mukul, 'Shor, Shor', Mukta, pp.25-26, April 1975

3. CBRI, Building Digest 35, Industrial Noise, Part II

Sugar	95 dB	
Printing and publishing	87	
Small fabrication	93	
Textiles	95	
Automobile	92	
Heavy Engg.	95	
Primary metals	97	
Air craft	93	
Pottery works	89	(Refer the experiment performed by the author)

PROCESSES

Manual Hammering -small	90-98 dB
-big	115-120
Drop forge	98-115
Riveting	95-115
Cocking	112-122
Chipping	108-116
Shearing	103 to 108
Small Punch and forming	95 to 100
Pneumatic jotter	105-110
Shot blasting	100-105
Wood plaining	105-110
Aircraft Engine test-Propeller	110-128
-jet	115-135
Jaw crusher	90-95

Table No.7

Comparative Recommendations of BSI, ISI and ISO for max. SPL and Exposure (considered safe)

	SPL (dB)	Octave Band (CPS)	Exposure in hrs.
British Standard, C.P.3, 1960 Chapter III, Sound Insulation and Noise Reduction	85	600 to 1200	8 hrs/day 5 days/week
Indian Standard Institution IS:3483-1965 (Ref.Fig.3.2-3)	85	600 to 1200	8 hrs/day 6 days/week
International Organisation for Standardisation	85 to 87	600 to 1200	5 hrs/day 5 days/week
Indian Factories Act of 1948	No mention about the protection from noise		

OBSERVATIONS

i) For the similar SPL and frequencies an Indian worker is exposed for 23 hours longer/week compared to ISO Standards or On cumulative basis he is exposed for 1196 hours longer/year.

ii) For the similar SPL and frequencies an Indian worker is exposed for 8 hours longer/week compared to BS Standards or On cumulative basis he is exposed for 416 hours longer/yr.

iii) The SPL of 85 dB for frequencies between 600 to 1200cps itself is very high for longer exposure and requires a serious reconsideration.

iv) Octave Band (600-1200) is chosen because of Pottery works.

3.2.4
METHODS OF NOISE REDUCTION

The level of ambient noise in a factory area can be reduced by following methods, based on the ~~it~~ source, path and the receiver, i) Location and layout, ii) Noise reduction at source, and (iii) Acoustical Treatment.

i) Location and Layout: In pottery industry the following processes are responsible for the high levels of noise.

(a) Jaw crusher for crushing of felspar and quarts,

(b) Grinding in ball mills and shaft driving,

(c) Dry grinding in pan mills, edge runner mills,

(d) Filter pressing,

(e) Blunging and agitating of clay slip,

(f) Pug milling of clay,

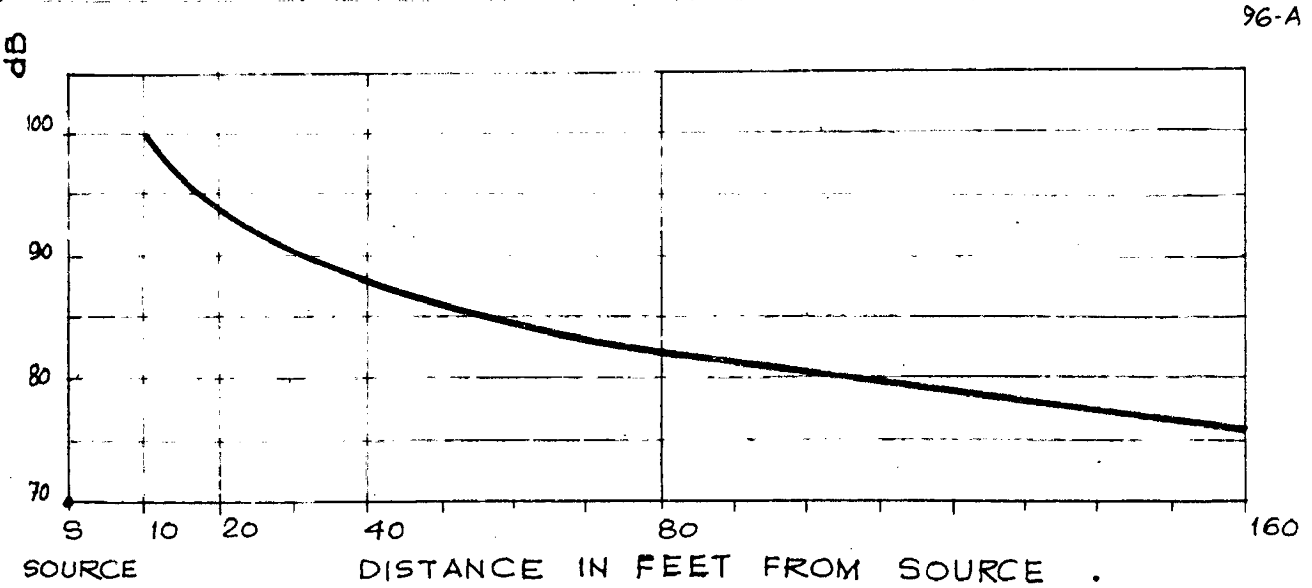
(g) Pressure pumps, (h) Vibrating sieve.

All the above processes can be located in the 'SLIP HOUSE'which in turn may be enclosed and separated by walls from the main shop. This will generally segregate the noisy processes from the quieter ones and the sonic pollution of the entire factory could be prevented.

(ii) Noise Reduction at Source:

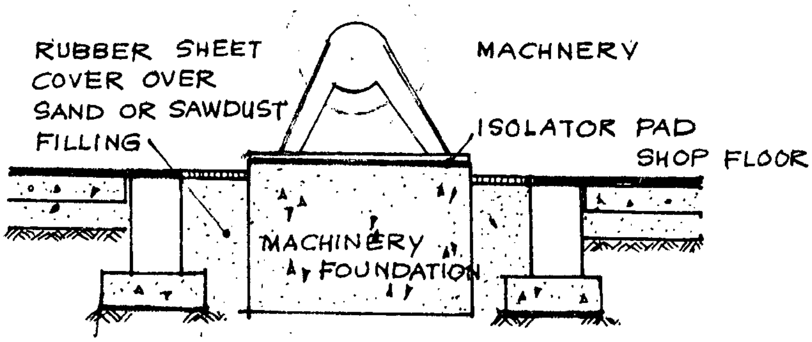
(a) Selection of Machinery: This is beyond control of an architect, however, choice would largely depend on manufacturer's advice and that of ceramic engineer.

(b) Reducing noises from potential sources: It is generally observed that the machinery in the slip house is run on 'shaft driving' with power transmitted to the individual machinery by driving belts over drums and pulleys. This constitutes a great deal of additional noise when the belt joints pass over the drums. Similarly trolleys used for carting of raw materials and the metal containers for

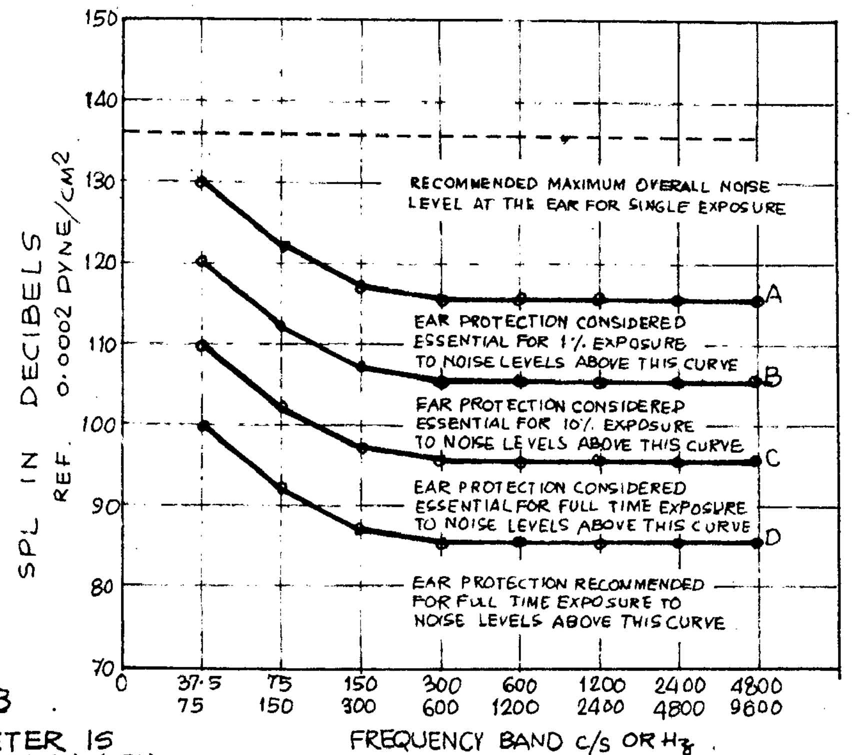


REDUCTION OF SOUND PRESSURE LEVEL DUE TO DISTANCE ONLY .

PREVENTING SPREAD OF VIBRATIONS .



BROADBAND NOISE LEVEL EXPOSURES FOR WHICH PROTECTIVE MEASURES ARE RECOMMENDED, BY IS:3483-1965 .



CURVES A, B .
TIME PARAMETER IS PERCENTAGE OF EACH WORKING DAY .

SOURCE : IS : 3483-1965, CODE OF PRACTICE FOR NOISE REDUCTION IN INDUSTRIAL BLDGS; PAGE 10.

FIG 3.2-3

carrying clay slip should be substituted with rubber tyred trolleys and plastic containers respectively. Lubrication reduces, considerably, the frictional noise.

(c) The machinery, specially the vibrating type, (i.e. pumps, compressors, sieves) should be laid on 'isolators' which may be of resilient materials like steel in the form of springs, rubber, cork and felt. However the exact material related to vibrations can be decided by a mechanical engineer. However, the 'machinery foundation' should be separated from the main floor as shown in fig. 3.2-3, wherever possible. This helps in preventing the transmission of vibrations to the main floor and structure.

(d) Acoustical Treatment : This can be achieved by

i) Enclosures, or barriers,

ii) Acoustical treatment of walls and ceilings,

iii) Suspended sound absorbers,

iv) Appropriate openings near the machinery,

v) Ear defending equipment.

Air borne noise generated by the machine may be reduced by placing the machine in an enclosure or behind a barrier. This however, may be relevant only for the agitators if placed in the making departments owing to its largeness, (rendering the transmission of clayslip from slip house through slip lines prohibitive as the heavy clay particles tend to settle down before casting x if unagitated) and can be effectively used to help towards the otherwise quiet environment of 'making department'.

This practice has limitations on use in the 'slip house' as enclosing of individual machinery demands individual attendant/machinery and hence not very practical.

Acoustical treatment of sidewalls or ceiling can be seen in following perspective.

(i) Whether it is possible to combine the sound absorption and heat insulation properties of material.

(ii) If used on walls, what is the degree of 'cleansability' of these materials in view of the large dust suspension in sliphouse atmosphere.

(iii) Whether the ceiling provided at 6M above the floor (as required by Factories Act) can really help absorption of sound and contribute to the reduction of SPL.

(iv) Suspended sound absorbers can be used being hung near the source of sound for its immediate absorption.

(v) The loading platform over the ball mills which is either of r.c.c. or steel sheets, can have absorptive surface along its entire soffit thus providing a good absorption in close proximity to the source.

It is observed that 'Sliphouse' generally has high level windows, resulting into

(i) Reverberation of sound from walls in plane with the machinery i.e. the source.

(ii) Absence of 'visual rest centres' for workers in the form of low level openings, simultaneously providing a centpercent sound absorption by way of loss through openings.

It is therefore suggested that windows for sliphouse should be provided at the same level as the machinery to help in alleviating the above mentioned facts, let alone the desirable wind movement harnessed by such openings.

It may be mentioned that, except in winter when windows are kept closed, it will provide an effective loss of noise in addition to lighting and ventilation. The effect of noise is to be seen as a cumulative effect of time and exposure. Such openings thereforė may contribute a great deal towards the the cumulative effect. The outgoing noise can possibly be blocked by suitable hedges. Use of ear plugs (flexible rubber type or moist cotton) would be the best ear protection for workers, however, these plugs should not provide a cent percent deafening but about 80 to 90 percent so that any warming or unusual noise from machine could be effectively noticed by a worker before the machinery is damaged.

Shaft driving andbelts may be substituted with'directly coupled' individual motors greatly helping the reduction of noise.

3.2.5 Summary: To summarise the following recommendations are made:

(i) IS: 3483-1965, recommendation for the ear protection and SPL and time of exposure should be given a serious reconsideration and experimentation. The 85 dB level in 600-1200 cps is itself a high level and should be brought down for recommendations.

(ii) Indian Factory Act, makes no mention at all about the ear protection against high noise levels in industries, and should therefore incorporate such a clause.

(iii) Use of suspended type sound absorbers and ear plugs with 80 to 90 percent deafening property.

(iv) Soffit-absorption treatment of loading platform over ball mills.

(v) Work shifts after four hours work in slip house could be changed in warehouse section and vice-versa to reduce the time of exposure to high noise level.

(vi) Provision of low level windows

(vii) Use of isolators, frequent lubrication of machinery parts, use of rubber tyred trolleys and plastic containers.

3.2.6 Experiment: Measurement of SPL in 3 slip houses at pottery development centre at Khurja on 14.2.1973 (Fig.3.2-4).

(A) PRACTICAL SETUP: Instruments used: i) A tape recorder (cassett type), (ii) A standard flat frequency noise generator, with a flat response loud speaker, (iii) Pickup having a reasonably flat response with respect to frequency and a good directivity, and (iv) A sound level meter.

(B) LABORATORY SETUP AND TAPE RECORDER CALIBRATION (Courtesy- Acoustic Lab- CBRI) (Fig.3.2-4).

Stage i) A noise generator was started and its SPL noted on sound level meter placed 0.90 from the generator's loud speaker.

Stage (ii) The sound level meter was replaced with casett type tape recorder with its pickup in same position as that of sound level meter, and the generator noise was tape recorded.

Stage iii) The tape recorded generator noise was replayed and its SPL recorded by sound level meter by keeping the identical distance of 0.90 M between them.

A number of readings were taken and tabulated and the calibration curves upto a great degree of linearity were drawn, varying with different parameters e.g. the input noise level and output-attenuation of the audio-amplifier stage of

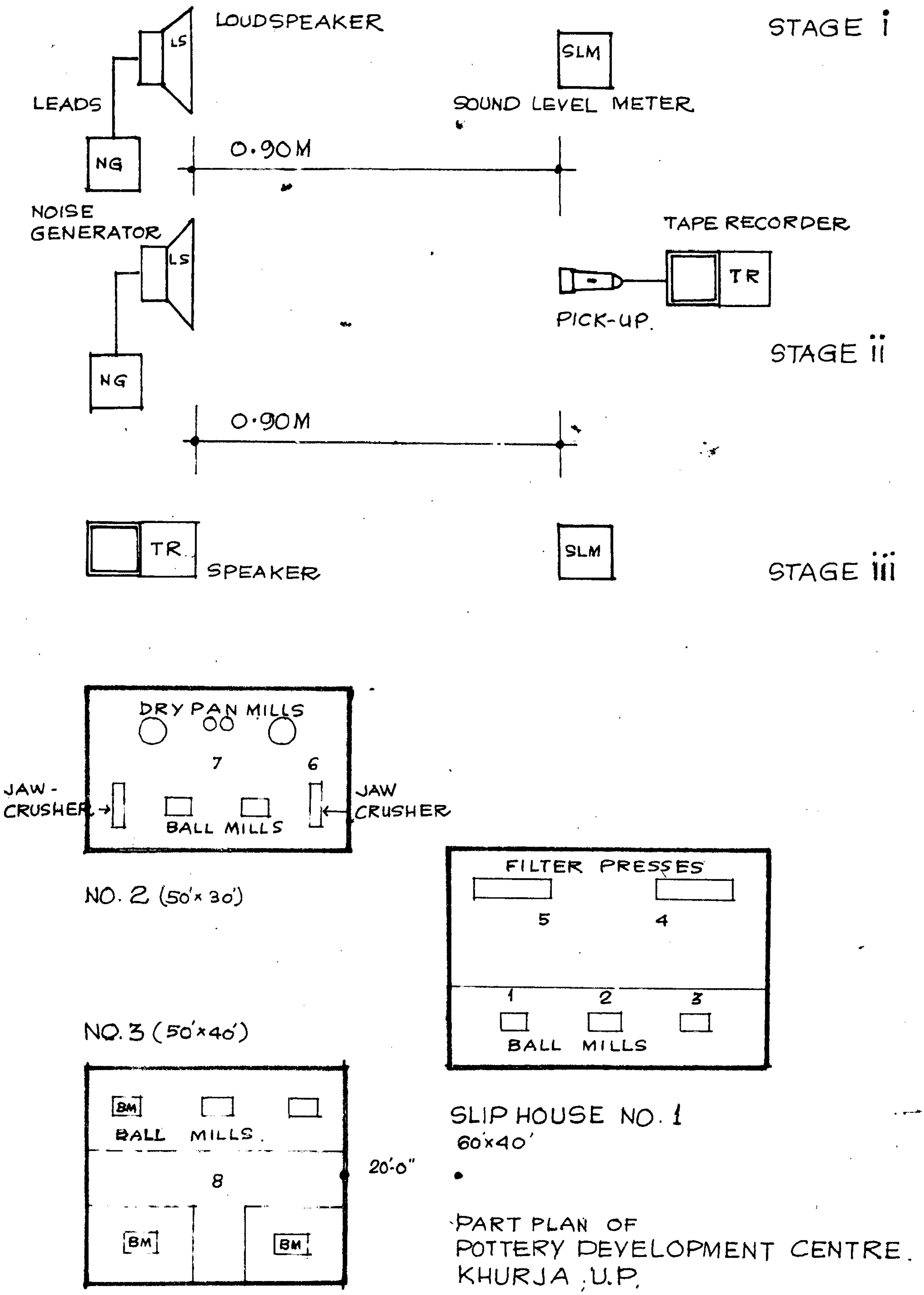


FIG. 3·2-4 : MEASUREMENT - SPL IN SLIP-HOUSE :

the tape recorder.

Table 8

Input and Output Calibration

SPL (dB)	While recording		While replaying	
	Input attenuation (tone)	Output amplification	Input att.	Output amplification
62	4	4	4	4.5
73	4	4	4	4.7
84	4	4	4	7.5
88	4	4	4	8.5

Once the calibration was done, the noise at locations 1 to 8 were tape recorded in 3 slip houses at Pottery Development Centre at Khurja and the SPL was read after (U.P.GOVT) replaying the taperecorder back in the Acoustics Laboratory at CBRI, Roorkee.

Table 9

Recorded Noise Levels: Frequency: 700 to 800 cps(Hz)
(Fig.3.2-4)

Location point	Location	Description and no.of machines running	Distance of T.R. from source.	SPL as read out in CBRI lab
1	Sliphouse No.1	1 Ball mill	2M	88 dB
2.	-do-	3 Ball mills	2M	89 dB
3.	-do-	3 Ball mills	2M	89 dB
4.	-do-	3 ball mills+ 2 filter presses	1M	90 dB
5.	-do-	-do-	1.5M	90 dB
6.	Sliphouse No.2	2 jaw crushers	1 M	89 dB
7.	-do-	2 jaw crushers + 2 pan mills	1.5 M	90 dB
8.	Sliphouse 3	5 Ball mills	2 M	89 dB

Results obtained: SPL of 88 to 90 dB in frequency 700 to 800 cps

SPL was found higher than the recommended level of 85 dB in 600-1200 cps(Hz)by IS: 3483-1965.

LIMITATIONS OF EXPERIMENT

The experiment has some limitations

i) Non-availability of sound level meter for its direct use in slip house.

ii) Noise generation is no more concentrated as in case of laboratory but a distributed one and the measurements would show GENERAL NOISE LEVELS in the sliphouse with reasonable accuracy.

However this experiment has established the SPL in slip-house of a Pottery works (a work not done so far) and gives a fair idea of the ear protection desired.

Efforts must be made to reduce this SPL in light of the above summary. A system of periodical medical checkup for the loss of hearing with due consideration for PRESBY-CUSIS (natural loss of hearing due to age) should be set up.

3.3 DUST CONTROL

General: Dust is formed by reducing the materials of earth origin to small size. Processes like grinding, crushing, blasting and drilling produce dust particles of sizes from submicroscopic to the visible, their composition being the same as that of the parent material.When a solid or liquid is broken up into finely divided particles and is dispersed in the air, two important changes take place.

i) the surface area is greatly increased, and

and ii) the space occupied by the dispersed material is expanded many times over the volume of original mass.

The effect of these changes is to intensify the chemical and physical activity of the material, which is intimately associated with the physiological effect. Small particles generally are of physiological importance than large ones. There are a number of processes and industries which give rise to dust in some form or the other and these are as listed below:

Metal mining,	Nonmetallic mining
coal mining (underground)	coal mining (open pit)
smelting, non-ferrous plants	smelting, ~~no~~ ferrous plants.
cement plants,	Asbestos products,
abrasive industry	Clay products,
cutlary,	Glass manufacture,
Granite, slate, marble and other stone products,	
Iron and steel, foundries,	
mineral fertilisers	Minerals and earths,
refreactory industries,	Textile (fluf)
Wood (saw dust)	

3.3.1
Effects of Dust Inhalation

A dust free and hygienic environment within the factory is most desirable. Prolonged exposure to dust leads to diseases like silicosis, pneumoconiosis, fibrosis,bronchitis, tuberculosis. These occur as a result of long-continued inhalation of dust and it depends upon the interaction between the man and the dust-cloud to which he is exposed.For Pottery Industry dust control is absolutely necessary because it involves achievement of skills over a period of time and the worker is to handle earth, clay and dust. Result is genemally speaking, once a worker takes up as a potter, he remains in the same trade for his life apart from the family tradition in Indian context. Constant contact with clay may also lead to skin-diseases.

The diseases occur as a result of deposition and accumulation of fine dust in the lung. Coarse dust is held away from the lung-interior by an impingement mechanism which deposits the particles on the ciliated epithelium of the upper respiratory tract, from where the dust gets carried away out from the lung. A fraction of fine dust reaching the lung-interior is again exhaled, the remainder is deposited. The mechanism of deposition is mainly the gravity settlement for the size range from 0.5 to about 5 microns. Approximately between 20 to 50 percent of the inhaled dust is not found in the exhaled air and must therefore have been deposited in the lung (Fig.3.3-1). A concentration of 5 mpp cft. and above is considered hazardous.

A factory as an enclosed space creates more problems of dust as compared to the open environment in which the village-potter does his work. However, in industrial context, the controlled environment in an envelope is of greater importance than the uncontrolled open environment.

The silicon dioxide as quartz (free silica) produces the most serious form of lung-fibrosis and the damage done is permanent; an unalterable tissue change takes place in the lungs. Of prime importance is the fact that prolonged exposure to these dusts results in increased susceptibility of tuberculosis, more so from quartz than from asbestos.

5.3.2 Objectives of Dust Control

These objectives are to establish the following:

i) Sources of Dust a) Materials, b) Processes.

ii) (a) Dust concentrations in various processes and permissible limits, (b) Time of exposure to dust.

iii) Precautionsand safety measures

(a) Local exhaust in specially ventilated hoods,

(b) General downward ventilation,

(c) Industrial dust cleaners

(d) Dust masks and protective clothing,

(e) Enclosing of processes.

(f) Use of detergents,

(g) Medical check-up.

(i) (a) Materials: Free silica contents of various raw materials are as given in the table No.10 ; Table No.11 gives the free silica contents of different bodies in the manufacture of pottery.

Table No.10[1]

Free Silica Contents of Raw Materials used in pottery works

Raw Material	Percentage
Quartz	97
Feldspar	8
China clay	Traces i.e. below 0.5%
Gypsum	below 0.1%
Ball clays	35
Talc	6
Fire clay	30

1. Office of the Chief Advisor of Factories (OCAF) Silicosis in the Pottery and Ceramic Industry, pp.10-11

Table No.11[2]

Free silica contents of different bodies in the manufacture of pottery

Bodies and Glases	Percentage
Crockery	31
Tiles	28
Pipes	36
Sanitary ware	17
Electric Insulators	34
Refractories	26
Saggars	29
Grog	26
Frit	20
Porcelain glaze	24
Earthenware glaze	7

Tables 10 and 11 indicate percentage of free silica of the various raw materials used and also that of bodies and glazes.

(i) (b) Various Processes

The main sections of the industry produce a very large variety of articles and a wide range of products, matched by an equally large variety of risks from dust. Generally 50 percent of the workers' population is involved in operations giving rise to dust with the exception of glazing and firing, sorting and warehousing sections. This large number of workers is exposed to composite dust, of which china and ball clays, flint , felspar and quartz and silica are the main ingredients. The processes giving rise to dusts are listed as follows:-

i) Loading of ball mills Dry

2. OCAF, Op-cit pp.10-11

ii)	Calcining of felspar and quartz	Dry
iii)	Crushing of felspar and quartz.	Dry
iv)	Handling of filter press cakes	Wet/semi dry
v)	Handling of clay lumps from pug mil	wet.
vi)	Slip casting	wet
vii)	Pressing and jiggering	wet
viii)	fettling , finishing and turning	dry
ix)	cleaning and scraping of floor	dry/wet
x)	spray glazing, saggering and sagger loading	dry and in suspension
xi)	Residue and ash from the coal firing in the intermittent type of kilns	dry

This indicates that a majority of processes and the material being handled itself are the sources of dust. It may be mentioned here that 36 percent of the cases of pneumoconiosis originated from Pottery industry in Great Britain during (1951-1960)[3]

(ii a) Dust Concentrations

The average dust concentration at any location was necessarily taken in the breathing zone of any individual spending his daily eight hour work period in the location. It has been expressed in million parts per cubic ft. of air (mpp cft.). This study has been done by the office of the Chief Adviser of Factories for getting factual data in Indian conditions covering about 12 factories in this country. This tabulated information gives a comprehensive study about dust concentration in various operations of pottery works. It may be noted that the maximum permissible limit is 5 mpp. cft.

3. Astbury, N.F., 'Pneumoconiosis in the Pottery Industry', Mineral Dust in Industry, pp. 1 to 16, 1961.

Table 12[4]

Dust concentration in mpp.cft.

Department	Factory A	Factory D
crushing section		
Bringing raw materials	8	17
Jaw crushing quartz, felspar	-	146
Hand breaking quartz, felspar	129	-
Edge runner mill	11- quartz 187- felspar	327
Breaking clay	429	405
Washing clay	65	60
General atmosphere	70	64
slip house		
charging blunger	-	260
at the blunger,	25	14
charging ball mill	210	59
at the blunger/ball mill	25	14
~~at~~ Vibrating sieve	45	20
Filter press	25	8
pug mill	20	9
Making or Manufacturing Deptt.		
Making on jolley jigger	6	8
Fettling and finishing	18	22
Hand finishing	70	51
slip casting	4	4
Fixing spouts/handles	4	8
Sponging	-	20
Firing Section		
Loading of saggars	7	12
Loading of kilns	5	10
Unloading of kilns	4	4

[4] OCAF- op.cit., pp.12-18, Concentrations in only 2 factories have been enumerated.

Table 12 continued

	Factory A	Factory D
Moulding		
Grinding gypsum	27	25
Calcining gypsum (50 mpp.cft. is permissible limit for gypsum)	48	63
Sieving plaster of paris	50	60
Mould making	6	10
Glazing		
Spray glazing	261	125
glazing and dusting	72	33
Saggar Section		
Fireclay disintegrator	1675	1305
Grog disintegrator	80	107
Hand sieving	154	225
Saggar press	35	26
Hand making of saggar	5	4
Mixing of materials	40	53

(ii b) Time of exposure to dust

It can be seen that the permissible limit of dust concentration is exceeded by almost all processes. Further the dust in this industry is extremely hazardous owing to the high silica contents of the materials handled. This study by office of the Chief Adviser Factories clearly brings out the high incidence of silicosis. 15.7 percent workers had x-ray evidence of silicosis. Of these about 60 percent had tuberculosis as well.

