CHEAP & HEALTHY

HOMES

FOR THE

MIDDLE CLASSES

OF INDIA

BY

R. S. DESHPANDE, B.E., B S.E., A M.I E. (Ind.)

Retd. Engineer, Bombay P. W. D.
Member of the National Planning Committee,
Author of "Modern Ideal Homes for India," "Build Your Own Home", "Sulabha Vastu-Shastra", "Disposal of Domestic Sewage," etc.

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FOREWORD

It was a very pleasant task to read these chapters. When it is realised that they are intended for the average educated middle class man, who may be contemplating building himself a house, it must be admitted that it has been very well done. It often happens that when such books are written, they are either too technical or so elementary as to serve no useful purpose. Most of them are so elementary as to contain many errors, inevitable in such elementary books, and they are on that account liable to perpetuate erroneous notions rather than to inculcate true knowledge. I am glad, your book, as far the chapters on Domestic Sanitation, which I have read, has presented a true version of the facts, which the reader is expected to acquire.

Although I have a great belief in the efficacy of official propaganda, I am a great upholder of the value of unofficial help, and I welcome the advent of your book as a real advance in that direction. I, therefore, wish you every success in this effort, and hope that your example may be followed by other experts in their own lines, presenting their expert knowledge to the public in the concise, lucid, and helpful way as you have done.

POONA
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Sd/- A. M. V. HESTERLOW,
Major, I. M. S.
Director of Public Health, Bombay Presidency

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(16) *Conservation Manual*—Marshall.
(17) *Introduction to Scientific Study of Soils*—Comber.
(18) *Physical Properties of the Soil*—Bernard A. Keen.
(19) *Soils, Their Formation, Properties etc.*—Hilgard.
(20) *Concrete for Farm House and Estate*—Ballard.
(21) *How to Make Good Concrete*—Concrete Association of India.
(22) *Indian Concrete Journal*—Concrete Association of India.
(23) *R. C. Designer's Handbook*—Reynolds.
(24) *Concrete Cottages, Bungalows and Garages*—Lakeman.
(25) *Sanitation in India*—Turner and Goldsmith.
(26) *Hygiene & Public Health*—Ghosh.
(27) *Manual of Vital Statistics*—Munsiff.
(28) *Our Homes*—Murphy.
(29) *Roorkee Treatise on Sanitary Engineering* 2 Vols.
(30) *Bombay P. W. D. Handbook.*
(31) *M. E. S. Handbook* Vol. 1.
(32) *Sir Gangaram's Pocket Book of Engineering.*

PREFACE

Some apology is needed for writing this book in English instead of in a vernacular of India, in which it would have reached more directly, the hands of the class of the people for whom it seeks to cater. This is quite true. But it is equally true that on account of so many different vernaculars in India a book written in English is sure to approach a greater number of readers in all communities distributed over all parts of the country, than one published in half a dozen important vernaculars together. Again, translating and printing it into so many vernaculars would entail great trouble and expense. Again, if the writer is really so fortunate, as he has been in the case of his previous publication, that a demand in some vernaculars is received, it is much simpler to secure the services of the best men to translate it into those vernaculars through the medium of English than through that of any Indian vernacular.

It was originally intended to include farm houses, barns, silos, stables and cow-sheds etc. in it, but as the book assumed a concrete form it was realised that they form a separate class by themselves, and if the writer has the good luck of receiving a warm welcome in the case of this book also, he will not be slow in publishing one such book on the problems of rural housing.

The first 178 pages, or a little more than half of this book has been devoted to practical hints on economy by suggesting different alternative methods of contruction in sequential order from the collection of materials and foundations, to the completion of the roof, with a close attention to securing the best of sanitation and comforts. Several alternative methods have to be suggested, and the responsibility of choosing the most suitable one has to be thrown on the lay reader, because it is impossible to lay down definite rules or prescribe particular methods in this vast continent of India with extreme variation not only of climatic conditions, but also of building practice, and materials available which make every difference even in the architecture of the place.

Still, as the habits and social customs affecting the general sanitation of the community are not so varying, it was possible to set forth a few rules and make practical suggestions with some precision for the improvement of the sanitary conditions, which occupy the latter half of the book. Some apology is, however, required that the writer was forced to abridge and print in a small type in an appendix, the chapter on such an important subject as Epidemics and the duties of a house-holder in preventing or fighting them, for fear of increasing the bulk of the volume.

To solve the problem of housing on economical lines, the efforts of one or two individuals are not sufficient. It requires the application of many brains, particularly to get over the difficulties as they present themselves in the extraordinarily varying conditions of the different provinces. The writer has endeavoured to do his bit in his own humble way.

Concrete has great potentialities before it in the future in forming part or the whole of the building, especially in view of the facts that gravel and clean river sand are available in any quantity in the rural districts for the cost of mere collecting, that with rapid increase of motor traffic the facilities for the transport of cement are fast developing, that indigenous cement of the best quality is becoming cheaper every day, and that the most efficient organisation of the Concrete Association of India is always ready to give free advice in whatever matter concerning the use of concrete.

But so long as simple block-making machines have not come within the reach of the cottage builder either for a cheap cost or for a small hire, that stage has not arrived and the writer has to content himself with making suggestions here and there where its use even at this stage makes for economy and efficiency.

The writer would be failing in his duty if he did not mention the great help and encouragement he has received in the compilation of this volume from numerous friends and well-wishers, amongst whom he must acknowledge with grateful thanks the assistance received from Mr. B. B. Kamat, Head Master, Northcote High School, Sholapur, and Mr. M. B. Sant, Inspector of Education, (Retired), Dhar State, C. I.

I cannot adequately express my debt of gratitude to Major A. M. V. Hesterlow, I. M. S., Director of Public Health, Bombay Presidency, for having gone, very carefully, through the chapters on Domestic Sanitation and Appendix No. 2, and made very valuable suggestions, which have been included in Appendix No. 4 at the end of the book.

It is earnestly hoped that the book will supply the long felt need and receive warm appreciation of the public.

1st August 1935. R. S. DESHPANDE

Preface to the Second Edition.

Except for a new chapter on check list of questions on health and safety, and minor alterations here and there, this is more or less a reprint of the First Edition.

I must say a word in reply to the comments received in several reviews that the rates adopted in the type estimates given in this book are too low. In order to verify this, rate lists were obtained from several provinces notably from Bengal, U. P. Behar, C. P., and Madras, and it was found that the rates adopted represented a fair average. It must not be forgotten that the book is essentially written for the middle class people living in rural towns and not in industrial cities and their suburbs, where the rates both of labour and material are bound to be high. The rates in the book compare favourably also with those obtaining in Gujarat, Karnatak, Mysore, and the Konkan.

July 1941. R. S. D.

Preface to the Third Edition.

When bringing out the second edition in 1941, I little thought that another edition would be required to be produced so early, at least before the end of the War. But there has been so much demand that I had to struggle against great odds to produce this edition amidst most difficult circumstances created by the Paper Control (Economy) Order, 1944.

As numerous suggestions were received that the subject of disposing of domestic sewage by suitable means was most desirable to be discussed in this book, which is essentially written for the benefit of the people living in rural towns and villages several methods, notably Earth closets, Borehole latrine, Trench latrines and Septic tanks have been treated in considerable detail. Beyond this, the whole book is merely a reprint of the second edition.

May 1945. R. S. D.

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Introduction

† Naturalists tell us that the duration of the life of an animal must be normally five times the period it takes for the full development of its growth. This has been amply proved in the case of lower animals. If we observe the domestic animals, such as the horse, dog, cow, goat etc., we shall find that they live almost the full span of life ordained to each by Nature. But if this principle is made applicable to human beings, we find that we are disappointed. Man possesses a very superior mental organisation and power of reasoning over the brute creation. He has utilised this to the fullest extent and devised means of defence to protect himself from the fury of elements, by building houses, lighting fires, making clothes, cooking food and so on. He is thus expected to live longer than 105 years, i. e. five times the period of 21 years, which he takes for the full development of his skeleton. But what do we actually find? The average span of life of man, even in the civilised countries of Europe, was, until two decades ago, only 42 years! But by careful attention to sanitation and rules of hygiene it has, of late years, been increased. Still it does not exceed 51 years! In India it is half of this, viz. 26 years! This, in other words means, that the average Indian succumbs to death when he is just on the threshold of maturity?

What is the reason? There must be some grand destructive agencies at work which shorten the human life. What can they be? if we observe minutely, we shall find that though man is subject to many diseases, from which the lower animals are exempt, for instance, certain diseases of mind, diseases descending from heredity, diseases caused by indulgence in vices or luxuries, contagious diseases etc. he, in his very attempt to out-wit Nature by devising means of defence such as building houses, villages, towns, etc., has created around him conditions most conducive to diseases, which are responsible for shortening his life. Thus Malaria, Typhoid, Anæmia, Tuberculosis, Neuralgic diseases, Cholera, Plague etc., which take annually such a heavy toll of human life, owe their origin entirely to deficient light and ventilation, to damp, and to general insanitary conditions in and around our habitations.

That malaria, plague, cholera and other diseases should make their abode permanently in India, should in no way be surprising to those who know that the most fundamental principles of domestic sanitation and personal hygiene are set at naught either through ignorance or solvenliness or both.

The following description of an average house in an Indian town will throw light on the causes of high mortality in India.

It is a house, owned, not by a poor man but a well-to-do money-lender, situated in the heart of a town, lining one of the main thoroughfares, which is, by the way, only 15 ft. wide. It consists of three storeys, each having a separate tenement of three rooms. The ground floor tenement is occupied by the owner. All the three rooms are six ft. wide and are one behind the other. The front room is 14 ft. long and is occupied by the business office of the banker and contains a moderate sized steel safe, two almyrahs, a chair, and two desks with mattresses in front, to squat upon. The central room is only 12 ft. by 6 ft. and is lit up by the diffused light penetrating through the door open-

† "*Comparative Longevity in men and the lower animals*" by Sir E. Ray Lankester.

ings and a small horizontal window near the ceiling in the partition wall. This is the only bed room of the family. The third room in the rear, almost of the same dimensions, is the kitchen, with a sink, which is used both for slop water and bath, and also serves as an emergency urinal. The sink consists of a large slab at the bottom and rough stones on the sides, once laid in bad lime mortar which, however, has now been washed away, leaving wide crevices and thus making the side stones loose. It was intended that the water and urine from the sink should go to a pit close by, in which a sort of an Aroidoe plant (Alu अळू, Marathi) which is used as a vegetable, is grown, but the water soaks just near the wall and never reaches the pit, causing damp to rise both in the floor and up the wall. Only the front room is paved, the other rooms have only a mud floor. The rear wall has a small window, but it is normally closed by day for fear of draught and by night, for fear of thieves. There is a small open space in the back yard, in which there is a latrine built of mud walls and mud floor. A steep staircase descends from the upper two storeys to the latrine as this is the only latrine for the benefit of all the three tenements. Another corner of the space is occupied by a cow-shed which has a mud floor and corrugated iron sheet roof which rests on the compound wall raised at the back and on wooden posts in the front, which is open. Between the cow-shed and the kitchen there is a well for drinking water, 4 ft. in diameter with a winch and rope for drawing water. The wall round the well is low and when bathing and washing is done on a flat stone placed in front, there is every chance of the soiled water flowing back into the well. A drain from the well in earth, leads the waste water from the well to the pit for the aroidoe plants referred to above. Between the kitchen and the latrine there is a muck-heap on which all sorts of rubbish such as sweepings from the house, garbage of vegetables, waste fodder from the cow-shed, leavings of food etc. are indiscriminately thrown. The children of all the three tenements make free use of the surrounding space, for answering the calls of nature, their excreta being left for the sun to dry. Whatever space remains over and above this, is utilised for making cow dung cakes; even the parapet wall of the well and the rear wall of the house is occupied by them. There is a lane barely 4 ft. wide behind the latrine for the sweeper to scavenge. The bed of the latrine is at a lower level than that of the lane, and therefore, liquid sewage stagnates in it to a certain depth. There are no shutters to the sweeper's door of the latrine in the rear, therefore, swarms of flies settle on the liquid sewage and fly from there and from the muck-heap directly into the kitchen to sit on the cooked food for a change. The condition of the latrine cannot be adequately described; suffice it to say, that it is used carelessly by the occupants of the three tenements and its mud floor is never cleaned by any body.

The pit in which the aroidoe plants are grown is a breeding place and nursery of mosquitoes.

The occupants of the ground floor are ten in number including four adults, and six children. During the night, beds are huddled up as the space would make it physically possible in all the three rooms. In addition to this, some room is made available for the calf, by the side of a bed, to avoid a chance of the cow's milk being sucked by it, if it were tied in a corner of the cow-shed. As one can naturally expect, the house is full of bugs and fleas, whom mosquitoes aid in busying themselves during night in disturbing sleep of the inmates. No nets are used. Rats confidently move about even by day.

In front of the house, in a recess, by the side of the road there is a Municipal dust-bin which is never properly used by anybody and is always overflowing. In stead of the dustbin holding *kutchera*, apparently the heap of the latter holds the dust-bin. Children of the neighbouring houses, who have no open space enclosed in their compounds, commit nuisance near the dust-bin. The rows of houses on both sides are two or three storeys high, and prevent the genial rays of the sun from penetrating the house during any part of the day.

This is no fanciful picture, nor one overdrawn, but a faithful one, depicting every day life in the average village, town, and city in India. The poverty-striken people are still worse off than this, living in the slums of cities, where overcrowding is far greater than shown in the above instance. For example,

7, 91, 762 persons, or 74 per cent of the population of the Bombay City live in one-room tenements! The latter form 81 per cent of the total number of tenements in the city!! *

When the pressure of persons on room space is seen the conditions are found to be still worse. Because, 2,56,379 persons live in rooms each occupied by 6 to 9 persons; 80133 people live in rooms each occupied by 10 to 19 persons; and 15,490 people live in rooms each occupied by 20 and over!! *

As one will naturally expect, this results in the whole-sale massacre of the innocents. Because, of all the infants born in the Bombay City in 1936, 72·6 percent were born of parents living in in one room tenements, while, of all the deaths of infants during that year, these one room tenements accounted for 78·3 per cent!! §

Is there worse degradation imaginable? What wonder if one epidemic after another makes ravages from one end of the country to the other!

Pious expressions of horror at this are of no avail. Those who have a real sympathy and a sincere desire to help, must translate it into action and the sooner it is done, the better.

It was this that set the writer to think about and search after the means to secure two things: (1) Cheapness and (2) Sanitation. He soon found that the efforts required for the attainment of the first object must be oriented in the following directions:—

(1) Elimination of transport, which is synonymous with utilisation of local material to the maximum extent.

(2) Employment of local labour, and that too, unskilled labour as far as possible.

(3) Cheap materials.

Our wise forefathers knew this very well. Because, nearly 90 p. c. to 95 p. c. of our old houses, whether in villages, towns, or cities have been built of stone or brick in mud, or in some instances only in mud, with a free use of timbers and other materials produced locally in the main. The craze for lime and cement for cottage building on the part of the poor, is modern, and is restricted to large cities and areas round them, called suburbs.

It is a pity that the present day engineers and architects have totally neglected this 90 to 95 p. c. of building construction and concentrated their sole attention on the remaining 5 to 10 p. c. only.

* Census report Vol. VI 1931 page 88 and 314.

§ Administration Report of the Municipal Commissioner for the City of Bombay for the year 1936–1937.

Many of such houses built some 200 or 300 years ago are still standing in perfect order. Hence, it is beyond question that this system has stood the test of time. There may be some inherent defects in it, no doubt, but they can be easily remedied by the application of the advanced knowledge of the present day.

This does not mean that the writer is averse to, or decries the use of, cement and lime and the products of the modern science. Far from it. He has already written two books in which he has described the up-to-date methods of Building Construction. But the first hand knowledge which he recently obtained by visiting several parts of the country to study the housing conditions, has convinced him that for the average Indian, who is very poor, they are rather expensive luxuries. Again, by using local material as far as possible, we help solve partially the problem of unemployment which, so frightfully stares the country in the face. Besides, in addition to cheapness there are some special advantages which this system possesses. These have been discussed elsewhere in this book.

It is true that we want more houses immediately to relieve the overcrowding, but a point of equal importance is, that we want them to be built on the most sanitary principles. It is for this reason that nearly half of the book has been devoted to Domestic Sanitation and a special chapter on repairs and alterations added, in which, practical hints on improving the sanitation of the existing building are given.

The book does not pretend to give the reader that amount of information which would enable him to build a cottage with its help from the foundations to the roof. The latter has been sought to be done in the author's other work viz., "Modern Houses and How to Build them."* The purpose of the present volume is to give the reader practical hints on economy and domestic sanitation, so as to enable a layman of the middle class to secure maximum health and comfort within a minimum amount spent.

However, cheapness is not always synonymous with economy. There are primarily two factors to be considered : one, the initial cost and the other, the maintenance charges. An item which is slightly costlier in the beginning, but saves a lot for upkeep, is more economical in the long run. Again, a note of warning must be sounded against the employment of unsound, cheap material of an inferior character, which soon deteriorates, and becomes unhealthy, or of bad workmanship, which one, in one's fondness for economy, is tempted to overlook, or connive at. These defects tend to foster in them a sense of carelessness and untidiness. How is it possible to keep a house neat and tidy, in which the plaster of walls is continually falling off in patches, the joints in wood work of the upper floor opening out and allowing loose earth to drop at a slight shaking; roof leaking and causing damp in floors and walls; the yawning joints in wood-work of doors, windows and cupboards etc. giving room for dust to collect, and bugs and other vermin to breed; drains choking every now and then and causing emanations of foul gases. etc. ? Even the tidiest housewife would soon be disheartened and become dull to the sense of dirt and uncleanliness. The spirit of tidiness once gone leads to untidiness in other things such as dress and personal hygiene, and makes the house dreary, filthy, and squalid, and no longer a pleasant, cheerful and sweet home.

* Sulabha Vāstu Shastra or Modern Houses and how to build them by the author, either in Marathi, Hindi, or Gujarati, price Rs. 3/— or Build your own Home in English Rs. 10/-

If a pleasant-looking, comely cottage, planned for comfort, and sound in construction, howsoever humble, is provided, the occupants instinctively take a lively interest in keeping it neat and tidy. Once they catch this spirit in right earnest, it is easy and inexpensive to render it more pleasant and attractive by little things such as a wash of economical distemper, planting a few roses here, a bed of seasonal flowers there, a few flower-pots at another place, and so on, and thus gradually develop an artistic taste for decoration.

Just imagine a cheerful wife and gay children taking delight in watering flower plants in the evening, and looking with pride at the flowers grown by their labour! Could there be a better recreation for them? Could there be a more refreshing sight than this to the humble clerk or the school-master returning home, exhausted after the day's hard labour?

In conclusion, the writer craves indulgence of the reader for appreciation of his humble but sincere attempt to ameliorate the housing conditions of his poor countrymen, fully conscious as he is, of the many defects and imperfections in the book.

Cheap and Healthy Homes for the Middle Classes of India.

Materials.

The question of material is of the greatest importance in building construction, because, upon it, depends, to a very large extent, its economic success. Materials which have to be transported from long distances are costly. Some times the cost of transport is twice or three times that of the materials themselves at the site of their production. Restrictions imposed by heavy tolls on roads, customs charges and freight charges on railways etc.: tend to check the transport and enhance its cost. Hence, for economic success of a building, materials which have to be transported from long distances, must be avoided as far as possible. This is tantamount to saying, that local materials available must first be explored, and ways and means devised for utilising them fully, so as to eliminate, or at least reduce to a minimum, the unnecessary cost of transport.

Again, materials always look well in the place where they are naturally found, and very unbecoming, away from it. Local materials are easily adjustible to their natural surroundings; they tend to retain their tradition, and maintain the architectural aspect of the place.

Amongst the materials required for building, those useful for walling form the main bulk. Next come, timber, mortar, roofing materials, ironmongery etc., in their descending order of cost in the estimate.

Walls are most commonly constructed of either stone or burnt brick or a combination of both. For cheap houses sun-dried mud brick or mud also is often used—a point to which we shall come later on. When a choice between stone or burnt brick is to be made, a layman is often very much puzzled as to which of the two, is to be preferred. We shall, therefore, briefly discuss the merits and demerits of each.

BRICK *VERSUS* STONE

From the fact that we see several stone buildings exposed to elements, still surviving the vicissitudes of ages, we can say with certainty that stone is more durable than brick and that it is capable of resisting the atmospheric and other external influence to a far greater extent than brick. But at the same time, we must not forget the fact that even the most optimistic person never thinks or imagines that his house would last for several hundred years. He would be content, if it lasts only for a hundred or hundred and fifty years. And we actually see brick houses built some three hundred years ago, still standing in perfect condition in defiance of the fury of the elements. Hence, we can justly say that for our practical purposes a brick house is as durable as a stone house, provided the brick is of a good quality.

2. From the point of view of protection from thieves and house breakers a brick-in-mortar wall is as strong as, if not stronger than, a stone wall. This is so because, to make an opening into a stone wall it is comparatively easy to rake out joints on all sides of a stone and to pull it out whole, but the adhesion of brick to mortar (good of course), is so great that in order to pierce a hole into a brick wall, small pieces of brick have to be chipped off, which cannot be done without a considerable noise and severe shaking of the whole wall.

3. In respect of ornamental or plaster work, brick possesses an undoubted advantage over stone. Because in the first place, plaster sticks to brick more firmly than to stone and secondly brick, by its very soft nature, allows its being roughly cut with an axe to the approximate shape, which can then be improved upon with plaster and be given the desired smoothness for decorative effect. With stone this is not possible, or at least is very difficult and expensive.

4. Brick having a right angled square shape is more suitable and cheap for corners. Even for jambs of doors or other work involving an acute or obtuse angle, the very fact that it can be easily cut makes it very convenient. Its size and handy weight make it very easy to manipulate.

5. Brick work requires a fixed quantity of mortar and on account of its flat, square shape there is a less chance of its remaining hollow at the hands of bad workmen. In stone work, there are far greater chances, of both waste of mortar occurring in the filling of the hearting, and also hollows being left unfilled if the masons are careless.

6. A still greater advantage which brick work possesses over stone work is, that walls of from 3 in. thickness with brick on edge, or $4\frac{1}{2}$ in. with brick laid flat, or 9 in., 14 in., or any width above this can be easily built. The least thickness of a stone wall, on the other hand is 15 in., in which case also, it is not regarded strong enough for supporting walls of the upper storey, because unless a stone wall is at least 18 in. thick, on account of the comparatively big and irregular size of the individual stone, there is no sufficient bond in it. A brick wall only 14 in. thick on the other hand, can support walls of the upper floor and an additional advantage is that for the same quantity of brickwork, rooms are made 4 in. longer and 4 in. wider than those with 18 in. stone walls.

7. Another advantage brick possesses over stone, particularly in tropical countries is, that brick does not absorb so much heat as stone does.

From the foregoing discussion it will be seen that in point of durability and strength, brickwork is, for all practical purposes, as strong as stonework and is certainly superior to it in several other respects.

However, the quality of bricks manufactured in India, except perhaps in Sind and some other places, is poor. Even the Bilimoria or Calicut bricks which are highly praised, do not stand comparison with bricks of English manufacture. If the quality improves in future there are bright prospects for brick industry in India.

The disadvantages of brickwork are that it absorbs moisture and is, therefore, unhealthy particularly in damp situations; that so long as the quality is not satisfactory it requires plastering on the outside. The plaster not only increases the cost but its repairs and the renewal of colour on it, have to be constantly attended to at a considerable recurring expense. Even if the colour fades, or the surface is disfigured by atmospheric influences, it presents a shabby appearance. A third disadvantage is, that though it absorbs less heat than stone, having once absorbed it, parts with it but very slowly. Hence, brick walls exposed to sun take a longer time to cool down during night.

As regards costs, very often the apparently higher rate of brick work leads one to imagine that it is more costly than stonework; but a little consideration will show that where stone walls 18 in. thick are required, brick walls only 14 in. thick do very well and therefore, within the same volume of masonry, a longer wall can be constructed in brick work than that in stone work. Hence the rate has to be reduced to $\frac{14}{18}$ for comparison with that of stone work. An example will make this more clear; the rate for brick work in lime in Poona is Rs. 48/- and that for 2nd class coursed rubble stone masonry is Rs. 40/-. Now the rate of Rs. 48/-, if reduced to $\frac{14}{18}$, because brick wall is 14 in. thick, while stone wall must be 18 in. thick, $55 \times \frac{14}{18} =$ 37/- to which must be added the cost of plastering on the outside which brick-work requires 100 cft. of 14 in. wall will have 86 sq. ft. of outside surface ($100 \times \frac{12}{14}$). The cost of plastering 86 sq. ft. at Rs. 10 per 100 would be Rs. 8 as. 10. Total cost of 100 cft. of brick work is Rs. 45-10. Hence, in this particular instance stone work is cheaper.

It is worth mentioning here that the thicker the brick, the better it is, from the point of view of economy. Because there being less number of joints, less mortar is consumed and there is also a saving in labour, as the progress of work is more rapid.

Regarding other materials which are locally available and used for walling such as wattle and daub, earth, bamboos and wooden boards etc., they will be discussed later on under "Walls."