Table No.13[5]

Silicosis in relation to exposure dust

Mean exposure levels mpp.cft.	Percent cases of silicosis
1-5	4
6-20	10.7
21-50	18.0
51-100	44.1
101-200	47.0
201-300	62.5
301-400	90.0

Silicosis in relation to duration of exposure

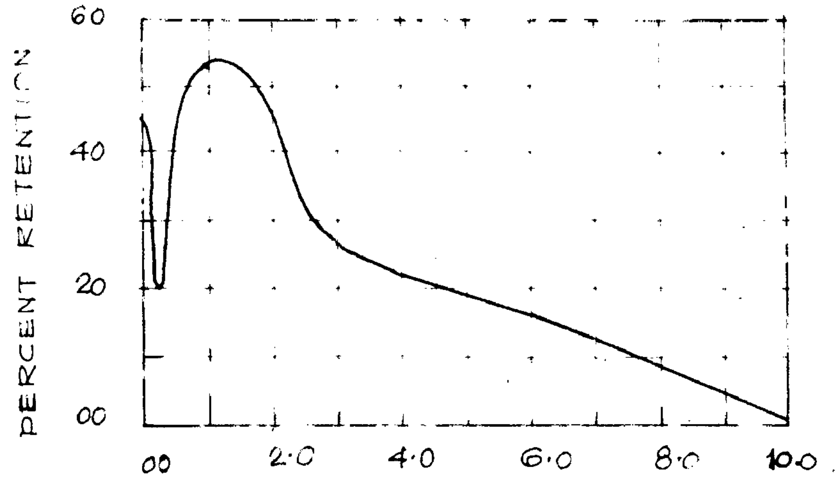
Service in years	Percent cases of silicosis
upto 5 years	3.0
6-10	9.2
11-15	16.5
16-20	26.4
21-25	51.3
31-35	50.0
36-40	85.7

(iii) Precautions and Safety Measures

General exhaust ventilation can be particularly useful for dusty rooms or areas such as the sliphouse, calcining section, but this should be based on a downward system, with fresh airflow from the top and the exhaust systems from lower levels. The obvious advantage in this system is in removal of the dust away from the breathing zones of the operatives.

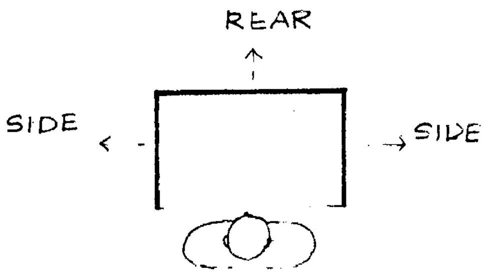
But in areas such as the downdraught intermittent kilns where the residue of the burnt coal is being removed or where

5. OCAF- Medical Studies, op.cit, pp.34-42

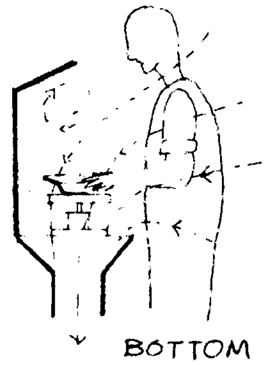


RETENTION OF INHALED DUST IN LUNG

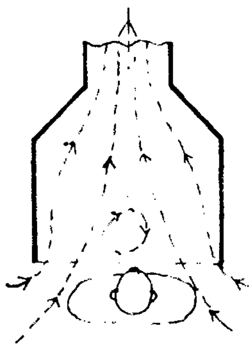
SOURCE : NAGELSCHMIDT J G , DUST PARAMETERS & THEIR BIOLOGICAL SIGNIFICANCE, MINERAL DUST IN INDUSTRY, PAGE 33, 33-42



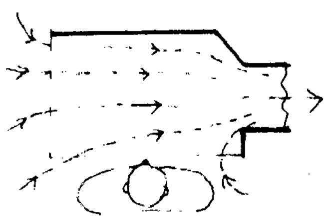
MAIN DIRECTIONS OF EXHAUST



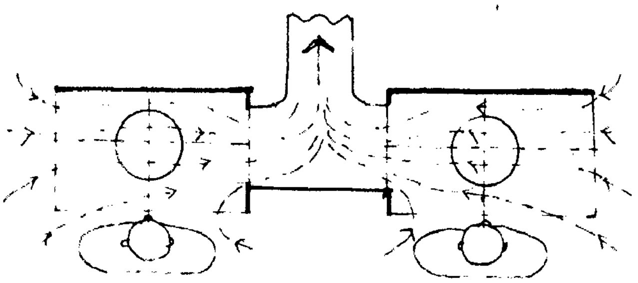
BOTTOM EXHAUST



REAR EXHAUST



SIDE EXHAUST



FETTLING HOODS WITH SIDE EXHAUST FOR SMALLER ARTICLES.

: DUST CONTROL :

FIG 3·3-1

the jaw crusher operates, use of dust masks by the operative is most desirable.

(a) Local exhaust in specially ventilated hoods

Problems of greater dust hasard are mainly with the finishing , fettling, dusting , turning, spray glasing which take place in close proximity of the workers' breathing zone and the fine particles produced drift upwards due to the convection currents. Even when a small amount of fine dust is produced , high concentrations of respirable size dust are breathed by operatives. Efficient dust control can usually be maintained by the application of following principles:

(i) Max. degree of enclosure , to minimize the size of the aperture through which the dust can escape and thus keep the exhaust volume to a minimum.

(ii) Provision of a physical barrier between the operatives' face and the dust source- in the form of a moving barrier of air which positively prevents the dust moving towards the operative's face.

(iii) Correct positioning of the exhaust outlet in relation to the operative's body. These principles can give considerable advantage when dust is produced by hand operation in enclosure or hood. With hoods having a frontal opening, there are four main positions for the exhaust outlet.

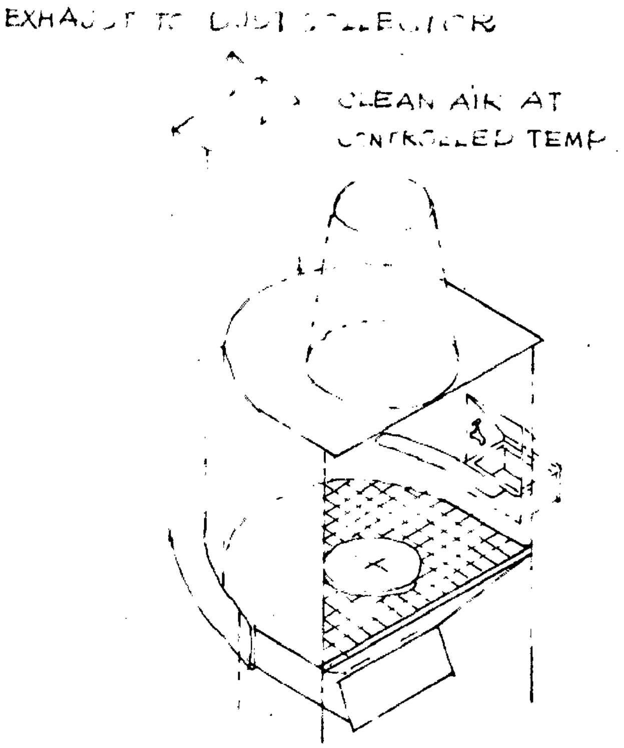
i) Down, though the grided base, ii) at the rear, iii) On sides- left or right. (Fig.3.3-1)

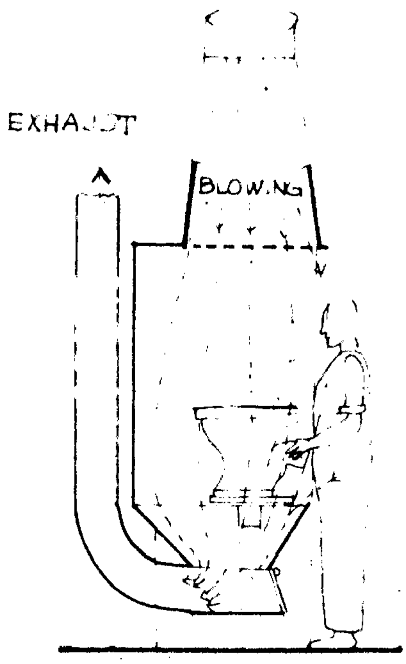
With exhaust downwards, the dust is carried away from the breathing zone but the 'wheel' blocks part of the area.

With rear exhaust, the operative's body forms an obstruction to the inflow of air and a stagnant area is set up in front of his body. Dust produced in this region is not immediately removed.

With side exhaust , the operative's body, instead of forming an obstruction to the air moving into the hood, becomes, in effect, one of the side walls of a ventilated tunnel. Owing to this tunnel effect, there is little reduction in velocity in the hood irrespective of its distance from exhaust outlet greater or lesser and as such high velocities can be achieved in the region of dust source with moderate exhaust volumes; therefore the principle of 'tunnel-flow' should be used wherever possible.

A typical hood (for fettling, finishing operations) based on the above principles may have a 3 sided enclosure with side exhaust almost as large as the 'hood end'. This helps to obtain even airflow and avoids turbulence. Operative's body forms the front side of ventilated tunnel. Air movement carries away the dust from the source and away from breathing zone. However, these smaller hoods cannot help the fettling and finishing of large articles such as the sanitary ware, weighing upto about 50 lbs. For larger hoods the operative scarcely can form the front side of tunnel. Hence, for larger hoods a combined blow and exhaust system with a downward flow may be adopted. Air is blown vertically downwards from a large dia. orifice at the top of the hood and the exhaust is applied to the gridded base via a hopper bottom which forms a receptable for the clay scraps and large particles. A shelf for the fettling tools and a small sink come to be very handy. (Fig.3.3-2)

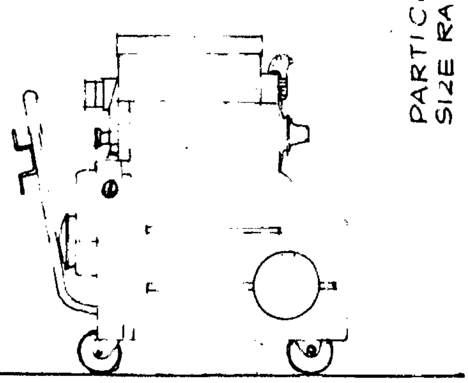


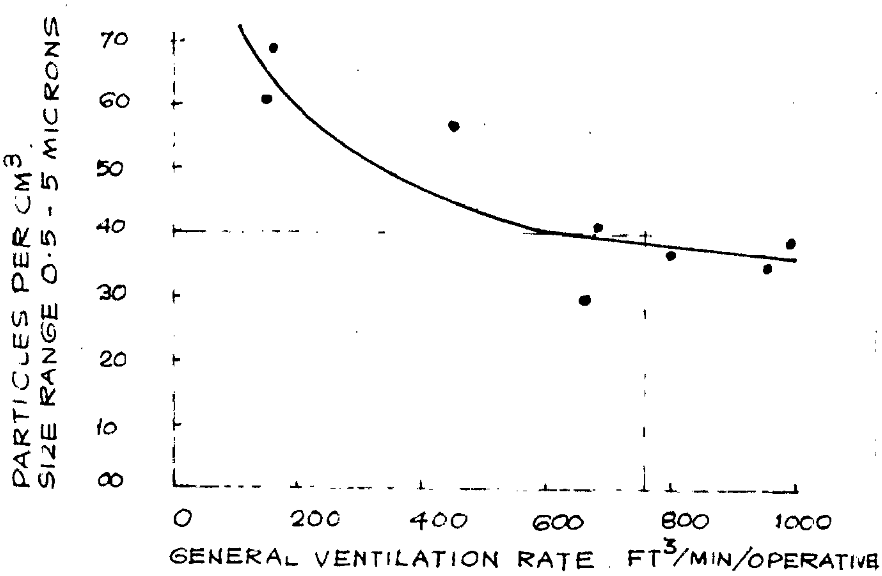


OPERATOR ALWAYS BATHED IN CLEAN AIR

FETTLING HOOD FOR SANITARY WARE.

A TYPICAL INDUSTRIAL DUST CLEANER.





LENGTH : 1190 mm
WIDTH : 525 "
HEIGHT : 1075 "
WEIGHT : 250 Kgs.

GRAPH : VENTILATION RATE & REDUCTION IN DUST PARTICLES/CM³.

SOURCE : PALMER. J M. DUST CONTROL IN POTTERY INDUSTRY, MINERAL DUST IN INDUSTRY; PAGE 126, 114-126.

: DUST CONTROL :

FIG 3·3·2

b) General Downward Ventilation

The general ventilation of the shops takes care of the minor and scattered sources not warranting a separate control. Since every worker is a 'dust-producer', the amount of clean air required depends upon the number of workers rather than the shop volume; i.e. cu.ft./minute /operative rather than air changes/hour. The graph shows the relation of air velocity/ operative and the particles/ cm^3. It can be inferred that ventilation should be based on an air quantity of 750 cft./minute/operative and the downward system (refer graph[6] and Fig.3.3-2).

c) Industrial Dust Cleaners

Problem of the spilled clay slip, dust, scrap can be solved by frequent cleaning so that the human and the wheeled traffic does not raise the undesirable dust in the atmosphere. Alternatively the industrial vacuum cleaners can be used. These are portable on wheels and can suck particles, scrapes upto 1" size. Dimensions of such a unit are length 1190 mm. width 525 mm height 1075 mm and weight- 230 kg. Suction is about 6000 kg/sqm. A good house keeping is thus ensured and reduces the possibilities of accidents due to slippary floors. (Fig.3.3-2).

d) Protective Clothing

Problem of 'secondary' dust is more alarming i.e. a dust collected by operative's clothing and subsequently given off into his breathing zone, this constitutes a serious dust hazard in ceramic industry. The analysis done in Great Britain

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Mineral dust in Industry- HMSO, London,
Palmer. J.M. Dust control in Pottery Industry, pp.112-126.

has showed that nearly 50 percent of the dust in the breathing zone is given off by operatives' clothing which is of cotton. Their findings are that the operative with cotton clothing is found to be breathing 145 particles/cu. cm., these are reduced to 65 particles/cm^3 with terylene. If, therefore, we switch over from cotton to terylene, we get a considerable reduction in the amount of dust. Such overalls should be free of dust-retaining devices such as pockets and should have buttons at the back.

In Indian context this change to terylene clothing needs to be examined in following perspective.

i) During summer terylene clothing is uncomfortable,

ii) During winter terylene clothing is rather cold.

iii) For industrialist terylene clothing is too costly to provide for workers.

iv) For industrialists terylene clothing is durable.

Dust Masks

Use of dust masks or atleast a massaline cloth tied around nose and mouth are particularly useful for operations like loading and unloading of saggers in downdrought intermittant kilns, jaw crushing of felspar and quartz and charging of ball mills.

d) Enclosing of processes

Dry grinding of materials is done in jaw crushers, pan mills and edge-runner mills. It is advisable to enclose these processes by grouping them together as they fall in an appropriate sequence. This precaution would prevent the excessive dust, arising out of dry-grinding, from spreading in the rest of the shop.

f) Use of detergents

Every worker at the end of his work shift should be compelled to take bath with a detergent soap. This would safeguard him or her against the possible skin diseases like 'dermatitis', 'hardening', 'skin-cracking' due to contact with the clay and the earth.

g) Medical check-up

It is urged upon the industrialists that as a step welfare and hygiene of the pottery workers, a regular medical check-up system should be set up in order to investigate and check just in time the growth of these diseases so that the operatives can be taken care of under the 'Employee insurance scheme' before it is too late.

3.3.3 Summary

In summarising the various recommendations are listed below and once again it is stressed that the 'dust control' is absolutely necessary in pottery industries in view of the resulting serious hasard.

1) General ventilation of the shops based on downward system, with the flow of fresh air so directed that the workers in their appropriate working places are bathed under a clean air at a controlled temp.

2) Local exhaust system should be adopted for operations like fettling, finishing, turning and spray glazing.

3) Use of dust-mask for those operatives engaged in loading,

unloading of intermittent kilns, calcining and crushing of felspar and quartz and charging of ball mills.

4) A system of regular 'medical check-up' be set up for early detection and curative steps for the diseases like silicosis, fibrosis and pneumoconiosis.

5) Use of 'industrial vacuum cleaners' for a quick and efficient removal of the spilled clay and scrap on the floor.

6) Separation or enclosure of processes involving dry grinding of materials.

THE SCHEDULE (Factories ACT 1948)

List of notifiable diseases:

1. Lead poisoning,
2. Lead tetra-ethyl poisoning,
3. Phosphorous poisoning,
4. Mercury poisoning,
5. Manganese poisoning,
6. Arsenic poisoning,
7. Poisoning by nitrous fumes,
8. Benzene poisoning,
9. Carbon bisulphide poisoning,
10. Chrome ulceration,
11. Anthrax.
12. Silicosis,
13. Poisoning by halogens,
14. Pathological manifestations, due to a) radium, b) x-rays,
15. Preliminary cancer of skin (epitheliomateous)
16. Toxic anaemia,
17. Toxic jaundice due to poisonous substances.

3.4 LIGHTING

For the purpose of illumination, light is defined as 'visually evaluated radiant energy'. Of all the great band of radiant energy, only a minute portion, roughly between 4000 to 7600 Angstroms (400 to 760 millimicrons) is capable of producing the sensation of light in human eye and this is called the visible spectrum. This portion of radiant energy is known as luminous flux. Energy outside of this band is not capable of producing the sensation of light. Light is one of the raw materials of vision under the control of specialist. Appropriate quantity of light indoors is very much desirable for good vision.

3.4.1 Objectives of Lighting

A good lighting of workspaces can be achieved by

i) day lighting,

ii) artificial lighting, or

iii) combination of (i) and (ii)

There are five main aims in industrial lighting. i) to provide sufficient light of the right quality and colour to enable the various visual tasks to be carried out efficiently and effectively; ii) to create a general visual atmosphere suited to the building - in industry this will usually mean a cheerful and stimulating atmosphere; iii) to eliminate, as far as possible, sources of excessive visual distraction which may divert attention away from task, and to avoid glare (direct and reflected) which tend to interfere with the work; (iv) to provide sufficient quantity of light, in lux or daylight factor (DF) as recommended, (v) to provide suitable vistas that are visually restful, so that the eye may relax during

Table No.14 contd.

6. Warehouses and bulk stores.

a) Large material and loading bays	100	1.25
b) Packing, storage and warehousing	150	1.88

Note: 1 foot candle = 1 lumen/sq.ft. = 10.78 lux,

1 percent D.F. = illumination in lux/80 or(100 lux = value of 1.25 percent D.F.)

Pay special attention to the colour quality of light in decorating section.

D.F. in a room is a ratio of level of illumination at that point to the total amount of illumination available simultaneously out of doors from the complete and unobstructed sky)

Before proceeding further, it is extremely important to analyse the working of factory, shifts and the processes. On surveying about 8 factories it is observed that excepting sliphouse, firing section, inflow of raw materials and despatch of finished products, rest of the departments operate only during the day shift of 8.00 a.m. to 5.00 p.m.

For artificial lighting, it should be borne in mind that the 'dusty' atmosphere tends to reduce luminous flux from the source and that the glased area for day lighting should have proper access for frequent cleaning of the accumulated dust.

3.4.3 Daylighting

What we see, we appreciate and what we appreciate, we execute well. It has been accepted now that improved lighting conditions improve productivity and reduce 'rejects' in industrial process. The human eye is a marvellous optical device which can adapt itself to a wide variety of lighting levels but when lighting levels go down there is a drop in the visual perception. The stresses and strains induced by working constantly under lower levels tend to result in deterioration of eyesight and the consequent mechanical errors and 'rejects' in final products.

Daylight Availability

The availability of day light out of doors in the plains of India is quite high throughout the year. (refer Fig.3.4-1 and 3.4-2). This consists of sky illumination and direct solar illumination. The former is nearly constant throughout the major portion of the day while the direct sunlight can be as much as four times the light from the sky . This wide variation and the chances that incidences of direct sunlight over moving machine parts in shop areas can cause undesirable visual fatigue and become a source of danger, necessitate its exclusion in the planning for apartunes for daylighting and the commonly used types are shown in fig.3.4-3)

The quantity of daylight reaching the working plane in factories consists of skylight and reflected light from the roof opposite the fenestrations and other reflecting surfaces. Factories being vast covered spaces, the windows on enclosing walls are not adequate to obtain the desired daylight in the major central portion of the factory; Hence some form of roof-lighting should always be resorted to, which not only promotes good lighting but helps ventilation also.

3.4.4 General Principles of Day Lighting

a) where the work is carried out during dusk-hours, the daylighting should be combined with electric lighting in such a manner, that the 'DIMINUTION' of daylight is in a way unnoticeable specially for those engaged in precision work involving eyestrain.

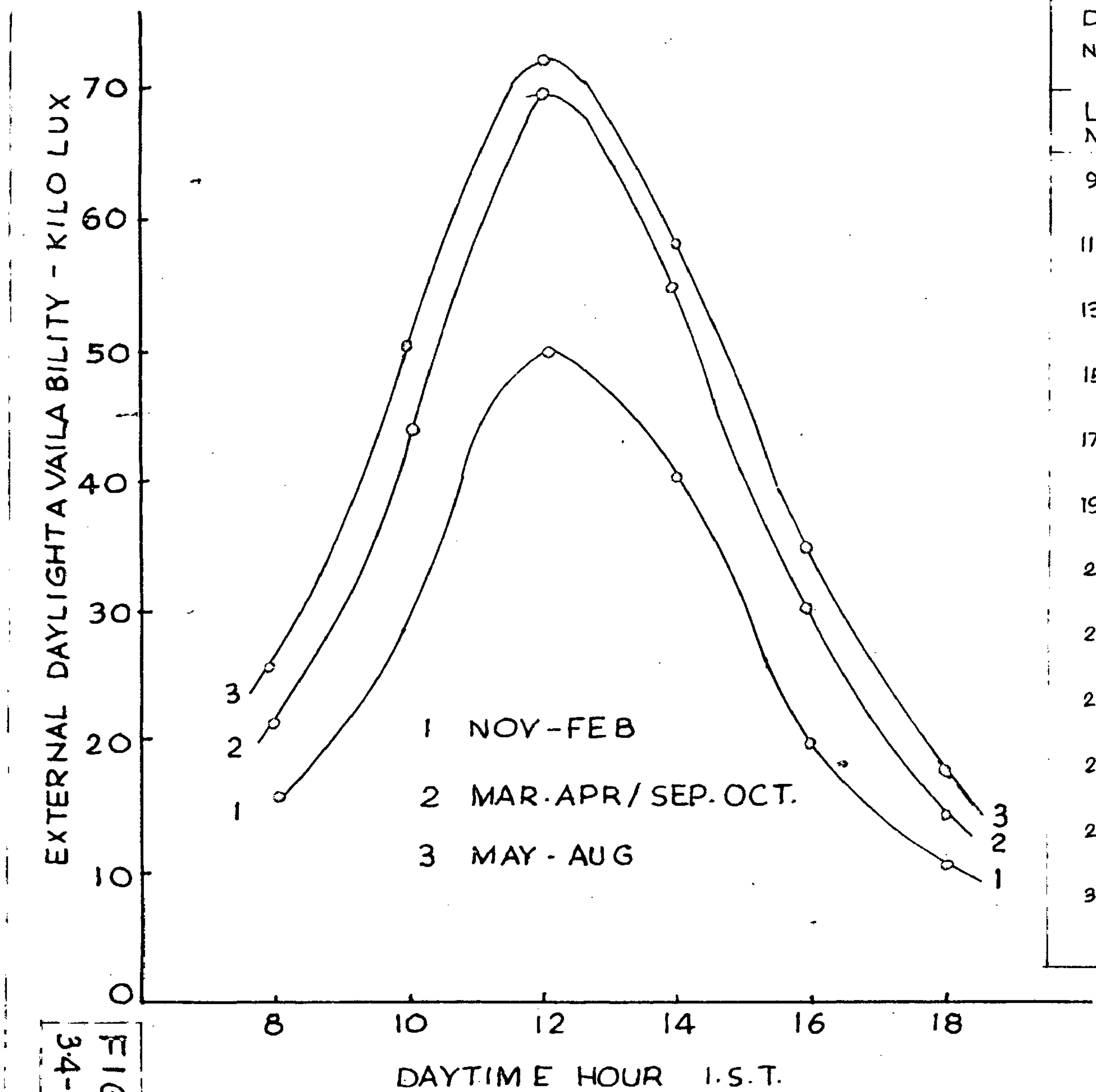


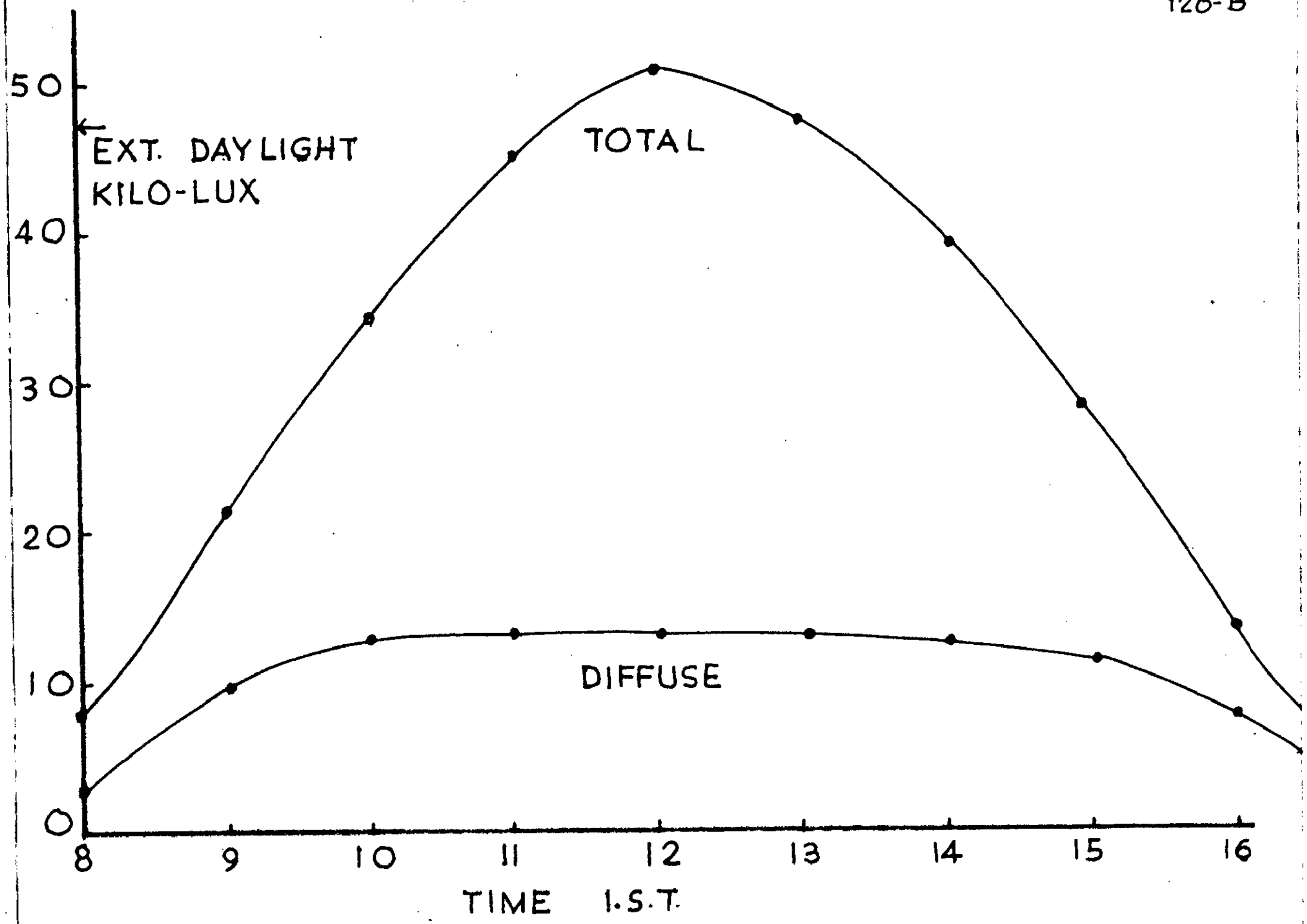
FIG. 3·4-1

AVAILABILITY OF DAYLIGHT OUTDOOR ON A HORIZANTAL SURFACE FROM SUN & SKY IN INDIA.

DURATION OF SUNSHINE ON FACADES FACING NORTH (SOLAR TIME).

LOCATION N°(LAT)	SEPT 23 TO MAR 21	APR 16 TO AUG 27	MAY 16 TO JULY 28	JUNE 21
9°	NIL	•THROUGHOUT •UPTO 10·30AM AFTER 1·30 P.M	THROUGHOUT	
11°	"	•UPTO 9·15 AM AFTER 2·45 P.M.	"	"
13°	"		"	"
15°	"	UPTO 8·40 AM. AFTER 3·20 PM	"	"
17°	"	UPTO 8·15AM AFTER 3·45 P.M	"	"
19°	"	UPTO 8·00AM AFTER 4·00PM	"	"
21°	"	UPTO 7·40AM. AFTER 4·10PM	UPTO 11·30AM AFTER 1·40PM.	"
23°	"	UPTO 7·30AM. AFTER 4·30PM.	UPTO 9·30AM AFTER 2 30PM	"
25°	"	UPTO 7·20AM AFTER 4·35 PM.	UPTO 9·00AM AFT. 2·50 PM.	
27°	"	UPTO 7·15AM AFTER 4·40PM.	UPTO 8·40AM. AFT 3·10 PM.	UPTO 10 30AM. AFT 1·30 PM.
29°	"	UPTO 7·10AM AFTER 4·50PM	UPTO 8·30AM AFT 3·30PM.	UPTO 10·00AM AFT 2·00 PM.
31°	"	UPTO 7·05AM AFTER 4·55 P.M.	UPTO 8·20AM AFT. 3·40PM	UPTO 9·00AM AFT 3 00PM.

SOURCE: NARSIMHAN V. DAYLIGHTING OF INDUSTRIAL BLDGS. TABLE II & FIG 1



HOURLY VARIATION OF EXTERNAL DAYLIGHT ON HORIZANTAL SURFACE IN INDIA (MEAN FOR DEC. 22)

NOTE THAT THE SKY ILLUMINATION-DIFFUSE-REMAINS CONSTANT FOR MOST PART OF DAYTIME HOURS.

TABLE. 15: TRANSMISSION COEFFICIENTS FOR VISIBLE LIGHT FOR SOME GLAZING MATERIALS.

MATERIAL	TRANSMISSION COEFFICIENT.
1 TRANSPARENT WINDOW GLASS	0.80 - 0.85
2 PATTERNED GLASS	0.70 - 0.85
3 WIRED GLASS	0.60 - 0.80
4 SAND BLASTED "	0.65 - 0.80
5 CLEAR ACRYLIC PLASTIC	0.80 - 0.85
6 CLEAN RIGID P.V.C.	0.70 - 0.80
7 WIRED " "	0.70 - 0.75
8 CORRUGATED GLASS FIBRE REINFORCED SHEET.	0.55 - 0.80

SOURCE: NARSIMHAN V; op-cit; FIG.2 & TABLE III

FIG. 3·4-2

involving eyestrain.

(b) Obstructions such as structural members, overhead installations, machines should be considered in relation to glazing.

(c) Working plane in pottery works is as low as 6" (15 cm) above the floor for processes done by squatting to as high as 6'-8' (1.8 to 2.4 M) for the overhead sliplines etc.

(d) There should be good distribution of light over the whole interior, 'light coloured' surfaces should predominate on the surface of the interior.

(e) glazing should be regularly cleaned and hence an 'access' is essential.

(f) Main walls of the factory should be kept free for providing the openings as visual rest centres, (generally the walls are found to be lined with supervisors' cabins, stores etc.) Such openings, in addition, provide the desirable wind movement.

NORTH LIGHT OPENINGS

These are superior to other types of daylighting since they keep off direct midday sun in latitudes north of 23°. (refer fig.3.4-1). The incursion of sunlight through N.L. is shewn therein. Indiscriminate use of north lighting in places located south of this latitude should be avoided. In south India N.L. is acceptable only with diffusing glasses so as to cut-off the direct sunlight entry.

Roofs in the class of NL would include cylindrical shell folded plate and the steel NL trusses. The uniformity of illumination on the working plane in NL depends on the width of the bay (distance between NL openings), the slope of the roof and the reflectance of the ceiling.

Monitor roofs

The longer axis of the fenestration should be east west. Use of miniature louvres in conjunction with glased apartures (tilt-45°) can send a diffused light flux to the working plane.

Roof Lights

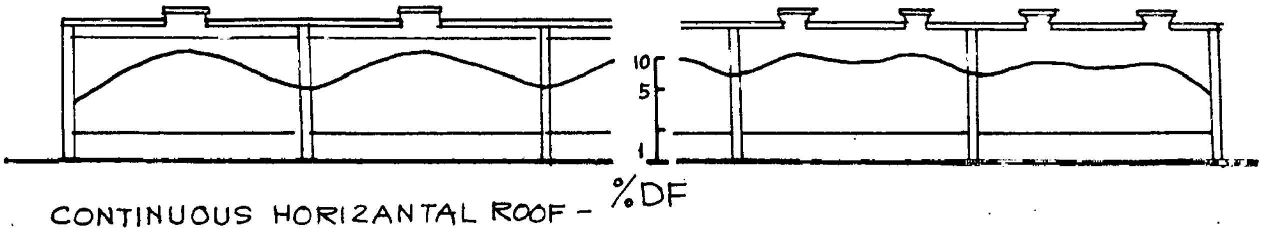
In areas where the direct incursion of day light is permissible, one may employ roof lighting using transluscent materials. The transmission properties vary and with plastic materials there is a considerable loss of light due to weathering.(refer table 15 fig.3.4-2). Distribution of trans-luscent material on the roof should be used in conjunction with artificial lighting to obtain uniformity of lighting on working plane.

Side Windows

The walls of a factory should be kept free for the provision of windows. The work plane being very low in a pottery industry , cill should be 30 cm above the floor. The light penetration due to windows is generally upto 8 meters. The walls around the windows should be of light colour to avoid the contrast glare. Size of windows for required level of illumination can be found out as per POLKA DOT METHOD developed by CBRI Roorkee.

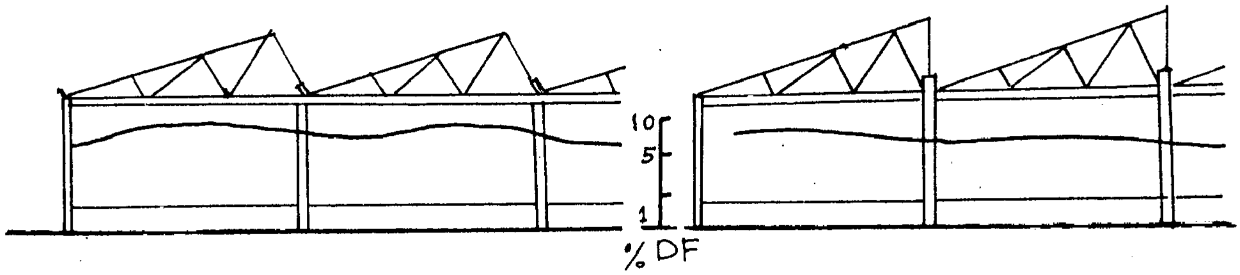
Fenestration

Methods of providing fenestrations and the daylight are shown in figure 3.4-3. The values of DF include sky and reflected components and the value of 0.85 for glass trans-mission. These diagrams come handy for architect while deciding the roof type and height of glazing in relation to the floor



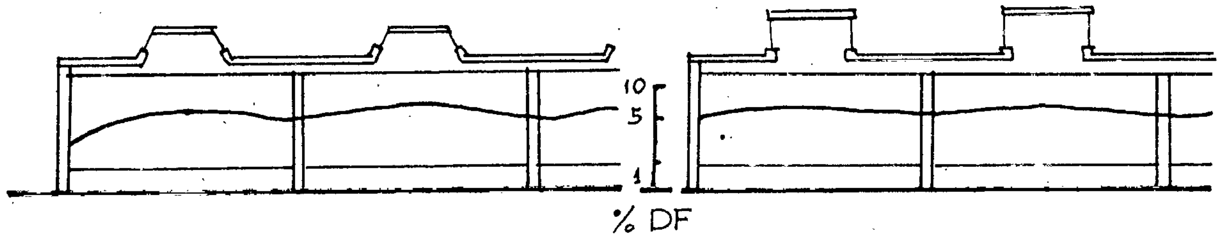
CONTINUOUS HORIZANTAL ROOF-
-LIGHTS WITH DIFFUSED GLAZING
17% OF FLOOR AREA.

GLASS AREA
11·5% OF FLOOR AREA.



NORTH LIGHT ROOFING.
INCLINED GLAZING
GLAZING 20% OF FLOOR AREA.

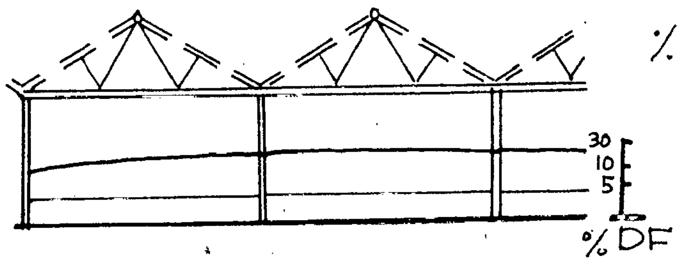
VERTICAL GLAZING.



MONITOR ROOF.
INCLINED GLAZING
16% OF FLOOR AREA.

VERTICAL GLAZING
GLAZING 30% OF FLOOR AREA.

NOTE:
%DF - PERCENT DAYLIGHT FACTOR.



SHED TYPE ROOF WITH GLAZING STRIPS CONTINUOUS. 10% OF FLOOR AREA.

FENESTRATION IN ROOFS.

SOURCE: IS:6060-1971, C.P. DAYLIGHTING OF FACTORY BLDGS. PP 10-22.

FUTURE MAY ENVISAGE A TRANSPARENT ROOF TO OVERCOME ANY DAYLIGHTING PROBLEM.
CLEANING OF ROOFS MAY ALSO BE DONE BY ROLLING GEARS OPERATED FROM WITHIN FACTORY.

FIG. 3·4-3

area for the desired daylight illumination.

3.4.5 Area Illumination Vs. Task Illumination

Task illumination is the minimum quantity of light which is needed for the satisfactory performance of a task. The science of lighting requires that the task, its immediate background and the overall surround should have levels of brightness of the order of 10:3:1. The daylight provides the task illumination as well as the area illumination.

3.4.6 Colour Quality of Light

On studying the various processes in POTTERY industry, it is found that the following areas are governed by this colour quality, i) Colouring, ii) Decorating, iii) Coloured glazing. Here the colour and the colouring pigments should be seen in natural day light so that they are perceived in their original colours. If the day light is not adequate, then the same can be supplemented by the 'day light' filament lamps or fluorescent lamps for the colour matching. However, the filament lamp tends to cast harsh shadows and hence the use of 'day light' fluorescent lamps is recommended. This prevents the distortion of colours perceived due to the usual filament lamps or fluorescent lamps.

3.4.7 Artificial Lighting

Although the role of this lighting is restricted only to certain departments of pottery industry, which operate through both the general and night shifts, artificial lighting contributes a great deal towards,

i) supplementing the daylight,
ii) use during the overcast sky (monsoon period)

iii) use during night shifts.

It should also promote an atmosphere of cheerfulness

3.4.8 General Principles

(i) Avoidance of harsh shadows and glare.

(ii) Reducing the brightness of sources by louvres, shades, etc. and also ~~mk~~ the apparant area of source as seen by eye by proper orientation of light fitting.

(iii) Reducing contrast between light source and the background by use of light coloured surfaces or ceilings in combination with fittings which allow a reasonable amount of flux in upper hemisphere to raise ceiling brightness.

(iv) Combination of filament and gas discharge lamps as a safeguard against voltage fluctuation.

(v) Colour quality of light.

The achiement of various objectives of good lighting needs following considerations:

i) Levels of illumination,

ii) Types of lamps and their luminous efficiency and colour quality.

iii) Light distribution characteristics of different lamps and luminaires.

iv) Arrangement of light fixture.

v) Initial installation and subsequent maintenance costs.

vi) Steadiness of performance through voltage fluctuations, and resistance to vibrations,

vii) flickering effect.

The illumination levels in lux relevant to Pottery works as per IS:6060-1971 Code of Practice for Day Lighting the factories have already been listed.

Table -16 Characteristics of various types of lamps commonly used.

Lamp (wattage)	Filament 40 to 1500 watts	Mercury vapour 80-1000	Colour corrected mercury 80-2600	Hot cathode 40-125	Cold cathode 68-81	Sodium vapour 50-140
Luminous Efficiency	Low	Medium	Medium	High	Medium	Very High
in watts/lumen	10-18	31-43	31-59	36-74	26-41	50-140
Colour	Yellow	Bluish white	White	Bluish white and a wide range of cohours possible		Orange yellow
Glare	glare and harsh shadows.	Slight glare and shadows	Medium glare	NO GLARE	NO GLARE	Slight glare
Nominal life in hours.	Short:1000 hrs.	Long: 5000	Long:5000	Very Long: 5000	Very Long: 15000	Long: 6000
Adaptability	Good in standard sockets ———			No adaptability ———		
Resistance to Vibrations	Poor	——— G O O D ———				
Brightness	High	High	Medium	Low	Low	Medium

Fluorescent tube light with inbuilt reflector- Good for dusty environment.

On scruitny it is observed ,

i) Sodium vapour lamp with its characteristics orange yellow light in the region of 589 A°u of the colour spectrum is out of question for being used in Pottery works as it tends to distort the colour perception of the objects so lit.

ii) Cold cathode is mainly used for advertising and neon signs and hence not much applicable excepting the name of industry.

iii) Mercury vapour lamps are suitable for general lighting excepting the colouring, glazing and decoration sections.
iv) The 'daylight' fluorescent tube lights of 40 watts are suitable for all purpose applications in view of its luminous efficiency as compared to low wattage, and the glare free flux and leads to efficient production.

The sorry state of affairs about the voltage fluctuation from as low as 175 to as high as 255 leads to the following considerations. 'The lighting design should always be based on combination of gas discharge lamps and the filament lamps.

a) when the voltage drop occurs, the gas lamps refuse to start as they require a high initial voltage for their start. Filament lamps in such a case glow instantaneously, although dim and prevent the factory from being dark in case the low voltage continues for a longer time.

b) When the current suddenly cuts off, and comes back after a while, the filament lamps immediately switch on and keep the factory lighted during the intervening period until the gas discharge lamps start glowing.

c) Filament lamps emit light in all the wavelengths of a visible spectrum (continuous spectrum) while the gas discharge types do not emit light in all the wavelengths of visible spectrum (discontinuous spectrum). The defficiency of 'red' in light from gas discharge lamps is compensated by combining filament lamps with them and this leads to lesser distortion of colour perception.

d) Filament lamps if exclusively employed have following disadvantages and advantages:-

i) lesser luminous efficiency compared to wattage and as such tend to increase electrical consumption.

ii) Give rise to glare and harsh shadows.

iii) Yellow light for vast areas is not pleasant and cheerful.

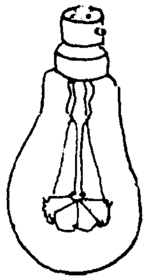
iv) colour distortion, v) They have adoptability in standard sockets, vi) They are cheaper than the gas discharge lamps

vii) 'Day light' fluorescent tube lights or 'daylight' filament lamps are particularly suitable for supplementing light in decoration, colouring and colour glasing sections.

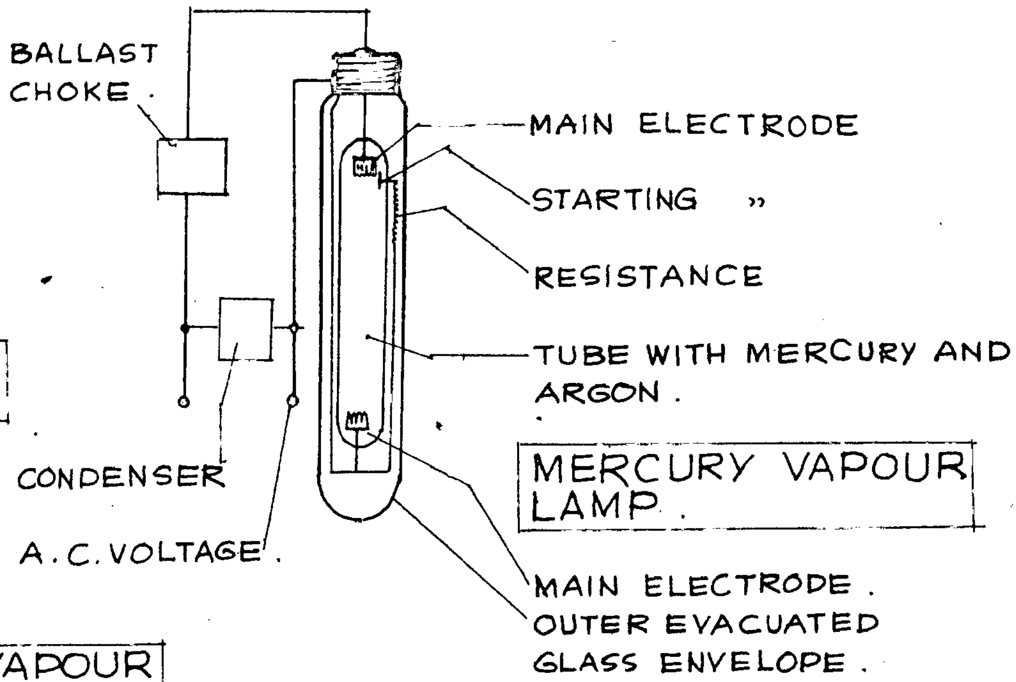
e) The dusty environment in the pottery industry particularly in the sliphouse , making and finishing departments leads to the application of fluorescent tube lights with inbuilt reflectors (Fig.3.4-4). The omission of luminaire saves on cost and maintenance.

During operation, a tube light becomes warmer than the ambient air. This causes a slight but continuous circulation of air around the lamp. Much of the dust in this air is slowly deposited on the upper side of the lamp where, in course of time, forms and fairly thick layer effectively inhibiting

SOURCE : GIMSON.C.E. FILAMENT & DISCHARGE LAMPS, ELECTRIC LIGHTING, CHAP IV, PP 53-80.

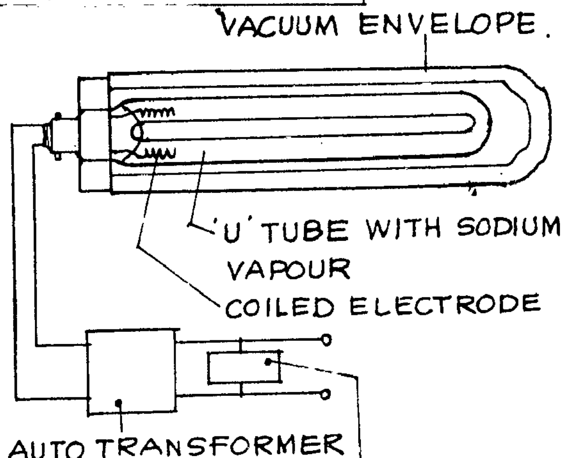


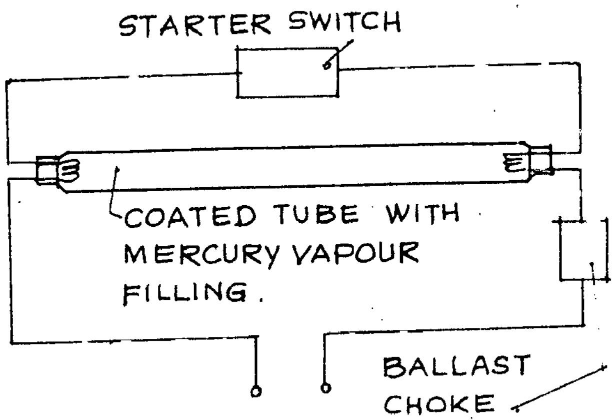
FILAMENT LAMP



MERCURY VAPOUR LAMP.

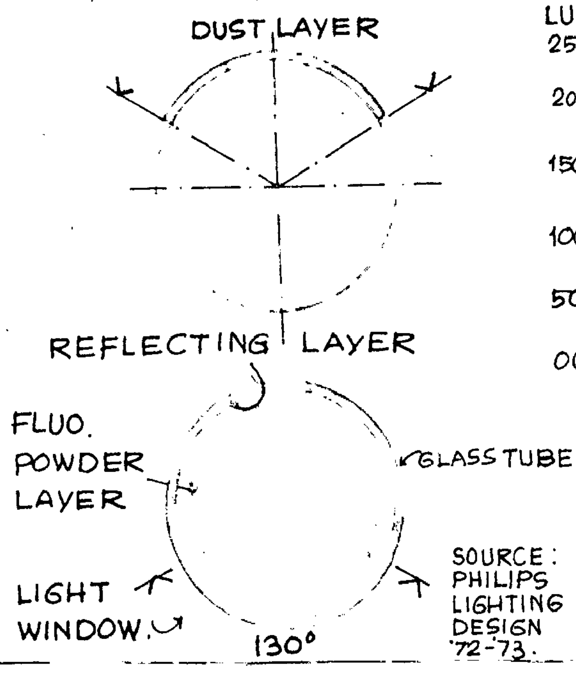
SODIUM VAPOUR LAMP



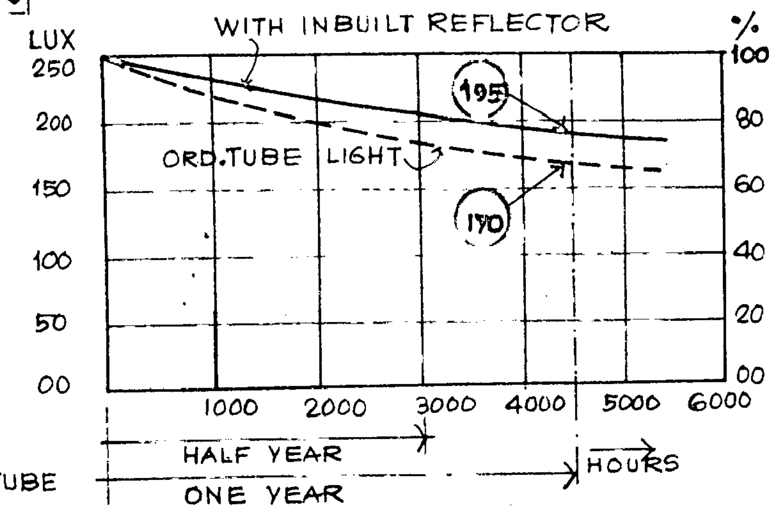


FLUORESCENT TUBE LIGHT.

FLUORESCENT TUBE WITH IN-BUILT - 120° REFLECTOR



SOURCE: PHILIPS LIGHTING DESIGN 72-73.



LUMEN MAINTENANCE OF ORD. TUBE LIGHT & ONE WITH INBUILT REFLECTOR IN DUSTY ENVIRONMENT.

FIG. 3·4-4

the upward light emission. The light depreciation may easily reach as much 30 to 40 percent.

To combat this, the tube light is inbuilt with reflector, covering 2/3rd of the circumference and is applied between fluorescent powder and the glass-layer.

Colour of Illumination[1]

Performance under artificial light differs from daylight. This has been illustrated by a study made by Pierce and Weinland in table No. 16-A

Table No. 16-A

The production in a repetitive manual task as related to the colour of illumination

Colour of		Relative production
Daylight	-	100
yellow	-	93
green	-	92
Blue	-	78
Red	-	76
Orange amber	-	76
Yellow amber	-	54

3.4.8 Selection Criteria for Luminaires

This depends on the following considerations

i) Character of light distribution,

ii) Upward dist of light to avoid contrast glare between source and the surroundings,

iii) Sturdiness of luminaires.

iv) Initial installation and subsequent maintenance costs,

1 Ghi Selli, E.E. and Brown, C.W., 'Conditions of Work and Productivity, Personal and Industrial Psychology, 2nd Ed. pp273-305, McGraw Hill, London 1955

v) Spacing to mounting height ratio.

Distribution of light depends upon the type of source, shape of the fitting, mounting height and the distance between individual lamps. The more the light is concentrated in a downward direction and the lower the mounting height, the lesser will be the illumination on the walls, but adequate light must reach the walls in order to provide a cheerful atmosphere and to reduce contrasts. Table 17 gives luminaire spacing and light distribution.

Table 17

Relation between luminaire spacing and light distribution

Mounting above work plane	Ratio of spacing to mounting height	Zone in which luminaire lumens are emitted.
less than 16' (4.8 M)	1.5 to 1	0^o-60^o - widespread
16'-30' (4.8M) to 9M	1 to 1	0^o-40^o- semiconcentrating ormedium spread.
Over 30' (9M)	0.5 to 1	0^o-20^o-concentrating

The figure 3-4-5 indicates some of the common types of luminaires used in industrial buildings. The polar curves show the character of light distribution. A part of light emission in upper hemisphere is most desirable as it tends to reduce the brightness contrast between the source and immediate surrounding apart from the fact that it makes the environment more cheerful.