Next in order of importance comes timber. Teak is undoubtedly the best, but though grown in forests in almost all parts of India, it is often costly on account of the long distances from which it has to be transported. In such places, some of the local varieties of timbers would be found to give perfect satisfaction, if used in positions in which they have been proved, by local usage, to give best results. For example, Ain* (Marathi) is a strong, durable variety of timber but is unsuitable for use in exposed positions, where it cracks by the heat of the sun. Otherwise, it is an excellent timber, as it keeps well in damp situations —even under water, and is not attacked by white ants. Similarly Neem ‡ (Margosa) is excellent in all positions except moist or damp ones in which it warps and bends. Hence, it is good for door frames, posts, beams, lintels etc. but not for rafters, or panels of doors and windows in exposed walls.

There are a number of strong and durable varieties of timber in India but many of them are attacked by white ants. Such varieties should be used only in such positions as would allow them to remain exposed to view and be easily replaced when necessary, without requiring any considerable part of the building to be dismantled; e. g. shutters of doors, windows, shelves, posts (not buried in walls), furniture etc.

Even more important than the white ant is the other enemy of timber to be most feared. It is "Dry rot". It is a kind of fungus, which once established, spreads over and eats into the entire piece with marvellous rapidity. It generally commences in sap wood. A scantling apparently sound may have been entirely hollowed out inside by dry rot. Its presence can be detected by gently tapping on the timber, when it sounds hollow, which is an indication of the fibres having been reduced to powder. The cause of its appearance is damp and want of ventilation. It is unfrequently due to the timber being insufficiently seasoned. It is found mostly in unventilated wooden floors, damp cellars, in timbers buried in walls such as, ends of beams, wall plates, door frames etc. Once it attacks timber there is no remedy but to remove the whole of it, with all the traces of the

* (1) Equivalents of Ain in other vernaculars are—Matti (Kannad); Sagada (Gujarati); Sain (Hindi); Maddi (Tel.); Usan (Bangali); Anemui (Tamil)

‡ (2) Equivalents of Neem in other vernaculars are—Nimb (Marathi); Vepa (Tel.); Vepum (Tam.); Bevu (Kan.); Said (Hindi).

fungus. Application of one or two coats of hot coal-tar is a preventive remedy. But the timber must be previously thoroughly dry.

A suggestion to laymen, while using timber will not be out of place here. It is this: when a scantling is used for resisting a stress coming at right angles to its length, as for instance, like a beam or rafter, its stiffness varies as the product of its breadth and the *square* of its depth which is indicated by the formula :—

$$S \propto B D^2.$$

i. e. Stiffness varies as Breadth × square of Depth.

Therefore, if a scantling of more breadth is used, there is some gain in strength no doubt, but it does not add to its stiffness or resistance to bending; but if the depth is increased even slightly there is a considerable difference in respect of stiffness. For example, see the three beams :—

No.	Beams		sectional areas and costs vary as	resistance to bending varies as
	breadth	depth		
(i)	4″	5″	20	100
(ii)	4″	6″	24	144
(iii)	3″	7″	21	147

This shows that though the 2nd is the costliest of the three, being of greatest sectional area, it is weaker than the third, and the third beam which costs almost the same as the first, is 50% stronger. Of course, if the breadth is too small in proportion to the length, the beam buckles sideways.

MORTAR.*

It would be out of place here to explain how mortar is prepared, what constitutes a good mortar, or how a layman can apply a rough test for distinguishing it from a bad mortar. All this has been done in great detail, especially from a layman's point of view, in the author's book "Build your own Home." It is only the economical aspect of all materials including mortar that is sought to be discussed here.

There are two varieties of lime used in the preparation of mortars. One, fat lime and the other hydraulic lime. Fat lime is one, which when slaked or treated with water makes a hissing noise, steams and bubbles up, giving out considerable heat, and increases in bulk. It is good for plaster or white-washing. It derives all its strength by chemical reaction with carbonic acid gas, which it absorbs from the atmosphere. Hence, excepting in positions like that of plaster, where it freely gets carbonic acid gas, it lacks in strength. It does not set in water and keeping it moist does not help it in gaining strength.

Hydraulic lime, on the other hand, slakes but slowly and while doing so, does not give out so much heat, nor increases so much in bulk. It sets in water and moisture helps it in hardening. It possesses considerable strength.

Of course, hydraulic lime is the best as a building material. But it is not locally available every where. Still, one need not be sorry for it and try to transport it from long distances; because in the first place, there is very little transverse stress in ordinary buildings. Practically the whole stress is of the compressive nature, that is, one coming vertically down. Hence, mortar of strong hydraulic lime is not necessarily required for ordinary buildings. Secondly, if more strength is desired the deficiency of it in the fat lime can be made good by grinding *surkhi*, or powdered burnt clay, with it. The latter also increases its bulk.

* The word 'Mortar' has been used in this book to convey the sense of any thing that binds together Hence it is not necessarily of lime; it may contain lime, cement, or mud and therefore may be called lime mortar, cement mortar, or mud mortar.

The strength of the fat lime mortar is slightly improved by mixing it with a slightly greater quantity of sand than ordinarily required. Because sand tends to make it a little porous and allows it a greater chance of absorbing carbonic acid gas, from the air, upon which its strength depends.

If the fat lime is of a pure, unadulterated quality, sand to the extent of 2½ to 3 times its bulk, could be safely mixed with it to make the mortar suitable for domestic buildings. Where sand is not available at a cheap rate because of its transport from a long distance, *surkhi*, may be used in its place either partly or wholly.

Lime mortar, after all, is an expensive luxury, which middle and lower class people cannot afford. I have already remarked above, domestic buildings have very little transverse stress coming on their walls. Perhaps the only transverse stress is that of wind pressing at right angles to their face, but as such buildings are not very high or of any considerable length unsupported by cross walls, that stress is negligible. Hence for all practical purposes, there is little justification for this expensive luxury. All that is necessary is, to make the external faces of walls reasonably water-tight, which is, invariably or at least in the majority of cases, done in India by means of either cement pointing or lime plastering even in the walls in which lime mortar has been used.

This fact appears to have been fully recognised and advantage taken of it by our wise forefathers. Because, if we examine the old domestic buildings—even those belonging to the nobility and richer classes of those days, standing in defiance of the meteorological changes of the past several hundred years, we shall see them invariably built in mud mortar. They have used lime mortar only in such places, like terraced roofs, parapets, bath rooms, drains etc.,—places where water-tightness is required. Lime mortar is found to have been used in walls of palaces, forts and some of the public buildings, such as temples and mosques. Even in our own days to-day practically cent per cent of the houses in villages and over 90 per cent of those in towns even of recent construction are of walls with mud mortar, with some special treatment for exposed surfaces. Even in large cities like Bombay, Calcutta, Madras, and others many old houses counted by hundreds will be still found to be of a similar construction. It is only very recently, perhaps under the compulsion of Municipal bye-laws, that new houses erected on old sites in large cities and new bungalows built in suburbs, that have walls built with lime mortar, and on extensions on the outskirts of large towns, cottages have recently been springing up after this fashion (though there is no compulsion of Municipal authorities), in blind imitation of the bungalows of their "refined" city brethren. It is a pity that none of the present day engineers and architects takes interest in reviving or rather preserving this time-honoured economical method of building construction with the direful result that we are fast forgetting it and it is becoming a fashion of the day to build everything in lime mortar though majority of our people cannot afford it.

The mortar ordinarily used in buildings is mostly or entirely of fat lime. Again if the sand mixed in it contains earthly matter, or if the mortar is not ground well—things which are of very common occurrence—the resultant lime mortar is no better than the specially prepared mud mortar, and yet its cost ranges from Rs. 20 to Rs. 30 per 100 cft. !

All earths are not suitable for preparing mud mortar. The best sort is the earth* which is more or less impervious to water,

* This subject has been treated in greater detail further on under Earth walls and in Appendix 1.

that is, is the least absorbent and which, therefore, allows water coming in contact with it, to flow away without allowing it to penetrate itself beyond the skin layer of a quarter of an inch at the most. Still, it must possess freedom from both excessive swelling when mixed with water and excessive shrinking when getting dry again. Otherwise, it will form cracks while drying. Earths containing too much of clay are bad in this respect. They can be improved by an admixture of sand in it, the proportion of which can be determined by actual experiment.

The ideal earth for this purpose is found in and around town and villages, where the earth perhaps by the constant treading of people and cattle, and by the action of the manure usually produced in homesteads, attains this property of imperviousness to water to a remarkable degree. It is generally whitish in colour and therefore goes under the name "white earth." Mixed with cowdung, it is used as a plaster by village people for annual repairs to mud walls and leeping the wall surface both inside and outside. It is in fact, the poor man's whiting for giving an annual wash to the walls of domestic buildings. On account of its remarkable property of imperviousness to water it is successfully used on the top of terraced roofs. A 6 in. layer of this earth on a flat wooden ceiling is sufficient to afford an excellent protection from rains. The next best earth is, what is called 'Chopan' soil in the Deccan. This is brown, grey, or yellow in colour and its main characteristic is, that it is non-absorbent and hard—so hard and compact indeed, that vegetation does not thrive in it as it does not allow its roots to penetrate its surface, and its compactness prevents their æration.

In many places this white earth is found to be not satisfactory in point of imperviousness to water. This is due to the preponderence of calcium (lime) and mostly potassium salt (knitre), which absorbs moisture from the air. Again, there are places where the white earth is, to all practical purposes, impervious, to start with, but in the course of a few years it loses this property and shows, day by day, an increasing tendency to absorb moisture from the air and become damp. The earth near the ground surface in walls showing such damp patches loses coherence and comes off in powder at a slight touch. Hence, people prefer to transport from long distances, special earth, popularly but wrongly called "*Khari Mitti*," which is, in fact, chopan earth, to rather using this local white earth. This *Khari Mitti*, too, deteriorates within a few years.

The remedy for this evil is to leach or wash out the salts from such earths. The easiest and cheapest way of doing this is given below.

Spread about a 6 inch layer of straw, hay, or any such materials as would facilitate drainage. Make on the top of this a heap of the screened loose earth, say about 2 ft. in height. Make a hollow on the top of the heap and fill it with water up to the brim. As the water sinks down add more and continue this for a number of days till the water level does not appreciably sink down. It will be found that most of the salt will have gone out with the water which percolated through the bed of straw, leaving only impervious earth in the heap.

It was the old practice to keep such heaps for "*Souring*" for a month or more before they were broken up and mixed with water for forming mud mortar especially for plaster. The whole secret of making the earth hard and impervious to water lay in this process of "Souring", which, in fact, was nothing but one of leaching salts.

MAKING ARTIFICIAL WHITE EARTH

In the places where white earth of the best quality, or even that of inferior quality impregnated, with salts as described above is not available, any earth can be artificially rendered impervious by the following device :—

The process involved is just the opposite of what is done for improving heavy soils and making them suitable for agriculture by "liming". For this dig out the earth to be treated and remove the top layer of about 9 in. of it, which is full of decaying matter and roots of vegetation, technically called "humus." Excavate the earth from the lower stratum and put it in a shallow heap to dry. Sift it through a screen of about $\frac{3}{4}$ in. mesh to exclude stones and especially nodules of lime kankar. Then mix with it any *Sodium* salt such as salt deposit from near the sea shore, surface earth from patches of land, spoilt by the rise of underground water-table, called *Reh* or *usar* lands etc. The distinguishing feature of the latter is that it is always found in powder of brown or grey colour and tastes salt and bites if applied to the tip of the tongue. Failing to obtain these within a reasonable distance mix impure variety of common salt, offered by Government at a very cheap rate for manurial purposes, and failing to get even this, use sea water. The exact proportion of salt required depends upon the nature of the earth proposed to be treated and the degree of concentration of the salt in the stuff. This may be determined by actual experiments, by trial and error, and that proportion, which gives the best result in the individual case may be finally adopted.

The salt mixed in the earth should be leached out by making heaps on a bed of straw and filling water in the hollows on their top as described above. The more perfectly the salts are leached out the more impermeable would the earth become.* The most satisfactory way of doing this is to stir the mixture thoroughly in water in a masonry or iron tank, allow the earth to precipitate, and remove the water from the top. This may be repeated once or twice again. But this is possible only when the quantity of earth to be dealt with, is small, otherwise, the cost becomes prohibitive. Hence, the above simple and more practical method is suggested.

In short, in order to prepare ' white ' or impervious earth artificially from any earth available, add any variety of *sodium* salt, whichever is cheaply available even in an impure state, such as a deposit of common edible salt ($NaCl$), washing soda (Na_2CO_3), glauber's salt (Na_2SO_4) etc. and then *wash the salt out.*

This is not the place to enter into the chemistry of the soils and explain the exact chemical actions involved. But for the satisfaction of those who want to go more into details a note has been given in the Appendix No. 1.

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* In order to determine whether a certain soil is "sodiumised" or made impervious, the following experiment may be made :—

Take a glass tube open at both ends, close one of the ends with a piece of muslin or any thin cloth and fill it with the sample to be tested. Place it vertically in a basin containing pure water, first, with the muslin end down, for some definite interval of time, say, one hour, and note the rise of water by capillarity. Then repeat the same experiment with a fresh sample in the tube, this time not in pure water, but in the same quantity of water in which some common salt is dissolved, for the same interval of time. If the sample is 'sodiumised' or made impervious, it will be found that the rise of water in the tube in the case of salt water is considerably higher than that in the case of pure water. For scientific explanation of this please see the Appendix No. 1.

This impervious earth, either natural or artificial, as it is compact and does not hold water, is generally free from swelling when wet, and from contraction when dry again, and therefore, the cracks if formed at all in it, are only superficial. Still, it can be improved even in that respect by mixing either sand or some other soil with it. Thus, if clayey earth is mixed with sandy soil the resultant mixture is quite good. The object to be aimed at is, that there should be sufficient clayey material to give the mortar hardness when dry, and there should be sufficient sand or sandy material to prevent undue shrinkage when drying.

Foundation

The walls of a house must be built on a sufficiently solid and substantial foundation to prevent them from sinking or settling into the ground, which usually causes them to crack. They have also to be formed of sufficient thickness to secure a due amount of stability and afford protection from the heat of the sun.

It is quite true that it is impossible to rectify weakness once allowed in the foundations when the walls are raised, and therefore, one should always err on the safe side by spending a little extra money to ensure the soundness of foundations. But it is observed that in the majority of houses of the middle class people in India, which are comparatively quite light buildings, much money is unnecessarily wasted in excessive depths. It is an erroneous impression that an increase in the depth of foundations always increases the stability of walls.

The ground surface, unless it consists of rock or hard murum, is generally loose and full of roots of vegetation upto a depth of say about 9 in. If we excavate deeper than that depth, we find that the soil grows more and more compact. But there is a limit, of the original virgin soil, which, when once reached, the compactness increases but very slowly, if at all, if the strata are uniform. Every soil has a certain amount of bearing power, and if the intensity of the load put on the soil is within the limit of that power, it does not sink.

If the compactness remains the same and if we still go deeper for foundations, what we do is, we add more load on the foundations and thus in seeking to strengthen, we actually weaken them.

There is some specific object in digging to a depth of about 3 ft. in the soil. It is generally held that the effects of atmospheric and other influences do not reach beyond that depth. That is to say, the foundations in soil, if carried to this depth, are not affected by rain-water soaking into the soil, by acids dissolved in the atmosphere causing it to decompose, and by rain-water flowing on the surface eroding it. A depth of three feet is generally regarded sufficient to resist all these influences.

Hence, unless it is a black cotton soil which requires a special treatmet, it is not advisable, in the interest of economy, to go more than 3 ft. below the ground surface and as a general rule, even in the case of black cotton soil or of the made up ground of recent filling, it is uneconomical to excavate below 6 fit., if we do not strike murum, or rock, one or the other of the remedies mentioned below, whichsoever would suit the particular circumstances will be found to be cheap and effective. These are :— (1) To lay one or two layers of boulders at the bottom of trenches, to flood them with water, and to ram them hard, so as to prepare an unsinkable base for the walls to build upon.

(2) To fill the lowest two feet of the foundation trenches with dry sand packed well, upon which the footings of the walls may be built. The word "Sand foundations" might sound rather queer to a layman who may be led to suppose that he is proposing "to build on sand" but in reality sand is practically incompressible and hence, if the sides of the trenches are not likely to yield by horizontal pressure conveyed by it, sand filling forms an excellent method of strengthening foundations under certain favourable circumstances.

(3) Excavating pits at intervals down to the murum or rock, filling them with lime concrete and connecting them all together by means of arches of the same material, a little below the ground surface. This is a very simple and cheap method.

(4) Widening the foundation trenches so as to distribute the load on a greater area and laying lime concrete at least two ft. in depth above it. The latter serves as a beam and helps in equalising the pressure above.

These and few other simple devices have been described in detail in the writer's "Build Your Own Home." In order to avoid repetition of the same, only a casual reference to them has been made here.

If the ground is of doubtful nature trial pits should be excavated and the soil carefully examined. Black cotton soil swells when wet and shrinks very much again when dry, and thus forms a very treacherous foundation. The only device which has so far been found successful in resisting its effects is to construct a reinforced cement concrete (R. C. C.) band 4 to 6 inches thick all round, of the full width of the walls at the plinth level. If the soil is very deep, another band of the same thickness may be similarly laid at the level of the top of windows and doors which also makes lintels unnecessary. Detailed information about this also, has been given in the book mentioned above. If this is done the foundations need not be taken more than four ft. below ground.

When the ground is sloping steeply it is possible to effect economy by stepping the foundations as shown in the skecth (fig. No. 1). Care should be taken to make the lower layer sufficiently overlap the upper, otherwise a weak spot may be formed at the junction of the step.

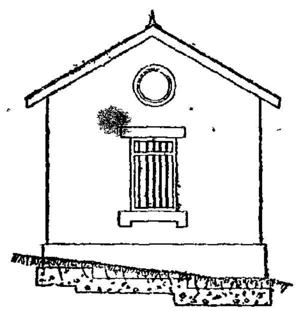


Fig. 1

FILLING IN THE FOUNDATIONS

If the soil is firm and the structure to be raised is a light, ground floor building only, it is not necessary to lay lime concrete in the foundation trenches. All that is necessary is to pack stones close together in mud mixed with a certain proportion of sand or soft murum. The stones should be as large as possible, laid on their flat surface and the intermediate spaces should be filled with smaller stones and chips packed in mud by means of a hammer. Even boulders may be used as they are found in natural state i. e. even without breaking them.

It is desirable to use stone up to the plinth level but where it is scarce e. g. in the alluvial tract of Sind, or the Punjab over-burnt or well-burnt bricks should be used.

HINTS FOR ECONOMY

If the soil is not sufficiently compact, or, if the building is to have several storeys and therefore, lime concrete has to be used, the following hints may be adopted for economy :—

For lime concrete, a proportion of 2 to 2½ parts of stone metal to 1 of mortar is generally used. But if the stone metal is graded that is, if all the sizes from 1½ in. to ¼ in. are used, by mixing gravel and sand in certain proportions, the quantity of the lime mortar can safely be reduced. By adopting the usual proportion of 2 to 2½ of metal to 1 of lime mortar what we do is, we fill all the voids of the metal by means of mortar. By using aggregate of varying sizes, we fill the voids in the metal by gravel, the voids in the gravel, by sand, and those in sand, by mortar and thus ensure even greater compactness by using less mortar.

2. It is possible to reduce the quantity of metal in the concrete and effect economy by using a fair number of big stones in the body of the concrete. This also adds to the strength of the concrete. The process of doing this properly is described below :—

(a) First lay a 4 to 6 inches layer of concrete and ram it well.

(b) On the top of this, lay some 2 inches of concrete and before it is rammed, place big stones with their flat or broad surfaces at the bottom, taking care that they are thoroughly embedded in the concrete below.

(c) The stones should not touch each other. It is advisable to leave sufficient spaces between them for the facility of packing concrete all round them. As the concrete is laid in between and round the stones it should be rammed by a wooden handle or pointed iron rammer.

(d) The top should be finished with a 3 inch layer of concrete and the whole thing should be rammed well.

This sort of concrete is called "Plum-concrete." It is not only cheaper than ordinary concrete but if properly made is also stronger.

3. In most cases lime concrete is cheaper than rubble masonry. Besides, the small pieces of stone in concrete ensure greater compactness when rammed well than the rubble masonry which is likely to remain hollow at the hands of a careless mason. Hence, it is both economical and sound to bring the concrete layer up to 6 in. below the ground surface in the case of external walls and up to ground level for internal walls. In the case of external walls it is necessary to keep the concrete at least 6 in. below ground to prevent its being exposed to view, if by chance the ground is scoured or denuded.

4. If the rate of concrete is considerably less than that of uncoursed rubble masonry, laying concrete even up to the plinth level in the case of internal walls would save a lot of money. It is necessary for this to fill in earth up to plinth first, then excavate trenches in it just above the concrete already laid below and fill concrete in them. As an alternative the walls should be provisionally lined with stones or bricks to facilitate filling and ramming of concrete. They can be afterwards removed and used elsewhere.

PLINTH

It is not prudent to curtail the height of the plinth for the sake of economy. The determination of the exact height depends upon several considerations. In damp situations or marshy sites the higher it is, the better. If the soil is of non-absorbent nature and the site is sloping sufficiently, so that rain-water is easily drained away from the building, the plinth need not be very high. 2 to 3 ft. should generally be sufficient for ordinary conditions. In no case should it be less than 1½ ft.

HINTS FOR ECONOMY

(1) It is customary to provide some sort of coping, at the plinth level, either of fine dressed champhered stone, or cement concrete 4 in. to 6 in. thick all round the building. Its purpose, viz. to allow the rain-water from the face of the walls to flow away from the masonry of the foundation is, in most cases, not properly served as a drip moulding is not provided. Hence, it serves no purpose beyond that of a decorative effect. It may therefore, be safely dispensed with in the interests of economy.

(2) Money is often unnecessarily wasted even in villages, where good stone is available, in building plinth of very finely dressed large stones. This practice on the part of the middle and lower classes is to be severely condemned as it does not add to the strength of the building. This waste, if stopped, can be utilised elsewhere in items which contribute to increase convenience and comfort.

(3) Very often the site is sloping steeply. If the slope is in the longitudinal direction, that is, if there is a difference of levels between the front and the rear of the house, there are two ways possible for economy (1) To design the floors of different rooms at different levels according to the slope of the ground and (2) To keep the floor level of the entire house the same, which, of course, must be a little above the ground surface on the higher side, and taking advantage of the slope, to construct a cellar below the floor on the lower-most side. If the floors are kept at different levels, there is some saving in the plinth masonry no doubt, but as the roof also cannot possibly be constructed at correspondingly different levels the ultimate saving is not worth consideration.

CELLAR

A well ventilated and lighted, dry cellar is an advantage particularly in small cottages in the tropical countries. Many and varied are the uses of a cellar. First, it affords an absolute protection to the room above it, from the evils arising from damp ground. Secondly, it affords an excellent place for storing certain articles which keep well only in cool places of equable temperature, away from strong light. Thirdly, though even in the best situations its use as a bed room is not commendable, it certainly provides a cool sitting room in hot climes during part of the day when the outside heat is unbearable. In such places a cellar is a necessary adjunct from the point of view of comfort. The fourth and the most important use of a cellar in modern days is as a shelter from possible air raids.

Many people, not accustomed to the use of these cellars, or '*Tahkhanas*' as they are called in Northern India, upon first entering, experience, a pleasant sensation of coolness and comfort on account of a considerably lower temperature in these subterranean chambers than that outside, but in a few moments a feeling of disagreeable stuffness or oppressiveness is felt by them and a free perspiration is caused. This is due to two reasons: one is, that a large amount of water vapour caused by the damp is present and secondly the air in the cellar is stagnant. If therefore, adequate means are provided for frequently changing the air, this source of discomfort would no longer remain.

Still, it is neither practicable nor desirable to construct a cellar in every house though it costs only about 60 per cent of that of the ordinarily built-up floor area, It is a common belief that rocky or murumy strata are best suited for construction of a cellar. But in reality, it is quite the opposite. Rock and other hard strata cost a good deal for excavation and cannot easily be kept dry on account of the joints or fissures in them. It is a different matter with soils. The more clayey the soil, the better it is, from the point of view of impermeability with respect to water.

The most economical and efficient method of constructing cellars is described below :—

Do not excavate below ground for cellar space first, if it be in soil or clayey material and build walls on sides afterwards, as is usually done. But excavate foundation trenches as usual, to 6 inches below the final bed level of the cellar, and fill them up with concrete right up to 6 inches below outside ground level of exposed walls, and even upto ground level under inner walls. If the soil is sandy or murumy and trouble from percolation of water through it is feared, the outer 6

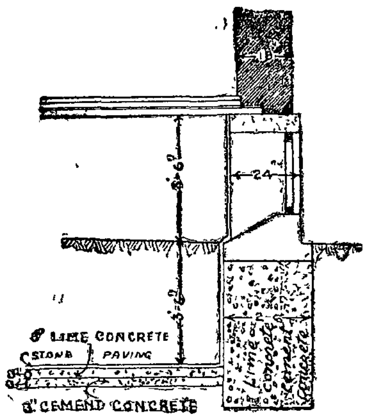


Fig. 2

to 9 inches width may be filled with cement concrete (one of cement, two of sand and four of stone metal) and the remaining inner width, with rather a rich lime concrete, both to be laid side by side in layers of 6 inches as shown in Fig. 2, and rammed well.