This basic knowledge acts as architect's guide in making choice for the lamps and the luminaires suitable for the

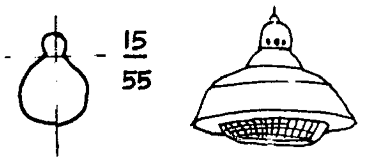
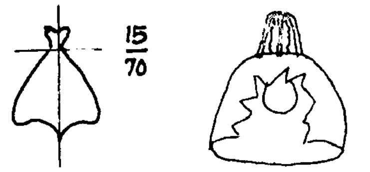
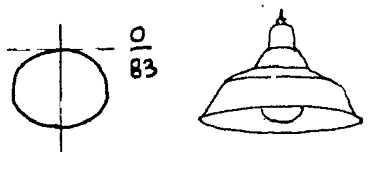
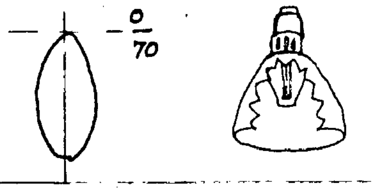
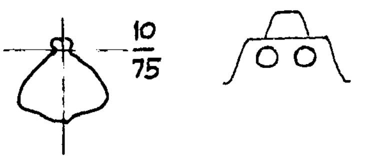
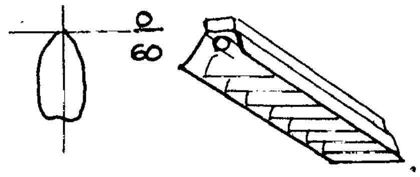
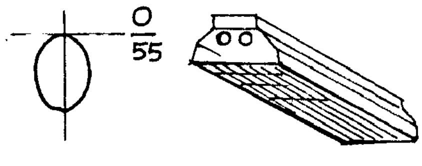
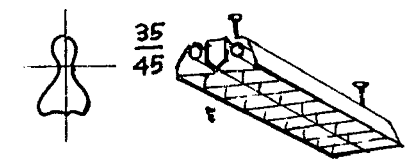
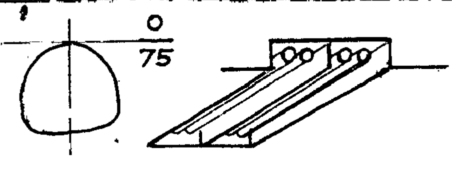
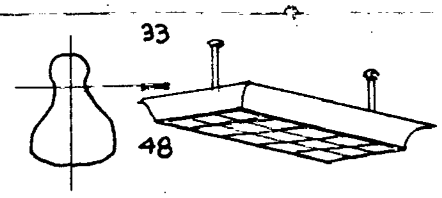
	GLASS STEEL DIFFUSER UPWARD FLUX TRANSMISSION HELPS TO REDUCE CONTRAST & PROMOTES VENTILATION.
	OPEN TOP ALUMINIUM REFLECTOR PROVIDES UPWARD EMISSION & VENTILATION. FOR HIGH MOUNTING.
	PORCELAIN ENAMEL REFLECTOR SHOULD HAVE VENT. HOLES ATOP. VERY COMMONLY USED. EASY MAINTENANCE.
	MERCURY LAMP IN MIRRORED GLASS OR AL. REFLECTOR. VENT. OUTLETS HELP MAINTENANCE. GOOD FOR HIGH MOUNTING.
	WHITE ENAMEL INDUSTRIAL REFLECTOR PART FLUX TRANSMISSION IN UPPER ZONE AVOIDS CONTRAST GLARE. EASY MAINTENANCE, FOR LOW MOUNTING.
	SINGLE LAMP PARABOLIC AL. TROFFER WITH BAFFLES. GOOD VISUAL COMFORT, EASY MAINTENANCE. FOR LOW MOUNTING.
	TWO LAMPS WITH WIDE TROFFER & LIGHT CONTROLLING GLASS, LOUVRES OR PLASTIC PLATES: GOOD COMFORT & APPEARANCE.
	TYPICAL DIRECT INDIRECT FIXTURE, WITH OPAQUE SIDE PANELS. GOOD APPEARANCE AND AVOIDS CONTRAST GLARE.
	OPEN COFFER TROUGH. FOR OFFICE AREAS.
	SPECULAR REFLECTOR. DIRECT INDIRECT FITTING. AVOIDS CONTRAST GLARE.

FIG. 3·4-5

: INDUSTRIAL LUMINAIRES-DATA :

SOURCE: KINZEY & SHARP. LIGHTING CALC. & DESIGN, CHAP. 19, TABLE 19·4. op cit. PP. 563-79 purpose. However the exact calculations of light is the field of an illumination engineer and his advice should always be sought for the resultant conductive environment. Some examples[1] of lighting and productivity in factories have been cited by British lighting Council

(a) A leather working factory where the light was increased from 35 lm/sqft. localised to 100 lm/sq.ft. all over resulted in increased production by 7.6 percent which had an annual value 13 times more than the cost of the improved lighting.

(b) In an American Women's sports ware factory after raising illumination from a low level to 100 lm/sq.ft. the increased output paid for the capital cost of the new installations in 38 days.

(c) Study in Indian context was conducted by ATIRA, Ahmedabad, in Loom Sheds of Textile Mills, in respect of effect of increased illumination on production and damages. In mill A, illumination was increased from 6-9 foot candles tungsten to 17-25 foot candles fluorescent. The results showed that efficiency increased from 77.91 to 81.46 percent and damages decreased from 4.6 to 1.5 percent. In mill B, illumination was increased from 2-3 foot candles to 10-13 foot candles and 18 to 23 foot candles fluorescent. The results showed that the efficiency increased from 67.85 percent to 70.21 percent and to 75.28 percent in different intencities of light (Information by correspondence).

3.4.9 Summary

The entire study can be summarised as follows:

1. Page, J.K. Environmental Control, Better Factories, 1964, Inst. of Directors. London. page 73.68-79

i) More reliance on daylight,

ii) Glazing related to floor area and D.F.

iii) Proper access to glazing area for frequent cleaning.

iv) Combination of gas discharge lamps and filament lamps as a safeguard against voltage fluctuations.

v) Use of 'Daylight' fluorescent tube lights for preventing colour distortion in colouring and decoration sections.

vi) Use of fluorescent tube lights with inbuilt reflectors for dusty environment.

vii) Frequent cleaning and maintenance of lamps and luminaires.

viii) Selection of luminaire as per the light distribution characteristics and the spacing to mounting height ratio.

ix) Overall predomination of light coloured, and low reflective surfaces for better light distribution and avoidance of contrast glares.

3.5 COLOUR

Colour was created on the first day in the beginning of time. More ancient than Adam, colour has been an important influence in the life of man throughout the ages. Colour, in earlier and less sophisticated ages, was to man more than a simple joy- colour was also associated with complicated mysteries. With childlike pleasure man painted himself , his clothes, weapons and homes. With advancement, the colour and its application has become a science and a medium for creating appropriate moods in the indoor environments. It has opened a new field for psychologists, physiologists psycho-physicists and architects.

Light or the visible radiant energy, is the cause of colour sensation. The visible spectrum which is also the visible colour spectrum, between 4000 to 7600 angstroms is capable of producing the colour sensation in the human eye. Beyond this range are the ultraviolet and infrared energy respectively on the violet and red sides and it is invisible. The retina in the human eye, however, is not equally sensitive to every wavelength within this range i.e. its luminosity response is different to each colour.

3.5.1 Scientific Objectives

Until recently factories and workshops were invariably drab and dirty. Now it is being recognised that the Building Scientist , colour consultant and the architect can contribute materially to the creation of environment in which workers can be both efficient and safe. A good colour scheme apart from being decorative aims at helping the workers to see clearly and quickly and at promoting safety, accuracy, tidiness, identity to each object with consequent increased output. In important respects, colour is serving the same ends as lighting and it is essential that colour and lighting be viewéd together as the 2 complimentary aspects of visual environment. The human being has an inherent attraction for colour.Even a child perceives a brightly coloured object faster and develops love for the same. This inborn quality stays with him throughout his life and develops attachment to coloured objects, may be it is a machine or any other object. Safety is one of the most important quality in industrial context that the colour contributes. It is found that 12 percent of the industrial accidents are due to failure in recognising the potential hazards.[1], which could be made conspicuous for quick recognition with appropriate colours. Scientific objectives of colour in industry.

1. Creates a cheerful and conducive environment.
2. Better workmanship,
3. Relief from eyestrain and fatigue, 4.Promotes tidiness.
5. Gives clear identity to machinery, passages, operation levers, pipes etc.
6. Lesser rejections and increased output
7. Leads to safety and fewer accidents.

3.5.2. Existing Conditions

The following table, shows the existing conditions of colour in pottery industry (based on a survey of few

1. Blum, M.J. and Naylor, J.C., Accidents, Safety and Fatigues- Industrial Psychology,1968,pp.516-550.

Table No.18

Existing colour Schemes in Indian Pottery Works

Industry	Walls	Structure (roof/stanchion)	Machinery	Kilns	Wheeled racks
1. U.P.Ceramics and Pottery Works, Ghaziabad.	White washed	Silver grey	Dark grey	exposed brick work	Dark grey
2. Hindustan Sanitary ware and Industries Ltd., Bahadurgarh.	exposed bk work cement pointed	silver grey	Dark grey	Exposed bk work	Dark grey
3. Pottery Development Centre, U.P. Govt. Khurja	white washed	Silver grey	Dark grey	-do-	-do-
4. Sri Ambica Pottery Works Khurja	-do-	-do-	-do-	-do-	-do-
5. C-1 Potteries Khurja	-do-	-do-	-do-	-do-	-do-
6. The Bombay Potteries Kurla, Bombay.	-do-	-do-	-do-	-do-	-do-
7. Malhotra Potteries, Khurja,	-do-	-do-	-do-	-do-	-do-

Colour schemes- Pottery works in foreign countries: Some colours observed in Pottery Industry (U.K., U.S.A.) (Information is based on the coloured photographs in various foreign magazines namely 1) American Ceramic Society Bulletin, British Clay worker, and claycraft in CBRI Lib.)

Walls: Light green, light blue, Structure: Silver grey or grey , Machinery: Green or blue,

Levers, Operation, wheels etc: Lemon yellow, Wheeled racks, industrial trucks: Yellow

Guards and fences on machinery or in other places: Yellow, Kilns- exposed brickwork industries bythe author. Reference is mainly to the work areas where the colour scheme is greatly desired)

3.5.3 Colour Perception by Human Eye

Eye receives and transforms the radiant energy in the form of light between 4000 to 7600 Angstroms and the brain and central nerve system translate it. The retina overlays almost all of the surface of the eyeball. Its function is to convert light into electrical impulses through photo-chemical action. The retina is composed of nerves with cells of modified ends. One type of cell is conical called 'cone' and the other type is blunt called 'rod'. The normal retina contains 15,000,000 rods and 34,000 cones. The rods and cones contain pigments which bleach under the action of light. The optic nerve and the central nerve system translate and interpret the stimulus and initiate appropriate response. The response of light is not identical in rods and cones. The cones operate at brightness levels above 1/1000 of a foot lambert and since the colour is perceived only by the cones, there is no colour perception at very low levels of brightness and poor colour perception in dim light. When eye receives light above 1/1000 of a foot lambert, both rods and cones are in action and such a condition is called 'photopic' vision. When light received is below 1/1000 of a foot lambert only rods are in action and this condition is called 'scotopic vision'. Under low illumination, when rod vision is dominant the eye becomes almost blind to red but is quite sensitive to blue. (Fig.3.5-1) This shift in sensitivity is called the Purkinje effect. This point is extremely important for denoting the 'fire fighting equipment' generally coloured, red, For being conspicuous, it has to be well illuminated during the night time.

Although the retina is sensitive to radiation between 4000 to 7600 Angstroms, it is not equally sensitive to every wavelength within this range. (Fig.3.5.-1).

3.5.4.Industrial Colour Planning

This involves following considerations: (a) Background colours, (b) Machinery colour,(c) Identification colours.

(a) Background Colours: These must be carefully considered in relation to the work carried out in the room. The walls and ceilings which form this background should not give rise to glare, should be restful and should provide a neutral light surround, adapted to the lighting conditions of the room and the conditions of work. Ideally, the background colour should be complementary to that of the material being worked on and at the same time should provide a suitable contrast in hue with the task. Colours from the middle of the spectrum such as buffs, yellows, greens, which provide suitable hue contrasts with most materials used in industry, can be used as background colours. Bright colours must be avoided in favour of pastel tones which afford relief to the eyes and assist speedy readjustment of vision. White colour could be used in the areas, near the roof for a uniform distribution of light. Colour can be used to vary the apparent temperature of a room, 'cool' colours such as greens and blues are useful for giving the impression of reduced temperature in boiler rooms, kiln areas/in pottery industry, while colours such as yellow can create an effect of warmth in cool areas. Grills etc. in the openings should be of light colour to avoid contrast glares.

(b) Machinery Colours: The colour selected for this purpose must provide a suitable brightness contrast with both the task and immediate surround. These requirements can be summarised as follows:-

i) It must harmonise with the surrounding so a blue or green shade is useful in decorations.

ii) It must not act as camouflage, but must accentuate or make possible , easy and automatic perception of different parts of the machine.

iii) It must provide a contrast between the task on the machine and the part of the machine forming the background to the task.

Such items as switches, starting buttons, levers, moving parts and tool points should be coloured to increase their visibility and to separate them visually from the body of the machine. The size of the machine will influence its colour treatment- the smaller the machine, the more delicate the colour scheme. Eggshell finish is preferred to glossy finish to avoid reflection.

(c) Identification Colours:

The quick identification of services and the marking of hazards is aided by proper selection of the right colour. Hazards shouldbe marked with an arresting colour and tests have shown that 'orange' is the best warning colour. Red should be reserved for the fire preventive- equipment and blue on such things such as electrical controls is useful as a cautionary colour. The insides of machine guards, the parts they protect and the insides of electrical switch boxes should be painted with a danger colour such as 'orange' so that they are immediately obvious if they are displaced.

For the decoration, colouring or colour glazing sections of the pottery industry, bright colours should be avoided as far example a mere glance at a brightly coloured wall, may have a hue impact on the ceramic colours or pigments and this will not lead to exact identification colours for the high class decoration work.

In purely casual spaces , such as wash rooms, rest rooms, cafetarias, lighter and cleaner hues may be used. In view of average colour preferences, blue becomes ideal for facilities for men and rose for facilities for women. In stair wells and passages usually deprived of natural light, bright tones of yellow are effective. In storage areas white is the best and will make the most of existing lighting installations.

For promoting safety yellow with black straps is very useful to mark 'strike-against', stumbling, falling hazards, low beams, platform edges etc. Yellow colour may also be useful for the various wheeled racks or industial trucks (fork lift etc.) so that they are instantly noticed while in motion. Where objects are suspended and difficult to see because of lack of local background, visibility can always be increased by suitably coloured target screens placed immediately behind the objects. It is important to note that the material handled in the pottery industry is mainly the clay in some form; its colour ranging from greyish-white or white , to light - brown or brownish-yellow for the fire clays. Thus with the overall colour scheme within work areas based on green-blue shades, the material would have enough contrast with the immediate surround and the cleaning of various surfaces would also be easier, the dirt being quickly noticeable. Indirectly this also leads to good house keeping within the shop. Further the blue-green is a cool hue, when the retina is saturated with it, a warm pinkish after image is produced which is flattering indeed to employees.

3.5.5 Psychological Aspects

Warm and cool Colours: The colours containing a predominance of red feel warm and those containing more of blue feel cool; while, the former seem nearer, the latter appear to be farther away than their true distance from the eye. Only yellow and purple appear to hold their actual position in space. On application, a long narrow room may visually be shortened so that the distance from the workbench to locker room seems less than it really is by painting the end walls in a dark value of advancing colours like burnt orange or maroon. Conversely small rooms may be given greater apparant dimensions so as to avoid feeling of crowdedness, by use of pale tint of a cool colour-pale turquoise, aqua-marine etc.

Moving around the spectrum we note that yellow brings good cheer (colour of sunlight), green effects human emotions, blue is definitely calming, red excites the courageous endeavour, purple is depressing (should be avoided in lunch rooms etc.) and the orange is the most powerful stimulant of all. In industrial plants the colour selection should be based upon working outward from man at the machine, through the man's immediate surroundings, to the surface farther away, the first consideration being the eye comfort at the machine.

3.5.6 Colour Appearance under Artificial Lighting

Different types of lamps vary widely in their effect upon the appearance of surface colours and people's complexion. For the general, after dark illumination, high efficiency types of fluorescent lamps are favoured because the illumination recommended can be obtained with less emission of heat than would occur with filament lamps. The 'Daylight' variety reasonably matches with natural daylight and serves to reinforce the illumination, when inadequate This is very important where the recognition of colour is involved like the glasing, colouring and decorating sections of pottery industry.

3.5.7 Reflection Factors

While choosing any colour, it is necessary to know the reflectance of that colour or material in the area which govern the illumination levels

Table 19

Reflection Factors (R.F.)

Material	R.F.	Colour	R.F.
1	2	3	4
White plaster	0.90 to 0.95	White	0.98
White paper	0.80	Greyish white	0.85
Silvered mirror	0.70-0.85	Ivory	0.82
Chromium plate	0.65	Cannary yellow	0.77
~~Al~~ Polished aluminium	0.62	Cream	0.75
Polished steel	0.60	Prime rose yellow	0.65

Table 19 continued

Material	Rate	Colour	R.F.
Lime store	0.35-0.38	Light tan	0.65
Polished marble	0.30-0.70	Light blue	0.65
Tracing cloth	0.30	Buff	0.63
Grey cement	0.20-0.30	Pale green	0.59
Granite	0.20-0.25	Light pink	0.55
Red brick	0.10-0.15	Silver grey	0.46
Black paper	0.05	Dark ton	0.43
Black cloth	0.012	Sky blue	0.34
Black velvet	0.004	Olive green	0.22
		Dark grey	0.17
		Black	0.20

3.5.8 Availability of Indian Colours

Different surfaces in any work area require a different kind of finish, which may range from a colour-wash to a oil paint. Availability of colours (in Indian context) suitable for finishing various surfaces must be thoroughly studied by architect taking following points into consideration.

i) Type of surface , ii) Degree of protection

iii) Durability of finish -visa-vis the factory-Act regulations requiring repainting once in a specific period.

iv) Cost of various colour finishes,

v) Ease of cleaning due to dusty atmosphere.

Type of surface could be metal, wood, brick or plaster, etc. and the degree of protection required will depend upon the extent to which a surface is exposed to weathering, attack by water etc. Factory Act - Chapter III, clause 11(1) d i and iii stipulates that in case the walls and partitions are painted, they will be repainted ONCE IN EVERY FIVE YEARS, in case of white or colour wash, they will be rewashed ONCE IN EVERY FOURTEEN MONTHS.

Table 20 gives the various available finishes with their cost.

Paints	Cost (at Roorkee during March 1975)	Coverage
1. Synthetic enamel paint	Rs.19.35 / litre	10-12 sqm/litre
2. Plastic emulsion paint	Rs.17.85/ litre	30 to 35 sft/lit
3. Snowcem paint	Rs. 4.00/kg	30 to 35 sft/kg
4. Oil bound washable distemper	Rs.6/-/kg	-do-
5. Colour wash	Rs. 4.00/kg	15 to 20 sqm/lit
6. (nonwashable) dry distemper	Rs. 4.50/kg	10 sqm/litre

Standard range available in Indian colours is enclosed, namely, the synthetic enamel, decoplast,distemper and snowcem for a ready reference. For the colourwash, the colours available are blue, parrot green, aquamarine, yellow, cream, pink, grey, buff.

The ease of cleanliness should be an important consideration for finishing walls etc. upto a height of 2M to 2.5M above the floor. A washable type of finish upto this height is most desirable.

3.5.9 Summary and some recommendations for Pottery Industry

The foregoing discussion can be summarised as follows:-

i) Colour scheme should be based on predominance of light coloured surfaces.

...THETIC ENAMEL

Ivory
Signal Red
P. O. Red
Gulf Red Oxide
Mercedez Red

Pearl White
Deep Orange
Merrie Pink
Pale Rose
...lle Buff

Stone
Broken White
Pool Green
Lilac
Emerald
Mushroom

Buff
Pale Rose
Aquamarine
Grey
Riveria
Electric Blue

Silver
Coral
Dolphin
Fire
Violet
Pool Glaze

Pearl Grey
Satin
Lavender
Orient
Lemon
Pale Blue

"Also available in White" and "Actual shades will be more or less as shown on this card"

STANDARD SHADES

Light Grey	Steel Grey	Summer Blue	Wedgewood
Smoke Grey	Comet Grey	Sky Blue	French Blue
Dk. Adm. Grey	RAF Blue Grey	Phiroza	Azure Blue
Pale Cream	Canary Yellow	Lemon Yellow	Golden Yellow
Water Green	Emerald Green	Opaline Green	Pale Lilac
Apple Green	Brilliant Green	Aquamarine	Majenta
Jade Green	Auto Green	Olive Green	Gold Beige
Bus Green	Mid. Bruns. Green		

Synthetic Enamels

ALSO BLACK & WHITE

SHADES SHOWN ARE FOR INDICATION PURPOSE ONLY.

PLASTIC PAINT

Haritaki

Madan Phool

Neelamber

Ghanashyam

Mewar Pink

Kalpana*

Champak

Chandan*

Belur Blush

Moti

Gulab

Swati

Malhar

Grace

Shahbad White

Coonoor Mist

Dakor Blue

Aquamarine

Pistachio

Charcoal*

Cactus*

Columbine

Bright Yellow*

Flake Grey

Summer Blue

Zephyr

New Mushroom

Nut Brown

Poppy Red*

Geranium*

Pale Lilac*

Mohan*

ALSO JET BLACK & WHITE*

* Available in **SILKONA** also.

Shades shown are for indication purpose only.

20 shades including SNOWCEM White II

Peach 402	Yellow 23	Pale Green 61	Dove Grey 302	Pink 41
Silver Grey 30	Ivory 21	Light Olive 602	Terra Cotta 44	Lavender 405

*Normally, just two coats of SNOWCEM are sufficient

Pale Blue 51	Buff 204	Pale Grey 31	Lilac Pink 403	Mid Cream 22
Mushroom 71	Aquamarine 64		Dark Grey 33	Apple Green 63

The patterns on this card show approximate colours only

ii) Overall scheme should be harmonious.

iii) I.S.I. should standardise certain colours and its use and application in industry especially in the areas requiring easy eye detection.

iv) Factories Act should stipulate regulations about proper application of colour schemes in various industries.

v) The choice of surface finish should be based on the cost visa-vis durability required as per Factories Act 1948.

vi) Glossy surfaces finishes should be avoided to minimise glare problems.

vii) Red warning colours should always be well illuminated specially during night time to overcome purkinge effect.

Some Recommendations

Factory and ware housing

Ceilings-	white,
Walls	green or blue (light pestal shades)
Walls (warehousing)	white
Machinery	green
levers, wheels safety guards)	yellow
Wheeled racks, industrial trucks	yellow
Switch boxes	blue with orange internal sides,
Fire fighting equipment	red with proper illumination,
Cabinets, shelves	grey/olive green.
kiln area-walls	green or blue (light shades)
Warm air ducts	orange and white straps
Fuel oil ducts	yellow / white straps
Electrical conduits	blue

Structural stanchions (upto 3M) - light brown

Stanchions and trusses (above 3M) - silver grey

3.6 ORIENTATION

By orientation in industrial context, we mean, a facing and locating of factories in such a manner so as to obtain maximum advantage from natural agencies like sun, wind, temperature, i.e. minimum and maximum solar heat gains during summer and winter respectively, wind-movement indoors etc. With proper orientation, the conditions indoors would be more comfortable naturally and expenses on mechanical devices for physical comfort will be reduced.

3.6.1 Factors affecting orientation

From the point of view of orientation, solar heat gain is the primary consideration but other factors like the direction of prevalent breeze, the amount and direction of rainfall and the site conditions cannot be overlooked. Factors that need consideration are as follows:

a) the four principal facades, b) locations of rooms or processes, c) The roof, d) shading devices.

(a) The Four principal facades:

A south facade in northern hemisphere has the advantage of receiving much larger solar radiation during winter and lesser during summer. Penetration of sun can be cut off by a small horizontal louvre. These obvious advantages are not available on any other facade.

For that part of India, north of 23^{o} latitude, the sun does not shine directly on north facade, except during early mornings or late afternoons in summer. Even for other latitudes south of 23^{o}N, the sunlight at mid-day during summer , in addition, comes from a very high altitude sun. The early morning and late afternoon sun can be cut off with vertical louvres on sides of opening and the mid-day sun south of 23^{o}N, by a small horizontal louvre at the top.

The eastern and western facades receive nearly equal amounts of daily solar radiation throughout the year. When sun shines on eastern facade, it is comparatively cool after a cool night, and the air temp. is also low. The solar heat gain through this facade is not so pronounced indoors unless of, course, this facade is all unshaded glass area.

The western facade encounters a different situation. Due to higher temperatures in the afternoon, the heat flow indoors is further augmented by the incidence of solar radiation. Glass areas on western side are a definite disadvantage unless otherwise properly shaded.

(b) Locations of rooms or Processes

Much of the solar heat inside the rooms can be offset by favourable breeze during the periods when these are likely to be occupied. In addition to the external heat gain, the heat is produced indoors by men at work and the running of machines. For the wind movement indoors, low cill windows are necessary. It has been found by experiments that in deviating by 60^{o} from optimum wind direction, the wind-velocity inside a room is reduced only by 25 to 30 percent. A slight departure from optimum wind direction can be compensated by providing rotatable wind catchers protruding through roof with their lower ends at about 1M above floor.

(c) The Roof

In tropical climate and particularly in industries the roof with its large surface poses a major problem of heat gain, through the fenestration and roof lighting and the roofing material itself. Fenestration should be adequately protected from the direct entry of sun. This is not possible if skylighting system is resorted to. Fenestration can be protected with diffusing glasses, overhanging eaves or miniature louvres. For minimising heat gains through this roof glazing, a proper orientation would necessitate its facing to north or south sides.

Thermal performance of a roof depends on its shape, reflective and emissive properties of roofing material, thermal properties and total area of exposed surface. In general light coloured materials are preferable to dark ones. The shapes like, hyperbolic parabola, folded plate, conoids, have inbuilt advantage of retaining parts of its surface under shade and as such the heat gain will be less. Moreover they offer larger surface in terms of area than flat roofs and this reduces the per unit area solar radiation over them. The radiation exchange is directly proportional to the effective surface area over which radiation is distributed. Concrete roofs relatively are better in thermal performance than A.C. sheets or aluminium sheets. For thermal comfort, the roof should ensure lower internal surface temperatures to minimise the radiant heat load to the occupants.

The factory act stipulates a clear internal height of 14'-0" with r.c. roofs and 20'-0" with trussed roofs without insulation and a minimum gap of 4 in. air space between insulation and sheets.

This difference in height does play some part in directing the airflow from the openings towards the floor because of higher air pressure on one face of the building. The wind velocity $V \alpha \sqrt{p_1 - p_2}$ and as such the bigger the p_1 due to larger heights and surface, the greater will be the V. However for thermal comfort the extra height does not contribute significantly. In a project sponsored by A.C.C. (India) Ltd. and the Fibre Glass Pilkington India and the studies conducted in recent years by C.B.R.I. on the insulation of A.C. sheet roofs of factory buildings with height of 20'-0" and 16'-0" have shown that no significant difference in the indoor air temperature inspite of a height difference.

The overall thermal performance index (TPI) is defined as the relative rating of the different building components by taking overall climatic data, thermophysical properties of building sections and indoor air temperature variations and the T.P.I. values for different roofs has been tabulated to help in the final choice of roofing material, on the next page.

(d) Shading devices

From the knowledge of solar altitudes and the azimuths, it is possible to design effective shading devices and the building shapes which provide maximum self shading on summer-days for rooms likely to be occupied at those hours when the solar heat is maximum. These can be categorised under the heads i) louvres, ii) grills, iii) building shapes, iv) landscape elements.

Table No.21

S.No.	Roof Section	Treatment External	Treatment Internal	T.P.I	Range of T.P.I.	Performance
1.	10.00 cm.r.c.slab	Tarfelt	1.5 c. plaster	225	175 225	Very poor
2.	10.00 cm + 5.00 cm mud phuska	5.00 cm brick tile	1.5 c. plaster	122	75 125	Fan
3.	10.00 cm + 5.00 cm Thermocole	Tarfelt	1.5 c plaster	64	75	Good
4.	10.00 cm +10.00 cm. foam conc.	Tarfelt	1.5 c plaster	66	75	Good
5.	10.00 cm.+5.00 cm foam conc.	-do-	-do-	81	75 125	Fair
6.	10.00 cm+2.5 cm Thermocole	-do-	-do-	86	-do-	Fair
7.	Aluminium sheets with 2.5 cm thermocole	-do-	Insulation fibre board	90	-do-	Fair
8.	A.C. sheet + -do-	-do-	-do-	85	-do-	Fair
9.	" + 2.5 cm mineral wool	-do-	-do-	86	-do-	Fair + Sound absorbant
10.	Aluminium + -do- sheets	-do-	-do-	84	-do-	-do-

i) <u>Louvres</u>

The exact inclination and projection of louvres is always governed by the climatic data of the place in question. As general guidelines , following thumbrules may be observed.