On the top of the concrete so laid, walls should be constructed with face masonry of stone or brick in mortar consisting of 4 parts of sand, 1 of cement, and ½ of cream of lime and inside masonry as usual in lime mortar but slightly larger proportion of lime in it, care should be taken that no hollows are left. This should be kept well watered for at least one week. Then the earth or murum in the cellar portion, should be excavated to 6 inches below the required final level of the cellar. A layer of 6 inches of cement concrete or at least 3 inches cement concrete at *bottom* and 3 inches of lime concrete above it, may be placed for flooring of the cellar, and the surface paved with slabs if desired. When the ceiling is constructed the inner sides of the concrete wall should be washed and dressed, where necessary, and plastered with a mixture of 4 parts of sand, one of cement, and ½ of cream of lime, with a final thin coat of fine sand and cement in equal proportions. The joints of the face masonry should be pointed with cement as usual. The floor should slope towards a small pit or sump. The cellars constructed in this manner may be depended upon for water-tightness.

For light and ventilation a sufficient number of windows should be provided with their sills at least 9 inches above the ground surface. Shutters of very fine wire mesh are required to keep out vermin. The height of the ceiling above floor should be at least 7 ft.

Damp and how to prevent it.

Damp is dangerous in several ways. Firstly, it seriously affects the strength of walls, sometimes causing them to collapse, particularly if clay in some form or other is used in their construction — either partially in the form of mud mortar or wholly as sun-dried bricks, or even as burnt bricks. To what extent it does so will be clear from a very common instance. Everybody knows how hard and tough the dry clods of earth in a ploughed field are. Many of them will bear the full weight of a grown-up man standing upon them. But notice what happens when a slight rain drizzles over them. The clods in the entire field are at once reduced to powder, and lie flat on the ground.

It is a common experience in villages that where damp has risen into the exposed walls, the earth in the exposed joints of stone or brick masonry, or on the surface of earth walls falls in powder at the slightest touch. This is due to the fact that the moisture rising from the bottom contains salts (mostly of sodium) and when the latter come in contact with the carbonic acid gas in the atmosphere, the earth loses coherence according to the chemical reaction explained in Appendix No. 1.

If the walls are of burnt brick masonry, the bricks absorb damp and with it, salts. The moisture evaporates and the salts are left behind in the brick. They cause the exposed surface of bricks to disintegrate and fall to powder. Thus, it is a common phenomenon, where damp has risen in brick masonry that in the lowermost one or two feet, the surface of the brick masonry is invariably seen to have worn out, leaving the upper surface to overhang a few inches. This is due to the above cause.

The effect of damp on health is still worse. It works out greatest mischief especially when it is present in close, dark rooms, with inadequate means of renewing the air. Even in rooms with free circulation of air, damp alone is a source of danger; it interferes with the natural evaporation from the skin surface of the human body; it carries the impurities in the air; and it maintains a low temperature. All these factors combined together, make the place unhealthy, even though actual disease germs may not be present. But when the rooms are close and dark and free circulation of air is wanting, the danger is enormously increased. Damp causes organic matter to decompose, and the latter gives out poisonous gases, which diffuse into the air, when full of water vapour. The latter forms a breeding place for microbes of diseases and when inhaled they get a direct entrance into the human system to work mischief. This has a very deleterious effect upon infants and women who have to keep indoors for the most part of the day.

Malaria, neuralgia, acute and chronic rheumatism are the direct results. These diseases suck the life blood and eat into the very vitality. The heavy toll of death on human life especially amongst infants and females by anæmia and consumption is the direct consequence of the presence of damp in ill-lighted and ill-ventilated, stuffy houses.

In spite of this, our people have lost a sense of fear about it, because, they are so familiar with it. It is the commonest thing in villages, crowded towns, and in old fashioned houses in cities with mud walls. The writer has specially visited a number of houses which Dame Superstition had denounced as haunted by evil spirits owing to the successive deaths which had occurred in them, and he invariably found them to have been ill-lighted, ill-ventilated and above all affected by damp to such an extent that it was most trying to stand there even for a few seconds breathing in the horribly stinking exhalations emanating from the mouldy surface of the walls and floors.

Is there no remedy? Is it not possible to fight and stamp out this diabolical evil of damp? Certainly it is. Only, you must have a strong will and a firm determination to do so. In this chapter I propose to discuss how damp can be prevented and later on under 'Sanitation' point out remedies to eradicate it, where already existing.

There are many sources of damp, but (1) the damp rising from the soil (2) damp descending from the roof into walls and (3) moisture driven by rain piercing through the external walls are important ones.

Damp rises from the ground in two ways. One, through the foundations and the other through adjacent ground surface touching or coming into contact with the material, of which the walls are composed. The moisture absorbed by the wall from the base is comparatively very little. That entering the wall from the earth against the sides is considerable. The exact quantity depends upon the wetness of the side earth and the absorbing capacity of the materials of the wall.

One remedy to prevent this damp rising up the walls is to keep the plinth level higher than the ground surface surrounding it. Still the moisture absorbed by the lower portion of the wall rises up by capillary attraction several feet and shows itself by direct evidence of irregular stained patches, or mouldy surfaces.

Very often houses are built close together and the narrow space between them gets filled with earth or other debris which goes on accumulating and its top rises higher than the plinth level. The moisture from this is absorbed by the walls even though the plinth may have been kept high enough above the natural ground surface all round, when first built.

Another cause of damp rising from the ground is the waste water from sinks in the kitchen and especially from bath rooms which, in many cases, is allowed to be absorbed in the ground close to the houses. The obvious remedy for the latter is to convey it through a pipe or an open channel of a non-absorbent material to a distance of at least 15 or 20 ft. away from the house into a cement lined underground cistern, lift it from the cistern, and distribute it daily over a large open ground, for evaporation by the sun. Small pails may be kept below pipes from the kitchen sink which should be similarly emptied every day. This will be treated in detail under 'Sanitation.'

For preventing damp rising from the ground, there are several remedies but the one which is cheap and efficient is to cut off the connection of the lower portion of the walls with the upper by interposing a course of some damp-proof material, a little above the ground level—preferably just below the plinth. Different materials might be found cheaply available at different places. Hence a few alternative suggestions are made here.

(1) Shahabad or other similar slabs of the full width of the walls laid in cement mortar all round. They should be at least $1\frac{1}{2}$ in. thick—and very carefully evenly embedded to preclude the possibility of being broken. The joints should be filled with a rich mixture of cement mortar, say, one of cement to 3 of sand.

(2) About $\frac{3}{4}$ to 1 in. thick course of hot asphalt laid all round on top of plinth walls.

(3) A 3 inch course of cement concrete of the full width of walls.

(4) Two or three layers of slate laid in cement.

(5) Sheet lead.

(6) A layer of glazed stone-ware bricks.

(7) A ¾ inch layer of cement concrete with coal tar.

The last is very cheap and most suited for cottage building and is therefore recommended. A ¾ inch layer of cement concrete, (1 of cement, 2 of sand and 4 of gravel) should be laid and kept moist for a day. The next morning hot coal tar should be poured over it to form a uniform layer ¼ inch thick. Sand should be freely sprinkled over it, a day allowed to pass, the extra loose sand should be removed and then wall work commenced. This is not only damp proof, but is also proof against white ants.

For preventing damp rising from the floor, if the latter is of murum or similar absorbent material, the best course is to spread a layer 6 in. thick. of shingle of varying sizes small and big, spread a little murum, say, about 2 inches thick above it, and on the top of it lay lime concrete 3 inches thick. Even if murum or mud floor is constructed instead of one of concrete, it remains dry.

The damp descending from the top of walls through leaky roofs can be prevented by constructing a leak-proof roof. It is comparatively an easy matter to construct a water-proof pitched or sloping roof, but where flat roofs are constructed parapets have necessarily to be built. These obstruct a free flow of water and cause it to soak through cracks into the walls below. Again, very often parapets are built at the ends of sloping roofs both for decorative effect and for carrying all rain water through down pipes, which, if otherwise allowed to drop from a height of storeyed building, would scour out the road or ground surface. Under such circumstances if special precautions are not taken, there is every possibility of damp soaking into the wall through cracks in the surface. These problems are discussed later on under 'Roofing.'

Remedies for preventing moisture being forced by high winds through earth walls are discussed in a special chapter under the caption of water-proofing of exposed surface of earth walls.

Another source of damp is the use of materials of absorbent nature employed in building construction; e. g. porous bricks. Some bricks would absorb their own weight of water. Mortar, if it contains sea sand, would absorb moisture on account of the particles of salt present in it which have a considerable affinity for moisture. Such materials behave like a sponge. In dry weather, they get dried up but during wet weather again, they absorb moisture and become saturated with water.

In the case of mud walls or stone walls in mud-mortar if the mud contains free salts, they absorb a large quantity of moisture from the air. The remedy is to leach or wash the salts out before use, by a process similar to the one mentioned above.

In short, if good shoes, in the form of a damp-proof course is used and a good hat in the form of a water-tight roof is provided even walls built of sun-dried clay bricks or of even lumps of clay, will give perfect satisfaction in respect of damp. Coat in the form of some special water-proofing treatment if provided, particularly in the case of earth walls, will prolong the life of the walls, but from the point of view of damp and its effects on health this source is not so important.

Walls.

Walls form by far the most important and costliest item on the estimate of a building and it is therefore, here, that some room for economy must be found. It can best be effected, as we have already seen, by using local materials. But certain materials available at a particular place may be scarce at another. Hence, it would be well to discuss the various alternative methods of wall construction with different materials.

FRAMED STRUCTURE *Versus* SOLID WALLS

There has been a time-honoured practice of building walls, in India, in which the walls are re-inforced by means of a frame-work of vertical posts and horizontal beams fixed on their tops and all embedded into the walls. In the houses of the rich, the wooden members of the framed structure used to be obtained from cut timber and therefore for the sake of decorative effect they were left projecting half an inch beyond the wall surface. while in the houses of the lower classes, they were either round rafters or roughly squared pieces embedded in the centre of the walls. The object of the framed structure was, to throw all the upper load of floors and roof over the posts, which were further strengthened by the lateral support they received from the walls. The walls, in this instance, had practically no structural function to perform, at least in the beginning, but to serve merely as partitions and to prevent transmission of heat, or cold and sound from one side to the other, and also to afford protection from thieves in those very troublous times. The fear of robbers weighed so much with the people of those times that though the walls were not primarily intended to take up the load above, they were built very thick 3½ ft. to 6 ft. or even more in some cases. The extra thickness of the inner walls was utilised in most cases for a staircase which was accommodated in the body of such walls.

Apart from the numerous merits of this system of framed wall construction, which have been discussed in the author's treatise "Build your own Home" there is a great outstanding disadvantage in it, which at once eclipses all its merits. It is in the fact that the members of the frames which consisted of wood were subject to the attack of Dry Rot* and termites (white ants), the greatest enemies of wood in India. Particularly dry rot works its mischief, as we have already seen, in places which are damp and which have a deficiency of free air. Now, in the situations the frames were used, either partially or fully buried in the walls, they could not get free air, and moreover, the defective drainage arrangements to which these old houses were usually subject, caused also damp to rise. Thus rot first started in the bottom of the posts which gradually spread to the top and ultimately attacked the post plates also. The natural result of this defect was, that in many cases the frame members having been hollowed out could no longer support the load, which consequently fell upon the walls. The secret of the long life of such old houses lay in the extraordinary thickness of the walls. If they were of ordinary thickness of 18 inches, they would certainly have crumbled down in a shorter period.

Thus a framed structure of wood should not commend itself to any body unless either the walls are built of extra thick-

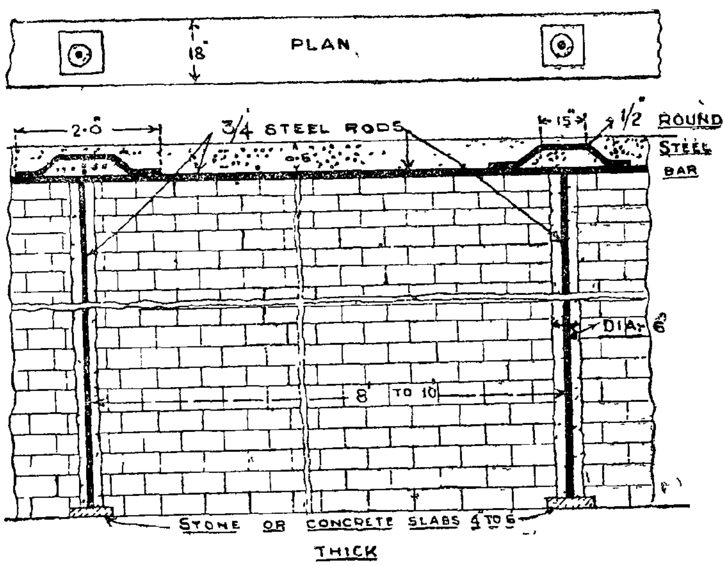
* Please see page 8

ness, which, in these days of restrictions of space and funds, is not likely to find favour with people, or some such material like steel, proof against white ants and dry rot is substituted for wood of the frames. This sort of construction would do well for temporary sheds, farm houses, barns, stables and cowsheds etc., but not for permanent structures built as an investment.

From the point of view of economy also it may be noted that where special "white earth" which is generally used for preparing mud mortar for such walls either of stone or burnt brick, costs more than Rs. 6/- per 100 ctt. including carting charges, this sort of construction even with round teak rafters for frames is more expensive than solid walls built in lime mortar.

most economical and efficient method is to reinforce them by means of some sort of slender steel columns.

Recent tests made by the Bureau of Standards, in America, have conclusively proved that such columns, if rigidly fixed all round in the centre of the walls so as to prevent any bending or buckling, can be counted on, to carry loads up to the yield point of steel, before failure occure. The columns may be in the form of either galvanised iron pipes, of say, $1\frac{1}{2}$ inch diam. filled with cement concrete, with wall-plates also of same connected to them with T pieces, or even better still, I-beams of the lightest section viz. 4″ in. × $1\frac{3}{4}$ in. weighing 5 lbs. per foot of length. with cement concrete filled between the flanges. Even at the conservative rate of Rs. 7/- per cwt. to allow for market fluctuations.



Figs. 3 and 4

It may be mentioned here incidentally, that for a ground floor structure only, that is, for a house without any storey, if 18 inch thick walls in mud mortar are well founded and built perfectly in plumb no reinforcement of posts etc. is required for supporting the load of the roof. If one or more storeys are to be constructed, the

and reasonable transport, the above I-beams cost annas 3 per foot and if annas 2 are added to it for the cement concrete and labour of joining and fixing, the aggregate rate of annas 5 per foot length compares favourably even with round rafters of timber and is absolutely free from the danger to which wood is liable.

It is possible to make it cheaper if the following method is adopted :—

Instead of wooden posts and post-plates above them, erect ¾ inch round bars of the necessary height with bottom placed on concrete or stone slabs, at least 4 inches thick and 12 inches × 12 inches at least in length and breadth. Tie on their top another horizontal bar of the same thickness and another small piece bent as shown in the sketch, (Figs. No. 3 and 4), 4 inches above it, by means of a piece of thin wire. After this is done, regular wall of stone or burnt brick in mud may be commenced leaving in each layer an irregular hollow space, of say, some 6 inches diam. all round the iron rod and fill it up, each time, when 4 layers of brick work or about 12 to 15 in. of stone work is built, with cement concrete. The objects of this are (1) to protect the steel against rusting (2) to give it the necessary stiffness against bending or buckling and (3) to form, in other words, a reinforced cement concrete pillar and beam at top, without centering. When work is commenced the next day, the concrete surface of the previous day should be roughened before fresh concrete is added. The vertical rod should have no joint. The horizontal rod can be lengthened by tying two ends of rod with an overlap of 18 inches by a wire. When the level of about two inches below the horizontal rod is reached, the edges of the wall may be lined with bricks laid flat, or stones, and a hollow space of 6 inches width may be left with the iron rod in the centre. The rod should be so placed that there will be a hollow space of two inches below it. This and the space above it may be similarly filled with cement concrete so as to form a rough concrete beam of 7 or 8 inches thickness, and of the same depth.

With the foregoing discussion about framed structures we now turn to the subject of walls.

The materials forming the composition of walls are of two sorts : one is called the aggregate, such as stones, bricks etc. and the other is called the binding or cementing material, like mortar. The latter may consist of lime, cement or mud.

In an earlier chapter, while discussing materials mud mortar has been advocated as a suitable material for walls of houses of the cottage type. But while using it, certain precautions have to be taken, as otherwise, not only will the bill for the maintenance and annual repairs of the building swell enormously, but the life of the building would be shortened. These are : (1) Proper selection of the earth; (2) Guarding against damp or any sort of moisture entering the walls and (3) Protection against rats and white ants.

Regarding the third precaution, viz. protection from rats burrowing under walls, and white ants eating out timber used in the structure, the subject has been treated in a special small chapter elsewhere in this book.

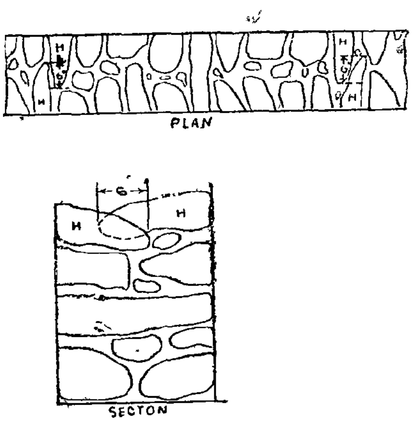
1. WALLS OF STONE

After a general discussion on framed structure versus solid wall we shall consider the different methods of building walls with whatever material locally available. Stone and brick are the most common materials. If stone is used there are two methods of building walls; one, which is called the coursed rubble, requiring faces of stones to be dressed to a rectangular shape. In this, the face of the wall has long lines of horizontal joints, with all the vertical joints at right angles to them. This sort of construction is pretty expensive. The other sort presents irregular joints in the face work and is called uncoursed rubble masonry, because, there are no regular courses in it. This is not only comparatively cheaper but also looks artistic.

With the use of mud as the cementing material, every little point, which tends to make the wall strong, cannot be neglected. Hence, it would not be amiss to point out, in passing, the common mistakes made in practice and the necessary precautions required to avoid them in the above two methods of stone walls.

The first precaution is the use on a generous scale of through stones or "headers" as they are called, that is, stones with their length equal to the full thickness of the wall. Their function is to bind the two faces of the wall together. They should be spaced, in each course defined by the corner, at intervals of 6 ft. When the corner stones for a course are fixed at the two ends of the wall, the headers for that course should be first placed in their positions and then the intermediate spaces between them should be filled with masonry. The headers in the course above it should be so fixed that each comes midway between the two in the immediately upper and lower courses.

If the headers of the full thickness of the wall are costly, two shorter ones



Figs. 5 and 6

should be so fixed side by side with their faces on the opposite sides of the walls as shown in plan and section in Figs. 5 and 6 at H. H., that their tails overlap at least 6 inches as shown in the sketch.

The second precaution necessary for strength is, that every stone fixed in the wall should rest on its broad surface at the bottom. Masons are in the habit of fixing stones on edges with their broad surfaces lining the face of the wall. They do it because it saves them the labour of making two or three joints which would otherwise be required, and therefore, they can speed up the work thereby. But this is a dangerous practice, though the face of the wall apparently looks more elegant. Even common sense will tell us that stones which have no sufficient base to rest upon, nor tail going into the thickness of the wall to bind it are likely to slip away under pressure from above. In this connection the general rule is, that *every stone used in the facework of wall must have a tail at least 1¼ times its height.*

The third necessary safeguard is, that not only should there be no hollow spaces left in the wall, but that every hollow must be filled, not with mud alone, but with stones set hard in the mud with a stroke of hammer. Again, instead of a number of small stones or chips, it is better, in the interest of strength and stability, to select large ones to suit the shape of the hollow.

Small stones, whether in the face work or hearting of walls, mean more joints and more mortar. This both increases the cost and weakens the structure.

2. BURNT BRICK WALLS

The quality of bricks manufactured in India, except perhaps in a few places, is poor. Especially, their skin being not so hard and non-absorbent, like that of English bricks, they absorb a good deal of moisture and become damp. To overcome these defects, the brick-work is generally plastered with either lime or cement which increases its cost. If the annual average rainfall of a place is above 50 inches, some water-proofing treatment is necessary to keep out damp, but at other places, if only well burnt, and uniformly coloured bricks are selected for the face work and they are laid perfectly in plumb, the work, if neatly pointed, is lasting and looks quite well, even without plaster. If the experience of one monsoon shows that it affords a sufficient protection from damp, as will generally be found to be the case at such places of low rainfall, there will be a considerable saving in the cost of external plaster.

3. HOLLOW CONCRETE WALLS

Cement concrete as a cheap building material is a modern product. Great strides have been, of late, made in using it successfully even in the extreme ranges of temperature in the tropics. As it possesses considerable strength, economy can be effected by adopting a thinner section of wall. But in a hot country like India, as a thin wall is likely to make the house hot, a wall thinner than 9 inch in width cannot be used especially on the outside. However, as the material is pliable when wet, hollow concrete blocks can be made. A wall built of these, affords protection from heat on account of the air space inside it. In towns and villages, served by a railway line or a good metalled road bearing motor traffic, cement concrete for cottage construction lends special charm, as clean river sand and gravel could be obtained in plenty, in the greater part of India, merely for the charges of collecting. Such buildings are not only strong and durable, but are easy and cheap to maintain, keep clean, and look neat and tidy. The only difficulty is of getting machines for moulding hollow blocks on a cheap hire so as to come within the reach of a house builder of ordinary means. On account of this difficulty its use has been at present restricted to buildings of considerable magnitude only, in which concrete blocks are required to be manufactured on a large scale. However, concrete as a cheap material has great potential future before it in India.

4. COMBINATION OF BURNT AND UNBURNT BRICK

There are many places where stone quarries are not within a reasonable distance and bricks from kilns which are almost entirely burnt by village potters may also have to be carted from a distant village or a small town. At such places, a composite work of a combination of burnt and unburnt bricks may be resorted to.

The idea is to use burnt bricks only on the exposed surface of walls for making them resist the atmospheric influences, and sun-dried or *kacha* bricks not only for the inner partitions but also on the inner face of the exposed walls. A further economy in this respect may be made by using clay lumps instead of regular sun-dried bricks. The process of preparing them is described below :—

Get a heap of white earth or whatever soil that may be available on the site, remove all roots of vegetation etc., sift it through a screen of half inch mesh. If it contains an undue amount of clay and shows a tendency to crack while drying, mix some sand or gravel with it and make a plastic mass of it with water, of such a consistency as a lump made in hand, if placed on ground, will not spread. Then on a level piece of ground sprinkle some sand or dry earth or ashes and form a roll of it 10 ft. or longer according as the space will permit, 13 inches wide, and 5 to 6 inches thick, roughly squared either by hand or a flat piece of wood, and cut it across into pieces 8½ inches long by passing a piece of wire vertically down across it by hand from top to bottom. Thus each piece will be roughly 13 in. by 8½ in. by 5 to 6 in. thick. The thickness will depend upon the thickness of the burnt bricks used in the face work. It should be twice

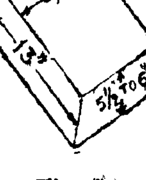


Fig. 7.

their thickness plus ½ in. Thus if the burnt bricks available are 2½ in. thick, the thickness of this lump should be 5½ in. and so on. One such piece is shown in fig. 7.

Allow these pieces to dry in the sun for two days, then turn them over for drying for one more day, after which, they are ready for use in the wall. The method of constructing the wall is as follows :—

A number of well-burnt bricks should be kept immersed in water for 2 or 3 hours before starting the work. Two masons should be employed, one with these burnt bricks and lime mortar on the outside face of the wall to be built, and the other, with the clay lumps and mud mortar on the inner. The mason on the outside should spread a layer of lime mortar of ½ inch thickness, and 4½ in. width along the exposed or outer edge of the wall and behind that the other mason should spread mud mortar of the same thickness and of width upto the inner edge of the wall, then the first mason sitting outside should lay bricks stretcher-wise i. e. parallel to the wall as shown in the fig. 8 leaving a space of ½ inch between the ends of bricks, they will of course rest on lime mortar. The half inch space between the bricks should be filled with lime

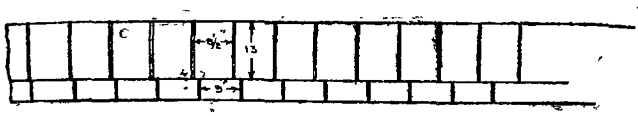


Fig. 8, First course of burnt bricks.

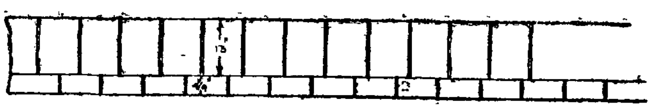


Fig. 9, 2nd course of burnt bricks.

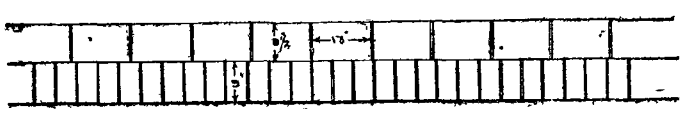


Fig. 10, 3rd course of burnt bricks and 2nd of clay lumps.

mortar. While this is being done the 2nd mason sitting inside should lay the clay lumps headerwise i. e. with their 13 in. side across the wall, as shown in fig. 8 making a joint of ½ in. thickness with both the burnt bricks already laid and with another clay lump, laid by its side, filling it with mud mortar.

For the 2nd course of burnt bricks the first mason should spread another layer ½ in. thick and 4½ in. wide, of lime mortar, as before, on the top of the layer previously laid, and lay bricks stretcher-wise as before but breaking joints in the centre of the bricks previously laid as shown in fig. 9. The 2nd mason should fill in the joint between this layer and the clay lump already laid, with mud mortar. This completes one course of the clay lump. As the thickness of clay lumps is twice that of the burnt brick plus ½ inch, the top of the wall at this stage will be roughly level.

The first mason should then spread another layer of lime mortar ½ inch thick and 4½ in. wide as before on the top of the burnt bricks and lay bricks near the outer edge headerwise i. e. 9 in. length across the wall as in fig. 10 making a vertical joint ½ inch thick between two bricks ; on the top of this another layer of lime mortar to be spread as before and another course of bricks laid headerwise as before, as shown in fig. 11 but with joints coming exactly over the centre of the bricks below. The front portion of these bricks 4½″ long will be laid in lime mortar, the remaining 4½″ portion being laid in mud.

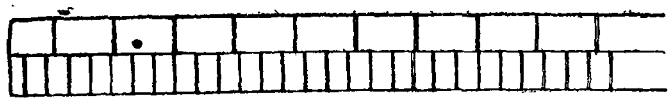


Fig. 11, 4th course of burnt bricks and 2nd of clay lumps.

The inner mason should lay lumps stretcherwise i. e. 13 inches length parallel to the length of the wall as shown in figs. 10 and 11, taking care to bring the front surface in plumb and filling joints of bed and the sides well with mud.

After this, two stretcher courses of burnt bricks on the outside in 4½ inch width of lime mortar and a header course of clay lumps behind it laid in mud, is to be repeated and so on.

How the outside surface of such a wall will appear is shown in fig. 12 and a cross section of it in fig. 13.

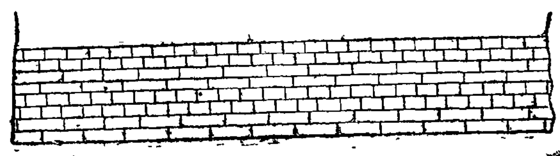


Fig. 12

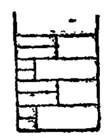


Fig. 13

The points to be specially noted in this sort of construction are :—

1. That the mud mortar should contain a little more sand than usual and it should be used a little stiff i. e. just sufficiently wet as would enable it to be thrust into the joints with a mason's trowel. These precautions are necessary because, we have to join mud work with lime mortar work. Mud mortar shrinks more than lime mortar. If the mud mortar contains more water it will shrink more and a crack will be formed at the junction of both the mortars. Admixture of some sand and use of as little water as possible in the mud mortar, would cause it to shrink less. The object to be aimed at is, to make the coefficient of shrinkage of both the mortars, equal. This may be tried by an experiment and if required the lime mortar may be made slightly more wet. It is for this reason, necessary, that the burnt bricks must be kept well immersed in water for a sufficiently long time before being used. Otherwise, they would absorb moisture from the lime mortar and affect its co-efficient of shrinkage.

2. The mason using lime mortar should be made to take special care in filling the joints neatly i. e. making them of uniform width, and making the horizontal joints exactly at right angles to the vertical, while laying the masonry in the first instance, so that, there should be no necessity of pointing them again.

3. Water should be sprinkled freely to help lime mortar set hard. It should not however, be done on the top of the wall but on the exposed face, because the water on the top might enter the mud mortar or clay lumps and thus damage the wall.

4. If the foundations are sufficiently sound it is not necessary to reinforce the wall with posts etc. if the building has no storey. 18 in. thick walls constructed in the above manner will easily sustain the weight of the roof.

5. There is no need of plastering the inner surface of walls if it is made plumb

and smooth just while laying the clay lumps, by dressing the projecting portion with a mason's axe and applying mud mortar mixed with a little cowdung, in the hollows.

6. The inner surface thus prepared should then be given a wash with a mixture of 12 parts of white earth, two of cowdung and one part of cement, and may then be treated with two coats of white wash.

7. Lintels over doors and windows should go a little longer, say, 9 inches at least into the wall on both sides of the opening.

8. If a water-tight roof, say, such as that of C. I. sheets is constructed, the house with walls as above looks like a pucca structure and does really behave as one.

5. WALLS OF EARTH.

Earth walling is of great antiquity in India. Even to this day, it is the common practice in villages and towns in every part of the country. Recently it has been gradually falling into disuse particularly in towns, perhaps on account of improved facilities of transport.

Earth is specially well adapted for walling in country districts away from large towns where a suitable variety of it is available in plenty merely for the collecting, where skilled labour is costly and unskilled labour cheap, and where site is not much restricted i. e. work of rather a bulky nature is not only admissible, but would rather conform to the general surroundings.

If earth walling is adopted it is necessary to modify the design to a certain extent as given below :—

(1) The exterior angles of corners should be rounded.

(2) Projections and recesses in walls should be avoided. Bays and ingle nooks are unsuited to earth walls.

(3) As far as possible walls upto the plinth level should be built of stone or burnt brick; but if a good slope away from the walls is given to the ground, so that rain water as it drops from the eaves, flows away rapidly, there is no harm if the plinth is also of earth.

(4) The eaves of the roof should project a little longer than usual, so that the top portion of the walls is protected from rain.

(5) Water-tight shoes and hats i. e. foundation of non-absorbing material, and a non-leaking roof should be provided.

Earth as a material for wall really possesses a good many virtues to commend it for more general acceptance. The special advantages which it commands over the stone or brick are given below:—

(1) It is the cheapest and easiest form of walling. Stone costs something for quarrying, carting and dressing; brick costs something for moulding, burning and transport. Earth alone is the only material which can be dug near the site and used directly into the fabric of walls without any elaborate or costly process of conversion.

(2) An earth wall can be built by an unskilled labourer or farmer. For stone or brick walls one has to depend upon mason and other men of the artisan class.

(3) Earth being a far better insulator of heat, houses of earth walls keep cool in summer and retain warmth in winter. Hence, they are found to be more comfortable. Besides, as constructing a slightly thicker wall of earth costs only a trifle more, it is within the easy reach of the poor, to secure greater comfort at a little extra cost.

(4) The repairs and renewals are very easy and cost very little, e. g. mud plaster

can be cheaply and easily renewed. Lime mortar does not stick so well to old mortar which has already set. This is not the case with earth. Again, if brick work is dismantled there is some loss of bricks in breakage. If, however, an earth wall is dismantled nothing is lost.

(5) The progress of the work can be speeded up to any extent.

(6) They are far less susceptible to destrcution by an earthquake than either stone or brick walls, as was proved in the earthquake of 15th January 1934 in Bihar. This is a very important discovery and this fact has been borne in mind in the reconstruction of Bihar.

(7) As the material from the immediately surrounding locality is used, earthen walls conform to the harmony of the neighbourhood.

(8) Earth walls are more secure from fire than stone walls. Stone when subjected to heat for a long time cracks and splinters.

There are three methods of earth walling : (1) Walls with sundried bricks (2) Walls built with mud in situ and (3) *Pise de terre*, or walls of rammed moist earth. The first is very common even to this day in towns and villages. This form of walling is extensively used for internal partitions. The second method was once very much in vogue, but has almost died out at present though its rude technique is found to have been still preserved by very poor farmers in remote villages. The third is almost unknown in India though it has many merits to commend itself for general adoption by middle and lower class people. It has been very extensively practised in western countries in spite of great natural disabilities obtaining there, such as the absence of dry weather and hot sun.

5 (a) WALLS OF SUN-DRIED *KACHA* BRICKS

The reason why this method is more popular than the other two is, the convenience and ease with which it can be worked. First of all the *kacha* bricks can be moulded at leisure, dried and kept ready, and work commenced at any convenient time later on. Secondly, walls of any desired thickness can be built according to the size of the bricks moulded, and thirdly, the plastering or giving a wash of white earth and cowdung can be taken in hand at some later convenient date. The only important thing is, that all the operations must be done before the rainy season begins. If the bricks are ready, actual building work does not require much time.

Any soil would be suitable. Of course white or impervious earth described on page 11 is the best. But if either of these is not obtainable on site any other soil would serve the purpose, provided the bricks formed of it, do not crack much during the drying process. In that case, some sand or better still, rock powder or fine murum should be mixed with it. If the structure is single storied, 18 inch thick walls can easily take up the load of the roof and resist wind pressure, without any reinforcement of vertical wooden posts. For a two-storied building, the thickness should be 21 inches throughout for both the floors, if reinforcing posts are not used. If space permits, thicker walls like this are preferable, both from the point of view of cost and protection from heat, to walls of a thickness of 18 inches or less even if reinforced with posts of wood. For, unless well seasoned cut teak posts are used, they are liable to be attacked by white ants or to disintegrate by dry rot. For a two storied building, a thickness of 21 inch *throughout* is recommended because, if the walls of the upper storey are made 18 inch thick and flush with the outer edge of the lower walls i. e. if an offset of 3 inches is left on the inner side, the centre of gravity falls towards the outside and the walls are likely to tilt on that side. If, on the other hand, the upper walls are built in the centre leaving equal offset of 1½ inch on either side, the rain water striking the outer surface is likely to soak through the outer offset unless a string course of some water-proof material with a drip mould to allow the water to drop away from the wall is provided at a considerable cost.

It is possible to make this sort of walling still cheaper by using earth lumps described in the previous chapter instead of regularly moulded bricks.

5(b) MUD WALLS BUILT IN SITU OR "COB WORK"

Once a very common method of wall construction, it has now almost died out in this country. It is still seen practised in some remote villages by indigent people. They take one or two off days from their farm work and men, women and children — members of the entire family concentrate together and build a hut for themselves, because they cannot afford to employ the services either of a skilled artisan or even of a slightly skilled fellow farmer. Again, the whole aim is to finish the work in a minimum period to save time for field work. They are, therefore, content if the hut just gives the family a shelter from the inclemency of weather. Hence, no attempt is made for obtaining uniform thickness of the wall, or, to test the surface with a plumb baub. The wall is generally crooked and tapering towards the top. It is built simply by piling lumps or balls of mud one upon the other, and wiping the surface smooth by hand dipped into water. No attempt is made to build the walls solidly on a sound footing ; hence, they begin to crack soon afterwards. The hut is invariably covered with a thatching of hay, paddy straw or even leaves of palm trees, of inadequate thickness, with the result that rain water soaks into them, and as there is generally no plinth provided, damp also rises from the bottom. Thus the whole thing presents an appearance of neglect and squalour.

Mud, however, forms an excellent material for construction, the virtues of which are not put to a proper test and appreciated in these days. Our forefathers knew the secret of construction very well. We still see old neglected forts or ramparts 30 or 40 ft. high still enduring, though in a ruinous condition, encircling villages or towns built formerly for protection from enemy's attacks in those troublous times. They used stones for the faces up to a certain height, and rammed mud between them for the hearting, and above this height mud appears to have been used even on the faces. Years amounting to two or three centuries have rolled on, they have never received any care of repairs at human hands, but on the contrary every neglect and contempt, still they stand obdurate all these years in defiance of the fury of Nature ; what more triumph can there be of the enduring power of cob work ?

To quote another instance the famous fort of Bharatpur near Agra, one of the most unvulnerable strong-holds of the Jats in India at that time, was built entirely in mud. It had been several times besieged by the English and bombarded with heavy guns on several previous occasions ; but without success, so much so, that this led to the establishment of a superstition to be associated with it, that, as angels protected the fort, it was not possible for any human effort on earth to capture it. At last it was when a strong contingent of army, under Lord Comberemere, was despatched and, only when an extraordinarily heavy mine of gun powder, on a scale hitherto unknown, was applied at the bottom and fired, that a piece of the rampart was bodily lifted with men on it and hurled into the sky. And through the passage made by it the British troops made their entry and captured the fort in 1826.

The Jat king constructed the bulwork of mud in preference to stone, not because stone was scarce or because he could not afford it, but because he knew confidently that a mud fort was stronger than one of stone and the result proved that he was justified in his conclusion.

There is a considerable evidence to show that this form of wall construction was once very common in domestic buildings but some how or other, it came to be forgotten and now it is almost extinct. The correct process of doing it is described below :—

The foundations should be first excavated up to murum or rock if the latter be found within a reasonable depth below the ground surface, or to a firm soil (except deep black cotton soil which requires special treatment), and the trenches should be filled with boulders of stone, rubble, or burnt brick, if stone is not available within a reasonable distance, using mud mortar. It is advisable to use stone or burnt brick upto the plinth.

The ground from which earth for preparing cob is to be utilised, should be cleared of all vegetation, the upper 9 inches layer of it which is full of roots of vegetation, decayed matter etc. should be removed and the stratum below it should be excavated and used. All lumps should be broken. The more impervious the earth is to water, and free from swelling when wet and from cracking when dry again, the better it is for cob work. It is screened to exclude stones above one inch in diameter. A circular heap is made of it with a hollow made in the centre at top which is filled with water and kept in that state for several days for " souring ". Then wheat or rice straw chopped into pieces 3 to 6 inches long is sprinkled over it freely and the wet earth is drawn by a phaorah and mixed while a man is sprinkling more water over it by means of a rose of a water-can. It is then well kneaded under the feet of workmen and thoroughly mixed into a suitable consistency. Some people mix dung from horse stables in it.

Lumps or balls of the cob are then formed which should be just wet enough to afford ease in laying ; if they contain more water, they have a tendency to spread and the wall bulges out.

Diagonal layers, instead of horizontal ones, laid as shown in the sketch. (Fig. 14) are stronger. Each layer is trodden under the feet by the man who stands on the top of it. In most cases, shuttering of boards to support sides are not used, but the extra earth on the wall surface is pared or dressed after 24 hours, with an instrument having an iron edge to which is attached a long wooden handle. See figs. (15 & 16.) A plumb line should be used at this time to make the faces truly vertical. If the lower

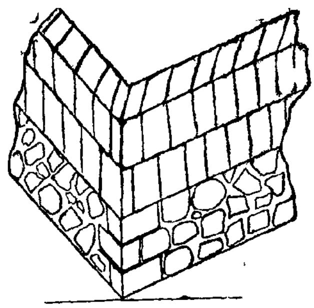
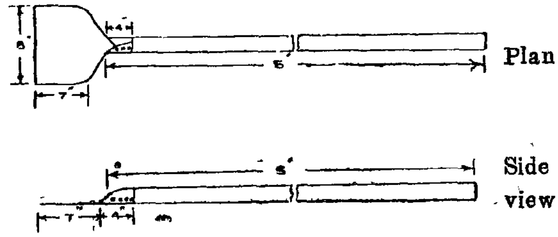


Fig. 14.



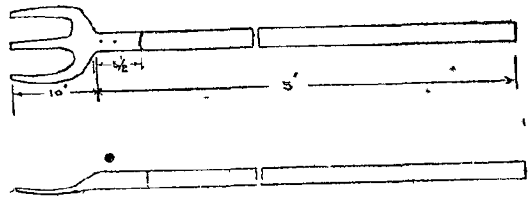
Figs. 15 & 16 Paring instrument

most one or two feet, or say, the plinth masonry on the outer face is constructed of either stone or burnt brick in mud, (which is strongly recommended in the interest of keeping the walls free from damp), it is very easy to keep the rest of the upper surface of cob work in plumb with this. Each course is 12 to 18 inches thick and is laid, between horizontal strings stretched on both sides of the wall. As each layer is being laid, it is trodden by the man standing on the top of the wall and receiving the balls of cob. Since very little water is used in the preparation of the balls of the cob,—just so much in fact, as would give the necessary pliability to the material for ease of work, each layer dries up sufficiently to take up the weight of another above it, in about an hour or two in this country, if the work is done in summer.

The thickness of the wall depends upon the height to which it is to be raised. For a single storied building 21 to 25 inches thickness is sufficient both from the point of view of its own stability, strength for supporting weight of the roof, and protection from heat and cold. The internal partitions are best made of unburnt bricks 9 to 18 inches thick, to save space. In Europe even two storied houses of cob walls, *without* intermediate supporting wooden posts, have been constructed and have stood well for over hundred years in spite of the wet weather which prevails there for almost 12 months in the year.

As the work progresses and the wall reaches a height not easily accessible to labourers for handing lumps or balls to the men standing above, a sort of tool consisting of an iron fork with a wooden handle as shown in the sketch, (see Figs. 17 & 18) is used for reaching the balls to the man above. The surface of the wall constructed is pared or dressed and made smooth and plumb after 24 hours. It is then given a wash on the inside and outside, of white earth mixed with a certain proportion of cow-dung.

On the top of a door, window or cupboard opening, lintels of wood, or, if trouble from white ants is feared, of R. C. C., may be placed. The point to be remem-



Figs. 17 & 18 Plan & side view of the fork

bered is, that they should be sufficiently long, projecting at least one foot over either corner. There are two methods of making door and window openings. In one the frames of doors or windows are erected in position by supporting them temporarily with inclined stays, when the wall work reaches their bottom level, and the wall built between them as usual. In the other method, wall is first built solid with only the lintels fixed at the proper levels in it and afterwards the recesses for doors and windows are carved through below them, and frames inserted in them. The 2nd method affords ease in construction, but as frames cannot be fixed by means of iron holdfasts, well anchored in the body of the wall, they are likely to be a little shaky in course of time. All outside corners should be widely rounded, so that they may present a neat appearance and be not susceptible of being easily knocked off. The corners of door and window openings should be chamfered as usual.

Roof :—A hipped roof is more suited to this sort of construction as the walls need not be raised so high as in the case of gables. Again, the latter expose greater unprotected surface to rain.

Any roof covering may be used, provided it is water-tight. In this respect, a roof of corrugated iron sheets, with sheets bolted to wooden wall-plates on top of walls, is excellent. For preventing iron sheets being blown away by high wind, the wooden wall-plates may be fastened down by means of wire ropes well anchored into the walls. A thatched roof looks more in harmony with cob walls, but firstly, it is insanitary, and again, it affords a breeding place for rats, and moreover, is likely to catch fire, and lastly, if not well cared for and repaired from time to time, it is likely to leak. The C. I. sheets may be covered with thatch if desired, as it will serve to keep off heat effectually.

The mode of water-proofing the outside surface of earth walls in general has been discussed in a special chapter.

5. (c) *PISE DE TERRE*

'*Pise de terre*' is a French expression for "Rammed earth." This method of construction does not appear to have been practised in India. It is however, an excellent and cheap method and most suited to Indian conditions. Hence, it has been treated at considerable length in the following few pages. The author has experimented on it on a small scale and found the results most promising.

Nothing would be better than to quote Mr. St. Loe Strachey, an authority on *Pise* building.

"As we do not possess the crystal air and intense sun heat of Australia, the earth walls do not harden in England."

We, in India, are very fortunate in possessing the advantage of both these "crystal air and intense sun heat."

To proceed with the quotation, "that, heat evidently produces a skin, which must be almost like brick. At the same time even in our English climate, the eighteen inch wall becomes perfectly strong and substantial for all practical purposes. As however, it had to face the rains of an English autumn and winter, I have had the outside covered with a mixture of coal-tar and pitch, which produced a surface very much like that of a tarred road on end, and is quite satisfactory. On the inside of the building the face is left untouched, and has already become very dry and hard. It is evident that it will make a peculiarly good wall for a house."

There is a very interesting account given of a *pise* church written by Abraham Reed, D. D., F. R. S. F., L. S. in volume XXVII of the Cyclopædia or Universal Dictionary of Arts, Sciences and Literature, from which is extracted the following quotation:

"A *pise* Church:—The Church was the most remarkable in this style of building; it is about 80 ft. long, 40 ft. broad, and 50 ft. high; the walls built in *pise* 18 inches* thick and crepe, or rough-cast on the outside, with lime and sand. Soon after my arrival, the Church, by some accident, was destroyed by fire and remained unroofed for about a twelve month, exposed to rains and frost. As it was suspected that the walls had sustained much damage, either by fire or the inclemency of the season, and might fall down, it was determined to throw them down partially and leave only the lower parts standing; but even this was not done without much difficulty, such was the firmness and hardness the walls had acquired, the Church having stood for over *eighty years*, and all the repairs required were only to give it on the outside, every twelve or fifteen years, a new coating of roughcast."

The essential difference between cob work and *pise* work is that whereas in the former mud is prepared with a free use of water, and straw is added to it, in the latter, the earth which is just moist, is rammed between boards or planks laid on both sides of the wall, and not only no straw is added to it but every bit of root

* *N. B.*—The 18 in. walls were carried to 50 ft. height *without* any vertical posts to re-inforce them!

of vegetation is scrupulously picked up and thrown away from it. Another difference is, that cob work, on account of its plastic condition does not admit of ramming hard, while, the success of *pise* work lies in quick and hard beating of the earth in moulds.

SUITABLE SOILS

Soils are sometimes called stiff or light from an agricultural point of view, according as they offer greater or less resistance to the plough. The stiffness is due to the greater proportion of clay, and the lightness, due to that of sand. The soil suitable for wall work should be neither heavy nor light. Between these two extremes there is a very wide range of soils which are suitable. The soils at these extremes also can be made suitable by blending them together in proper proportions. But no sooner complications of this nature enter, the *pise* work loses its greatest virtue of cheapness, because, one of the two soils has to be transported at considerable expense and also the cost of labour in the process of mixing the two together, has to be added to it.

Fine silt in the river bank is eminently suitable, so also silt from canals or tank beds.

Soil denuded every year by rain from hill slopes and deposited at the foot, is very good.

All earths which are suitable for brick or tiles, form an excellent material for *pise*. Thus, between the excessively heavy on the one hand, and the excessively light on the other, there is a countless variety of soils which are suitable. Of course, some of them are better than the others.

Before deciding upon the final choice of a particular soil for work, it would be well if the following simple experiment be made.

Dig a pit in ground, say, about 3 ft. by 3 ft. and 18 inches deep. Then take a bottomless iron bucket of ordinary size and put it in the centre of the pit on a piece of stone slab or a wooden plank. Put the earth selected for the *pise* work into the bucket to form a layer of 4 inches in loose state; also put the other earth excavated from the pit, round the bucket to form a layer of equal thickness. Ram both the earths hard until the layer is reduced to half its thickness. Then add on its top, layers of similar thickness, taking care to consolidate each before another is added; continue this till the top of the bucket is reached. Let it remain in that condition for 24 hours, after which, dig out the earth in the pit outside the bucket, till the latter, with the lump of earth inside it, can be lifted up. Take the bucket out and make it topsy turvy on ground, with the broad mouth down. Hold only the bucket now in hand and lift it up so that it comes off leaving the lump of earth on the ground. Protect its top by means of a slab or a piece of board from rain if any likely to fall, otherwise, let it be exposed to sun and wind quite freely. If it does not crack, but goes on hardening every day, as it dries up, the soil may be taken as quite suitable. If, on the other hand, it forms small cracks, it needs sand or some light soil to be mixed with it. This should be done and the experiment repeated until the exact proportions are determined.

Another test is to make balls of earth, with or without mixture of sand and watch their behaviour in respect of cracking and hardening. The mixture which gives the best results may be employed in the bucket lump test mentioned above.

Foundations and Plinth:—The foundations should be like those usually made for the burnt brick masonry. It is desirable to use stone for foundations and plinth, and if stone be scarce or costly, then burnt brick. This is necessary to protect, the *pise* work from the splashes of rain water dropping from eaves, or streams of storm water scouring the side at the bottom. If lime is cheap, its mortar may be used upto the plinth. This will ensure a dry bottom for the *pise* walls and further, besides increasing their strength and longevity, afford protection from the inroads of rats and especially bandicoots, which have a nasty habit of digging out heaps of earth from below the walls.

The site from which earth for the *pise* work is to be obtained, should be excavated to a depth of 9 inches and all the stuff dug out, removed, and thrown away, as it is bound to contain roots of vegetation which are to be scrupulously excluded from the *pise* work. The soil below it should be excavated and all lumps broken by means of a wooden handle. Stones and pebbles above the size of one inch should also be picked out.

Moisture :—The correct degree of moisture is a very important factor. In most cases the soil at this depth below the ground surface, if used fresh, will contain sufficient moisture. The test of the correct quantity of moisture is, that the soil should neither jump under the stroke of the rammer, nor stick to its bottom. 8 to 15 p. c. of moisture is found to give the best results. If the earth contains but slightly more moisture than that necessary for good consolidation, the mass of earth below the rammer becomes elastic and deadens the effect of ramming ; and though the surface sinks below the rammer, it rises up elsewhere. Thus, a little too dry and a little too wet earths are both bad, though a little too dry is a lesser evil. It should be just moist enough to be crumbly and yet adhesive enough to retain the impression of fingers when pressed in hand.

Boxing or shuttering :—When the earth of the proper consistency is prepared, boxes are placed in position. For economy and good workmanship properly designed boxes are necessary. The chief desiderata of good boxes are : (1) That they must be of such wood as will not swell under the action of moisture, nor warp, nor buckle under the pressure of ramming. (2) That they must admit of easy fixing and removing, and still be rigid enough to stand true and square under the heaviest ramming. (3) That the space between the two sides of shuttering must be as little obstructed as possible. (4) That there must be an arrangement for putting stops for door and window openings. (5) That the tie rods must admit of easy removal without injury, to the work already done. (6) The corners in particular, must be very rigid. (7) The entire mechanism must be light, simple, easily repairable and fool-proof.