(a) Where possible louvres should be free from wall surface to promote the air movement around the glazed area, for higher connectional heat losses.

iv) Landscape Elements

These elements in the form of water ppols, shelter belts of trees, hedges, lawns and creepers can be effectively used to minimise the heat gain through the building. The western and eastern sun penetration should be minimised with shelter belts on these sides. Hedges could be located as to divert the breeze towards openings.

3.6.2 Orientation for Various Latitudes

The best orientation , in industrial context, is from the solar point of view whereby the building as a whole should receive maximum solar radiation in winter and minimum in summer. For practical evaluation, it is necessary to know the duration of sunshine and hourly solar intensity on the representative days of the seasons. Example as tabulated below (Table 22 and 23) will show that for all latitudes, an otientation with longer sides facing north and south is appropriate from solar heat gain point of view, the wind being taken care of by the rotatable roof wind catchers as already suggested.

Table 22

Daily total direct solar radiation on vertical surfaces in Gm. Cal./sq.cm./day for two representative days

	8°N		13°N		19°N		23°N		29°N	
	May 16	Dec 22	May 16	Dec. 22	May 16	Dec. 22	May 16	Dec. 22	May 16	Dec. 22
1	2	3	4	5	6	7	8	9	10	11
North	187	-	140	-	83	-	64	-	46	-
North East	228	35	214	27	194	20	188	15	180	9
East	225	187	232	173	240	157	247	146	253	126

Table 22[1] continued

1	2	3	4	5	6	7	8	9	10	11
South East	100	291	115	294	141	295	158	297	188	281
South	-	358	-	377	-	393	18	398	64	390
South West	100	291	115	294	141	295	158	297	188	281
West	225	187	232	173	240	157	247	146	253	126
North West	228	35	214	27	194	20	188	15	180	9

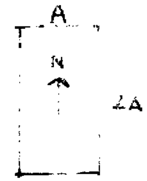
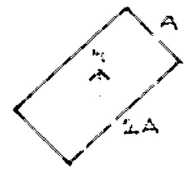
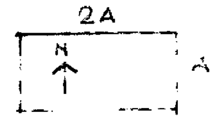
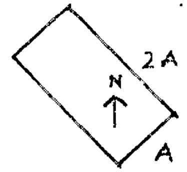
3.6.3 Summary

Wherever possible according to site-conditions, due consideration should be given to various factors affecting orientation in light of the above discussion.

The factory buildings should be oriented with longer sides facing north and south. Shading devices should be used to minimise the solar heat gains and the consequent thermal discomfort. Roof glazing should face north or south sides. Windows with low cills of 30 cm. will provide wind movement at the low plane of work in pottery industry. Insulation of roof and western walls is absolutely necessary and should be provided. Western areas of factories should be allotted for storage, godowns as these are mostly nonoccupied for human activity. A system of adjustable or rotating type roof wind catchers should be introduced.

1 CBRI, Building Digest, No.74.

TABLE 23²: COMPUTATION OF SOLAR RADIATION OF LOAD (Gm cal/day)

		8°N TRIVENDRUM		13°N MADRAS		19°N BOMBAY		23° CALCUTTA		29°N DELHI.		ORIENTATION
		MAY 16	DEC 22	MAY 16	DEC 22	MAY 16	DEC 22	MAY 16	DEC 22	MAY 16	DEC 22	
1	NORTH	187A	—	140 A	—	83A	—	64A	—		—	
	EAST	450A	374 A	464 A	346A	480A	314 A	494A	292A	46A	252A	
	SOUTH	—	358 A	—	377 A	—	203 A	18 A	398A	506 A	390A	
	WEST	450A	374 A	404A	346 A	480A	314 A	494A	292 A	64 A 506 A	252A	
	TOTAL	1087A	1106 A	1088A	1069A	1043A	1021 A	1070A	982 A	1122A	894A	
2	N.E.	228A	35A	214 A	27A	194 A	20A	188 A	15 A	180A	9A	
	S.E.	200A	582A	230A	588A	282A	590A	316 A	594 A	376A	562A	
	S.W.	100A	291 A	115 A	294 A	141 A	295A	158 A	297 A	188 A	281 A	
	N.W.	456A	70 A	428A	54 A	388A	40A	376 A	30A	360A	18 A	
	TOTAL	984 A	978A	987A	963 A	1005A	945 A	1038 A	936A	1104 A	870A	
3	NORTH	374 A	—	260A	—	166A	—	128 A	—	92A	—	
	EAST	225A	187A	232A	173 A	240A	157A	247 A	146 A	253 A	126A	
	SOUTH	—	716 A	—	754 A	—	786A	36A	796A	128 A	780A	
	WEST	225A	187 A	232A	173 A	240A	157A	247A	146 A	253A	126A	
	TOTAL	824 A	1090A	744A	1100A	646A	1100 A	658A	1088A	726A	1032A	
4	NE	456A	70A	428 A	54 A	388 A	40A	376 A	30A	360A	18A	
	SE	100 A	291 A	115 A	294A	141 A	295A	158 A	297A	188 A	281 A	
	SW	200 A	582 A	230A	588 A	282 A	590 A	316 A	594A	376A	562 A	
	NW	228A	35A	214A	27A	194 A	20A	188A	15 A	180A	9A	
	TOTAL	984 A	978A	987A	963 A	1005 A	945A	1038A	936A	1104 A	870A	

2. CBRI. BUILDING DIGEST NO. 74.

CHAPTER-IV

F I N I S H E S

4.1 GENERAL

These fall under the categories of external and internal finishes. While the external finishes have to be strong and durable against weathering in addition to the aesthetics, the internal finishes constitute a great deal to the indoor environment.

Floor finish, the most important of all, has to be most suitable for the process, and resistant to wear and tear.

Wall finish should have a greater consideration for ease of cleaning, distribution of light and colour.

Roofing material should be such as to remain unaffected by the vapours or gas from the process. In addition to the protection from rain and sun it should provide good thermal insulation particularly in industrial context as the roof surface is very large.

The text in this chapter provides general guidelines based on critical analysis. It is worthwhile mentioning here that the choice should be based on the overall advantages offered by the finish and its suitability to the process.

4.2 FLOOR FINISH

General Requirements: For taking a final decision on the type of floor to be adopted it is essential to have detailed information on the following points:

i) Live load on the floor due to the movement of pedestrians, trolley with metallic wheels and round metallic objects and industrial trucks (pallet, forktype etc.)

ii) Specific pressure due to concentrated load.

iii) Impact on the floor due to fall of the moving articles.

iv) The particular purpose for which the floor is designed i.e. whether it has to resist heat, acids/alkalies, mineral oils, organic matter , dielectric property or sparking etc.

The floor can be regarded to consist broadly of three parts: the floor finish or the top coat, the underlying layer or the base coat, and the earthen base. The floor finish takes care of most of the loads. The underlying layer is intended mainly for the distribution of the load onto the earthen base. The base may sometimes be an existing r.c.c. slab.

The different functions occuring on the floor finish:

A floor finish has to be designed for the various purposes which it has to serve. Table 24 gives the various loads and aggressive agencies to which a floor finish may be subjected. It also summarises briefly the reactions of the various types of floors to these loads and other factors.

The coefficient C, given in the column 4 of the table 24 $= P/b\sqrt{D}$, where P = the greatest load of the wheel in kgs; it is multiplied by a load factor which is 1.1 for static load and 1.3 for dynamic load, b = width of the contact area of wheel in cms., D = dia. of the wheel in m.

This property describes the wear of the floor due to the movement of the round metallic objects.

The impact due to the fall of objects is indicated in column 9. The fall is generally considered from a height of 1 meter, like falling of loads from autocars and trolleys and dumping of parts. In case the articles are likely to fall from a 2M height, then their weight as given in col.9 may be reduced by half for a safe impact. Similarly for a fall from 0.5M, this weight may be increased to 1.5 for safe impact. The impact effect while working with crowbar or hammer directly on the floor is considered equivalent to the fall of article weighing 30 kg. from a height of 1M. Scratches on the floor while dragging hard articles with sharp angles and edges is considered equivalent to the fall of a weight of 10 kg. through a height of 1M.

The temperatures upto which the various types of floors can be heated without detrimental wear are defined in column 10. Effects on the floors due to petrol, diesel, oil, kerosene, and emulsions made out of them is shown in col.12.

Considerable quantities of alkalies and acids are sometimes likely to fall on factory floors, cols.15 and 16 give the concentrations of acids of various types which can be resisted by the different types of floors. The limits of concentrations indicated in the numerator are for nitrous, sulphuric, acetic, phosphorous, hypochlorous and chromic acids and in the denominator for butryic, lactic, formic and oxalic acids and their highest possible concentration given as 100 percent, column 17 relates to the effects of alkalies

TABLE 24[1]. TYPES OF FLOOR FINISHES (FOR INDUSTRY)

NO	FLOOR FINISH	RESISTANCE TO ATTACK BY: MOVEMENT OF PEDESTRIANS, HAND TROLLEY WITH RUBBER TYRE ETC.	MAX VALUE OF C	MOVEMENT OF TROLLEY METALLIC WHEELS & ROTATION OF ROUND METALLIC OBJECTS	MOVEMENT OF ELECTRIC CAR ETC	MOVEMENT OF TRANSPORTER CATERPILLAR TRACKS	MAX SPECIFIC PRESSURE DUE TO LOAD Kg/cm²	MAX WT OF FALLING OBJECTS CAUSING IMPACT Kg	MAX TEMP TO WHICH FLOOR IS HEATED °C	WATER, LIQUID WITH NEUTRAL REACTION	MINERAL OILS & THEIR EMULSIONS	ORGANIC LIQUIDS, BENZENE, TOLUENE, XYLENE ETC	ORGANIC MATTERS SIMILAR MATERIAL	ACIDS: MAX CONCENTRATION %	ACIDS: DEGREE OF RESISTANCE	ALKALIES & THEIR SOLUTIONS	DIELECTRIC PROPERTIES	NO SPARKING	DUSTING	HEAT ASSIMILATION VALUE, Kilocalories/m²/hr/°C
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	CONCRETE	V G	100	V G	V G	V G	100	10	100	V G	V G	V G	F	-	V P	P	V P	V G	F	25
	GRANOLITHIC CONCRETE	V G	60	G	G	G	50	5	100	V G	V G	V G	F	-	V P	P	V P	V G	G	25
	CONCRETE WITH SURFACE HARDENER	V G	[100-500]	[V G]	V G	[V G]	100	10	100	F	G	G	F	-	V P	F	V P	V P	F	60
	HEAT PROOF CONC WITH PORT CEMENT	V G	100	P	G	F	50	5	[100-800]	F	G	G	V P	-	V P	F	V P	V P	F	20-25
	PRECAST CONC TILES WITH CEMENT-SAND MORTAR	V G	60	G	G	V P	30	5	100	V G	V G	V G	F	-	V P	P	V P	G	P	25
	ASPHALT CONC	V G	60	G	V G	V P	2	5	50	G	F	P	P	10/20	F	G	V G	V G	F	22
	XYLOLITH WOOD	G	60	G	F	V P	20	5	50	V P	F	F	V P	-	V F	V P	V P	V G	P	18
	HEAVY DUTY CLAY BRICK ON EDGE	G	100	F	G	[V G]	50	10	[100-500]	G	G	G	G	10/20	G	G	V P	V P	F	35
	DO - LAID FLAT	G	100	F	F	[V G]	10	5	100-500	G	G	G	G	10/20	G	G	V P	V P	F	35
	STONE BLOCK	G	100	F	G	[V G]	50	[10-50]	[100-500]	G	G	G	G	10/20	G	G	G	V P	F	40
	ACID RESISTANT BKS LAID FLAT WITH BITUMINOUS MASTICS	G	60	F	F	V P	10	5	70	G	G	V P	V P	[10/20]	[G]	G	V P	V P	F	20
	CERAMIC UNGLAZED ACID-REST TILES	G	60	P	P	V P	20	5	100	G	G	G	G	[10/20]	[G]	P	V P	V P	P	23
	IRON PLATES WITH SAND LAYER	G	300	G	G	G	[3 TONS ON PLATE]	10	[100-1400]	F	G	F	V P	-	V P	V P	V P	V P	P	100
	PERFORATED IRON PLATES WITH CEM LAYER	G	100-500	G	G	G	50	10	100	G	G	G	G	-	V P	V P	V P	V P	F	90
	LINOLEUM	G	V P	V P	V P	V P	5	V P	50	G	G	F	G	-	G TO P	V P	V P	G	[DUST PROOF]	[14-17]
	RUBBER FLOORING	G	V P	V P	V P	V P	5	V P	50	G	P	F	G	-	F	G TO F	V P	V P	[DUST PROOF]	[14-15]
	FLEXIBLE PVC ASBESTOS TILES	G	V P	V P	V P	V P	10	V P	50	V G	V G	F	V G	-	F	G TO F	V P	G	[DUST PROOF]	[14-17]

PROPERTIES OF BEDDING & JOINTING MATERIALS FOR FLOORS

		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	PORTLAND CEMENT/SAND MORTAR	V G	100	F	V G	V G	30	10-50	100	V G	G	G	G	-	V P	V G	-	V G	F	G
	BITUMINOUS MASTICS	V G	100	F	V G	V G	20	10-50	70	G	F	P	P	10/20	F	G	V G	V G	F	P
	JOINTS FILLED WITH SAND	-	100	F	G	G	50	10-50	100-500	F	G	F	V P	-	V P	V P	V P	G	P	G

G - GOOD, VG - VERY GOOD, F - FAIR, P - POOR, V P - VERY POOR, [ ] SPECIALLY SUITED TO RESISTANCE TO ATTACK BY:

1 RAMESH CHANDRA, DESIGN OF FACTORY FLOORS (SP. REF TO BHEL HARDWAR) INDIAN CONCRETE JOURNAL, PP. 105-108, MARCH 1978

TABLE NO. 27[1]. THICKNESS & COMPRESSIVE STRENGTH OF STONE FOR TOP COAT.

TOP COAT	BASE COAT	FLOOR TYPE	WT OF HARD OBJECTS FALLING FROM 1 M CAUSING IMPACT: UPTO 30 KG, THICKNESS OF STONE	UPTO 30 KG, COMP STRENGTH	30 TO 50 KG, THICKNESS OF STONE	30 TO 50 KG, COMP STRENGTH
STONE BLOCK	SAND	STONE BLOCK	120 to 160 mm	≮ 800 Kg/cm²	160 to 200 mm	≮ 1000 Kg/cm²

on the floors.

In many structures electric current at a high voltage is used for various jobs. Also in some floors very sensitive electrical instruments are set up and used. In such instances the floor has to have good resistance to the flow of electric current, which is termed as dielectric property of floor and shown in col.18.

4.2.1 Various Finishes

Various finishes have been listed in col.2 of table 24. The capacity of resistance of these floors for the various types of actions is described as very good (VG), good (G) fair (f), poor (P) and very poor (V.P.). The type, specially suitable for a particular action is indicated by being enclosed in a rectangle.

Concrete finishes: These are very commonly used, their various grades being M100, M150, M200, M250 and M300. Concrete floors with hardeners where wear and tear is more. Some of the concrete surface hardeners marketed in India are purelite, ironite, hardonate etc.

Ordinary cement floors can resist temps. upto 100°C. Special heat-proof cements are available which can resist temperatures upto 800°C. They are used with usual aggregates. For concrete resistant to acids, acid proof cement is used, but the aggregates used must be checked for acid resistance. Asphalt concrete floor is mainly used for its dielectric properties and resistance to acids.

Paving bricks: These conforming to IS:3583 1966 have good resistance to impact and wear and may be used where heavy wear and tear is anticipated. They can also withstand temps. upto 500°C when used with sand. Ceramic unglazed vitreous acid resistant tiles conforming to IS:4457-1967 have good resistance to acids and are also suitable for floorings subject to acid attack and abrasion.

STONES :

The types of stones useful for flooring are granite, basalt, quartzite, sandstone, shahabad. Granite is very hard and resistant to wear by abrasion or impact and is particularly suitable for loading and unloading platforms of industry. A broken stone can be easily replaced. Keemuch and Mandana stones have fairly good resistance to acids and alkalies and wear and tear.

Steel and C.I.Floor Finish

Trey are very useful where heavy and round metallic objects are moved. When used on sand layer they can resist temperatures upto 1,400°C.

4.2.2 TOP COAT: THICKNESS

Table 25 gives the thickness to be adopted for various types of floors, which depends upon the types of mechanical actions further explained in table 26. The thickness of floor to be adopted in the case of stone flooring is given in table 27, which depends mainly on the impact due to falling objects.

TABLE 25[2]. THICKNESS FOR TOP COAT

SR. NO	TOP COAT	MECHANICAL ACTION ON FLOOR: CONSIDERABLE		MEDIUM OR FAIR		LIGHT (WEAK)	
		THICKNESS IN mm	GRADE OF CONCRETE	THICKNESS IN mm	GRADE OF CONC	THICKNESS IN MM	GRADE OF CONC
1	CONCRETE	30	400	25	300	20	200
2	GRANOLITHIC	NOT APPLICABLE (NA)		25	800	20	200
3	ASPHALT CONC	50	-	40	-	25	-
4	XYLOTH WOOD	N.A.	N.A.	20	-	15	-
5	CERAMIC ACID REST. TILES	N.A.	N.A.	20-50	-	20-25	-
6	ACID PROOF CONC.	50	150	40	150	30	150

TABLE 26[2]: EFFECTS ON FLOOR DUE TO MECHANICAL ACTIONS.

DESCRIPTION OF ACTIONS.	INDEX.	CONSIDERABLE	MODERATE	WEAK
MOVEMENT OF PEDESTRIANS ON 1 M WIDTH OF WAY.	NO. OF PERSONS IN A DAY	-	500 & MORE	LESS THAN 500.
ROLLING OF ROUND METALLIC OBJECTS LIKE PIPES.	NO. OF TRANSPORT & ROLLING-STOCK IN A DAY	50 AND MORE.	LESS THAN 50	ABSENT
IMPACT DURING FALL FROM A HT. OF 1M, OF HARD ARTICLES.	KG.	10	5	-do-
SCRATCHING OF FLOORS.	—	DURING DRAGGING OF HARD ARTICLES WITH EDGES.	SHARP INSTRUMENT	-do-
MOVEMENT OF 'POWER (INDUSTRIAL) CARS' ON EACH LANE OF TRAFFIC.	NO. OF TRANSPORTING-MEDIUM PASSING PER DAY	100 AND MORE	LESS THAN 100.	MOVEMENT OF ONLY HAND-TROLLEY ON RUBBER TYRES.

2: RAMESH CHANDRA, op-cit, PP 105-108.

BASE COAT: THICKNESS

The base coat distributes the load on the earthen base below. The minimum thicknesses for different types of base coats are indicated below:

i) Sand - 60 mm

ii) Slag - 80 mm.

iii) Gravel - 80 mm

iv) Dry rubble packing 200 mm.

v) ballast layer - 80 mm

vi) Concrete -100 mm

vii) Acid proof concrete- 100 mm.

For concrete floors, the concrete for base coat should be of M100 grade. In the floors where the concentrated load does not exceed 200 kg, 80 mm thick conc. floor may be used.

4.1.3 Bedding and Jointing Materials

This is to be chosen very carefully so that it is also able to withstand the various actions on the floor, just as the floor element itself. Table 24 gives the various bedding and jointing materials that are recommended for use. Cement:coarse sand mortar is the most common material, and it is exclusively used. It is very good for use except where temperatures more than 100°C are involved, in such cases heat resistant cement should be used. where acid resistance is desired , bituminous mastics or acid-resistant cements should be used.

4.2.3 Requirements for Pottery Industry

For pottery industry the floor finish must have the following qualities:

i) Resistance to abrasions, impact, wheeled traffic of wheeled racks, industrial trucks etc.

ii) Ease of cleaning for the spilled clay ship or dry clay.

iii) Minimum number of joints.

iv) Resistance to heat in kiln areas.

v) Resistance to acids for laboratories.

During the casting, filling of moulds, pressing and jiggering, a lot of clay,or slip spills on the floor and if allowed to remain there,tends to give rise to dust when dry. Frequent cleaning or scraping is most desirable. As such the lesser the number of joints, the easier it is for cleaning or scraping. Hence for the main shop , a cast in situ type floor finish is more appropriate. Durability is indicated by the resistance qualities. A durable floor although initially costly saves in the long run on its maintenance

4.2.4 Adequate drainage is a must for all industrial floors. No matter, how well a floor has been laid, some minor depression will always be there, which would collect liquids. To avoid this, the floor finish should be sloped 1/80 to 1/60. A slope more than 1/40 is generally dangerous and makes the floor more slippery. The floor area must be designed so as to move the traffic across than down the slope.

The spillage of materials and liquids should receive proper attention because some of the best materials might show poor durability because of inadequate cleaning arrangements and lead to extra expenditure on its maintenance.

Services in floors can be best laid out in a floor duct, which should be covered with removable precast r.c.c. panels. This system has following advantages:

i) Economical

ii) Easy access,

iii) Leakage do not spoil the space as with overhead services

iv) Ease of carrying out repairs.

The top of floor duct must be in the level with general shop floor so as to ensure smooth movement of trolleys etc.

4.2.5 Economics of Floor Finishes

In the context of industrial buildings the requirements of the process almost always dictate the type of floor finish. The costliest floor finish may not always be the best suitable for the process. The cost has to be seen in the light of the advantages desired in terms of durability, resistance to impact and various agents and suitability to the process and subsequent maintenance cost. Table 28 gives a comparison on an approximate cost/sqm basis of various floor finishes from which the final choice can be made by studying cost vis-a-vis suitability.

TABLE-28: COMPARATIVE COSTS OF SOME INDUSTRIAL FLOORS Rs/Sq.M.

FLOOR FINISH	OFFICE OF KUDIANWALA BOMBAY.	PUNJAB P.W.D CHANDIGARH.	C.P.W.D	MAHARASHTRA P.W.D.	U.P. LUCKNOW DIST.	GWALIOR M.P.	JODHPUR.	CALCUTTA CORPORATION	HYDERABAD HEAD QUARTERS
CONCRETE FLOOR	27 - 30	22	27	23-25	24	20	18	24	22
GRANOLITHIC TOP.	32-35	28	36	38-40	29	30	28	34	30
CONC. +SURFACE HARDENER TOP.	46	35	37	40	34	33	30	36	32
ASPHALT CONCRETE.	20	15	15	17	–	14	15	16	16
BURNT CLAY BKS. HEAVY DUTY	8	8	7	12	11	7=30	9	9	13
TERAZZO.	35	35	32	30	33	37	32	35	38
MOSAIC.	30	33	36	35	35	35	34	36	35
HEAT RESISTING CONCRETE.	35	28	32	28-30	20	–	30	–	–

NOTE : INFORMATION OBTAINED FROM N.B.O., WHO IS PREPARING REGIONWISE SCHEDULE OF RATES FOR THE WHOLE COUNTRY.

4.2.6 Citation of some industrial floor finishes and their performance

	Industry	Type of floor finish in work areas.	Laid in the year	Performance
1.	Hindustan Sanitary ware and industries pvt ltd Bahadurgarh	concrete with surface hardener	1962	Excellent and no maintenance required excepting a few cracks in the slip house due to vibrations of machinery
2.	Bharat Heavy Electricals Ltd. Hardwar.	a) Concrete with surface hardener	1964-65	Excellent and no repairs carried out so far.
		b) Asphalt concrete	1964-65	satisfactory not so good against impact good dielectric qualities
		c) Heat resisting conc. in foundry shop.	1969	Satisfactory
3.	SP Glazed Tile Plant Kassar	Concrete with ironite topping	1970	Satisfactory (metal straps desirable)
4.	Atul Glass Industries Faridabad.	Concrete with a surface hardener	1971	Excellent no cracks or settlement
5.	Hindustan N.Glass Industries, Bahadurgarh.	Concrete with ironite topping	1973	Very good
6.	Unichem Laboratories Ghaziabad	Kotah stone	1965	Good performance.

4.2.7 Summary

From the forgoing discussion, tables floor citations and performance, following floor finishes are recommended.

i) Production areas- a) concrete with surface hardener,

b) Granolithic concrete.

ii) Kiln area and firing section: Heat resisting concrete and concrete with surface hardener respectively.

iii) Laboratories a) P.V.C.

b) acid resistant ceramic unglazed tiles.

iv) Offices, guest rooms. Marble mosaic or terazzo

v) Conference rooms a) P.V.C.

4.3. Walls

'Infactories and mills, the structure is enclosed in the masonry work like the works of a watch in its case'.

The walls act as enclosures for any factory building and this skin, in the form of surrounding walls, performs the role of a screen between the indoor and outdoor conditions. The first broad decision will be governed by the structural system and roof type adopted ie whether to have loadi bearing walls or filter walls or cladding. Factory act requires a height of about 6M inside the shop and this influences the thickness of walls. Also the parameters laid down by IS:1905-1969 structural safety of buildings: Masonry restrict the slenderness ratio to a max. of 18 which gives a minimum thickness of wall for 6M height as

$$\frac{\text{effective height}}{\text{slenderness ratio}} = \frac{6000}{18} = 334 \text{ mm i.e. } 13.5 \text{ in.}$$

or one and a half bricks. This also implies that the wall, must have a support by way of cross wall, column or a pier at every 6M of horizontal distance. These parameters when superimposed over a 15Mx15M grid (suggested as a suitable grid for pottery industry in the previous chapter) pose following problems:

a) Whether to have structural column along the outer periphery of the enclosure for supporting the roof.

b) or allow the load bearing walls to support the ends of roof structure along the periphery.

The latter is obviously the answer as the min. thickness comes to $1\frac{1}{2}$ bk i.e. load bearing. For supporting the trusses, as stipulated by IS:1905-1969, piers should not have a slenderness ratio of more than 13 i.e. the minimum thickness of pier would be 6000/13 = 461 i.e. 18 in. or 2 bks. The piers should come at a distance of 3.75 M to suit the grid of 15Mx15M and also to keep the slenderness ratio within limits apart from the overall stiffness, that is achieved, for the long and high enclosing walls of the factory.

4.3.1 Factors for Choice

The final choice is governed by the various considerations as listed below. In addition to the above parameters, the decision has to be viewed in the following perspective.

i) Structural stability,

ii) Ease of cleaning (Internal surfaces)

iii) Resistance to weathering (external surfaces)

iv) Colour of the material used.

v) cost,

vi) Possibility to extension

vii) Property to take up different finishes

viii) Thermal resistance.

ix) Fire resistance.

4.3.2 Choice of Materials

A judicious choice of building materials depending on their physical properties will cause better thermal conditions within the structure.

a) Reflective and Emissive properties

The radiation impacts on buildings can be encountered very effectively by choosing materials having favourable reflective and emissive characteristics. They are of particular importance in overheated conditions prevalent in our country. Materials which reflect rather than absorb radiation and which more readily release the absorbed quantity as thermal radiation will cause lower temperatures indoors. The reflectivity of materials to solar radiation largely depends upon colour of the surface. White materials have very good reflectivity and black ones very poor. On the other hand the characteristics of materials in regard to long wave infra-red heat do not depend upon colour . All surfaces, except shiny metal surfaces emit heat -radiation approximately at the same rate. Thus for surfaces exposed to the sun, white washing, light colours or materials made of light colour provide appropriate answer.

(b) Heat Transmission Properties:

Heat percolates through the structural elements by virtue of temperature difference between the exte: and internal surfaces. Thermal damping and time-la dependent on the thermal properties of the materia..

Promotion of Radiation and Convection Losses:

Wherever possible the areas of the exposed surfaces should be increased to reduce per unit area solar-radiation over them. Horisontal surfaces are of particular importance as they experience largest heat impacts. The radiation exchange is directly proportional to the effective surface area over which radiation is distributed. For western walls corrugated uneven surfaces like alternating recessed brick layers can provide large surface area (Fig.3.6-1). The rate of convective heat transfer to the outside air is also increased by additional surface area. Louvers over the window openings should be as far as practicable clear of the walls, to all the free air movement for cooling and for reducing the heat conduction into the building.

4.3.3 Thermal Performance Rating and Classification of Walls and Roofs in Hot Climate

An efficient building design involves not only functional aspects with respect to structural and space utilisation but also the environmental aspects. The enclosing walls and roofs should be so built as to minimise heat stress imposed by external climate. The steady and periodic thermal characteristics, which in turn depend on the thermal resistance and heat capacity of the building components, provide the basic indication of their relative thermal performance. The exposure aspect, orientation and the surface colour constitute a great deal in the heat transfer.

Rating Criteria

Suitable criteria has been evolved by C.B.R.I., Roorkee, for the roofs and walls and is given in Table No.29 and 29a. The thermal performance index (T.P.I.) acts as a guide, for making choice of materials for construction.

T.P.I: It is the relative rating of the departmental building components by taking overall effect of climatic data, thermophysical properties of Building Sections and indoor air temperature variation.

Table No.29

Basis for Thermal Performance rating of roofs and walls.

S.No.	Peak Degree hrs. P.D.H.[2] Deg C above 30°C.	Thermal Performance Index T.P.I.	Quality of performance	Remarks
1.	$\leqslant 6^\circ C$	$\leqslant 75$	Good	Preferable for better standards
2.	$> 6^\circ \leqslant 10^\circ C$	$> 75 \leqslant 125$	Fair	Acceptable
3.	$> 10^\circ \leqslant 14^\circ C$	$> 125 \leqslant 175$	Poor	Unsatisfactory
4.	$> 14^\circ \leqslant 18^\circ C$	$> 175 \leqslant 225$	Very poor	Very unsatisfactory and insulation absolutely necessary
5.	$> 18^\circ C$	> 225	Extremely poor	

Table 29(a) continued on page 166

Thermal Performance Rating and Classification of Walls-Hot Climate

(Walls with West Orientation and Solar Absorption Coeff(a) of 0.7 cement grey or brick red colour)

2. PDH 8°C corresponds to 100 in P.T.I.

S.No.	Brick Walls	Treatment external	Treatment Internal	T.P.I.	Performance
1.	11.5 cm. solid bk	1.25 cm plaster	1.25 cm plaster	164	Poor
2.	23.0 cm solid brick	-	-do-	96	Fair
3.	23.0 cm. solid brick	1.25 cm plaster	-do-	93	Fair
4.	34.5 cm solid brick	-do-	-do-	64	Good
5.	46.0 cm. solid brick	-do-	-do-	61	Good
6.	23.0 cm perforated brick	1.25 cm plaster	-do-	85	Fair
7.	20.0 cm. bk cavity wall	1.25 cm plaster	-do-	109	Fair
8.	28.0 cm -do-	-do-	-do-	78	Fair
9.	20.0 bk cavity wall filled with mineral wool	-do-	-do-	68	Good
10.	11.5 cm. bk + 5.0 cm from concrete	-do-	-do-	90	Fair
11.	23.0 cm solid bk wall	7.5 cm sand stone	-do-	76	Fair
12.	15 cm. light wt. bk (800 kg/m^3)	-	-	83	Fair
13.	15 cm. light wt. bk (400 kg/m^3)	-	-	92	Fair
14.	11.5 cm. solid bk	-	5.0 cm light wt. bk (800 kg.m^3)	95	Fair
15.	11.5 cm solid bk	-	-do-(400 kg.m^3)	111	Fair
16.	-do-	-	7.5 cm thermocole	85	Fair
17.	23 cm solid brick	-	5.0 cm light wt. bk (800 kg/m^3)	74	Good
18.	23 cm solid bk	-	-do- 400 kg/m^3)	74	Good

S.No.	Brick walls	Treatment External	Treatment Internal	T.P.I.	Performance
CONCRETE PANELS					
1.	10.0 cm precast conc. panel	-	-	223	Very poor
2.	15.0 cm precast conc. panel	-	-	173	Poor
3.	20.0 cm precast conc. panel	-	-	135	Poor
4.	10.0 cm. foamed conc. panel (siporex)	-	-	112	Fair
5.	12.5 cm. -do-	-	-	95	Fair
6.	15.0 cm. foamed conc. (siporex)	-	-	84	Fair
HOLLOW CONC. BLOCKS AND PANELS					
1.	20.0 cm dense hollow conc. blocks (2 holes)	-	1.25 cm plaster	136	Poor
2.	20.0 cm dense hollow (3 holes)	-	-do-	142	Poor
3.	20.0 cm dense hollow conc. blocks (4 holes)	-	-do-	131	Poor
4.	15.0 cm. dense conc. hollow panel (6 holes)	-	-do-	171	Poor
5.	15.0 cm dense conc. hollow panels (6 holes) (filled with foam conc.)	-	-do-	125	Fair
6.	7.5 cm. cellular unit	-	-	211	Very poor
7.	7.5 cm. -do- (filled with thermocole)	-	-	177	Poor
8.	15 cm. cellular unit	-	-	132	Poor
STONE WALLS					
1.	30.5 cm rubble masonry	-	-	89	Fair
2.	38.0 cm. sand stone	-	-	75	Good
3.	38.0 cm. granite	-	-	99	Fair

S.No	Brick walls	Treatment		T.P.I.	Performance
		External	Internal		
STONE WALLS CONTD					
4.	30.0 cm. granite	-	-	121	Fair
5.	15 cm. sandstone + 5.0 cm air space+15 cm sand stone	-	-	76	Fair
6.	-do- granite + 5.0 cm. granite	-	-	82	Fair
SANDWICH PANELS					
1.	G.I. sheet	-	-	357	Extremely poor
2.	0.64 cm.A.C. sheet	-	-	324	Extremely poor
3.	Aluminium sheet	-	-	330	-do-
4.	A.C. sheets with 5.0 cm air space	-	-	211	Very poor
5.	A.C. sheets with 5.0 cm filled with aluminium foils	-	-	146	Poor
6.	A.C. sheets with 5.0 cm thermocole	-	-	100	Fair
7.	Aluminium sheets with 5.0 cm. thermocole	-	-	94	Fair
8.	A.C. sheets with 10 cm. foam conc.	-	-	97	Fair
9.	Al. sheets with conc.	-	-	90	Fair

From C.B.R.I. Building Digest No.101

4.3.4 Internal Finishes :

The internal finishing is of great importance particularly in view of the dusty atmosphere. Having seen a number of pottery works, it was observed that the walls generally upto a height of 2 to 2.5 M above floor were covered with dust. Any finish upto this height should be easily cleaned and should be impervious to the washing. This finish should also be capable of taking a desired colour as per colour scheme. Various points requiring consideration are listed below.

a) Easy to clean,

b) impervious to washing,

c) colour of the finishing,

d) cost.

e) appearance.

Wall surfaces near the roof should always be of light colour for a better distribution of light. The various finishes have been enumerated in Table No.30.

Table No.30- Internal Finishes

S.No.	Finish	Properties	Colour and Pattern	Remarks
1.	Cement plaster	Hard and good resistance to weathering and water	can be finished in various patterns and colours.	Cheapest and the most commonly used finish
2.	Glazed Tiles	Hard and impervieus. Easy to clean	Wide range of colours and patterns.	Expensive and requires skilled workmanship cost:Rs. 4 to 7/ sft.
3.	Terasso or mosaic	Hard and impervious. can be tiles or cast insitu	A no.of colours and patterns possible.	Not very expensive .Good appearance.
4.	Stone Slabs (Tiles)	Hard and impervious to water	Different sizes can form a pattern.	Not commonly used in industries. No colour possibilities.
5.	Clay Tiles	Good wearing qualities	Available as terra-cotta tiles and a wide range of patterns possible.	Used for the decorative purposes only

S.No.	Finish	Properties	Colour and Pattern.	Remarks
6.	Ceramic mosaic (Venitian Tiles)	Good wearing qualities and impervious surface	Available in a variety of colours white, grey, blue, deep red. Smooth surface.	Expensive and good for exterior finishing.
7.	P.V.C. tiles	Good wearing qualities acid resistant Easy to clean	large range of colour and patterns.	Expensive and not commonly used. Not a hard finish though impervious
8.	Vitrum	Good weathering qualities and impervious to water. Easy to clean.	A wide range of colours and patterns possible.	Expensive and requires a skilled workmanship . Good for exterior only

4.3.5 Summary

The above discussion and the stated parameters indicate that a 34 cm. ($13\frac{1}{2}$ in.) brick wall provide appropriate answer for the enclosing structure. For external finishing c.plaster is the cheapest and the easiest answer apart from the fact that it can take any colour wash. For internal finishes upto 2 to 2.5Mheight, cement plaster and mosaic or terrazzo would be suitable. The 34 cm brick wall in addition to thermal comfort, provides ease of putting plugs into the wall at any point for supporting service ducts/pipes etc. Stone walls do not provide this ease.

For roofing with A.C. sheets or aluminium sheets, a 2.5 cm. mineral wool insulation over the sitatex boards is desirable. Mineral wool, in addition to thermal insulation, helps to absorb sound thus contributing to the acoustical quality of the internal areas. This costs about 10 to 12 paise/sft. of floor area.

External walls facing SW or W, should be white washed and if possible corrugated with alternate projecting and recessing brick layers.

4.4 SUITABLE GRID AND STRUCTURE

Several factors, functional and aesthetical, have a bearing on the problem on providing the most appropriate structural framing and roof for a factory building at the minimum overall cost consistent with the fulfilment of all requirements. The choice is not easy and has to be based on a number of considerations.

4.4.1 Relevant considerations for a Pottery Industry

These may be broadly divided under five categories:

(a) Structural considerations,

(b) Materials of construction,

(c) Services,

(d) Aesthetics,

(e) Future expansion.

The broad divisions could be further subdivided as follows

(a) Structural considerations

(i) Spacing for internal columns governed by process, machinery and equipment.

(ii) Clear internal Height,

(iii) Speed of erection

(iv) Possibility of dismantling and reerection,

(v) Cost/sqm or sft.

(vi) Overall weight on foundations.

(b) Materials of
Constructions.

i) Special requirements of a process,

ii) Nature of process,

iii) Desired floor and wall finishes,

iv) Ease of maintenance,

v) Thermal insulation,

vi) Fire resistance.

(c) Services

i) Suspension of services like ducts, pipes, fans, sliplines, light-fittings.

ii) Protruding chimney through roofs.

iii) Daylight considerations,

iv) General ventilation,

v) Roof drainage.

vi) Materials Handling- Introduction of industrial trucks.

(d) Aesthetics.

i) External shape of roof.

ii) Appearance from within

(e) Future Expansion

i) Ease of addition or extension,

ii) Problem of expansion joints.

4.4.2 Steel and Concrete Structures

In Indian context, the industrial structures are limited mainly to the two materials namely steel and concrete. It is worthwhile therefore to study the merits and demerits in respect of these principal materials used for industrial buildings. In table 31 every point enumerated, is assigned a value out of ten, to give its relative merit or demerit over other material. This system of value assignment helps to make the final choice easier and faster. (page 173)

4.4.3 Structural Grid

Decision as to the appropriateness of column spacing has to be based on various factors. While the single span roofs without any intermediate supports are the best as they offer a complete freedom for process layout , these aspects should be viewed in the following perspective.

(i) Size of the biggest machinery or equipment.

(ii) Any particular process requiring maximum space including circulation space.

(iii) In absence of intermediate supports, problem of suspending services like ducts, slip lines, pipes etc.

(iv) Comparative cost of a single span roof vis-a-vis the roof with intermediate supports of columns or stanchions.

(v) Areas requiring gantry-girder services for handling of materials.

(vi) A column spacing that would allow free movement of the industrial pallet and fork lift-trucks should the factory switch over to 'mechanised-handling' systems for materials and products.

The minimum area required for machinery or equipment or process in case of Pottery Industry is as enumerated below. This consideration is restricted to certain machinery or processes which influence the column spacing.

S.NO.	Reinforced Concrete Structure	Value Assigned out of ten for each point	Steel Structure	Value assigned out of 10 for each point
1.	Slow erectio-n (excepting prefabricated construction)	3	Faster erection	8
2.	Difficulties of suspending services like ducts, pipes, slip lines etc.	3	Ease of suspending serv-ice	10
3.	In case of future expansion the expansion joints create problems.	6	Expansion joints pose no problem in case of future expansion	10
4.	Requires lesser maintenance	8	A regular maintenance by way of painting is necessary	5
5.	No possibility of dismantling unless a specially designed prefabricated type.	2	Could be dismantled and reerected	8
6.	Chimney cannot protrude through roof at any point without a specially designed opening	3	Chimneys can be allowed to protrude at any point on the roof.	10
7.	Satisfies requirements of process	10	Satisfies requirements of process.	10
8.	Good daylight possibilities	10	Good daylight possibilities	10
9.	Wt/sqm of roof and supporting structure is more, bigger found-ations and consequent greater costs.	6	Wt/sqm of roof and supporting structure is lesser, relati-vely lighter foundations and consequent saving on costs	8

S.No.	Reinforced concrete structure	Value assigned out of 10 for each point.	Steel Structure	Value assigned out of 10 for each point
10	Withstand fire better	8	relatively weaker against fire resistance	4
11.	Acoustically shells are difficult to treat.	6	Lesser acoustical problems	8
12.	Roof shapes help general ventilation.	8	Roof shapes help general ventilation	8
13.	Possibilities of flat as well as ridge, shell, N.L. roofs.	10	Possibilities of flat roof are almost absent in present Indian context, other shapes include NL, ridge roofs etc.	6
14.	Provides better thermal insulation.	6	Poor in thermal insulation	5
15.	Flat roofs provide lesser surface area for promoting convection and radiation heat losses.	6	Sloping roofs provide greater surfaces area for promoting convection and radiation heat losses.	8
16.	Aesthetically, concrete structures offer wider scope for architects, in terms of shapes and forms.	8	Lesser scope for architects in terms of forms or shapes.	4
	Total value assigned	103/160		120/160

It can be seen from above, that for industrial buildings the steel structures offer obvious advantages over the reinforced concrete structures.

Table No.32

Machinery Equipments, Processes and the Column Spacing

S.No.	Machinery Equipment or process.	Size length	Size width	Minimum space required including circulation space around
1.	Ball Mill.	6'-0"	6'-0"	15'-0" or 4.5 M in one direction.
2.	Down draught kiln	30'-35' in dia.		50'-0"x50'-0" or 15 M x15 M
3.	Tunnel kiln	upto 400'-0"	40'-50' including 3 tracks	50'-0" or 15M in one direction.
4.	Conveyer casting process	150'-0" to 200'-0"	40'-0" including mould dryer	40'-0" or 12M
5.	Free movement of Industrial trucks-as envisaged in future development and mechanised handling systems.	-	-	50'-0"x40'-0" a column spacing as recommended by Manufacturers of handling equipment.

Looking to the above table and also with personal discussion with factory-owners and ceramic engineers, a column spacing or a structural grid of 50'-0"x50'-0" or 15Mx15M is suggested for pottery industry. It gives freedom for the process layout which can be oriented in both the directions. It may be noted that in American and British industries a 60'-0" x40'-0" or 18Mx12M is the most commonly used structural grid.

4.4.4 The choice of Roof (figs.4.4-1 to 4.4-3)

Having considered the column spacing and the merits and demerits of concrete and steel structures, finally the type of roofing has to be selected. Factories being large covered spaces, have to rely on some form of roof lighting for its major central area and that side lighting alone would be inadequate. Drainage is another important factor the needs consideration. Following types of roofs are considered for the suggested 15Mx15M grid.

Reinforced Cement Concrete	Steel
a. North Light Shell	a. Northlight roof.
b. Conoidal shell	b. Northlight roof with r.s.j principal raftor
c. Barrel Shell	c. Tubular Steel trusses with monitor.
d. Waffle floor slab with monitor.	d. Umbrella type tubular trusses with skylighting
e. Hyperbolic parabolide	e. Suspension structure.
f. Folded plate.	

4.4.5 Roof Type and the Cost Consideration

The overall cost of a roof depends upon a number of factors, and it should be seen vis-a-vis the advantages offered by a structure. The cheapest structure need not always be the choice if advantages are missing.

Shell roofs are competitive for areas over 800 sft. provided atleast eight units are built to reuse the shuttering.

Tubular steel work in roofs weighs less than 3 lbs/sft. and results in the greatest economy by way of reduced weight of steel.

From the daylighting point of view lantern light should be prefered to skylighting to ensure a uniform lighting indoors.

For having some idea as to the cost of various roofs enlisted, an estimate was made based on the cost of material, quantity and labour and tabulated. It includes only the trusses and roofing materials, slabs and beams (for concrete roofs) and does not include columns or foundations. This would vary from place to place, and every year and as such gives idea of relative costs of different roof types.

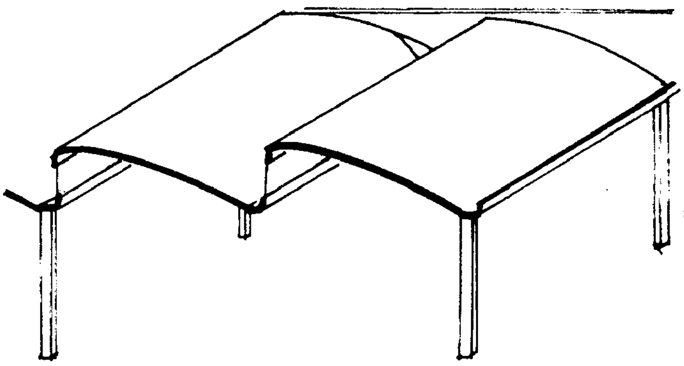
Table 33

Cost/sft. of some roofs for 15Mx15M grid

R.C.C. structure	cost/sft.	Remarks
a) North light shell	Rs.6.50/sft.	Cost includes concrete work above columns
b) Conoidal shell	Rs.6.00/sft.	-do-
c) Barrel Shell	Rs.8.00/sft.	-do-
d) Waffle floor slab	Rs.6.00/sft.	-do-
steel		
a) North light	Rs. 8.00/sft.	Cost includes trusses and covering materials
b) North light with r.s.j. principal rafter	Rs. 7.50/sft.	-do-
c) Tubular steel trusses with monitor.	Rs. 5.50/sft.	
d) Umbrella type tubular trusses.	Rs. 5.00/sft.	Reduction of cost is because of reduced weight of materials

ADVANTAGES:
- GOOD DAYLIGHT
- LESSER MAINTENANCE.
- GOOD DRAINAGE.
- EFFICIENT USE OF MATERIALS.

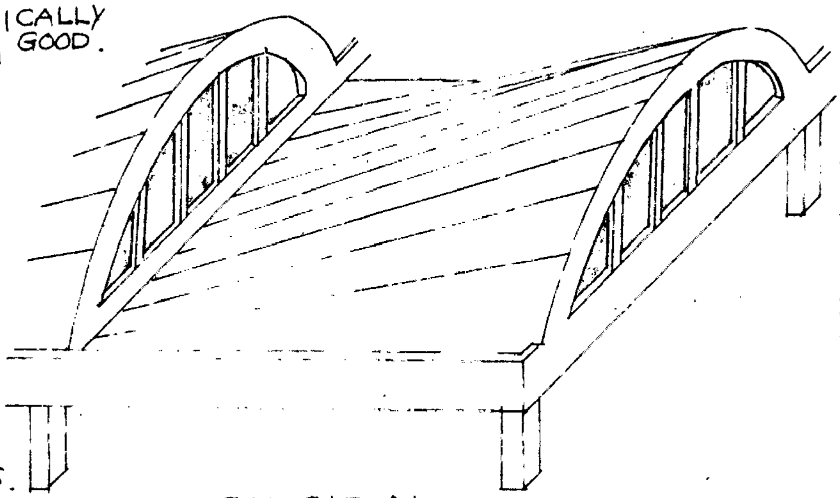
DISADVANTAGES.
- UNECONOMICAL UNLESS EIGHT UNITS ARE BUILT.
- SUSPENSION OF SERVICES DIFFICULT.
- SLOW ERECTION.
- CREATES ACOUSTICAL PROBLEMS.



NORTH LIGHT SHELL

ADVANTAGES: ÆSTHETICALLY GOOD.
- UNIFORM DISTRIBUTION OF DAYLIGHT.
- EFFICIENT USE OF MATERIAL.
- COST OF CENTRING

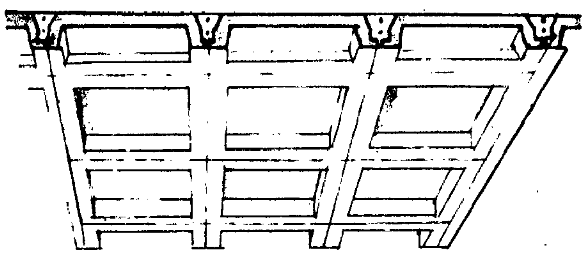
DISAD: ECONOMICAL WITH MIN. 8 UNITS.
- DIFFICULT TO DESIGN.
- SUSPENSION OF SERVICES DIFFICULT.
- GIVES RISE TO ACOUSTICAL PROBLEMS.



CONOIDAL SHELL.

ADVANTAGES:
- SITE FABRICATION POSSIBLE.
- SUPERIOR FINISH.
- FASTER ERECTION.
- GOOD SOFFIT APPEARANCE.
- SAVES ON CENTRING.
- GOOD THERMAL INSULATION

DISADVANTAGES:
- DAYLIGHT POSSIBILITIES ONLY WITH MONITOR.
- SUSPENSION OF SERVICES DIFFICULT.
- DIFFICULT TO WATERPROOF.



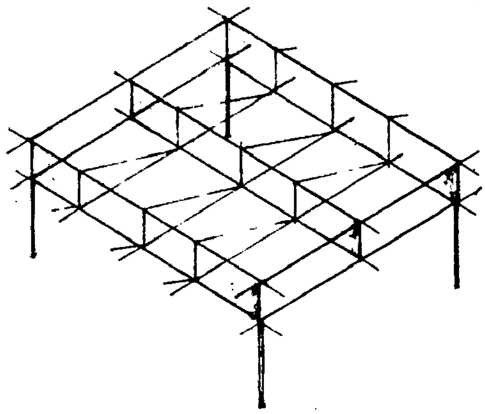
WAFFLE FLOOR SLAB.

: ROOF-TYPES : R.C.C.

FIG. 4.4-1

ADVANTAGES
- GOOD DAYLIGHT
- FASTER ERECTION
- SUSPENSION OF SERVICES EASY

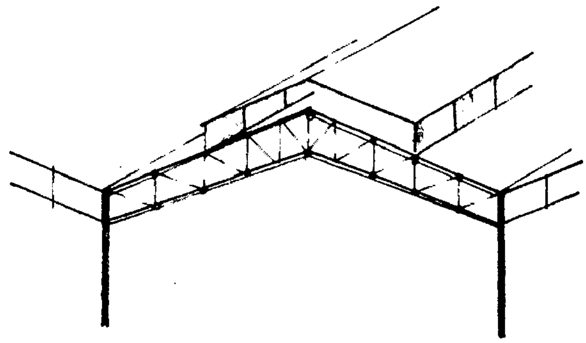
DISADVANTAGES;
- REQUIRES REGULAR MAINTENANCE
- POOR THERMAL INSULATION
- EXTRA " " COST.
- LEAKAGE FROM GUTTERS.



NORTH LIGHT ROOF.

ADVANTAGES;
- FASTER ERECTION
- LIGHT WEIGHT.
- MOST ECONOMICAL.
- EASY SUSPENSION OF SERVICES.
- GOOD DAYLIGHT.

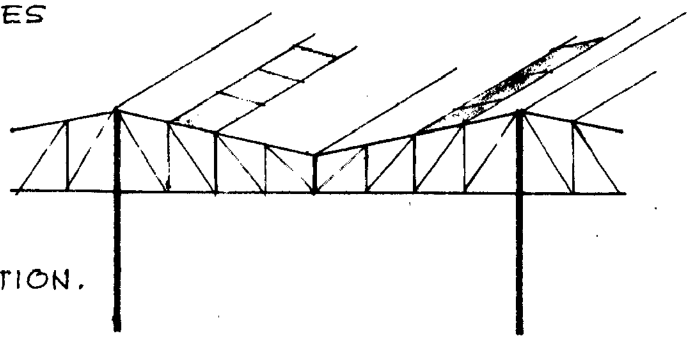
DISADVANTAGES;
- POOR INSULATION
- NEEDS REGULAR MAINTENANCE.
- LEAKAGE FROM GUTTERS.



TUBULAR STEEL TRUSS WITH MONITOR.

ADVANTAGES.
- FASTER ERECTION
- EASY SUSPENSION OF SERVICES
- ECONOMICAL.
- LIGHT WEIGHT.

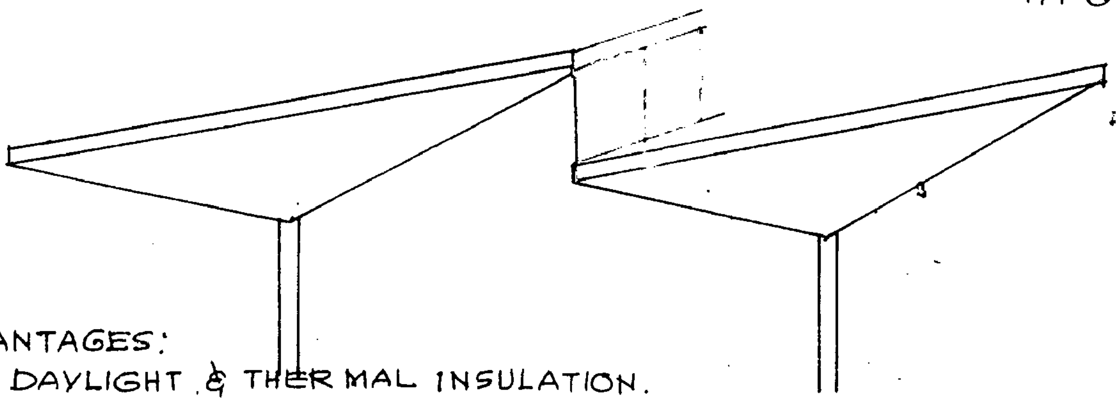
DISADVANTAGES.
- SKYLIGHT GIVES RISE TO GLARE.
- UNUNIFORM LIGHT DISTRIBUTION.



UMBRELLA TYPE TUBULAR STEEL TRUSS.

: ROOF-TYPES : STEEL:

FIG 4·4·2

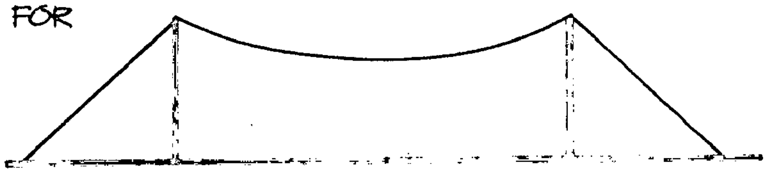


ADVANTAGES:
- GOOD DAYLIGHT & THERMAL INSULATION.
- AESTHETICALLY GOOD,
- EFFICIENT USE OF MATERIALS.

DISADVANTAGES;
- CENTRING NEEDS SKILLED WORK.
- DIFFICULT DESIGN
- SUSPENSION OF SERVICES NOT EASY.

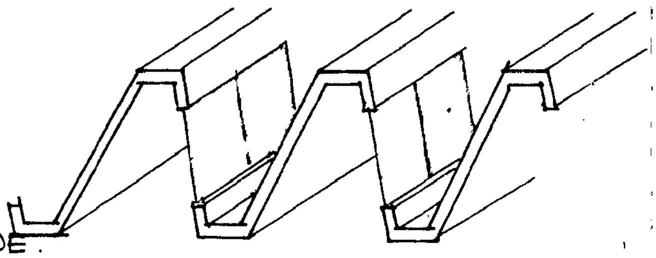
HYPERBOLIC PARABOLOID.