Deal wood boards $1\frac{1}{2}$ in. thick serve the purpose best. There is a lot of scope for the inventive brain to design and perfect a form of boxing which would satisfy the needs under the severe climatic conditions of India. A type of boxing which has proved, by experience, to be well suited is shown in Fig. 19. It consists of 4 deal wood boards 8′ to 10′ long, 9 in. wide and $1\frac{1}{2}$ in. thick, joined together by vertical teak battens 4 in. by $1\frac{3}{4}$ in. screwed on to them. For clamping these in position, so that they should not move apart or deviate even a bit from the plumb line, vertical posts of teak wood 3 in. by 3 in. and cross pieces of wood at top and tie rods of $\frac{1}{8}$ in. iron bar at bottom and centre are required for this.

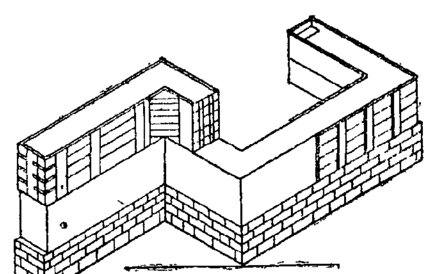


Fig. No. 19 :—Showing how shuttering or boxing is fixed. The plinth is of burnt bricks. Boxing has been laid in position above it on the right hand side for the first course, and on the left hand side for the second course.

It is likely that the cost of such shuttering would be high—rather disproportionately high, for a small single cottage, and also out of the reach of the poor cottage builder, but if 3 or 4 house-builders combine together, or contractors get them made and use them successively on several works, the expenses might be distributed over all of them and the incidence of cost, on any single cottage, would be reduced.

On an ordinary work two straight boxes, two corner boxes, and four stops for blocking up for doors and windows, would suffice.

The boxes should be so placed that they overlap the plinth masonry or the *pise* wall already laid at least 6 inches as shown in Fig. 20. The surface below, should be slightly moistened, and loose earth containing sufficient moisture should be spread in 4 in. layers at a time. Each layer should be rammed hard and consolidated till it is approximately reduced to half its original thickness.

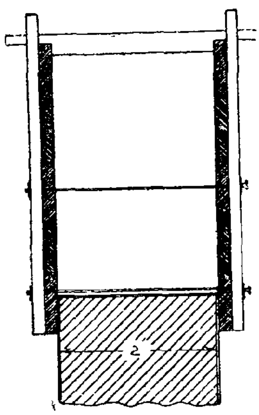
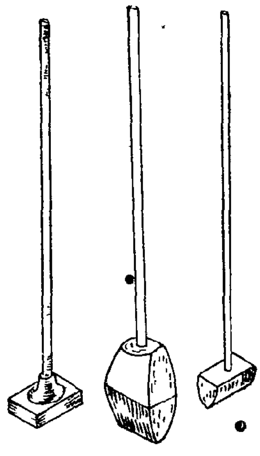


Fig. 20

Rammers:—The ordinary rammers used for consolidating road metal or concrete, are of no use for *pise* work. Three rammers of different shapes are required. The one shown in Fig. 23 is V—shaped. Its peculiar shape causes the pressure to be concentrated on a smaller area, and prevents mud sticking to it; again, it can be used towards edges and corners. The one shown in Fig. 22 serves the same purpose better as it is heavier. After using these for some time the one shown in the Fig. 21 which has a flat bottom should be used. This distributes the pressure evenly on a large area, and is useful also for surfacing. The rammers should be either of iron or hard wood. If wooden, the surface should be quite smooth. A layer should be said to be sufficiently rammed when the rammer thrown from a height of 2 ft. does not leave any mark on the surface. At junctions a slope should be left. Edges and angles should be rammed with special care. Hard ramming is the secret of the *pise* walls. It forces out the moisture and brings the particles closer together, which causes their cohesion to increase enormously and prevent the earth from shrinking and cracking.



Figs. 21, 22 and 23

A special point should be noted while ramming, viz. that the rammers should never work in unison, i. e. the workmen should not strike the rammers, at just one and the same time, but one after another. Because, if they do it all together, severe vibrations are set up in the entire wall, in consequence of which, it may likely be separated from other walls, not under rammers.

At the close of each day's work, it is necessary, especially during summer, in this country, to cover the top of the wall with moist gunny bags.

Speed of work:—For Indian climate it is advisable to fill and ram the boxes by day and allow them to remain in that position during night so that, the earth, in moulds, shrinks sufficiently for the easy removal of the boxes in the morning, which should then be put up again. Out of the total height of the box, six inches go in the overlap. Hence, if they are 3 ft. high only $2\frac{1}{2}$ ft. are useful, Therefore, 3 to 4 ft. high boxes may be used according to the strength of the labour available.

Lintels over doors and windows may be fixed at the proper level as usual, with the only proviso that their ends should spread out at least 12 in. on each corner.

Jambs of doors and windows may be formed by arranging the stops at the particular angles.

Beams :—The *pise* walls are capable of bearing not only the weight of the roof

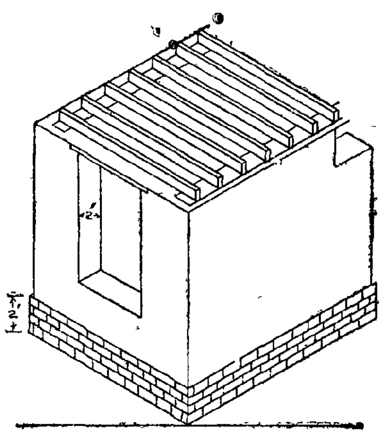


Fig. 24

but also of floors. Actually buildings three storeys high have been constructed; two storey buildings are quite common. These are without any wooden or iron posts embedded in the walls, but, beams are laid directly on *pise* walls, upon these the floors are built. The ends of the beams should rest on pieces of boards of hard wood 3 or 4 ft. long and 3 inches thick, so that the presure may be distributed on a larger area. Fig. 24 shows wooden joists laid directly on a wooden plank on the top of *pise* walls.

For fixing pegs, picture rails etc. plugs of wood may be built into the *pise* wall during the construction at the proper levels.

Plastering :—It is not necessary to plaster the inner surface of walls at all. All that is required is, to pare or dress it by means of a shovel or paring instrument (Fig. 15 page 31) and make it smooth with a mason's trowel laid flat and rubbed against it. If necessary the trowel may be occasionally dipped into water. However, if it is desired to plaster the wall surface, it is necessary to make marks or dents on it close together by means of some edged wooden or iron instrument. This is better done when the wall is fresh and wet. After the dents are made the extra loose earth should be removed with a hard coir brush, water sprinkled over it and a thin coat of plaster of either cement mortar or lime mortar applied to it. It is essential that the wall should be thoroughly dry before the plaster is applied to it, otherwise, the moisture will cause the plaster to peel off. Indenting the surface is quite necessary to give a key to the plaster to stick to the wall.

Roof :—Rafters should be nailed to the wall plates laid on the top of walls. The roof must be absolutely water-tight and it should project a little more than usual say, 2 to 2½ ft. beyond the eaves, to protect the upper portion of the wall from wind blown rain.

A practical difficulty :—It is possible that on account of hard ramming the planks of the shuttering may bulge out a little; to prevent this, strong cross ties to bind together both the faces of the shuttering are required. If the latter are of ropes they will stretch or even break under the stress. If iron rods are used and are bolted on the outside they will be difficult to remove. Hence, two methods are found to be suitable : one, to provide wires and to cut them at the ends at the time of disengaging the boxes and allow them to remain permanently in the walls after the shuttering is removed. 2nd, when the surface of earth reaches the level of tie rods, which in this instance, should be of wrought iron bars about ⅜ in. round, sand should be put into the box so as to encircle the rod. It will be found afterwards that if some suitable leverage is applied at one of the ends, the rod can be easily removed. The sand may be removed as much as possible and the holes plugged with earth thrust into them from both ends.

WATER-PROOFING OF EXPOSED SURFACE OF EARTH WALLS

We have seen in a previous chapter, how important the question of keeping earth walls dry is, not only from the point of view of their stability but also from that of preventing damp, for the preservation of the health of the inmates. One of the sources of damp is the moisture absorbed from the wet air, or that driven by rain striking against the wall surface. The material used for water-proofing must satisfy the following conditions :

(a) It must be absolutely non-absorbent, i. e. it must be compact, and devoid of pores. Certain tallows are non-absorbent and water-proof, but they do not stand the heat of Indian climates.

(b) It must stick well to the surface so that even during changes in weather conditions it must not peel off.

(c) It must be hard enough to be not easily scratched or damaged by anything striking against it.

(d) It must be cheap and also pleasing to the sight.

A few suggestions are given below :—

(1) The usual method of giving an annual wash to the wall surface with white earth and cow dung, mixed together applied by hand does really protect the wall temporarily from wind blown rain. This may still be improved upon by adding some cement to it. 12 parts of earth, 4 of cow dung, and 1 of cement are the proportions experimented upon, by the author, and found to give satisfactory results.

(2) Coal tarring the surface. This should be done only after the walls have thoroughly dried. Otherwise, the coat of tar will come off in the form of scales, by the sweat of the wall surface. The tar should be boiled and made thin. To this may be added some powdered dry pith (coal tar) while being boiled, and when of the proper consistency, should be evenly applied while hot, with a brush. This remedy is fairly effective and is good also from the sanitary point of view. But several people do not like the dark surface, besides, it absorbs heat. To remedy this defect, two or three coats of white wash may be applied on it when the tar has thoroughly dried.

(3) The following is recommended by the U.S. Bureau of Standards in abstract No. 1806 issued by the Building Research Station, Garston, near Watford, Herts :—

"Make a solution of 12 oz. of paraffin wax in one gallon of gasolene (petrol). The melting point of the wax should be above the highest summer temperature of the walls and the solution should be applied when the wall is dry and warm."

(4) The simplest and perhaps the cheapest recipe, which the writer has experimented upon and found most successful, is, to prepare a sort of paint by mixing ordinary 'white' or chopan earth in boiled linseed oil, of the proper consistency, so that it can be easily applied with an ordinary brush. This has the special advantage that all the materials are easily obtainable and the process is very simple. If necessary some colouring pigment may be used ; instead of complex colours obtainable in the market, it is best to use '*geru*' or red earth, or iron oxide '*Hurmuz*', Multan (*peeli*) *mitti*, or yellow ochre etc. found cheap and in abundance in nature.

(5) Another simple recipe is, to slake fresh lime first partly with milk (say 5 p. c.) and then with water, and mix it with linseed oil, or in fact with any oil,

To this should be added 2 p. c. common salt (by weight of the quantity of dry lime). It would be found that a sort of paste is formed which may be thinned properly by adding water and applied with a brush.

(6) The usual remedy of applying rough cast plaster is also good. For this the surface may be well indented very closely by an edged iron or wooden instrument, while the work is still wet, and when it is dry it should be scrubbed with a stiff coir brush to remove all loose earth, then watered, and roughcast cement plaster about ¾ in. to 1 in. thick consisting of three parts of sand to one of cement, may be screeded or dashed on the wall surface so as to spread evenly. Cement colour looks quite well ; but if desired some pigment may be mixed with it.

6. WATTLE AND DAUB WALLS

In districts close to forest areas, bullies (round rafters) of teak or other good timber are available at a cheap rate and material for lath, such as bamboos, reeds, or straight and thin branches of certain trees which are strong and tough, is also to be found in abundance. It would be very cheap at such places to construct a framework of bullies (round rafters) and for the walls, a sort of wattle or rough trellis of the reeds or split bamboos may be made and thickly plastered with mud on both the sides. This could be further improved if the wattle is nailed in double rows on both sides of the bullies, and moist earth moderately rammed between them. If this is done, heat can be effectually shut out. If split bamboos are used, a precaution to lay them in such a way that the glazed side is inside, is necessary, otherwise, mud plaster will not stick to it. The strength and the life of the plaster can be considerably increased if a mixture in the proportions of 12 of earth, 4 of cow dung and 1 of cement, is made and the plastered surface leeped with it.

This sort of wall construction is subject to the attack of white ants. Especially if bamboos are used the wall must be renewed every third or fourth year.

7. FLAG STONE LINED WALLS

Another suggestion for cool walling which is cheap, is useful in districts where thin paving slabs of stone such as Shahabad, Tandur, Kadappa. in the Deccan and South India, or Katni, Rajputana, Chamba, or Rewari, in Central and Northern India, are sold at a very cheap rate. A framed structure of teak bullies with roof either flat or pent, supported on vertical posts may be constructed. The intermediate spaces between the posts, may be filled with a wall of sun-dried bricks on the inside and the above-mentioned slabs on the outside, or the exposed surface. They should be laid erect on edge one above the other, filling the joint with lime, or better still, with cement mortar. If the slabs are $1\frac{1}{2}$ in. thick and are laid perfectly in plumb, and if, as an additional safety, iron clamps with diamond shaped pieces of thin sheet, just to support the four corners of slabs on the face and a tail piece embedded in sun-dried bricks are usd as shown in Figs. 25&26 there is absolutely no apprehension of their ever being dislocated. They will stand any rain and are bound to remain cool. If slabs are very cheap they may be lined on both the sides, and moist earth packed in between them, as the work progresses.

One often sees glazed tiles fixed in this manner to line the wooden walls of lavatories in 2nd class railway compartments, where they use brass clamps at corners and nail them to the woodwork behind. The above suggestion is based on the same principle.

If the diamond shaped heads of iron clamps are fixed in cement mortar and painted from outside, not only will they remain permanently in position unaffected

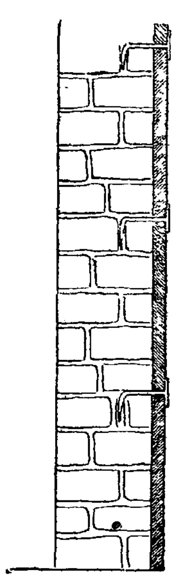


Fig. 25—Cross Section

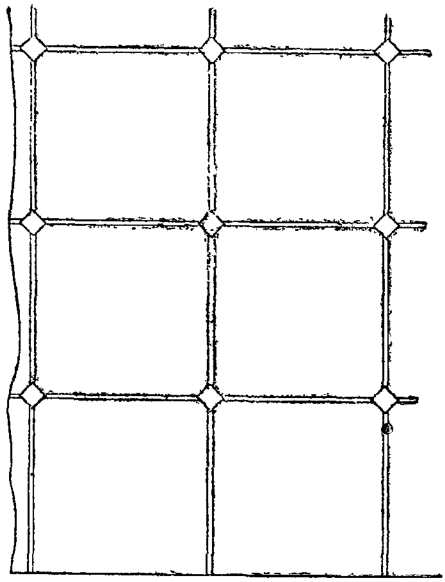


Fig. 26—Elevation

by rust, but they will give in addition, a decorative effect to the wall surface.

8. NO-FRANGO WALLS

No-frango is a novel method of reinforced cement concrete construction, in which instead of steel bars, as in the ordinary reinforced concrete, hessian or jute fabric (used in preparing gunny bags) is the reinforcing material employed. It is invented by Major J. H. de Waller of Dublin, who has taken a world patent for it. It has recently been introduced as a cheap building material and remains yet to be tried by the criterion of time and use. But whosoever have experimented upon it, including the writer, are very enthusiastic about it, and if what the inventor claims for it as being fire-proof water-proof, vermin-proof and also cheap and strong at the same time, it will provide the long cherished panacea for the middle and poor classes, more particularly in India, where on account of its elastic nature, it is more suitable to meet the stresses caused by the extremes of temperature. The method of building walls with it is described below.

The foundations should be filled and masonry laid up to the plinth as usual. On the top of the plinth vertical wooden posts, or studs as they are called, say 2 in. by 4 in. in the walls which support the weight of the upper floors and roof, and 2 in. by 3 in. in walls which serve merely as partitions may be erected, spaced at 3 to 4 ft. apart. It is desirable to give a coat of hot coal tar on them and to fix their bases in cement concrete blocks either pre-cast with holes in their centres to receive the bottom ends of the posts. If the house is to have but a ground floor only, a wooden wall plate 3 in. by 4 in. may be fixed on the tops of the posts to which the rafters of the roof may be nailed. The reinforcing fabric of hessian which should be, if possible, of special make with open mesh of at least ¼ in. should be tacked to the posts at one end and stretched tightly and fixed to all the remaining posts also by means of tacks. The jute strands of the fabric should be, as far as possible, straight, that is, not much twisted. The fabric that comes directly from looms without passing through rollers or undergoing the calendering or sizing process, is the best. The test of this is, that it should present a hairy, coarse texture. The idea is, that in the interest of maximum strength the fabric should be as thoroughly impregnated as possible with the cement grout which is to be applied to it. Too much twisting and sizing leads to bad impregnation of the strands by cement. The stretched fibre should then be thoroughly soaked with water and while still wet, a grout prepared with one part of cement to two of fine sand mixed in water should be applied to it by means of a brush, both on the inside and the outside of the fabric surrounding the outer surface of the posts. While this grouting coat is still wet, cement mortar, consisting of one part of cement and 3 of coarse sand, should be screeded against the surface with a mason's trowel, to form a key to the plaster to be applied to it later on. Then 2-inch wire nails should be driven into the posts at random and left projecting $\frac{3}{4}$ in. beyond the surface just to hold the layer of plaster, which should be commenced as soon as the mortar already screeded is sufficiently hardened. This plaster should be in two layers; the first, about $\frac{1}{2}$ in. thick, with 3 parts of coarse sand and 1 of cement, and when this has sufficiently set, another of equal thickness, with mortar of the same proportions of cement and sand, but the latter should be slightly finer. The inside of the fabric should be also plastered but it is not necessary to give two renderings; only one of about $\frac{3}{8}$ to $\frac{1}{2}$ inch thickness is sufficient and need not also be made smooth.

When this is done fabric may be similarly fixed on the inside of the posts also, to form a hollow space between the two fabrics. The process of soaking with water, grouting and plastering should be repeated as in the case of the outer fabric, the only difference being that it is not possible to plaster both the surfaces of the inner fabric.

If insulation from heat is to be aimed at, it is necessary to seal the cavity, of whatever thickness, between the coverings of fabric. Generally a single cavity is sufficient, but in countries subject to extremes of climate it is possible to attain any degree of insulation by providing two or more sealed cavities. It is also possible to leave a cavity of 9 inches to one foot thickness and fill it with earth moderately rammed such as was suggested for a form of walling with a lining of thin paving slabs.

Cavities in walls not only prevent heat but also damp from outside. Walls with a sealed cavity of even $\frac{1}{4}$ of an inch have proved successful.

No-frango walls have a special advantage viz., that they are rat-proof.

Many houses have been built in Ireland, after this fashion with not only walls, but even floors, stair cases and roofs of No-frango construction, and have been giving perfect satisfaction these ten years. The method of building floors and roof has been described later on in this treatise.

IMPORTANT NOTE:—No-frango Construction has been tried during the past few years in India, and it is found that unfortunately the jute rots in a very short time in the tropical climate of India. Hence though it may still be very useful for partition walls etc. which are not exposed, its use in such important details as roof, floor etc., is not commendable. The same type of construction, using expanded metal, seems much more suited to Indian conditions.

Protection against Rats and White Ants

Rats are a distinct danger to health as they are carriers of fleas, which often bear germs of plague. They, especially the bandicoot variety, are particularly to be guarded against, in houses with mud walls and *murum* or mud floors, because, they burrow under them and dig tunnels which often affect their stability. Their work in this respect is made easy by damp, if present in the walls, because, it causes earth to lose cohesion, and therefore, the latter comes out easily at the slightest effort on the part of the rat. Thirdly, they eat out corn and other foodstuffs and even more important than this, is the fact that they cause a greater loss by doing damage to it. Hence, special safeguards have to be taken to prevent them from harbouring in the neighbourhood of the house. If we make a careful study of their habits, we find that they make their abodes either underground under walls or floors, or in the roof, and that for their underground habitation they make holes by burrowing at the junction of the walls and the floors. This gives us some clue to work on some definite lines. A few alternative suggestions are made below :—

(1) The floors may be made of lime concrete. A layer 3 inches in thickness of concrete of stone metal, or brick-bats-and-gravel rammed hard, will suffice, and this can be done at a very small cost. While still wet, if a dry mixture of two parts of very fine sand, and one of cement, is very sparingly sprinkled to form a layer, say, $\frac{1}{32}$ of an inch thick and the surface polished with a mason's trowel, a very durable and decent floor is formed. In addition to this, the walls on the inner side may be lined at their junction with the floor with flooring slabs or slates. Even the thinnest slabs would do. The slates may be one foot in width and may be so laid in lime mortar that about 3 or 4 inches go below the floor, and 8 or 9 inches remain above it, as shown in the marginal sketch (Fig. 27). The concrete flooring, and slate or slab skirting effectually preclude the harbouring of the rats under the ground surface. If slabs are costly, lime or cement plaster one inch thick may be laid instead of one ft. skirting of slabs.

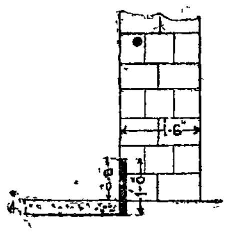


Fig. 27

(2) Second suggestion is, to insert galvanised wire gauze netting one inch mesh about $\frac{3}{4}$ to 1 in. below surface at the junction of the floor and wall on the inner side. This sort of wire-netting is usually employed round tennis courts on which creepers of luxuriant foliage usually trail, and can be had of 3 ft. width very cheaply. It should be bent at right angles and 18 inches should be laid flat horizontally into the floor and 18 inches vertically into the wall plaster. If a rat tries to burrow out a hole, he can go as far as this netting, against which, however, he is helpless.

(3) The third is an ingenious method and requires to be tried. It is this: Ordinary mud used for plaster should be mixed with finely powdered glass or hard flint and used as a material for plastering the lower one foot of walls, and similarly powdered glass should be used in concrete for surfacing one foot near the edge of the flooring. If the powder is fine and if a smooth surface is made by polishing it with a trowel, there is no fear of getting one's fingers cut or scratched if one happens to rub them against it. However, to the rat it presents a distinct danger. Because

no sooner it begins to burrow out with its teeth, nasty cuts and scratches to the tongue are sure to be made, which would cause it to desist from the attempt.

For preventing rats harbouring in the roof it is comparatively easy to construct such roofs as would block their passage to the cavity under the roof.

Another source of danger to which mud houses are liable is that from termites or white ants. All timbers except teak, and perhaps one or two others, are attacked by them.

The remedies consist mostly of the preventive measures which are given below :—

At the time of clearing site, and before building operations are commenced, a careful search should be made and any evidence of white ants should be removed by digging out their nests and destroying the queen ants at bottom, and grubbing up old tree trunks showing the slightest indication of their activities.

In places where the trouble is apprehended most, teak alone should be used, even if it costs a little more. Or, whenever possible R. C. C. (Re-inforced Cement Concrete) work should be substituted, e. g. for door frames, wall plates, posts etc. It is even cheaper than timber.

Timber should be used only in exposed situations. White ants do not like their activities being watched and interfered with. Hence, they prefer dark, secluded, damp places where their lonely activities are least likely to be interrupted.

Posts, door-frames and such other members of the structure which usually have to touch the ground should be provided with stone or concrete heels to avoid direct contact with ground, and sides of door-frames, wall-plates etc., which have to be partly or wholly embedded in masonry should be given a coat of hot coal-tar before being put in position. Coal-tar contains 30 to 40 per cent of creosote which is an excellent ant-destroyer. Hence, if very hot and thin coal-tar is applied, the creosote is absorbed by the pores of the timber, which makes it resist their attack.

Only the absolutely dry and well-seasoned timbers should be used. All sources of damp should be vigilantly watched and precautions taken to remedy them promptly.

Timbers in situations exposed to sun and rain should be treated with some preservative paint or simple boiled linseed oil. Crude oil also is cheap and effective but has to be applied every year.

Doors

Doors are unavoidable, although they form one of the costly items in an estimate of a building. A teak door of the minimum size, viz. $2\frac{1}{2}$ ft. by 6 ft. even if of plain design, costs Rs. 30 at the rate of Rs. 2/- per sq. ft. Besides, it necessarily requires either an arch or a lintel. If the latter be of R. C. C. which is much cheaper than wood, another amount of Rs. 5/- has to be added. Thus a single door costs Rs. 35.

Hence, it is worth while to carefully scrutinise the plan of the proposed house and to see if it is possible to reduce the number of doors by considering several alternatives of grouping of different rooms. Of course, convenience should never be subordinated or sacrificed to economy.

Still very often too many unnecessary doors are provided. They not only increase the cost but also make the structure weak by leaving so many hollow spaces in the otherwise solid walls. They also interfere with the privacy inside the house.

Another way of effecting economy on this item, is to allot different widths to different doors according to the purpose of each. Thus the front door through which heavy pieces of furniture are likely to be carried in and out, need be 3 ft. wide if not more, but doors in the inside partitions need scarcely be more than 2 ft. 6 inches wide. For doors of bath rooms and W. Cs. even 2 ft. width will suffice.

The same may be said with regard to height; 6 ft. or 6½ ft. should be quite ample. Heights of 7 ft. or more are fit for public houses, such as schools, libraries, theatres etc.

A third source of economy is to provide one leaf only instead of two, wherever possible. There is a saving not only in wood and labour but also in hinges, tower-bolts etc. They are particularly suitable for bath rooms and W. Cs. and in partition walls. When placed at the end of a wall a single leaf door opens against the surface of the wall, and in this position it takes up the least space and obstructs the least. In a bedroom it contributes to increase the privacy, because, when open, it conceals the view behind it.