ADVANTAGES:
- GREATER SPANS POSSIBLE.
- EFFICIENT USE OF MATERIALS.
- FLEXIBLE & ADJUSTS FOR LOADING.



DISADVANTAGES.
- UNECONOMICAL FOR SPANS LESS THAN 100'-0".
- STIFFENING ESSENTIAL.
- DIFFICULTY OF GETTING STANDARD FITTINGS & HOLD FASTS.

SUSPENSION STRUCTURE.



ADVANTAGES.
- GOOD APPEARANCE.
- " DAYLIGHT.
- " DRAINAGE
- " THERMAL INSULATION.

ALTERNATE SIDES ARE IN SHADE.
- EFFICIENT USE OF MATERIALS.

DISADVANTAGES;
- EXPENSIVE FORMWORK
- DIFFICULTY IN SUSPENSION OF SERVICES.

FOLDED PLATE.

: ROOF TYPES :

FIG 4·4-3

4.4.6 <u>Advantages of Adequate Height</u>

There are a number of advantages offered by a height of 5.4M to 6M above floor. This has a prerequisite of stiff columns which should be designed against possible buckling.

a) Mezzenine floor can be easily introduced with sufficient head room to both the subfloors.

b) Facilitates crossing over of services like ducts, conveyers, pipe lines etc.

c) Allows overhead handling above the plant on floor.

d) Permits full use of stacking trucks.

e) Helps thermal insulation to some extent.

f) Psychologically, for vast areas, if the height is less, a feeling of depression is likely to arise which is overcome with adequate height.

g) The Factories Act stipulates a minimum height of 14-0" for r.c.c. slab roofs and 20'-0" for trussed roofs.

4.4.7 Summary

The foregoing discussion lays down guidelines for making the final choice of roof type and the structure. For pottery industry, the steel structures have obvious advantages over concrete ones, namely

a) Faster erection, possibility of dismantling and re-erection.

b) Ease of suspension of service ducts.

c) Chimney can protrude at any point of the roof.

d) Expansion of bays is easier.

In view of the above, and the 15Mx15M grid, and the following structures are suggested, in order of preference and based on overall merits.

1. Tubular trusses with monitor.
2. Steel North Light trusses.
3. Umbrella type tubular trusses.
4. Conoidal shell roof.
5. Folded plate.

Aluminium sheets are preferable to A.C. sheets as a covering material over steel trusses because, they reflect 85 to 90 percent of solar heat, require no maintenance, they are lighter, stronger and hence safer. During maintenance , aluminium sheets are more safe to be walked over than the A.C. sheets.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 BACKGROUND

It is now recognised that the areas of common ground between architecture and Civil Engineering have expanded in realm of industrial, Mechanical , Electrical and other specialised engineering projects. Their importance is all the more in collaboration rather than demarcated works in seclusion or unrelated compartmentalisation. Modernisation of this vital inter-discipline leads to superior results in all its encompassing aspects. Further in the later part of the 20th century, architecture has made a specialised contribution in respect of cost-dynamics by new rational approach that any structure infused with aesthetic qualities of merit, need not cost more than a similar structures, less pleasing or drab in its environmental coordination of the interiors and exteriors.

In this dissertation, the author has endeavoured to focus attention on the many problems confronting the architects in the design of industrial buildings in general and pottery industry in particular, followed by an analytical discussion on the criteria and principles pertaining to the design and construction of this industry.

The working environment has become as important as the production process to achieve overall operational efficiency. Why can't the working in factories be made more enjoyable with a clean, well lit, ventilated, colourful and acoustically satisfactory interior with an enclosure that satisfies the thermal and structural requirements?

5.2 CONCLUSIONS

Each chapter has been summarised at the end of its text. However to render the reference at a glance easy and in consolidated form, these have been given below for reader's convenience. Based on the studies presented in this dissertation, the following conclusions are made.

i) The most significant conclusion to be drawn from the study, is that architect with certain personalised studies, is the only specialist capable for providing appropriate envelope for industrial buildings. He is the best coordinator of various specialists and their services.

ii) Architecture of industrial buildings should be vivid enough and enhance the landscape.

iii) Industrial buildings should not upset the ecological balance.

iv) Industrial buildings should be functional in every inch of its space.

5.3 RECOMMENDATIONS

These are divided under the following broad categories.

a) Physical planning and orientation,

b) Psychological aspects and the indoor environment.

c) Fabric of the factory,

d) Welfare of employees,

e) Miscellaneous.

A system of key-references is introduced to facilitate a quick glance at the relevant text, with its citation against each recommendation.

(a) PHYSICAL PLANNING AND ORIENTATION

(i) Appropriate sequence of corelation of various units should be the basis for planning (page 45-49, Fig. 1.5-6/7 para 2.1.2 and 2.1.4)

(ii) Walls of the main work areas should be as free as possible for openings and the supervisory staff. This would make further expansion possible in any direction and openings would provide ventilation and visual rest centres for tired workers (page. 55, Fig.2.1-1a, para 2).

(iii) Special requirements enumerated should be considered while working out the design requirements (page.62-63, para 2.1.6).

(iv) Wherever possible IS:1256 recommendations should be followed in respect of minimum standards for factory design.(page 23 to 25, para 1.4.2).

(v) Cill level of windows should be 30 cm. above floor in view of a low work-plane. (page 122, para side windows, Fig. 2.1-1b)

Handling of Materials

(i) Double handling should be minimised by way of sloping storage bins (page 70-71, para 2).

(ii) Factory should be planned as one-level floor space for easy movement of wheeled racks (page 85, para iii).

(iii) Mechanical handling should be introduced with respect to stage of production. Power trucks should be used only for the fired wave and manually operated wheeled racks for the stage of formation of ware (page 67-68, para 2.2.2, fig. 2.2-1).

(iv) Furniture and wheeled racks used in formation stage should be soft lined with sponge and rubber and furniture should not be fixed to the floor to provide flexibility in its layout (page 76, para 2, fig.2.2-3, 2.2-4).

(v) Door openings in firing and warehousing section should be 3Mx3M for movement of power trucks and with shutters, sliding or rolling type (page 83, para 2).

Orientation

(i) It is strongly urged that wherever possible, the orientation should be followed as governed by the latitude of a place (page 144-145, Table 23).

(ii) Longer walls should face North and South to minimise solar heat gains during summer, and western walls should be insulated and used for godowns, storage etc. (page 144-145, para 3.6.1a, page 150, para 3.6.2)

(iii) Roof glasing should face north or south (page 146, para c).

(iv) For ventilation, in addition to windows, a system of adjustable rotating type roof wind catchers should be adopted.(page 145, para b).

(v) External surfaces of roofs and walls should be light coloured to minimise the heat gains (page. 163, para 4.3.2a)

b) PSYCHOLOGICAL ASPECTS AND THE INDOOR ENVIRONMENT
- NOISE CONTROL

(i) Slip House should be separated from other departments with a full height wall to prevent transmission of noise (page 96, para (i).

(ii) Trolleys with rubber tyres and buckets, containers of P.V.C. should be used (page 96, para (ii))

(iii) Charging platform over ball mills should have absorbent soffit and use of suspended absorption units near jaw crushers in recommended. (page. 98, para v).

(iv) Workers in slip house should have change of shift to other departments every 4 hours, to reduce exposure time to noise (page 99, para v).

(v) Use of ear plugs with 80 percent deafening capacity is recommended so that warning noise from machinery could be heard and subsequent injury or damage prevented (page.99, para (i), Fig.3.2-2)

Dust Control:

(i)Dry grinding processes should be enclosed from the sliphouse (page 114, para c)

(ii) Workers engaged in charging of jaw crushers, ball mills, loading and unloading of downdraught kilns should use dust mask or atleast a massaline cloth covering nose and mouth (page.114, para 3).

(iii) The fettling and spray glazing operations should be carried out only in ventilated hoods. (page.111, para (a), Fig.3.3-1 and 3.3-2).

(iv) Use of industrial dust-cleaners is recommended for fast removal of the spilled material (page 113, para (c), Fig. 3.3-2).

(v) Workers should be compelled to take bath with detergent soap at the end of each day's work and as such,washing facilities should be provided accordingly (page.115,para (f)).

Lighting

i) There should be more reliance on day light and to get the required DF x indoors, glazing area should be in relation to floor area.(page 120-122, Fig.3.4-5).

ii) Illumination levels should be in accordance with IS:6060-1971 Code of Practice for the day lighting of factory buildings (page.118, para 3.4.2, Table 14).

iii) Use of day light fluorescent tube lights with 'inbuilt reflectors' is recommended for the dusty sections like slip house, fettling and glazing hoods. (page.127, para (e), Fig.3.4-4).

iv) For correct colour-identification use of daylight fluorescent tube lights is recommended for decorating section (page. 123, para 3.4.6).

v) Overall lighting system should be based on combination of fluorescent tubes and filament lamps as a precaution against voltage fluctuation or power failure (page. 124, para 3.4.8) and (page 126, para (a))

vi) Fire fighting equipments should have adequate illumination during light to overcome Purkinje effect (page 135, Fig.3.5-1, para 3.5.3).

Colour

i) Colour scheme should be based on cool colours such as green or blue with predominance of light coloured surfaces. (page 139, para 1 and 3.5.5).

ii) Preference should be given to pastel shades over glossy, and bright colours to minimise the glare (page.136, para 3.5.4(a)).

iii) All wheels, levers and fencing on machinery should be given a warning colour for early eye detection. (page. 137, para iii).

iv) Walls near the ceiling should be white for uniform distribution of light (page.136, para 3.5.4(a).

Fabric of the Factory

Floor Finishes

i) For work areas, use of concrete with surface hardener or granolithic finish is recommended, for firing section use of heat resisting concrete floor is recommended and for administrative areas use of terrazzo or mosaic and for laboratory use of acid resistant tiles is recommended. (page 157, para 4.2.3, page 160, para 4.2.6, Table 24).

Walls

i) Enclosing walls should be of 1½ brick thickness, with external surface plastered or cement pointed (page 161-163, para 4.3 to 4.32a)

ii) Internal surfaces upto a height of 2.5M to 3M should be finished with mosaic for ease of cleaning and the possibility of desired colour with mosaic finish (page. 168-169, para 4.3.4 Table 30).

Structure

i) A column spacing of 15Mx15M is recommended as representative of economy, a reasonable degree of flexibility and minimum obstruction to process or machinery(p.175,Table 32).

(ii) Tubular steel structures should be preferred to r.c.c. structures for the various advantages pertinent to pottery industry (page. 173-174, Tables 31 and 33).

(iii) Roofs should have thermal insulation to minimise heat transmission indoors (page.148 Table 21)

(iv) Preference for structure (in order of merit) Tubular shell trusses with monitor, steel N.L. trusses; umbrella type tubular trusses; conoidal shell; folded plate (page 178-179, para 4.4.7, figs.4.4-1 to 4.4.3)

(d) WELFARE OF EMPLOYEES

i) Facilities like wash rooms, canteens, toilets, drinking water, recreation, rest rooms, grain shops should be provided (page 23 to 25 para 1.4.2).

(ii) Precautionary measures like dust masks, bath at the end of each days' work, use of spitoons, should be enforced by the management and so also the regular medical (check-up system (Page. 115, para f).

(e) MISCELLANEOUS

(i) The I.S.I. and office of the Chief Inspector of Factories should establish better coordination and frame comprehensive parameters in respect of minimum standards for factory design. (page. 36-37- Para 1.4.7).

(ii) The 'IS:3483-1965', Code of Practice for Noise Reduction In Industrial Buildings' should be revised in respect of

SPL and the time of exposure as pointed out (page. 95, Table 7 and Para-Observations).

(iii) In general, a good house keeping shouldbe scrupulously followed in respect of, cleaning of floor spillings, roof glazing, walls, lighting fixtures, periodical colour washing, oiling of machinery. This would render the indoor environment ever clean, fresh and hygienic, colourful, quiet and consequently conducive to efficiency.

The author hopes that the suggestions will prove useful, in planning of new factories or in improvement of existing ones. If this work has helped in throwing some light on the planning considerations of an industry or even kindled in others the urge to carry it on further, the author will feel highly rewarded.

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A P P E N D I X

GLOSSARY OF CERAMIC TERMS

B

BAT: The sheet of plastic body spread on the plaster mould at the instant the jiggering operation is started.

BATTER OUT: The operator who makes the bat.

BELLEEK WARE: A variety of ware originating at Belleek in county Fermanagh, Ireland, consisting of cornish stone & china clay. It has a Parian body & a lead-glaze similar to that used on English bone china. The term is applied to bodies having a high translucency, usually enhanced by the use of frits.

BINDER: This usually refers to organic or inorganic agents that increase the plasticity & mechanical strength of ceramic bodies in the green state.

BISQUE OR BISCUIT FIRE: The first fire used in China process. In this fire, the body is matured.

BITT STONE: Coarse silica granules used as supporting medium in the glost firing of hollow ware.

BLEB: A blister.

BLUNGER: A mixing tank used in the preparation of ceramic slips, slurries.

BODY: The structural portion of a ceramic article (less the glaze) or the material or mixture from which it is made.

BONE CHINA: A translucent vitrified china body in which bone ash is one of the principal fluxes. It is manufactured mainly in England & is characterised by its white colour and high translucency.

BOX: To stack hollow ware preparatory to firing.

BUNG WARE: A stack of ware.

C

CAST: To pour a deflocculated suspension of ceramic body in water, into a plaster of paris mould & allow the water to be removed by the plaster forming the shape of the mould. The resulting object is of approx. uniform thickness; when the desired thickness is obtained, the slip remaining is poured out of plaster mould. ~~Ditto~~; Solid Casting refers to the process of casting, in which there is no pour-off & by use of cores, solid objects are formed.

CLAY-UP: To place dry refractory clay between the flat green-ware; This operation prevents the ware from sticking during the bisque-fire & supports it in the fire.

COB: A small pile of pulverized refractory clay placed between the flat-ware to prevent slumping in the fire.

COTTLE: A temporary device for confining plaster-slurry against the surface to be reproduced.

CRACKLE - WARE: A term applied to glazed ware, in which glaze is crazed. It is possible to control the size & location of craze pattern; the finer the pattern, the greater the value. Colouring agents were rubbed into the craze marks, enhancing the ware-value.

CRAZED WARE: A term applied to hair cracks, sometimes appearing on a glazed ware. There are two types:

1: where the coeff't of thermal expansion of the glaze is greater than or approx'ly equal to that of body, the glaze is thrown into tension & usually crazes. The coeff't of expansion of glaze must be less than that of body to throw glaze into compression & make it safe against crazing; this is known as glaze-fit.

2: In the case of glazes, on semi-vitreous bodies, crazing sometimes develops after long usage, owing to the fact that the body is porous & moisture entering this porous structure produces a partial de-hydration resulting in an expansion of the body which throws the glaze into tension & crazing results; this second type being known as delayed- " .

D

DECAL-COMANIA: A multi-colour process used in decorating pottery. The technique of lithography in the ceramic industry is essentially the same as ordinary lithography except that colours must be resistant to the fire & fluxes used to fuse the colours to body or glaze: Two methods used:

1. **UNDER-GLAZE DECORATION**: in which the colours are applied to the body & glaze is applied over the colours.
2. **OVER-GLAZE DECORATION**: in which colours are applied over the glaze & fluxed to glaze to resist the wear & washing.

DECORATING FIRE: The fire in which the over-glaze decoration is normally fixed over to the glaze.

DE-FLOCCULANT: An agent used to liquify or reduce viscosity of clay-slips.

DOPE: A flocculant or de-flocculant; acids or acid-salts usually act as flocculants & bases or basic salts as de-flocculants; Neutral salts in the presence of clays act as acids due to preferential ion-adsorption.

DRY-MIXER: An edge-runner mill, which is used principally for mixing air-floated dry materials.

DRY-PAN: An edge-runner mill used for grinding & mixing dry materials.

DENTING / DENT: A type of body-failure or cracking that results when the ware is cooled too fast. The fracture is con-choidal, with a high sheen as distinguished from fractures due to impact.

E

EDGE-RUNNER -MILL: A type of mill for mixing or grinding in which the treatment is carried out by the pressure between one or two large millers on the face of the mill.

ENGOBE: An intermediate layer between the glaze & the body. This layer is usually opaque & hides a body of inferior quality or acts as a background for coloured decoration. It often contains ceramic colour & is then referred to as engobe or coloured-slip.

ETCHED -DECORATIONS: This method is one in which a design is etched into a glaze by means of hydrofluoric acid & such design is usually accentuated by means of gold decorations or colours; the negative of the design is printed on the glazed ware-called a 'resist'. The exposed part is etched & the resist is then removed & etching coloured or gold-coloured.

F

FETTLE: To remove the fins from leather hard or green-ware.

FINISHER: The operator who sponges the dry ware to remove the irregularities, imperfections in the shape.

FLOCCULANT: An agent used to "set up" or gel a clay slip or glaze.

FRITTED -GLAZE: The suspending medium used in most glazes is water & it is necessary to reduce the solubility of all ingredients in this medium to obtain uniform composition throughout the glaze suspension. It is necessary to fuse a part of glaze to the glass in order to have low solubility, the fused portion is called "frit" & a glaze made of part frit & part raw-constituents is a fritted glaze.

G

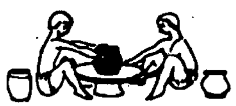
GAGES: Blocks of steel used used to set the profile of "jigger-arm".

GLAZE - WARPAGE: In glazed semi-vitreous bodies with high absorption, the glaze is often much stronger mechanically than the body & when these glazed bodies are cooled, the difference in expansivities of the body & glaze is made evident by the warpage of the body.

GLOSSARY : CERAMIC TERMS

1

A. L. CHHATRE.



GLOST FIRE : The second fire used in china process in which the glaze is fixed on to the bisquit.

GOLD DECORATIONS : There are 3 forms used :
1 Burnished gold ; in which the gold, in a fine powder form, is suspended in a vehicle containing the proper fluxes, is applied to ware by brush or a print. This form comes from kiln with a dull texture. It is brightened by burnishing with round sand.
2 Bright gold : which is a liquid gold resinate, is applied to the ware by brush or print. Bright decoration, coming out of kiln needs no polishing.
3 MATTE GOLD : is somewhat similar to burnished gold, but the surface is not polished (burnished).

GREEN-WARE : The unfired, formed ware.

HAND-FILL : A process for decorating in which the outline of the design is transferred to the ware as a print & the remainder of the decoration completed by brush with suitable vehille & cer colour.

HARDENING-ON : In underglaze decorating it is often necessary to remove the printing medium from the ceramic colours by firing before the glazing & this process is known as hardening-on decorations.

JIGGER : A machine for forming pottery that consists of a horizontal head on which is mounted a plaster mould & a lever-arm which can be moved through a vertical angle above the rotating head. The lever-arm carries a "profile", which when brought into contact with the plastic clay, spread on the plaster mould, forms either the inside or outside of the ware being formed.

KNOCKINGS (TAILINGS) : The coarse fraction remaining on top of the screen during the lawning operation.

LAWN : A sieve or screen made of silk fibres, also refers to "metal-screens".

LINE : A term used to describe the process of line-decorations to ware by brush carrying a liquid vehicle with ceramic colours.

NATCH : small guides that serve to hold the various parts of a "plaster-moud" in correct position. They consist of 2 parts: MALE, FEMLE.

PARIAN-PORCELIN. : A body of high translucency used chiefly for figures & decorative ware. It is supposed to resemble "PARIAN MARBLE". It is of a high felspar content having a characteric texture.

PEELING : A defect in pottery that results when there is an improper fit between body & glaze. In this case the glaze or the engobe flakes off the body.

PERIODIC KILN : A batch Kiln.

PLACE : To place ware in a sagger or other refractory objective prepatory to firing.

PRINT : A process of ceramic decoration in which the design is first printed from an engraved copper plate or roll onto a "tissue-transfer paper" & then transferred to the ware. The paper is removed by soaking in water. The medium used for carrying the ceramic colours is known as printer's oil.

PROPS : refractory posts for supporting slabs.

PUG MILL : A form of auger machine for mixing plastic bodies. From this auger, the plastic body is forced into a mouth-piece, that shapes the plastic body into column, which is cut into convenient lengths called "pugs" (puggings) or blanks.

PYROMETRIC CONES (SEGAR CONES) : small triangular pyramids of ceramic compositions used to measure temperature, when a definite "time-temperature" cycle is followed. The conditions of use of such as "time-temperature"s gas-atmosphere must closely simulate those used at the time of calibration, in order for the cones to be of much value.

RIDDLE : A filter screen.

SAGGERS : refractory box-like shapes used to hold the ware during firing.

SAND-UP : To place sand between flat green-ware preparatory to firing. This serves to support the ware in the bisque-fire.

SETTERS : refractory bats for supporting ware during firing.

SHIVERING : This term is used to denote the 'reverse' of crazing; in other words, the coefficient of thermal expansion of body is very much greater than that of the glaze & the glaze fails by compression. This is particularly noticable on sharp edges where stresses are the greatest.

SIZE (MOULD) A soft potassium used as a parting agent between the parts of a plaster mould.

SLIP OR SLURRY : A suspension of ceramic body or glaze ingredients in water.

SPARE : When it is undesirable to use a "knife-trimmed" edge on ware, an addition is made to the mould to cast the edge. This additional part of the mould is a 'spare'.

T-VALUE : The temperature at which the resistivity of an electrical-insulator becomes equal to 1 megohm/cm/sq.cm.

THROWING : The shaping of ceramic ware by the hand from a mass of plastic body while it is revolving on potters' wheel.

TRIM : To remove undesirable 'build-up' formed in the casting process.

TUNNEL KILN : A type of kiln in which the ware is placed on cars & the cars are pushed through a tunnel. The ware gradually passes into the hottest part of the tunnel & afterwards into the cooling zone.

VACUUM PUG MILL : An auger machine in which the plastic clay is forced thro' small slits, thus forming ribbons, into a chamber that is evacuated. The reduced pressure in the chamber tends to remove the entrapped air from the body. The ribbons are reformed in a second auger, which is also under reduced pressure, into a homogeneous column of plastic clay, which is then extruded thro' a die or mouthpiece.

WAD : wet plastic extruded rods of refractory compositions used to seal saggers during firing of ware.

WET PAN MILL : An edge-runner-mill used used to grind & mix wet plastic materials.

WHIRLER : A small rotating table used by modelers & decorators in shaping & decorating ware.

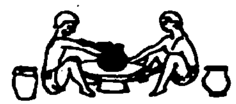
REF : ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY : VOL 5 : ECT-KIRK.

GLOSSARY : CERAMIC TERMS

2

CONTINUED FROM 1.

A. L. CHHATRE.



CERAMICS : मृच्छिल्प, मृत्कला, मृत्तिका शिल्प,
कुलाल विज्ञान, कुझागरी,
KERAMICS (GERMAN), CERAMIQUE (FRENCH)

CERAMIC DECORATION : मृद्भांड अलंकरण

CERAMIC REMAINS : मृद्भांड अवशेष

CERAMIC INDUSTRY : मृत्कला शिल्प उद्योग, कुंभकार उद्योग,
मृत्तिका उद्योग,

CERAMIST : मृत्तिका शिल्पी, कुझागर, CERAMISTE (FRENCH)

CERAMIC : मृत्तिका शिल्प विशेषज्ञ.

POTTERY : मृद्भांड उद्योग, मृत्तिकाभांड उद्योग, POTERIE, (FRENCH)
कुंभकारी, कुम्हारकी कला,
चिनीमाती उद्योग,

POTTER : कुम्हार (हिंदी) कुंबार (कन्नड)
घुमयार, कुम्हार (पंजाबी)
क्राल (कश्मिरी) कुंभकार (संस्कृत)
कुंभारु (सिंधी) कुंबुकरू (सिंहली)
कुंभार (मराठी, गुजराथी)
कुमोर (बंगाली)
कुमार (आसामी)
कुम्हारॉ (ओडीया)
कुम्मरी (तेलुगु)
कुयवन् (तामिल)
कुशवन् (मल्यालम्)

: SOME EQUIVALENT WORDS

APPENDIX II

APPENDIX III

ARCHITECT'S CHECKLIST APPROACHING THE DEVELOPMENT

This checklist is included so as to be useful while planning individual units. This would ensure that every relevant aspect is given due regard while coming to finaldesign solution, and that nothing is missed through oversight.

1. SITE

a. Map, number and scale.
b. Site information, observation, local enquiries. (see boring engineer and surveyor).
c. Name and site occupant (if any) legal implications if any.
d. Configuration and levels of site.
e. Position on site unsuitable for building (water logging etc.)
f. Plot trees and other features.
g. Evidence for any previously existing building.
h. Type and use of adjoining property.
i. Ancient lights, rights of easement.
j. Condition of boundaries.
k. Nature of road accesses.
l. Any portion reclaimed by filling.
m. Nature of soil and subsoil.
n. Trial hole records and foundation conditions of adjoining sites.
o. Bearing capacity of soil.
p. List of names, addresses and telephone numbers of authorities.

2. BYE-LAW AUTHORITY

a. Collect copy of local byelaws.
b. Collect copy of factory act.
c. Discuss with factory inspector.

3. TOWN PLANNING AND LOCAL AUTHORITY

a. Area planning office.
b. Applications to appropriate authorities.
c. Land zoning.
d. Floor space index/floor area ratio.
e. Development restrictions in terms of heights, materials etc.
f. Elevational treatment of adjoining properties.

4. HIGHWAY AUTHORITY (IF DIFFERENT FROM LOCAL AUTHORITY)

a. Nature of road accesses in terms of widths and finish.
b. Repaired and maintained by.
c. Any new proposal for roads.
d. Restrictions on access to site, permanent and for building purposes.
e. Any road restrictions such as for heavy vehicles or light vehicles.

5. RIVER BOARD FOR RIVERS AND FLOODING

a. Is site likely to flood.
b. Record of flood levels.
c. Is the river usable for transport.
d. Is the river usable for potable water supply.
e. Nature of effluents and is their discharge allowed in the river.
f. Is the river perineal .

6. DRAINAGE

a. Nature of public sewers - combined or separate.
b. Nearest sewer, position, size and invert levels.
c. Alternative solution if no public drainage systems exist.
d. Suitable location for a disposal pt.
e. General slope of site.
f. Is subsoil drainage necessary for the waterlogged areas.
g. Any stream or nallah and its suitability for discharge.
h. Soaking capacity of soil.
i. Effluent considerations.

7. WATER SUPPLY AUTHORITY

a. Sources of water supply.
b. Position of municipal water main, size, pressure.
c. Suitability of water for the industry.
d. Position of hydrants.
e. Possibility of tube well supply.
f. Water tests as to hardness, acidity etc.
g. Name, address and telephone number of fire officer/station.
h. Water softening plant, degree of purification.
i. Overhead tanks etc.

8. ELECTRICITY SUPPLY AUTHORITY

a. Sources of supply
b. Overhead or underground supply.
c. Type - A.C./D.C.
d. Voltage - if A.C., single or 3 phase.
e. Govt. restrictions on use of power.
f. Desirability of a self owned generator / Essential.
g. Generator - capacity, feasibility.
h. Location of electrical substations.

9. GAS SUPPLY AUTHORITY

a. Nearest source
b. Size and pressure
c. Possibility of using gas from sewage disposal plants.

10. TELEPHONES AND TELEGRAPHS

a. Local service, overhead or underground.
b. Telex service if available.
c. Number of connections permissible.
d. Nature of 'intercom' system.
e. Telegraph office.

11. HEALTH RESTRICTIONS

a. Smokeless zones.
b. Discuss with factory inspector.
c. Nature and degree of air pollution, water pollution from various processes.
d. Effluents and toxic effects and disposal.

12. RAW MATERIALS

a. Raw materials used - list.
b. Method of delivery/transport.
c. Frequency of delivery/transport.
d. Nature and size of storage.
e. Method of handling.
f. Method of stacking.
g. Unit quantity, capacity of days/consumption - storage requirements.
h. Special storage - if any - such as controlled humidity etc.
i. Weigh bridge.

13. CONTRACTORS AND SUPPLIERS

a. Complete list of local contractors.
b. Suppliers of local materials likely to be used.
c. Availability of local materials.
d. List of reputed contractors experienced in similar projects alongwith their credit commanding capabilities.

14. PRODUCTION PROCESS

a. Details of process lines to be discussed with production engineer.
b. Timing, duration of various processes.
c. Approximate number of operators seating and standing.
d. Raw materials used in each process.
e. Method of conveying raw materials to production areas.
f. Extent of mechanical handling.
g. Schedule of machinery, weights, sizes, type of mountings.
h. Optimum lengths, widths, heights for processes and working levels.
i. Amount of waste from each raw materil and its removal.
j. Nature of effluents from each process and method of disposal.
k. Method of stacking processed articles.
l. Inspection arrangements.
m. Services required for each process i.e. electricity, water gas etc.
n. Sizes, turning circles etc. of material - moving machinery.
o. Daylight requirements for processes.
p. Temperature and humidity control for processes.
q. Fumes, dust given off by processes.
r. Noise level in decibles.
s. Total number of persons involved in production process male and female.

15. PACKING

a. Method of containing finished articles, size and weight of each packed unit.
b. Volume or quantity of articles stored prior to packing.
c. Special packing arrangements for exports or long distance delivery.
d. Cartons, containers, boxes etc. produced on site.
e. Nature of packing materials.
f. Fire protection required for combustible packing materials.
g. Extent of mechanical handling.
h. Size, turning circles etc. for the handling equipment.
i. Services required in packing processes.
j. Total number of persons in packing - male and female.
k. Arrangements for check by excise officers.
l. Allied workshops, weigh bridge.

16. WARE HOUSING

a. Items to be stored in ware house.
b. Method of delivery in ware house.
c. Method of handling in ware house.
d. Method of stacking in ware house.
e. Number of separate categories of storage.
f. Loading/unloading platforms, levels of truck-platforms, stop-bars.
g. Total number of persons - female and male working.
h. Degree of fire resistance required.

17. VEHICLE MAINTENANCE SERVICE

a. Number and type of vehicles.
b. Extent of maintenance undertaken.
c. Pit system, lifts, compressors, washing arrangements etc.
d. 'Spare-parts' storage.
e. Refuelling arrangements.
f. Number of vehicles to be housed.
g. Total number of persons involved.
h. Nature of materials used for construction of service areas.

18. BUILDING MAINTENANCE SERVICE

a. Scope of work undertaken.
b. List of materials in storage.
c. Overall works cleaning arrangements.
d. Overall office cleaning arrangements.
e. Total number of persons involved.

19. MECHANICAL, ENGINEERING SERVICE

a. Scope of work undertaken.
b. Number and types of maintenance workshops.
c. List of fixed equipment alongwith their loads for foundations.
d. Service requirement in processes.
e. Storage requirement.
f. Total number of persons involved.
g. Compressed air service.

20. GENERAL AND WORK OFFICES

a. Departments - where they are required.
b. Schedule of persons by grades.
c. Furniture and storage requirements - files etc.
d. Hours of use.
e. Essential grouping or association of persons.
f. Intercom and telephone facilities.
g. Relationship - general offices, reception and showrooms.
h. Any strong rooms for each departments.

21. SPECIAL ACCOMMODATION

a. Show room, reception, waiting rooms.
b. Storage.
c. Conference rooms.
d. Library, dark rooms etc.
e. Laboratories.
f. Training centre.
g. Guest house or mess.
h. Medical centre.
i. Scope of chemical work undertaken.
j. Furniture and equipment required.

22. Environmental control (internal)

a. Air conditioning required for offices, laboratories, storage or processes - central or window type.
b. Special temperature, humidity requirement.
c. Heat source - heating system.
d. Fuel storage.
e. Heat distribution and emission.
f. Possibility of using kiln heat.
g. Any drying required by process.
h. Ventilation, number of air changes etc.
i. Dust control by exhaust system.
j. Use of industrial dust cleaners.
k. Artificial lighting - colours, illumination levels, type of fittings etc.

23. FIRE FIGHTING

a. Schedule of fighting equipment.
b. Nature of processes and materials and their combustibility.
c. Chemical extinguishers, sprinkler system, fire alarm, hydrants.
d. Means of escape.
e. Fire brigade telephone number.
f. Degree of fire resistance governed by type of materials used.
g. Fire insurance.

24. COMMUNICATIONS

a. Road transport.
b. Rail transport and nearest railway station.
c. Water transport.

25. WORKERS' FACILITIES

a. Scope of facilities.
b. Housing - staff and workers, security staff.
c. Recreational - for staff and workers.
d. Rest rooms.
e. Wash rooms, toilets, drinking water, locker rooms.
f. Canteen facilities - area, kitchen, toilets, storage, kitchen yard, fuel, access to trucks, vans etc.
g. First aid rooms.
h. Union rooms.

26. SPECIAL REQUIREMENTS OF STAFF/WORKERS

a. Protective clothing and equipment worn and where.
b. Locker space.
c. Laundry arrangement.
d. Dust masks, crash helmets etc. goggles, radio active protection.

27. SPECIAL REQUIREMENTS - BUILDINGS

a. Floor finish - acid, alkali, impact, abrasion, oil resistant etc.
b. Walls - colour, cleansability, insulation.
c. Roof - height, insulation required, water-proofing, admission of light and ventilation.
d. Structure - suitable grid, fast erection, possibility of dismantling and re-erection. Ease of suspending ducts, lighting equipment etc.
e. Desired orientation and feasibility.
f. Heights as per process.
g. Elevated storage tanks for oil, water. etc.

28. TRANSPORT

a. Parking for cars and lorries.
b. Garaging or covered areas for above.
c. Number of bicycles, scooters, motor-cycles, cars and staff cars.
d. Pedestrain traffic.
e. Separation of vehicular and pedestrain traffic.

29. CONTROL

a. Checking in arrangements.
b. Time offices.
c. Communication with office.
d. Weigh bridge.
e. Fencing.
f. Night watch/security.
g. Accommodation for security staff - residential - preferably on site.

APPENDIX IV

FORMALITIES FOR APPROVAL OF PLANS

Architect should be conversant with the procedure for approval of plans in respect of industrial buildings. The final approval is given by the Chief Inspector of factories of respective states. This procedure, as laid down in the factory rules is given together with the forms (No.1 & 2) and the accompanying questionnaire that is to be annexed to Form No.1. It also specifies the type of drawings and information required to be submitted. Architect and engineer, both are considered as qualified persons to give the certificate of stability.

Architect after getting the process diagram from manufacturer or the ceramic engineer, should prepare plan within the framework of planning parameters as laid down by I.S. code and factories Act, in respect of minimum standards and with due regard to the following sections and subsections :

(1) Health

Cleanliness, disposal of wastes and effluents, ventilation and temperature, dust and fume, artificial humidification, overcrowding, lighting, drinking water, latrines and urinals, and spit rooms.

(2) Safety

Fencing of machinery, work on or near machinery in motion, casing of new machines, hoists and lifts, lifting equipment, revolving machinery, pressure plant, floors, stairs and means of access, pits and sumps, excessive weights, protection against fire.

(3) Welfare

Washing facilities, facilities for storing and drying clothing, sitting, first-aid-appliances, canteens, shelters, rest rooms and lunch rooms, creches etc.

In case of special situations and difficulties, he should obtain clarification on provisions of act from the Regional Factory Inspector.

Once the plans are submitted to the Regional Factory Inspector, he on scrutiny, recommends it for approval, to the Chief Inspector of factories. The Chief Inspector in turn sends certificate of approval, to the regional factory inspector with its copy to the applicant.

Before the execution of plans, it is necessary to take concurrence from :

a. Local authority.
b. Electricity board (for grant of required power).
c. Local fire authority (for provision of fire fighting equipment as stipulated by them).

Extracts from Factories Rules Section 6(1) and 112.

3. Approval of plans : (Section 6(1) & 112).

1) No building in a factory shall be constructed, reconstructed or extended nor any manufacturing process be carried on in any building constructed or extended or taken into use as a factory after the date of enforcement of this rule, unless previous permission in writing is obtained from the State Government or the Chief Inspector.

Application for such permission shall be made to the Chief Inspector of Factories through the Inspector of Factories of the region concerned in the prescribed form No.1 which shall be accompanied by the following documents in triplicate.

a) A flow chart of the manufacturing process supplemented by a brief description of the process in its various stages.

b) Plans in triplicate drawn to scale showing -

(i) the site of the factory and immediate surroundings including adjacent buildings and other structures, roads, drains etc., and

(ii) the plan, elevation and necessary cross sections of the various buildings including all relevant details relating to the natural lighting, ventilation and means of escape in case of fire. The plans shall also clearly indicate the position of the plant and machinery aisles and passage ways.

c) Replies to the questionnaires annexed to form No.1.

d) Such other particulars as the Chief Inspector may require.

2) If the Chief Inspector is satisfied that the plans are in consonance with the requirements of the Act he shall, subject to such conditions as he may specify, approve them by signing and returning to the applicant one copy of each plan or he may call for such other particulars as he may require to enable such approval to be given.

3) No manufacturing process carried on with the aid of power shall be begun or carried on in any building, or part of a building, until a certificate of a stability of a building or part of buildings in Form No.2, signed by a person possessing the qualifications prescribed in sub-rule (4) has been delivered to the Chief Inspector through the Inspector of Factories of the region concerned and accepted by him. No extended portion of any factory shall be used as a part of the factory any time after the extension nor any plant or machinery shall be added in any factory, nor brought into the use any time after such addition until a certificate in respect of such extension or plant has been delivered to the Chief Inspector through the Inspector of Factories of the region concerned and accepted by the Chief Inspector of Factories.

4) The person signing Form No.2 shall possess one or other of the following qualifications :

(a) Corporate membership of any of the following institutions.

(i) The Institute of Civil Engineers.
(ii) The Institute of Structural Engineers.
(iii) The Royal Institute of British Architects.
(iv) The Institute of Engineers (India) together with a degree of a recognised Civil Engineering College in India, provided that he has also been for three years in bonafide practice on his own account as Chief Assistant of a recognised firm of Civil Engineers, or

(b) Such other qualifications as the Chief Inspector of Factories may approve.

5) No person except in the case of building occupied by any Government shall be authorised to sign a certificate of stability, who is in the employment of the owner or a builder of the building in respect of which the certificate is given.

6) (i) The internal height of a work room shall be not less 14' measured from the floor level to the lowest part of the roof, and if the roof is of corrugated iron, which is neither covered with tiles nor has an inner ceiling or lining of heat resisting material with an air of atleast 4" between it and the corrugated iron, the internal height shall not be less than 20'.

Provided that in the case of building having a brick or concrete roof, or a combination of the two, the minimum height may be 12 feet, if approved by the Chief Inspector of Factories.

Provided further that in case of all factories registered under section 2(m)(ii), and factories registered under section 2(m)(i) of the Act employing upto 50 workers, the Chief Inspector may where he is satisfied that the conditions of work are reasonably good, exempt such factories from the provisions of this sub Rule.

FORM No.2
(Rule 3(3))

Certificate of stability of a factory or a part of factory

To be submitted after completion and before working

I hereby declare that I have personally examined the plans and specifications of the building described below, the actual materials and methods used in its construction, and the finished building and am satisfied that its construction is such that its stability will be satisfactory when used as factory or part of a factory for the purposes of herein declared.

Description of building

1. Name of the factory.
2. Name of builders or contractor(s).
3. General type of construction
   (a) Full name of signatory (in block letters).
   (b) Qualifications.
   (c) Present occupation.
   (d) Permanent postal address.
4. Purpose for which the building is to be used.
5. Name of room or building for which this certificate is granted giving reference to plan number.
6. Nature of work to be carried on in the above room/building.
7. Nature and amount of moving power.
8. Signature.
9. Date.
10. Signature of occupier with a n endorsement that the certificate of Engineer inspected the factory at his request and certified its stability.

Registration and licensing

6. Mode of application : The occupier of every factory shall submit to the Chief Inspector an application together with Form No.4, prescribed under section 7, in triplicate for registration of the factory and grant of a licence, at least fifteen days before he begins to occupy, or use the - premises as a factory.

7. Registration and grant of licence :

(1) The factory shall be registered and a licence for a factory shall be granted by the Chief Inspector in form 3 and on payment of the fees specified in the schedule :

Schedule of fees payable

Quantity of H.P. installed (max. H.P.)	Max. No. of persons to be employed on any day during the calendar year					
	Upto 20 Rs.	21 to 50 Rs.	51 to 100 Rs.	101 to 250 Rs.	251 to 500 Rs.	501 to 750 Rs.
Nil	10	25	50	125	250	375
Upto 10	25	50	60	150	300	450
Above 10 but not above 50	50	75	100	250	500	750
From 51 to 100	100	125	150	375	750	1125
Above 100	150	200	2500	500	1000	1500

FORM No. 1

Name of the Factory

(Rule 3(1)

Particulars of rooms in the factory

---

1. Number of rooms in the factory.
2. Length
3. Breadth
4. Maximum
5. Minimum
6. Average
7. Total area in Sq.ft.
8. Floor area occupied by machinery in the room
9. Breathing space (Contents in cu.ft.)
10. Total volume of air in the room
11. Number and size of doors
VENTILATION :-
12. Number and size of window openings.
13. Number and sizes of sky light openings
14. Total area in Sq.ft.
15. Maximum capacity of the room
16. Maximum number of persons intended to be employed in the rooms.
17. Whether the room is to be used as a work-room or for storage only.
18. Date of construction.
19. Remarks

Signature of the occupier

Signature of the Manager

APPENDIX V

SELECTION OF SITE

While there are many reasons why the free choice of a site for new factory is limited, prior consultation with professional advisors is of great value. Unsuitable sites can be ultimately expensive because of the limitations imposed on the management, architect and the ceramic Engineer.

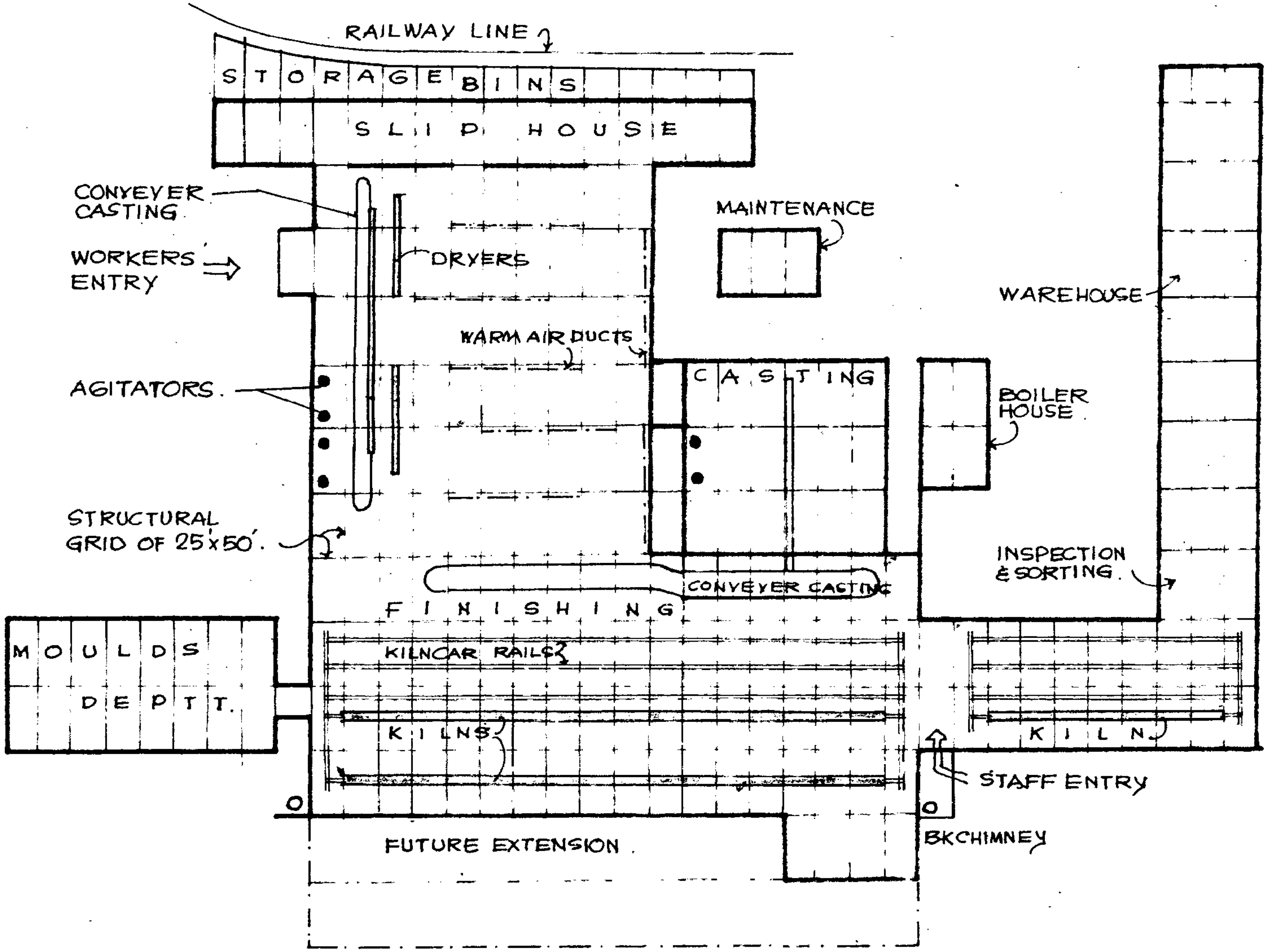
An intense desire and determination backed up with a follow-up policy and the capital formation are the pre-requisites for starting any new industry. Various factors that require consideration, are only enumerated with a value assigned out of 10, to each, indicating its relative importance and hierarchy from the priority point of view.

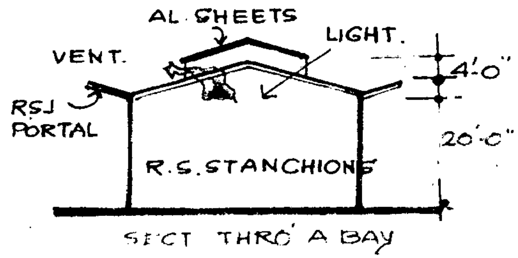
Sl. No.	Factors		Value assigned out of 10 to show relative importance and hierarchy
1.	Suitable site	a) Level site	10
		b) Free of water logging	8
		c) Development plans of local authority.	10
		d) Future expansion	6
2.	Raw materials	a) Availability of materials like chinaclay, felspar, quartz, talc, fire clay, gypsum, coal, oil. (For production of 4 tons/day, following quantities will be required/month. Mixed production of crockery and insulation). China clay 55 tons/month Felspar 30 ,, Quartz 30 ,, Talc 01 ,, Fire clay 25 ,, Gypsum 3 ,, Coal 45 ,, or oil, for tunnel kiln 2.5 ton/day	10
		b) Principal raw materials within a range of (300 to 500 kms.) (Distance as expressed by various factory owners).	8

Contd.

3. Labour	a) Skilled - 20 b) Unskilled 50 (a + b include female labour) c) Female labour 20 (For production of 4 tons/day about 50 workers are required)	6 10 6
4. Transport facilities	a) Rail b) Road c) Water way (very rare)	8 10 2
5. Market for the product	a) Within a range of 300 kms. b) Distribution of industry within the region.	10 6
6. Services	a) Electricity (for 4 tons/day foundry production 150 H.P. is approx. required).	10
	b) Water supply (soft and Cl_2 & SO_4 not to be more than 50 ppm)[2]. (for 4 T/day production about 800 gallons/day is required).	10
	c) Drainage of waste water	0
7. Economic feasibility	a) Return on the investment	8
	b) Capital formation	10
	c) Intense desire	10
8. Ecological Consideration	a) Effect of pollutant/gases & exhausts of coal fired kilns on	8
	(i) Vegetation) Carbon soot affects the very breathing of plants and destroy them. (ii) Crops)	
	(iii) Mango crop[1]) SO_2, ethylene affect the mango crop considerably.	
	(iv) Water - negligible effect.	
	b) Suitable climate and wind movement	6

1. Dr. Agarwal G.D. Head of Civil Engineering Deptt. I.I.T.Kanpur, Enquiry & findings of Effects of air pollution at the U.P. Govt. owned Pottery units at Chinhat, Nov.72, investigation sponsored by Ministry of Health.
2. For a sanitary ware plant, water requirement could be 5000 gallons/day because of 'Slip Casting' process.





INFORMATION :

YEAR OF CONST.	1962
DESIGNER.	MSK-DELHI
COLLABORATION	TWYFORDS. U.K.
TOTAL COST.	2.12 CRORES
LAND (20.25 HECTARES)	Rs 3,09191
BLDG.	Rs 45,70,000.
PLANT, MACHINERY, KILNS	Rs. 1,33,56000.
CAPACITY	5400 M. TONS/ANUM
PRODUCT.	SANITARY WARE.
SHIFTS. GENERAL	8.00 AM TO 5.00 PM
NIGHT	SLIPHOUSE & KILNS

STAFF.

ADMINISTRATIVE	60.
TECHNICAL	90.
SECURITY	18 (4 HORS SHIFT)

LABOUR. SKILLED - 400
SEMI " - 150
UN " - 100

STRUCTURE. WALLS 13½" BK, C. POINTED
50'x25' GRID. STEEL STANCHIONS & PORTAL FRAMES MONITOR

WATER - JAMNA CANAL 40,000 G/DAY

FLOOR - HARD TOPPING (IRONITE)

WORKERS' FACILITIES.
CANTEEN, RESTRMS, DISPENSARY, HOUSING, CLUB
OILFIRED BOILER FOR WARMING
LIGHTING: DAYLIGHT + FLUORESCENT TUBES

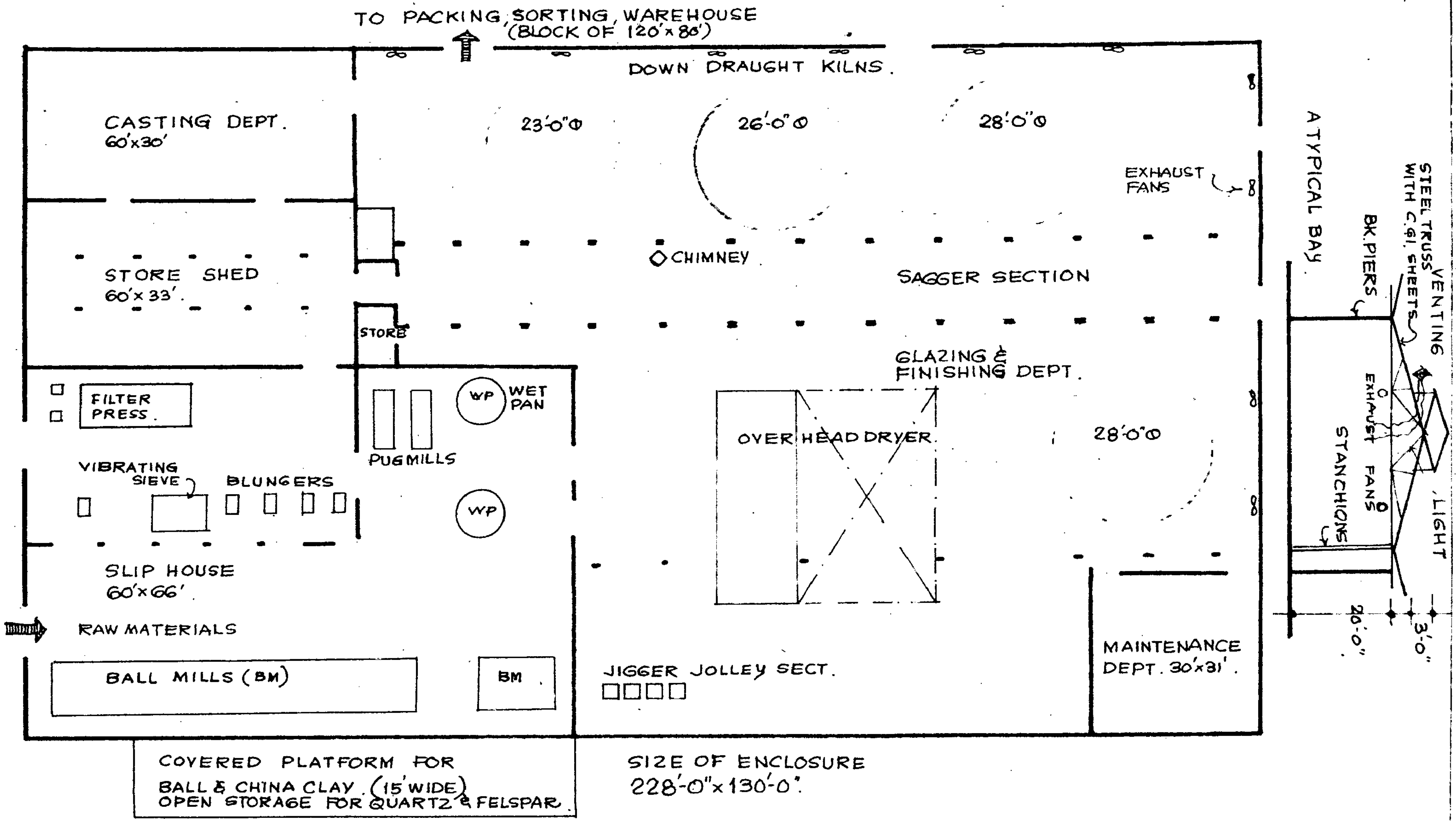
APPENDIX VII-1

CANTEEN & RECREATION 4760 SFT.

RESEARCH CENTRE 4192 SFT.

ADMINISTRATIVE BLOCK 6000 SFT

HINDUSTAN SANITARYWARE BAHADURGARH.



U.P. CERAMICS & POTTERY
WORKS: GHAZIABAD.

208-C

APPENDIX VII-2

107928

[illegible]

REPORT OF THE [illegible] FOR AWARD OF M.E. DEGREE

1. Name of the Candidate — Ashok ~~K~~ Laxman Chhatre.
2. Department — Architecture.
3. Specialised subject — Architectural Design.
4. Title of dissertation — Ceramic Industry with special Reference to Pottery works.
5. The Viva-Voce Examination was held on Friday the 20th July 1973, at 3.00 P.M. at Roorkee.

The candidate has presented exhaustive material on the working and p-hysical planning consideration necessary for efficient functioning of ceramic factories. His analysis of factory (as such) various codes and bye-laws relevant to ~~faxstx~~ factory design, tolerable noise levels in the ceramic factories and [illegible] needs, is highly commendable.

Although [illegible] of the optional costs for various sizes of facto[illegible] initial ~~instrument~~ [illegible], maintenanc of operation [illegible] production would have been useful for inc[illegible] thesis; however, this might have resulted in [illegible] rather bulky.

The overall performance of the candidate both in terms of documentation and presentation of the dissertation in viva voce examination has been excellent.

(a) The dissertation is approved/
(b) The dissertation is graded as Excellent.

Signature of Internal Examiner   Signature of External Examin

Dated 20.7.73

UNIVERSITY OF ROORKEE
ROORKEE

NO.EX/ /PF/ALC   Dated Aug. ,1973.

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