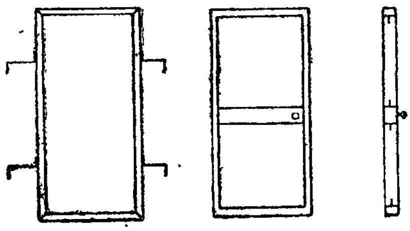
Yet more room for economy will be found by making a door sufficiently strong to suit its particular purpose. In order to stress this point further to make it clear, let me ask a question "what is the function of a door?" The obvious reply is that the function is two-fold — first, to protect the house-hold from thieves and unwelcome intruders, and the second, to afford privacy. So far as these two objects are concerned, we are perfectly justified in making all the doors in the exposed walls strong and stout, as we have been already doing all along. We should be equally justified in making the doors of the internal safe room, if any, strong and thief-proof. But the question remains — "Where is the necessity of making all the internal doors also of uniform strength when their only purpose is to afford privacy between different rooms of the same house?" In fact, we indiscriminately make the interior doors also unnecessarily strong as if thieves are coming to break the doors, even of the kitchen and the lavatory with an axe! They need only be sufficiently strong to withstand the rough use to which they are often subjected.

Light leaves would mean light frames also. No such stout frames of heavy scantling as 5 inches by 3 inches or 4 inches by 3 inches, would any more be required. Just 2 inches by 3 inches would be quite sufficient. That alone means a saving of 50 per cent in the cost of the frames.

The ideal design should, in the writer's opinion, embody the following desiderata :—

Frame :—This may be of steel, either a T-iron or angle-iron of very thin section, such as that used for frames of steel spring beds. It should be fixed by means of steel holdfasts rivetted to it, well-anchored into the side walls, or of a thin section R. C. C. either pre-cast or filled in situ by means of cement grouting.

Leaf :—The frame of the shutter should also be of steel—either of sheet, bent to form a hollow square section or angle-iron. The intermediate panels which may be 2, 3 or 4 in number should consist of water-proof canvas with suitable designs printed on it, stretched and fixed to the inner edges of the panels by means of fillets screwed or bolted on to them as shown in the sketch (Figs. 28, 29 & 30). It is thus possible to choose the colour of the canvas, so as to conform to the general colour scheme of the room. The door might thus form a feature in the internal decoration. It is also an easy matter to clean the water-proof canvas with a moist rag, and as for its wearing qualities, since even for camp lounges or easy-chairs, canvas lasts for years together, its lasting qualities for use in panels, cannot be questioned as it is subjected to no stress, in the position of a door panel.



Figs. 28, 29 & 30
Frame, shutter and vertical section of a door.

Such shutters are likely to rattle and make a noise when opened or closed with a bang, to stop which, the frame may be lined with felt, or fillets of hard rubber, fibre, or lead, etc. may be fixed at 3 or 4 places as is usually done on the window frames of compartments of railway carriages.

A general line on which the design might be made, has been indicated here. It is upto the manufacturers to perfect it and offer it at a minimum cost. It should be possible to offer such a complete door with frame for less than Rs. 10. Such doors will have an additional advantage of being absolutely free from the risk of fire or of white ants and dry rot.

So long as such enterprising manufacturers are not forth-coming, let us be content with one of the following means temporarily improvised.

A frame of 2 inches by 3 inches scantling of teak wood embedded in the wall as usual and shutters made of a frame of 3 inches by 1 inch Moulemein teak with intermediate panels filled with either of the following :—

(1) Cardboard with wall papers of designs pasted on to it.

(2) Thick canvas stretched and painted in suitable colour.

(3) Cement asbestos sheet.

(4) Masonite or similar boards.

(5) Gunny cloth stretched and coated with cement grout (No-frango) etc.

All these are very cheap, light, and durable materials.

Sills of door frames may be necessary for doors in exposed walls in order to keep off vermin ; but if they are omitted in the case of all interior doors, not only would economy be effected, but obstructions would be removed and the work of cleaning floors would be facilitated.

Windows

Shutters and frames of all the inner windows can be made of lighter design as suggested for doors in the previous chapter. If iron bars are provided for windows, ordinarily there should be no fear of thieves. Hence, a cheaper design for shutters of the windows even in the exposed walls can be adopted. The usual scantling adopted for a window frame is 4 in. by 3 in. Sometimes 4 in. by 6 in. is also to be met with. For windows of the ordinary size suitable for cottages, even, 3 in. by 3 in. should be quite sufficient.

It is very economical to have long and narrow windows in preference to low and wide ones. There are two reasons for this. First, that both the span and the thickness of the lintel is reduced—length, because, the window is narrow, and thickness, because, the span is small. Second, that if the window is high, say, almost touching the ceiling, there is very little weight to bear on the part of the lintel and hence, the section may be thin.

This arrangement of long and narrow windows is beneficial also from the sanitary point of view, because the air, made foul and hot by human respiration, rises to the top in a room, and if outlets at this level are not provided, it cools down after some time, becomes heavy, and descends, to be breathed in again. Windows, opening almost to the bottom of the ceiling, provide such outlets and help in driving it out to be replaced by fresh air from outside.

Again if the design of the elevation is somewhat suitably altered, such long and narrow windows would form also an architectural feature from an æsthetic point of view.

Another hint in the interest of economy may be given. If a door and a window

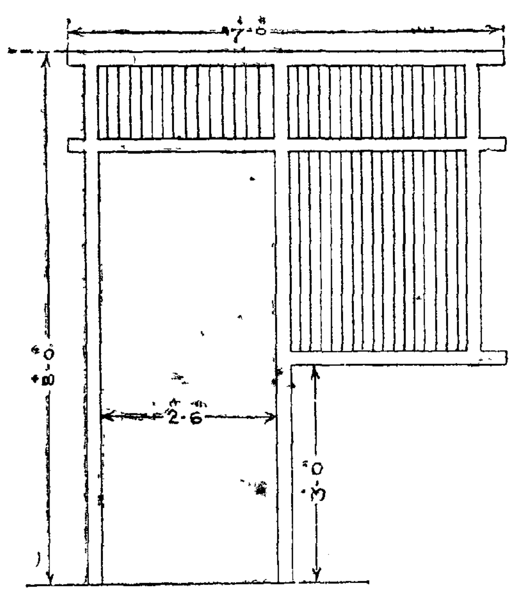


Fig. 31

are combined together as shown in the above sketch (Fig. 31) considerable saving is effected. It is far more than what a casual observer may imagine it to be on the first thought. With the dimensions of the door and window shown in the sketch, there is a saving of 8 ft. length of wood ; because, not only one vertical side piece of the window, but five pieces projecting at corners i. e. in all about $\frac{7}{8}$ of a c. ft. of wood and three ft. length, or 2 c. ft. of lintel are saved. This means a net saving of about 8 rupees, which is more than 30 per cent on the cost of an average window.

One more suggestion for economy is, to utilise the space below the sill of a window for a cupboard. Ordinary cupboards require a lintel at top ; but this particular cupboard does not ; because, there is already a lintel at the top of the window. Thus a cupboard is formed for a small cost only, in a space which otherwise would have not only been wasted, but filled with solid masonry, which, moreover, is saved if a cupboard is placed there.

Another use of this space in the wall below the window-sill is, for providing a seat, especially in such windows as command a good view of the landscape. Even then, either a box for storing linen or a chest of drawers may be provided below the seat.

Very often money is unnecessarily wasted in providing elaborate ornamental projecting cornice below windows on the exposed side. The object of the cornice is to allow the water collecting on the sill to drop away from the face of the wall. Hence, if a good slope is given and a drip moulding is provided, any cheap cornice of simple design either of cement concrete, brick or Shahabad or other slabs, will do equally well.

In most parts of India, weather-boards or window-hoods, as they are often called, are required to prevent the wind-blown rain getting into the window openings.

These act also as sun-shades in hot weather. If such weather-boards are provided, shutters to the ventilators above the window proper, may be omitted. At the most, some wire gauze netting to exclude birds, is quite sufficient.

A hint for economy in the annual maintenance and repairs charges of doors and windows, and in fact of any exposed wood employed in building construction, may not be out of place here. The exposed wood has to be painted for protection against sun and rain which cause it to disintegrate and also look shabby. Paints are costly both initially and afterwards for renewal. But if they be selected of a dark, or slate, or grey colour, the latter can be preserved for a long period by a periodical coat of kerosene or at the most pure boiled linseed oil. They retain at the same time a good and neat appearance. If blue, green or other similar colours are used they soon fade away and if not renewed almost annually, the cottage presents an appearance of neglect.

Another means of reducing the bill on account of doors and windows is to cast their frames with cement concrete in a mould specially prepared. The section need not exceed the usual one of timber, viz. 4″×3″ and one rod of steel ½″ in dia. should suffice for the re-inforcement. This sort of frame costs about Rs. 2/-per c. ft. as compared with Rs. 5-8-0 per c. ft. of teak wood frame. Besides, it is free from the danger of fire and attack of white ants. A difficulty in respect of fixing hinges for shutters, by means of screws in the abovementioned concrete frame is likely to be experienced. But if hollow spaces are left in the frame while moulding at the places of hinges, by inserting wooden plugs and if these hollows are subsequently filled with concrete made of 4 to 6 parts of screened coal ashes and one of cement, hinges can be fixed very firmly in it by means of ordinary screws as if in a wooden frame. Detailed instructions regarding the preparation of such frames are given in Appendix No. 3.

Cupboards

Cupboards ought to be regarded as a fairly good investment, especially in small cottages. Because, not only are they comparatively much cheaper than movable wardrobes, but they cause in addition, a saving in space and are free from the dust and dirt which usually accumulates below and behind the movable almyrah. Therefore, no corner or recess under the roof should be wasted, but turned into cupboards with shutters of whatsoever cheap material, one may like to choose.

Even in earth walls excellent cupboards, safe enough for storing even valuables, can be built, if they are lined on the inside with plain G. I. sheeting or flag stone slabs, even, of the thinnest section available, whichever is cheaper.

It is worth mentioning here, that very often shelves of Shahabad or similar paving stones prove to be cheaper than wooden boards, which are, in most cases, used in cupboards. For shelves, teak boards, one inch thick even at so cheap a rate as Rs. 6 per c. ft. including planing, fixing, oiling, etc., cost 8 annas per sq. ft.; whereas, Shahabad slabs at Rs. 10 per 100 sq. ft. cost about 1½ anna per sq. ft. i.e. they are 5 times as cheap. If, for rounding the edges of the latter for the sake of appearance, one anna more per sq. ft. is added, the rate of 2½ annas is only ¼ of that for teak boards.

The slabs have the additional advantage that they form one piece without joint, whereas, teak boards, wide enough to cover the full depths of the cupboards, are scarcely cheaply available. The stone slabs are, again, absolutely free from the danger of destructive white ants and fire.

With stone, slabs, however, the width of the cupboard is restricted to 2½ ft. because 3½ or 4 ft. long slabs, though not quite unusual, are not easily obtainable. The standard length is 3 ft. out of which three inches on either side go for the ledge in the wall.

Remarks made about the light and cheap designs of shutters for doors in a previous chapter, apply with full force to cupboards also.

Provision of one or two small underground cupboards at suitable places add considerably to the convenience at a small extra expense. They are like miniature cellars and should have lining of stone slabs or cement plaster at bottom and sides, and wooden frames at top to which are hinged planked shutters, flush with the floor surface, so that, the top can be used as a part of the floor. The economical width of such cellars is 2½ ft. to 3 ft. so that, one inch boards can be used for shutters. If such cupboards are placed against or partly in the exposed wall, it is possible to provide light and ventilation from outside below the plinth by means of 6 in. glazed earthenware pipe with fine wire-gauze at the end to exclude vermin. Such underground cupboards are very useful for storing lumber, coal, fuel etc.

Partition Walls

The main function of a partition wall is to divide one large room into two or more smaller ones, which is required for the sake of privacy. Privacy is of two kinds: one, which is required in respect of sight and the other in respect of sound. It is a simple thing to provide for the first. Even a cloth screen is sometimes sufficient. But it is very difficult to make a perfectly sound-proof partition. A feeling of privacy in respect of sound particularly in some rooms is one of the factors which go to make a house comfortable. A thin partition of plain galvanised iron sheet or a frame work of split bamboos, battens or wattle plastered over, to serve as partitions scarcely afford any more privacy than the paper walls of a Japanese house.

In rural districts where space is not much restricted, the cheapest partition which is also sound-proof, is one, built with sun-dried bricks. A thickness of one foot is sufficient. Earth is a far better insulator of sound than stone or brick. Another advantage of such partition walls, is that it is possible to provide plenty of cupboard space in them if they are thicker. This advantage more than counterbalances the apparent waste of space.

In order to be really sound-proof, a partition wall must be carried up to the ceiling, whether flat or sloping. Above the height of the horizontal ceiling level it may be made thinner for economy.

In places where space is very much restricted, thin partitions of No-frango, described in the previous chapter, can be built at a cheap rate. Air is comparatively a better insulator of sound than stone and brick and as the cavity between the two sides of the No-frango partition is occupied by air, the partition, even though thin, is rendered more sound-proof. If it is desired to make it still more sound-proof, the cavity may be filled with felt or loose coir waste, or wood shavings or two thin air cavities may be formed.

Glass is a good insulating material, even better than air, hence, a partition of frosted glass, provides privacy of either kind. It is, however, more costly. Besides, it is liable to be broken every now and then. Glass, with wire gauze netting impregnated in it (wire glass) satisfies this condition also.

Lintels

Economy in lintels can be effected, as already stated on page 46 by combining a door and a window together, so that the combined length is much less than that of the two separate pieces otherwise required.

Another way is to design high and narrow windows, which causes a reduction in the length and also in the thickness of the lintel.

As far as possible wooden lintels should not be used. For, not only are they costly but, if once affected by dry rot or eaten out by white ants it is both troublesome and expensive to replace them in that position. For stables, barns and other structures of minor importance, however, economy can be effected by using roughly squared round logs of hard wood instead of cut scantlings, with quarter cut pieces of bigger logs at ends. To prevent loose earth falling down through the joints, plain G. I. sheets should be bent to a form of a channel and nailed from below to the pieces of wood which should be generously treated with coal-tar to prevent them from being attacked by dry rot or white ants.

The next cheap form of lintels is the flat brick arch. It is very simple in construction and suitable for ordinary domestic buildings. It does not require any support or centering during construction, beyond a wooden plank at bottom. A radius equal to the width of the opening should be assumed and all joints made to converge to a common centre below. Only sound, well-burnt bricks should be selected and they should be kept immersed in water for three hours. Mortar of good hydraulic lime should be used, and if it is not of good quality, a little cement, say, in the proportion of ten of lime mortar to one of cement, should be mixed. For a width up to 3 ft., one brick or 9 in. thick arch is sufficient; for spans exceeding 3 ft., 13½—inch thickness should be adopted. The arch should be kept covered with a moist gunny-cloth for at least two weeks.

The next cheapest and simple in construction is a lintel of reinforced brickwork which also does not require a support beyond a bottom plank as above. (Detailed instructions for this will be found in the author's *Build your own Home*).

Reinforced cement concrete lintels have now become very common. Instructions or preparing them also will be found in the above mentioned book. In the interest of economy, it is worth mentioning here,* that if the walls are solidly founded on *murum* or rock, for spans upto 3 ft. there is no need of the reinforcing steel bars if the lintels are 6 in. thick, and if bars are used, thickness of 3 or 4 in. is quite sufficient for lintels over spans up to 4 ft.

Brick arches are comparatively much costlier and do not fit in with walls with mud mortar.

Where stone slabs are available at a cheap rate, the thickness of the stone lintel may be adopted according to the rough rule : to allow one inch for every foot of span, plus one inch. Thus for a 4 ft. span, thickness of 5 in. is sufficient.

A mistake is commonly made of building an arch over door or window openings close to the end walls. The result is, that the end walls are thrust out of the plumb-line by the load of the arches, tending to stretch outwards and a crack is formed. The best plan is to provide flat lintels over such openings, and if arches are at all required for the sake of uniformity, a tie at springing, of say 2 in. by ¼ in. flat iron, well anchored and countersunk in the wall, should be used.

Staircase

No part of the house requires such a thought and careful attention in designing, as does the staircase. Its position governs and modifies the arrangement of the rest of the house. But unfortunately this matter of utmost importance is never pre-thought in India and in most cases is postponed to be decided at the last moment. It is then squeezed in somewhere into a verandah in a narrow space, and with winding steps, with such a steep ascent that to climb it, is an acrobatic feat. In most cases it is barely 24 to 27 in. in width. It ought surely to be kept in mind that people who build the house for heir own residence, cannot escape old age, sickness and infirmity some time in their life ; that besides, accidents are likely to occur on such staircases and that it is only then, that the folly of having constructed a steep and narrow staircase would be realised.

The ideal position for a staircase should be such as will allow it to be approached from every important room independently through a lobby, however small.

*The details of the service requirements of a properly designed staircase, have been dealt with at great length in the author's *Build your own Home* and it is not necessary to repeat them here.

It is a common practice to build the staircase of wood. Because, it can be made to look as elegant as required and there are also other conveniences in it. But it costs a good deal, particularly for labour, and entails the potential danger of catching fire.

A very simple, cheap and fire-proof staircase suitable for cottages is described below.—Take two pieces of rolled steel joists 4 in. by $1\frac{3}{4}$ in. weighing 5 lbs. per foot of length, of the required length of the slanting staircase. This length should be previously calculated according to the instructions given in the author's book referred to above. Place them in position at the proper distance apart, equal to the desired width of the staircase.

Their ends at bottom should be securely fixed in cement concrete and the tops also either bent a little and buried in cement concrete, or fastened to the floor in any other way. Take a piece of T–iron, 3 in. by 3 in. by $\frac{3}{8}$ in.

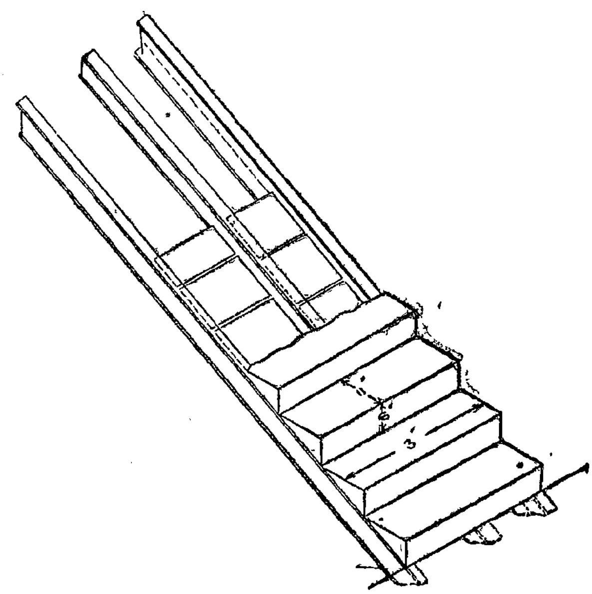
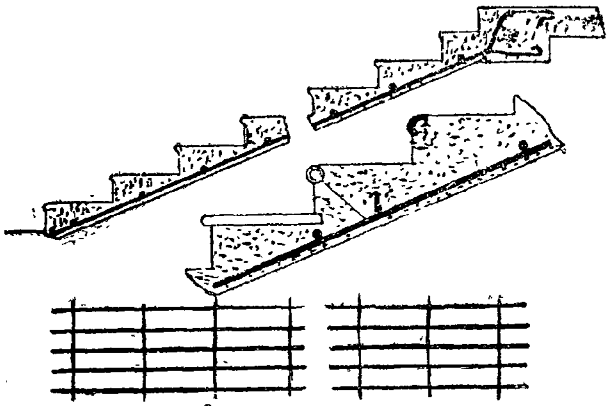


Fig. 32

thick, weighing 7·21 lbs. per ft., of the same length, and place it mid-way between the joists, with the T–flange pointed upwards. Thus if the staircase is to be 3 ft. wide, there will be two joists at the ends and the T between them, leaving between flanges of the T and either joist, a space of 18″ width. Cover this space by laying Shahabad or other paving slabs $1\frac{1}{2}$ in. thick with one side resting on the flange of the T–iron and the other on the inner flange of the joists from bottom to top as shown in Fig. 32. The joints should be filled with cement mortar and when this is done, start laying brickwork in lime to form regular steps from the bottom. On the top of each step may be laid a wooden board or a stone slab with its front edge left projecting half an inch. If stone slabs are not available at a cheap rate to cover the space between the joists and T–iron, expanded metal sheet of the necessary width may be fixed by means of bolts, to the joists and plastered on both sides with cement mortar to form a slab about 1 in. thick. This makes a cheap, light, sound-proof, and fire-proof stair-case.

The following is a very simple method of constructing a reinforced cement concrete staircase, which does not require much skill, and hence, can be built by any cottage–builder without expert advice. The joists and T–iron, used in the above staircase, can also be dispensed with in this case.

Take 5 pieces $\frac{1}{2}$ in. round iron bars of the necessary length of the slanting staircase plus about 3 ft. and bend their ends as shown in Fig. 33. If bars of the necessary length are not available in the market join ends of two bars in such a way that they overlap at least 2 ft. and tie the ends together by means of a wire. Place the rods side by side in the slanting position of the staircase at equal distance apart, so that they cover the width of the proposed staircase. Bind them by 6 or 7 cross pieces of $\frac{3}{8}$ inch round bar, and of length equal to the width of the staircase, by means of a thin wire at the points where they cross the long bars. When this is done, erect some sort of boxing below the bottom and sides of the iron frame placed as above in position, so that a space of one-half inch remains at bottom and both sides, between the steel bars and the boarding of the box. Fill cement concrete prepared in the usual proportions of 1 of cement, 2 of sand, and 4 of broken metal, the latter below one inch in size, to make a slab of 5 in. thickness. On this, lay brickwork in lime to form regular steps.



Figs.

33

34

35

If it is desired to form the entire staircase of one homogeneous mass of concrete, the sides of the box should have regular steps cut into it. With these and pieces of deal boarding nailed to them to form boxing for each step, it is quite easy to cast the entire staircase with steps also of concrete. There is no necessity of any reinforcing bars in each individual step.

In order to protect the edges of the concrete steps against being knocked off, insert either pieces of $\frac{3}{4}$ in. pipe, or brass or steel castings, and bind them to the rods by wire before pouring concrete, or lay round edged flagstones or wooden boards on top of concrete. See Fig. 34, in which all, these three different methods are shown in the three steps.

Flooring Suspended

The usual form of wooden flooring almost universally in vogue, in towns and villages, is not only uneconomical, but it is liable to be easily gutted if the building accidentally catches fire. Besides, it involves great labour.

In the author's book *Build your own Home* nine different types of flooring have been dealt with. It is proposed to briefly describe here a few cheap ones among them, which are also fire-proof.

As a preliminary to starting the work of flooring it is necessary to take a precaution. If the walls which are to support the flooring are built with frames embedded in them (See p. 21) i. e. if there are vertical posts and wall-plates on their top to support the flooring, it all right; if on the other hand, the walls are solid and of brick or stone in mud, it is desirable to cover their top with Shahabad or other paving stones not less than 1″ thick, in order to distribute the pressure of the floor evenly on the walls. If such paving stones are costly lay cement concrete 2 in. thick instead.

Then place on the top of the walls thus prepared, rolled steel joists 4 in. by 1¾ in. weighing 5 lbs. per foot of length, if the span does not exceed 12 ft., or 4¾ in. by 1¾ in. weighing 6½ lbs., if it exceeds 12 ft., but is less than 14 ft., they should be spaced 12 inches apart centre to the centre (See Fig. 36). Give a coat or two of bitumen or hot coal-tar to the joists before laying them in position.

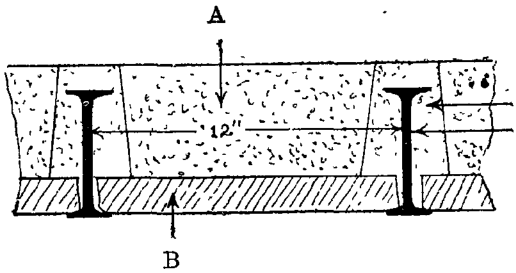


Fig. 36—A—Any cheap stuff; B-Paving Slab.

Then, if paving slabs 1½ inch thick are available at a rate of Rs. 8 to 10 per 100 sq. ft. insert pieces of them one foot wide from one end. If a ledge of ½ inch is obtained for the slabs on the flanges of the joists, it is sufficient. Fill the joists with cement mortar and fill the spaces above the slabs upto the top of the joists with anything light, say, broken pieces of burnt brick, coal clinker, *murum* etc. and ram it with a moderate force. On the top of this, construct any sort of flooring of ¾ to one inch paving slabs laid in lime mortar and cement pointed, or even simple *murum* flooring will do.

If the rate of the paving slabs exceeds 8 to 10 rupees per 100 sq. ft. it would be economical to follow the instructions given below :—

Erect some sort of centering so that its upper surface is about ½ inch below the bottom of the joists. A centering of corrugated iron sheets (even old sheets will do) is very cheap and convenient. The corrugations give it a stiffness, hence, the wooden supports placed below the sheets, need not be so very strong and close together. However, it is necessary to cover the corrugations with mud to make a flat surface and when it is dry leep it with cow-dung. Then prepare cement concrete with 5 parts of gravel, 2½ of sand and one of cement and dash it against the sides of the joists to give them a wedged shape, 2 in. wide at top and 4½ in. at bottom as shown in the Fig. 37. When this sets,

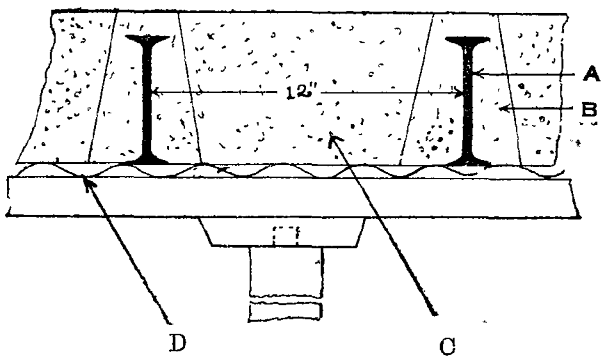


Fig. 37

A—Girder, B—Cement Concrete ;
C—Lime Concrete D—Corrugated Iron Sheet.

in about six hours, prepare lime concrete with broken brickbats or screened boiler slag 3 parts, sand one part and lime mortar one part, and put it evenly upto the top of the joists and ram well.

After about a week remove the centering of C. I. sheets from the bottom and place it below the next portion to be prepared. The object of putting cement concrete against sides of joists is twofold. Firstly, that the alkalies in lime concrete speedily attack steel and cause it to rust rapidly, the cement concrete not only prevents their coming into contact with lime, but increases their strength in addition; and secondly, that the particular shape given to the cement concrete gives the intermediate mass of lime concrete a shape of a wedge with the broad part at top and prevents it from sliding down. The whole thing behaves like a flat arch between two joists.

This method is not only very cheap and simple but as it allows small portions to be done at a time, it is possible for even a small cottage-builder to build a fire-proof flooring with only 3 or 4 old C. I. sheets for the centering.

The floor should be kept moist for three weeks by covering it with grass frequently wetted with water. On the top of it construct Indian patent stone or lay Shahabad paving stones as may be desired.

Another cheap form of flooring described below is suitable for timber districts, where, hard wood is available at a cheap rate.

For this, take scantlings of well-seasoned timber 4 in. thick and saw them so as to cut wedge-shaped long pieces 1½ in. at top and 3 to 4 in. at bottom as shown in Fig. 38. Treat them generously with two coats of hot coal-tar mortar and ram it well. The centering can be removed after about 10 days.

The wedge-shaped pieces of wood should not be planed, but left as rough as possible which increases their adhesion and helps to make the floor stronger.

No-frango Floor*

This type of floor is quite new and has so far not got the opportunity to stand the test of time, but deserves to be tried. If it is found successful it will satisfactorily solve the problem of cheap, semi-fire-proof flooring suitable for cottages. Its exponents claim that a No-frango floor one in. thick over the supports and 1½ inch thick at the centre will carry a safe load of 112 lbs. per sq. foot with a spacing of joists no less than four feet apart.

For this type of flooring, wooden joists are more suitable. The room may be divided into several bays with beams preferably of rolled steel girders, and wooden joists may be fixed on them at right angles to the beams by means of dog spikes† at a distance of 12 in. between their centres. Hessian or jute fabric may be fixed by nails on a joist at one

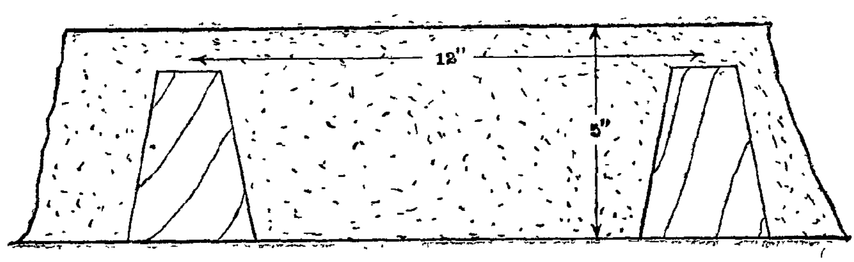


Fig. 38

and place them in position with centres 12 in. apart. At the bottom of the intermediate space, place some sort of boarding or C. I. sheet centering with corrugations filled with mud as described above. Then pour into the space above it, a slightly rich mixture of lime concrete formed of 2½ parts of broken bricks, one of sand, and one of lime

end and stretched and fixed by wire-tacks on every intermediate joist. It should then be freely soaked with water and a coat of cement grout consisting of one of cement to two of fine sand, mixed in water applied to it with a brush on

* Vide foot-note on p. 41 on No-frango construction.

† A peculiarly shaped nail.

both sides. Before this dries up, cement and sand of all grades below ⅜ inch, should be first thoroughly mixed in a dry state, in the proportion of 1 to 3, then formed into a mortar with water and applied evenly on the upper surface of joists to a thickness of about on 1½ in. The surface will naturally sink between the joists, which should be made level by adding mortar in the central portion. Thus, if the fabric is stretched well, and if a layer of 1½ in. is spread over joists, the thickness of the central portion will be 2½ in. This catenarian form (one of suspended chain) is an ideal one for strength, because, the centre, which has to bear more weight than the supports, is thicker and therefore proportionately stronger. For extra strength two layers of hessian may be laid with intermediate grouting coat. The top surface of this floor may be treated in any way desired, i. e. either Indian Patent Stone (described later on) or asphalt, or any other covering may be formed on it.

The above floor would look uneven and ugly from below. To remedy this, a ceiling of some sort—even that of *khaddar* or gunny-cloth stretched and tacked to the under surface of the joists may be made and white-washed.

Jack Arch Floor

Next to these, comes the Jack Arch flooring, in simplicity and cheapness. For this, rolled steel joists are to be placed on the walls at suitable distances, say, from 2½ ft. to 4 ft., and brick arches in lime 4½ in. thick, are to be built between, as shown in Fig. 39.

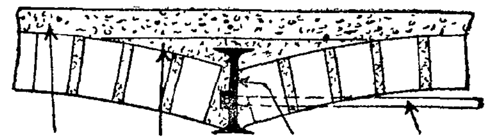


Fig. 39

These arches can be built without any centering* and in fact, unless this is possible, the Jack Arch flooring loses its advantage of cheapness.

For the guidance of the layman sizes of steel girders and wooden joists for different spans for the above two methods are given in the sub-joined table :—

Table of Steel Girders and Wooden (Teak) joists

Span in ft.	Bay or the space between two girders	Size of steel girder. in. × in.	Weight of girder in lbs. per foot.	Size of Wooden joists. in. × in.
8	6	5 × 3	11	2½ × 4
	7	6 × 3	12	3 × 4
	8	6 × 3	12	2½ × 5
10	6	6 × 3	12	2½ × 4
	7	7 × 4	16	3 × 4
	8	7 × 4	16	2½ × 5
12	6	7 × 4	16	2½ × 4
	7	7 × 4	16	3 × 4
	8	7 × 4	16	2½ × 5

* The process of doing this has been described in detail in the author's *Build Your Own Home.*

Plastering

It is usual in India to plaster brickwork in general with lime mortar on the outside. This is done for two reasons :—(1) The quality of bricks manufactured in India, except perhaps in a few places, is bad. Hence, unless the outside surface is plastered, they present a bad appearance. (2) At many places the monsoon is severe, hence, unless the walls are plastered on the outside, moisture is sure to be driven into them by wind-blown rain and cause damp.

But plaster is very expensive both in initial cost and the subsequent maintenance and repairs. Hence, it would be advisable in the interest of economy, to avoid it wherever possible.

To obviate the difficulty due to reason (1) above, viz. to improve the appearance of bad bricks, plaster should not be necessary. Because, if a slightly greater attention is given to select good bricks for the face work and pointing is done a little more neatly, a far better decorative effect can be obtained than with plastering. If however, plastering is required for the second reason, viz., to make the exposed surface impervious to water, it cannot be avoided. Still, economy can be effected in another way, viz., by using cheap bricks ; even ground, moulded country bricks will do, provided they are strong and durable. There is a great difference in the rates of table-moulded bricks of standard size and ground-moulded country bricks. If the surface is to be covered under plaster, then why not use the cheap stuff if it is sufficiently strong ?

If it is found necessary to plaster the outside surface of walls, economy, at least in the renewal of colour washing, may be effected by using some cheap pigment of lasting colour in the final coat of the plaster itself initially, so that, it dries out to a pleasing tint, and omitting the annual colour or whitewash altogether. *Multan mitti* gives a buff colour, if some red ochre is mixed with it, a cream colour is obtained ; lamp black gives a grey colour, a little blue mixed in it gives slate colour. All these colours are pleasing and lasting, and mix well in cement.

If walls are built of brick or stone in lime mortar, economy might be effected by omitting the plaster in certain rooms of the house, where it is really redundent e. g. in store room, fuel room, loft etc. It is also very difficult and expensive to maintain it in such rooms, because, there is every chance of its being damaged every now and then by something striking against it.

When a wall is one brick i. e. 9 in. wide it is possible to so build it with care that one of its faces is quite even. If then the latter is rubbed by a hard brick and whitewashed, no plastering is necessary on it. If a smoother surface is required, cream of lime may be daubed here and there against it and spread over the surface by rubbing it quickly with a piece of brick dipped into water in which, some *jaggery* is dissolved, so as to form a plaster $\frac{1}{8}$ in. thick or even less. This is very cheap and durable.

Mud plaster is cheap in initial cost and cheaper still in maintenance. It, furthermore, possesses the advantage that as the building grows old and the wall gets covered with many coats of colour and whitewash, it is a simple matter to scrape off the coats and make the surface smooth again by giving a hand wash of mud and cowdung mixed together. On the other hand, lime plaster if scraped, is damaged and cannot be made smooth again even at great pains and expense.

The proper way of plastering the inner surface of walls with mud is as follows :—

Select proper earth ; earth containing too much clay will cake and form cracks ; while that containing too much sand or loamy matter, will not stick properly. If earth found in natural state is not suitable, blending the two together in correct proportions will make it so.

It should then be screened through a ⅜ inch mesh sieve, so as to exclude bigger stones and lumps of earth, and be left to soak into water for at least 24 hours. Some people allow it to soak for a month, but unless the earth has salts in it the advantage is dubious. On the contrary, unless it is turned over and mixed with water every day and kept in a pulpy condition it is likely to form lumps which are difficult to break.

While mixing, cut straw should be freely added to it. Some people put some cowdung or crushed droppings of horses with advantage.

The surface to be plastered should be prepared by raking out joints to give a hold or key to the plaster, and the mixture of the proper consistency should be evenly spread on the surface and worked with a wooden float.* After 24 hours, while it is slightly wet it should be tamped well with a wooden or metal edge ; the dents should be as close together as possible.

The secret of success lies in this tamping. Even if a portion cakes and sounds hollow, the tamping will cause it to stick to the wall permanently again. This must be done in right time, once the inner skin of the plaster dries up, no amount of tamping is of any avail.

After tamping, a thin wash of cowdung is given and tamping done again at places where small cracks are seen to have developed. Then the final slightly thicker wash of cowdung and good *chopan* or white earth or better still, of sodiumised clay (please see page 12.) is applied by hand just to cover all the indentations made during the tamping process. After this the colour or the whitewash may be applied.

The above is for plastering inner surfaces of walls. For outer or exposed surface, the same process is to be repeated till after the tamping. The final coats to be given after this, must be such, as would help the plaster to resist atmospheric influences. Hence, instead of a wash with mere cowdung and earth one with a mixture of 12 parts of sodiumised clay to 1 of cement, should be given to close the indentations. If the earth is specially made impervious by the process described on page 12 viz. by mixing salts with it and precipitating it in water, excellent results would be obtained. In that case the cowdung may be altogether omitted. This makes the skin of the surface hard and non-absorbent, which, in consequence, wears well even in rain. The above wash is very useful for walls of earth.

For making the exposed surface waterproof to resist piercing rain and wind, recipes suggested on page 38 for waterproofing exposed surfaces of earth walls may be noted.

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* Float is an instrument consisting of a flat and smooth piece of wood used for planing and levelling plaster.

Flooring (Ground)

If a house is not likely to be infested by rats, *murum* or earth floors, if properly done, are excellent. They are cheap, easily made, wear sufficiently long, and are easily maintained and repaired. They maintain an equable temperature i. e. they do not get cold in winter, nor hot in summer, and hence, for Indian people who, in most cases walk bare-footed, inside the house, they are very suitable. Some people condemn them as insanitary on the ground that they absorb water and that in order to maintain them properly, they have to be frequently coated with cow-dung, which rots, stinks, and breeds millions of microbes.

To a certain extent this is true, but when all other factors are considered and it comes to choosing between two evils, the writer would be inclined to choose the lesser evil of *murum* or mud floors than that of any stone paving, imperfectly done.

In the houses of the poor, stones for paving, if used at all are laid, generally on top of *murum* or mud instead of on concrete. The quality of the slabs and workmanship are far from satisfactory. Again, unlike in the houses of the well-to-do, the floors are subject to rough use. As a consequence, the *murum* or mud sub-layer soon sinks, the joints in the slabs open out and an uneven surface is formed. For proper sanitation the floor must be washed with copious water mixed with some disinfectant at least twice a week. But in the houses of the poor, this is never done except once or twice during the year on ceremonial occasions or on certain holidays, when the whole house is cleaned as enjoined by religion; that too, is done without any isdinfectant and in most cases with a scanty supply of water. One can easily imagine what the process of washing and cleaning would be like, when the surface is rough and uneven, with several open joints, through which water must be soaking into the absorbent layer of *murum* or earth below! In fact the washing, instead of removing any dirt, multiplies it.

Besides, in certain orthodox sections of the Hindu community, even if a particle of food drops down, the ground is defiled, to sanctify which, comes a wash of cowdung! In the kitchen, where food is cooked and in the dining room, where it is served, local application of cowdung, is made several times a day, no matter what sort of a floor it is. It can be easily imagined to what extent, dirt must be sticking to the rough-grained paving slabs, and with wide open joints inviting swarms of house flies — the dreadful enemy of human health!

From this point of view, *murum* or mud floors are preferable. They are easily made smooth and as such take the least quantity of cowdung and dry up again very speedily.

Constructing *murum* floors is a matter of common knowledge and experience. Still the salient points which ensure success are described below :—

Murum or Mud Floor

All black earth, at least that in the portion one foot below the ground should be removed and the surface should be filled with boulders of stone or brick clinker, packed together in a layer of six inches. Above this should be spread 6 in. of loose *murum* with coarser pieces at bottom and finer at top. On the top of this, a layer of powdery or flaky *murum* 1 in. thick should be spread. Then water should be freely sprinkled on the surface which should be rammed well at the same time. After this, copious water should be evenly spread until it stagnates and appears about $\frac{1}{4}$ in. at top. The surface should be roughly levelled and trampled under feet of workmen until the cream of *murum* rises to the top. It should then be left to itself for 12 hours and then rammed by means of a wooden rasp for two days, both in the morning and evening. After this a wash of cowdung about $\frac{1}{16}$ in. thick should be given and the floor rammed again, once in the morning for two days. If it be summer time, it will be sufficiently dry by now, and will be ready to receive the final thin wash with 4 parts of cowdung, and 1 of cement mixed in water and applied evenly, and wiped clean from the surface by hand. If necessary, some lamp black may be added to it for the sake of appearance. The floor made in this way is very smooth, hard, and fairly impervious to water.

If the *murum* be earthy and very soft, or, earth has to be used instead, sand may be very thinly sprinkled on the surface on the third day and rammed well with a rasp. Instead of cement and cowdung, a coat of hot coal-tar may be applied and polished with a mason's trowel. This makes it more impervious, but some people do not stand the smell, which is unavoidable for a few days in the beginning. Before applying this coat, the floor must be thoroughly dry, otherwise the moisture of the surface might cause it to cake and peel off. *Murum* is available in Southern and part of Central India. At other places earth floors are made. The difference in constructing *murum* and earth floor is, that whereas water is freely used in *murum* floors, it is very sparingly done in the earth floors. If earth, as it comes from the pit, is moist, there is no need of watering it at all. It should be spread in 6 in. layers and rammed until very little impression is made by the heel of the shoe; then a wash of cowdung and cement should be given to it as above. While renewing earth floor, the upper layer of at least 6 inches of the old earth must be removed and replaced by new. For *murum* floor, this is not necessary, the old *murum* lasts for 10 to 12 years.

Concrete Floor.

In places where trouble, from rats burrowing under walls, is apprehended, floors of concrete may be done at a cheap cost. The surface below the concrete must be absolutely unsinkable, otherwise, cracks might result. Where stone is available at a cheap rate, the floor may be packed with boulders about 6 in. thick and upon them should be spread a layer of 3 in. of *murum* or gravel which should be freely watered and rammed. Upon this may be laid 3 in. of lime concrete prepared with 3 parts of metal to 1 of unscreened sand, free from earth, and one of lime mortar and rammed very hard. Upon this should be sprinkled very very lightly, dry mixture of 1 of cement and 2 of fine sand through a sieve of fine mesh and immediately polished with a mason's trowel, so that the cream of lime on the top of concrete dries up and forms with the cement a hard skin layer. This must be done just at the proper hour. This sort of floor if done well, wears very well and is absolutely water-proof and rat-proof.

Indian Patent Stone.

This is a further improvement on the concrete floor. In order to ensure absolute freedom from cracks, the sub-layer must be made quite unsinkable with great care. Upon this is to be laid 3 to 4 in. of lime concrete as above and rammed for two days. Before this sets, lay on its top, a $\frac{3}{4}$ inch layer of a mixture of 3 parts of sand and gravel of all sizes below ½ inch and 1 part of cement, in water evenly laid and rammed at the same time by the mason's trowel, and as soon as it partially sets, that is, in about six hours, another half inch layer of slightly finer sand 2 parts, and cement 1 part, mixed first twice in a dry state and then twice again in water, should be applied and levelled with a wooden float. Colouring pigment, if necessary, should be added to this mixture and the surface polished with a trowel. A very smooth polish is harmful in two ways. Firstly, the surface is liable to crack as a thin film of cream of cement rises to the top, and secondly, it becomes slippery.

To prevent the latter, lines crossing each other are drawn about ⅛ inch deep to show squares or diamonds, which also sets the floor off. If the surface is long and extensive, expansion joints are necessary. The floor is divided into rectangles by erecting either battens, 2″ by ½″, on edge or cardboard, and the cement concrete is laid on both sides of it. When the latter sets and dries up, the battens or boards are removed and the space filled either with hot asphalt or coal-tar mixed with sand upto ½ inch below the top, the space above which, is filled up with sand and the joint wiped off. In course of time the asphalt rises up and consolidates the loose sand.*

Another very cheap, durable, and water-proof flooring can be constructed in the following manner :—

Spread a layer of road metal about 3 inch deep. It does not matter, if the metal is slightly soft, but should not be *murumy* or earthy and liable to be crushed to powder under the strokes of a rammer. Consolidate it well in a dry state as is done for preparing roads so that all the pieces at top are interlocked together, and that, there are no loose pieces at the surface. When this is done pour on it, hot coal-tar just enough to form a film of, say, $\frac{1}{10}$ of an inch. Sprinkle on this, a layer of fine sand free from earth. It should be just thick enough to cover the tarred surface i. e. about ¼ to ⅛ inch thick. This should be rolled with a small stone or iron hand-roller, or if the latter be not available, beat it with a rammer, first lightly, and afterwards vigorously with a wooden rasp. The rasp should be so applied that the surface under it becomes smooth and even.

For the first month, the surface smells of coal-tar, which, to some people, is disagreeable. This sort of floor wears very long and, is perfectly satisfactory in every respect.

No-frango Floors.*

These are new to India. The writer has experimented on a small scale and found them to be successful. They are made in the following manner :—

As soon as the walls are raised upto the plinth level, the intermediate space is filled with loose earth, and a layer about ¾ inch thick of loose gravel is spread at the top. Then, with a heavy iron-bar, holes of 1½ inch diameter, 18 in. deep are made in it, at a distance of 2½ feet both longitudinally and cross-wise. In these holes, cement concrete is poured and while it is wet, a wire nail 1½ in. long, is inserted with ½ inch length left projecting above the top of the concrete. These are a sort of piles of concrete called *Plunger Piles*. Hessian or jute fabric is then stretched from outside of a wall on one side to the outside of the wall on the opposite side. The seams are made by overlapping the hessian fabric 6 in. upon each other and sewing it, by means of a thin wire. The

* Instructions in detail about this sort of flooring, have been given in the author's *Build your own Home* especially regarding guarding against failures.

* Please see the important foot-note on p. 41

projecting parts of nails must come above through the hessian. The latter is then soaked freely with water and treated in the same manner, as described for walls on p. 41 with a grouting coat, and then plastering. The fabric must be stretched well so that it does not sink much in the centre under weight. The surface is to be made level by adding more material in the hollows when wet. If the hessian is stretched properly, a depth of 1½ inch on the top of the plunger pegs, and 2½ inches in the middle, is sufficient, for obtaining a perfectly level surface. In course of time, the loose earth at bottom sinks down, leaving a cavity between the ground and the undersurface of the No-frango floor. This ensures protection from damp and white ants.

Roof

Roofs are of two types; one, flat and the other pent. The latter is also called pitched or sloping. On account of the extreme variations in temperature to which all parts of India, except perhaps the coastal region and hill stations, are subjected, flat roofs, unless very carefully and scientifically constructed, cannot be entirely relied upon in India. In coastal regions and hill stations also, though the temperature is equable, the proportion of the average rainfall is much greater than that on the plains and therefore, there is no less apprehension from leaky roofs than elsewhere. Besides, flat roofs necessarily require a parapet wall, which, if not constantly watched and kept neat and tidy, presents a squalid appearance.

If, on the other hand, a flat roof is rendered really water-tight, it provides an extra accommodation for sitting on cool evenings, or, sleeping during nights in the hot season at a high level. But this advantage does not really count in rural districts where open space surrounding the house is unrestricted.

If a pent or pitched roof, on the other hand, leaks, it is easy to set it right. Besides, it always looks elegant and presents a home-like appearance.

In cities and crowded towns it is the best policy to choose a mean i. e. to cover the greater part of a building with a pent roof and construct a terraced roof on the remaining part, so that, the advantage of a flat roof would be derived, and at the same time, the fear of leaks would be reduced.

It is often argued by the advocates of flat roofs that the latter keep the rooms under them cool, but this is doubtful; because for affording a real protection from the heat of the sun, the thickness must be something like 12 in.. which, no one ever adopts. The usual thickness given is from 4 in. in the case of R.C.C. roofs, to 7 in. in the concrete terraces or mud roofs. The degree of coolness afforded by this thickness, can be easily obtained from pent roofs, if a wooden ceiling is constructed and some air space is left between it and the tiles above. With modern insulating materials, any roof can be made cool in summer and warm in winter at a reasonable cost, to any extent.

On the contrary, a building with a flat roof on, is fully exposed to sun unlike that with a pitched roof, the projecting eaves of which afford a considerable real protection both from heat and rain, besides keep the building dry as the water from eaves flows away from it.

Let us take the pent roof first. Thatch is the cheapest material and if carefully laid in sufficient thickness, the roof gives an absolute protection from the sun and rain. But there are two disadvantages which very much detract from its usefulness. The first is, that it possesses the potential danger of catching fire, and the second, that it absorbs rain-water which causes the straw to decay. and give out foul gases.

Then come tiles, either half round or flat, which have been used from very old times. They, however, absorb heat and are liable to be broken by run-away monkeys, and have, therefore, to be turned and partly replaced by new ones every year. Besides, for country tiles, which are heavy, rather substantial scantlings of timber have to be used, which go to increase the cost.

Mangalore pattern tiles are light and more durable, but they also absorb heat. Again, they are likely to be blown away by hurricane. To remedy this, wooden or other ceiling has to be constructed below them, which also serves to mitigate heat. A still further objection to their general use in small towns and villages, is, that the tiles are not locally manufactured, and therefore unless a sufficient spare stock of this breakable material is always maintained, as they are liable to be broken or blown away, great inconvenience is caused, until they are fetched from cities or large towns.

Slates are utterly unsuitable for the hot climate of India. Besides, they are liable to be broken and are even more difficult of replacement in upcountry places than Mangalore tiles. Their cost also is heavy and prohibitive.

The material most suitable for cheap buildings is the corrugated iron sheets. They are light, very strong and durable. Although something has to be done to them to prevent them from being blown away by wind, and from absorbing and radiating heat of the sun, they are the most satisfactory as regards cheapness, durability, and the thorough protection, they afford from rain, if a sufficient slope is given to the roof.

Fortunately, excellent sheets are now manufactured in India by the Tata Iron and Steel Company, and offered at the same rates as those of foreign manufacture.

For preventing heat radiating from the C. I. sheets, the following are some of the remedies :—

Colours play an important part in either absorbing or reflecting heat. Dark colours absorb most, and white, the least. But the latter causes a glare to the eye. Hence blending of some other colour in white, so as to make it either grey or brown or chocolate, is necessary. The latter matches with the colour of the bricks or tiles and is pleasing to the eye.

Ordinary white wash, made of freshly slaked fat lime and water, in which 15 per cent of boiled linseed oil is mixed, forms an excellent wash for application to the C. I. sheets. It not only remains permanent, but reflects sun's heat and also protects the sheets from corrosion to which they are very susceptible, particularly near sea coasts on account of the sea-borne breeze, in which particles of salt are dissolved.

Another remedy for the preservation of the C. I. sheets from corrosion and mitigating radiation is to apply a thin coat of neat cement with a brush preferably in-the evening so as to allow it a full opportunity to set slowly in the cool weather during night time. After about a week, another thin wash may again be similarly applied.

Other remedies for mitigating heat are to spread a grass matting on the top so as to leave an air space of 3 inches between. This, however, harbours rats and the mat requires to be renewed every second or third year, otherwise, it rots, falls to powder, and obstructs the flow of rain-water by choking the channels in the corrugations.

Still another remedy is to cover the top with bamboo matting, which is an excellent reflector of heat. If an arrangement is made to sprinkle water on the matting at intervals so as to keep it moist, radiation is effectually prevented.

Asbestos cement sheets, particularly the corrugated variety and the red Trafford sheets though breakable, are very well suited to Indian conditions. Besides, they are an indigenous material.

Modern methods of insulation against heat by interposing a layer of non-conducting material such as straw, weeds, loose coir, rockwool etc. or by a curtain of aluminium or copper foil (Building paper) on optical principles, are discussed in detail in the author's *Modern Ideal Homes for India.*

Wooden ceiling fixed below the C. I. sheets so as to leave an air space of at least 3 inches is also a good remedy to check radiation of heat.

A few remedies for preventing the roof from being blown away are suggested below :—

The simplest and most rational is, to provide sufficient apertures just below the eaves on both sides of the house so that the wind should enter through them on one side and pass through those on the other. Generally what happens is, that the wind striking horizontally against the wall changes its direction and applies a lifting force below the projecting eaves. Once the eaves are lifted up, the whole roof is blown away. If such apertures are provided, ordinary precautions taken against the roof being blown away, are sufficient.

Another way is to lay tiles over the roof just for weighting it. But if 2″ by 1″ battens from ridge to eaves, 2½ ft. apart, and above them again usual battens are fixed to them across at right angles, and Mangalore tiles laid over the latter, not only are the sheets weighted but the 3-inch air space provided between, serves to reduce the radiation to a great extent. There is one objection to this method, viz. that the hollow space is likely to harbour rats. But, if brick-bats are laid in cement mortar on top of sheets near the eaves and end tiles fixed on them there remains no space for rats to enter.

If country tiles are to be used for weighting, give a generous coat of coal tar to the roof surface, spread hay or straw on it and lay the country tiles as usual. The tiles at ends must be securely pressed by means of a long piece of flat iron, or teak batten, bolted to the sheets to prevent the tiles from sliding down the slippery surface of the straw. This very effectually prevents radiation of heat.

There is, again, the usual elaborate method of fastening down the sheets at the eaves and gables by continuous lengths of a steel flat or a steel wire rope fixed by bolts embedded in the masonry at about 4 to 6 feet intervals. These bolts should be 1½ feet in length and anchored into the walls by means of 6 inch square iron plates.

Oftentimes steel joists or angle irons are cheaper and more suitable as purlins under corrugated iron sheets on account of their property of resisting fire and white ants. In that case, special steel wire bolts may be used, as shown in Figs. 40, 41 and 42.

Fig. 40

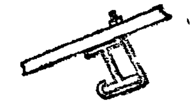


Fig. 41

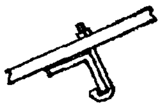
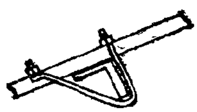


Fig. 42



It is necessary to punch the holes in the C. I. sheets neatly with a sharp cold chisel. Otherwise, they are likely to be torn asunder causing leaks. The carpenters who do this job, are generally very careless and must be vigilantly watched. Similarly, they often fix the galvanised screws by hammering on their heads just to save their own labour. This makes them loose. First, a hole of a smaller diameter must be drilled in the wood and then the screws must be fixed by means of a screwdriver.

If some 2 in. of cement concrete is laid over the C. I. sheets, the roof is weighted against being blown away and in addition, the radiation of heat is reduced to a certain extent. If this is done, care should be taken to lay the concrete in the evening. Otherwise by the heat of the sun, it sets so quickly that ramming becomes impossible.

The second point to be noted is, that unless some sort of reinforcement is used on the top of the concrete just in the lengths, where C. I. sheets supported from below, cracks are sure to develop. To prevent this, wire gauze netting even of 1 in. mesh in strips of 9 in. width, may be embedded about $\frac{1}{2}$ in. below the top of the concrete. The cracks are unimportant from the point of view of leakage or structural strength. But they form an eye sore.

No-frango Roof. *

As a roofing material, No-frango has great possibilities in tropical countries like India; because, on account of the elasticity it possesses, which is due to the hessian (jute) fabric embedded in it, it is least susceptible to form cracks on account of the temperature stresses.

The construction of the framework is similar to that of the Mangalore tiles, the only difference being, that the battens required for the Mangalore tiles are not required for the No-frango roof.

Even a thinner section of rafters would do, as the No-frango slab is not more than one inch thick, and is much lighter than Mangalore tiles. Hessian fabric, as wide as available, may be soaked in water and stretched from one end to the other, an overlap of 6 in. being given at the joints which should be stitched either with hessian, twisted yarn, or thin steel wire. Instead of stretching the whole piece from one end to the other, better results are obtained, if the portion from one rafter to another is stretched and fastened by means of tacks. This may, again, be soaked in water and a grouting coat of mixture of one of cement, and two of fine sand, should be applied by means of a brush. When this sets, but is still wet, the usual coat of cement and sand mixed in the proportion of 1 to 3 should be screeded on to it and the surface rendered smooth by means of a float. The surface is bound to be uneven showing ridges over the rafters and furrows between them. This is, however, an ideal condition, because so many channels for draining off rain-water are automatically formed.

It is necessary to take particular care in respect of watering the roofing slab in the tropics. Unlike ground or suspended floors it is exposed to sun. On account of the fabric being stretched well, the excess of water drains away and hence, if special care is not exercised it may get quite dry before it sets and obtains suffi-

* Please see the important foot-note on p. 41

cient strength. Saw-dust may be spread on the top to retain moisture.

This sort of roof would give a perfect protection from rain but not from heat. For the latter, wooden ceiling may be fixed on the under surface of the rafter so that an air space equal to the thickness of the rafters is obtained.

In Ireland they first lay boards for ceiling, upon them a layer of felt impregnated with bitumen, and on the top of the latter, No-frango slab is cast. The bitumenized felt serves two purposes:—Water-tightness and reasonable protection from heat (or cold), as felt is a non-conductor of heat. For Indian conditions, this would not be sufficient to prevent radiation of heat inside.

If flat roofs are to be constructed of No-frango they may be done just like the suspended floors described in the previous chapter. For additional strength, instead of one, two layers of hessian fabric may be laid. A good cross slope for draining off the water collected is absolutely necessary.

Flat roof of No-frango is however, not commendable for Indian conditions. Please see the foot-note on p. 41 regarding the suitability of No-frango construction to Indian climate.

Some Practical Points and Hints for Economy in Pitched Roof.

1. A wall plate is supported by the wall below, throughout its length and therefore, is not subjected to stress like a beam. Its functions are, firstly, to distribute the pressure of the roof uniformly on the wall and secondly, to make a junction between the roof and the walls below. Hence, they need not be of such heavy section as 4″ by 5″ or 4″ by 3″ as is commonly done. Even 2″ by 3″ will do. Concrete bed-plates will also serve the purpose equally well.

2. Instead of one heavy verandah post of, say, 6″ by 6″ if two pieces say, of 4″ by 3″ or even 4″ by 2″ are joined by cross-pieces and latticing is done as shown in Fig. 43 to form a compound pillar, not only is its strength increased, but they can either be spaced at longer distance apart or the depth of the post plate may be reduced. Such sort of pillars also look more elegant.

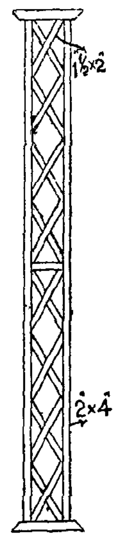


Fig. 43.

3. It is unnecessary to plane timbers which are likely to remain hidden from view e. g. wall plates; and if a horizontal ceiling is constructed, all roof timbers may be left unplaned.

4. Alternative rough estimates should be made to see which of the two—horizontal or sloping ceiling is cheaper. The horizontal ceiling looks well and is better for prevention of heat as it encloses more air space and also requires less boarding but a heavy framework is required to suspend it.

5. Ends of C. I. sheets should never be embedded in masonry.

6. Very often an oil paint does not stick to new C. I. sheets, or if applied, it cracks and comes off in curly flakes. This should be remedied by washing the surface with washing soda or the paint should be applied if the sheets are exposed to weather for a few months.

7. If it is intended to cover the C. I. sheets with tiles, and if the latter are of good quality, considerable economy may be effected by overlapping even half a

corrugation, as shown in Fig. 44. If no tiles are to be laid then 1½ corrugation must overlap. (Fig. 45). The end overlap must be 4 in. and if the slope of the roof is small, 6 inches.

Fig. 44.

Fig 45.

8. Instead of lead washers, which are costly, if pieces of strong cloth soaked in asphalt are wound below screw-heads to form washers, they are cheaper and more watertight.

Flat Roof.

Unless perfectly water-proof materials like bitumen or asphalt are used at considerable cost, flat roofs cannot be expected to afford absolute protection in the hot climate of India. They necessarily require some sort of parapet wall and as the gutter collecting the rain water on the surface of the roof behind the parapet is just on the top of the wall below, any small cracks —even hair cracks—in the gutter cause the water to descend directly into the wall below.

The merits and de-merits of the flat roof have been already discussed in the preceding chapter. There are various methods of constructing flat roofs, according to the climatic conditions, materials available, and the local practice of the different places. The cheapest form used is that of round ballies nailed on to wooden beams to span the space across them, over which, are laid some sort of reeds or wattle or long twigs of trees, such as *Sarkand* or *Samalu* in Northern India, or *Karvi* or palm leaves in Southern India.

On the top of these is spread a 6-in. layer of stiff mud which is beaten hard; if the mud is not of earth which is non-absorbent, special non-absorbent earth (*Khari Matti*) is brought from a long distance and spread loosely in a layer of about 1 to 2 inches. The wattle is sometimes replaced by timber-waste obtained from saw mills, which is nailed to the rafters.

At some places, better class people use mild steel T-pieces, which are inserted and laid in an inverted position, one foot apart, and special roofing tiles, 12 in. by 6 in. by 2 in. (usually) are laid on the flanges of the T-pieces, and over these, mud and loose earth are spread as above.

The top surface of flat roofs must be suitably sloped, the exact degree depending upon the local circumstances, such as the rainfall, the quality of the clay available, and so on.

The water-tightness of such roofs depends entirely upon the quality of the earth used. At certain places it is an extraordinary thing, that though such roofs crack badly during hot weather, when it rains, the cracks are automatically filled up by the loose earth carried by the rain-water passing over them, and the roofs are rendered perfectly water-tight inspite of heavy rain.

Such roofs, however, need careful attention both in the beginning and at the time of subsequent repairs, and where good earth is not available, they are sources of considerable trouble and inconvenience, and sometimes of danger, if the walls are of earth, or even of brick or stone in mud mortar. Again, in places where trouble from white ants is feared, the timbers have to be renewed at short intervals.

If C. I. sheets are used instead of the reed or wattle and the roof made as usual with a layer of good quality of earth, not only an absolute protection from rain is obtained, but the covering of the earth removes every fear in respect of both, the roof being blown away by wind, and heated by the sun. Of course, the necessary slope must be given to the surface.

An additional advantage in respect of cheapness given by this sort of roof, is that as the incline is small, fewer sheets are required than for the usual sloping C. I. sheet roof. and that the stiffness caused by the corrugations saves a considerable amount in timber supporting them, as the spacing apart of the latter can be safely increased. If mild steel rolled sections are used for purlins, the roof becomes fire-proof and practically a permanent structure.

Before laying the sheets in position they should be given two coats of cement with a brush ; this would prolong their life. In order to make mud roofs water-tight, the remedy suggested for making exposed surfaces of mudwalls water-tight on p. 38 may be tried with success.

Concrete Terraces.

Concrete terraces, whether of lime concrete, or cement concrete, must have a rigid sub-layer. Even a slight movement in it, whether due to mechanical agency or to expansion and contraction caused by heat or cold, causes the concrete above it to crack and through the cracks, water leaks. Wood is therefore, quite unsuitable as it swells by moisture and as a result expands and contracts considerably. Iron and steel in the form of rolled sections are much more preferable, as they are not affected by weather and behave as much more rigid material than wood.

The upper concrete layer in terraces is carried on either jack arches, or on tiles or stone slabs etc. The tiles or slates are laid on steel joists or wooden beams. The concrete is made of 2¾ parts of the broken brick-bats, one part of unscreened sand, and one of lime mortar. The pieces of brick-bats are allowed to soak in water freely for 2 or 3 hours before mixing. The concrete should be laid in a stiff state and beaten well. During the process of beating, the surface should be sprinkled with water, in 8 *gharas* or 6 kerosene oil tinful of which, is dissolved 3 seers of molasses and 2 seers of *beal* fruit. The success in respect of compactness, which is synonymous with water-tightness, depends upon the thorough consolidation made. This should be done by beating for three days, and should only be stopped when the rammer rebounds and a heeled shoe cannot make a mark on it. Clean water should then be freely sprinkled and when the cream of lime at the surface is softened, the surface should be rendered smooth by polishing with a trowel. No fresh mortar or cement should be added, as it forms a skin layer which soon swells and forms hair cracks.

In order to render a terraced roof quite water-tight, the surface of the concrete should be coated with hot bitumen, and over it, should be laid, flagstones or tiles, filling the joints with cement mortar.

Another method of making a water-tight terraced roof is to lay, on top of lime concrete, flagstones of as large a size as practicable, so as to minimise the number of joints, which form the only weak spots. When paving stones are laid, the joints of the slabs should be kept 1 inch to 1¼ inch wide and they should be raked out to their full depth and filled in again with cement mortar consisting of one part of cement and two of fine sand. The idea is, that if leaks occur at all, they will do, through the joints only, which, in the first place are much less in number, and again, have received a special treatment with cement mortar. Hence, the chances of leaks occurring are few. However, if they occur at all through some of the joints in course of time, through hair cracks, formed in them, it is a simple matter to open them by a chisel and fill in asphalt or some other water-proofing material and end the trouble once for all, at a small extra cost. The purpose of keeping wide joints, is that they should admit of a chisel being used for opening them.

Domestic Sanitation

The fundamental principles underlying perfect domestic sanitation are enunciated below :—

(1) All refuse and waste matter, whether solid, liquid or gaseous, which is offensive and injurious to health, must be removed away from the house, as rapidly as possible after it is produced, and disposed of in such a way as to render it harmless.

(2) No part of the house should hold damp anywhere.

(3) All substances which are of such a nature as to absorb, catch, carry, hide, or retain particles which are likely to hold germs of diseases, must be avoided as far as possible, whether employed in the structure of the building itself, or in decoration and furnishing; thus, porous and absorbing bricks, sea sand impregnated with salt, which absorb moisture, are bad. Thatch, for roofing which is sure to decompose, is bad; stone carvings, embossed plasterings, mouldings, ornamental railings, cotton or woollen fluffy carpets etc., which are likely to catch, hold, or hide dust, are bad.

(4) Every room of the house must be provided with adequate means for admission of fresh air and expulsion of used air, so that it is continually charged with a stream of fresh air.

(5) Every part inside the house including every nook and corner should be fully lighted as far as possible, by the direct light of the sun.

(6) The house should be supplied with a copious supply of pure water.

Let us take these in order and see how they can be enforced to suit the peculiar conditions of India, caused by the habits, customs and religious prejudices of the people.

All refuse matter may be divided for the sake of convenience into two classes :—

(1) Matter of fæcal or excremental nature both human and animal.

(2) Other waste refuse, such as straw, ashes, waste papers, rags, garbage etc.

The first is of the greatest importance, because if it is not efficiently removed from our surroundings, it soon decomposes and the germs of diseases, such as Infantile Diarrhœa, Dysentery, Cholera, Typhoid etc. are disseminated by flies and dust reaching the eyes, food, milk, and water.

The only satisfactory means of efficient removal, especially of fæcal matter, is the water-carriage system with underground drainage. It also simplifies its disposal. But India is so backward and poor, that whereas the system prevails in all towns and most of the villages in the Western countries, not more than two dozen cities and large towns in the vast continent of India, can boast of it. In villages and small towns there are often no Municipalities at all. There are, therefore, no sweepers and scavengers to remove the filth from premises of houses, which are used by young children and often by women, for answering the call of nature! Males do so in and around the village site, wherever some privacy is afforded by shrubs, mounds or banks of earth, stone quarries etc. The fæcal matter is allowed to decompose and dry, during which period it attracts swarms of flies. It is then constantly stirred up under feet of cattle and men and when reduced to powder, is blown away by wind to be deposited on water and foodstuffs and to be inhaled into lungs.

Even the cities and towns blessed with Municipal organisations, are not a whit better. In the first place, more than 50 per cent of the houses have no latrines of their own, with the result, that the same conditions as those described above prevail perhaps in a worse degree, because the houses being crowded, and there being no open space available round them, the streets are made use of, any time by day by children, whom their age gives a privilege in respect of privacy, and by grown-up people, during the small hours of the morning or after dusk. The free public latrines provided by Municipalities are either inadequate in number or the people are so slovenly in their habits that many of them do not take the trouble of walking a few steps to take advantage of them. Even where latrines are built, the open drains of the street receive the contents of the overflowing baskets in the latrines; the semi-fluid matter stagnates in the gutters and forms a breeding and feeding ground for the flies and mosquitoes. The habits of some people are so bad that even the most enthusiastic and consciencious sanitary inspector though backed by the authority of law, soon becomes disheartened in his thankless task and loses much of his efficiency.

Poverty and ignorance of the most fundamental principles of hygiene, coupled with conservative and religious prejudices, are some of the causes. The only remedy is education by proper methods, such as popular lectures with the aid of lantern slides, health exhibitions, broadcasting leaflets, posters etc. by volunteer organisation rather than by authority. If a band of enthusiastic volunteers in each village or town go on rounds and by actual example rather than by precept show how to clean the town or village, wonders would be worked out in a short space of time. The author has actually organised such a volunteer corps and he writes from personal experience. Enthusiasm is never wanting in youths and if under proper guidance, they are taught to clean up with their own hands the stink left by insanitary householders and if they have once absorbed the spirit of social service and do it whole-heartedly, not only would those responsible for the filth be put to shame and taught a lesson, but the gospel of the dignity of labour and social service would be brought home to them in a more telling manner against the age-long habits and religious prejudices, than by any amount of effort made in all other directions.

Really speaking, in villages and small towns, where there is generally some elbow room, at least in rear yard of the house, the problem of dealing with the sewage produced in the individual homestead, should present no difficulty. But unfortunately a strong determination and an earnest desire to solve the problem is lacking on the part of the people.

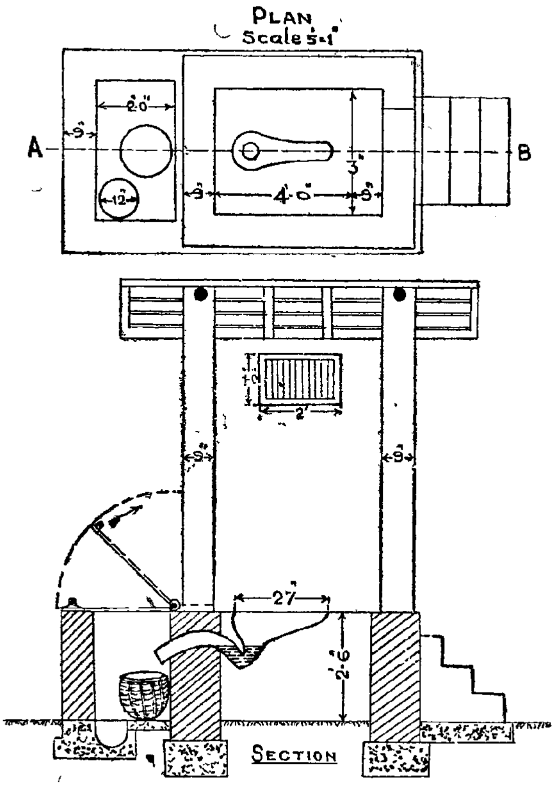
It is not possible to give in the short compass of this book the various types of latrines and to describe the various methods of disposing of sewage; this has been attempted at some length in the author's other book. It is proposed to describe here only two very simple and cheap methods, one suitable for town areas, where there are municipal scavengers, and the other, suitable for rural areas, where some method of rendering the sewage harmless promptly has also to be adopted.

From the foregoing discussion it will be seen that the conditions which an ideal latrine must satisfy are:—

(1) That it should not give out noxious smells.

(2) That it should not attract flies and other vermin.

(3) That the contents should not be visible to the user.



Figs. 46 & 47.

(4) That the night soil and the liquid contents should either be removed away from the site at the earliest opportunity or suitably treated so as to render them innocuous.

Let us see how far the two types to be described below satisfy these requirements. To take the one, which is suitable for municipal areas first :—

Figs. 46 and 47 show a simple design of a latrine which does not differ from the ordinary ones usually constructed in municipal areas where the night soil is collected in baskets and removed to a distant place by sweepers.

In fact, any type of latrine can be improved by making additions and alterations in it. The outstanding feature is an earthenware closet of a simple design laid just below the seat to receive the liquid and the solid excrements. Such closets are manufactured by Messrs. Burn and Co. and sold for Rs.8. Its plan, and section are shown in the sketch. It is glazed on the inside and has got a sloping bed, so that the contents slide down to the lowest level where a trap is fixed which always holds a certain quantity of water. The human excreta, as soon as they fall down drop into this water. The ablution water causes them to be carried through the trap into the basket placed below. Thus being always covered by water, no noxious smells are carried. There is no connection between the seat side and the basket side of the latrine except through this trap, the neck of which being always sealed with water there is no possibility of any foul gases from the basket entering the closet unless the trap runs dry. As the basket is hidden from view, its contents cannot be seen by the user.

There is a small rear chamber of burnt brick in lime with inside dimensions of 2 ft. by 3 ft. Its bottom and sides are lined on the inside with cement plaster and there is, in one of its corners, a small pit or sump, also lined on all sides with cement for holding the liquid contents. The bed of the chamber is made to slope towards this pit. The chamber has a cover of galvanized iron sheet at top, which is hinged to hooked bolts, inserted in the rear wall of the latrine. The contents of the closet above, fall into the basket provided with a fairly deep layer of fine coke breeze, mixed with ash, so as to act as a kind of filter. Failing this, sand or porous earth may be used. In these cases, the fæces will lie on the surface of the material and be very readily and cleanly removed. The basket should have numerous small holes in the bottom, so that if any liquid filters through coke breeze or sand, it will flow into the sump. The sweeper has to lift the lid, remove the basket with its contents, scavenge the floor, remove also the liquid contents of the pit, put the empty basket in position and replace the cover before he goes away. The efficiency of this arrangement is due to the following facts.

(1) As the chamber is always covered, there is no chance of flies sitting on the filth.

(2) The solid contents, separated from the liquid, remain dry and do not readily putrify and can also be easily and cleanly removed.

(3) The liquid as it filters through a layer of coke breeze or sand, does not give out foul odour.

(4) The whole thing remains quite clean and hidden from view. An occasional coat of coal-tar, or better still of pesterine, to the cover and the outside of the chamber is recommended.

If the earthenware closet with trap is omitted by those who cannot afford it and instead of it a simple half round 6 in. diameter earthenware pipe is fixed in a slanting position on the top of a trap, it would serve the purpose. But the closed chamber on the rear side is absolutely necessary, if flies, which transfer germs of disease are to be excluded.

Disposal of Sewage in Rural Districts.

As compared with crowded towns and cities there is plenty of everything in rural districts—plenty of fresh air and sunshine, plenty of fresh vegetables and fruits, full of vitamins, plenty of milk and eggs and also plenty of outdoor physical work. Thus a dweller in rural area is expected to possess more strength and vitality and immunity from diseases than the city dweller. But what do we actually find? The life in villages is more uncertain due to the frequent ravages of epidemic diseases, mostly carried and spread by bacteria. This is due to lack of sanitation, particularly in respect of the neglect of disposal of human and animal waste. Cholera, Typhoid, Dysentery and Hook-worm owe their origin entirely to intestinal waste matter, carelessly allowed to rot and dry in proximity of dwellings. The germs of the first three diseases, *viz.*, Cholera, Typhoid, Dysentery are actually swallowed either with food or water. Hundreds are the ways in which this is unwittingly done. For example, flies sit on the rotting filth and then settle on food with their feet full of dangerous bacteria. The germs may be carried to the sources of water supply either directly or by infiltration of sewage through soil saturated with it. The dry excreta might also be crushed under feet, blown by wind in the air and settle on the surface of food, bazar sweets, water or milk as dust and find a direct entrance to human intestines.

The fourth disease, *viz.*, the hook-worm grows in the intestines of human beings and its eggs are thrown out in enormous numbers in excreta. One worm produces about nine thousand eggs per day.

The worm develops into the larvæ stage in warm, damp earth. When persons walk barefooted on such a ground the larvæ, which are picked up on the feet, enter through the skin into blood stream and are first carried to lungs, whence they break through into the air sacs, pass up into the throat and are swallowed. Thus they finally reach the intestine, where they develop into the worm stage. Sometimes, the larvæ are directly swallowed with green vegetables eaten raw. Though the disease is not fatal, it lowers the general vitality of the victim who then easily falls prey to other diseases like Malaria, Tuberculosis, etc.

All these are preventable diseases and they can be prevented only by perfect sanitation, particularly in respect of disposing of excremental matter in such a way as to render it harmless. The requirements of an ideal system of sewage disposal are that,

(i) It should be cheap.

(ii) Its construction should be so simple as to be within the capacity of the village carpenter or mason to make or repair it.

(iii) It should not give access to flies.

(iv) It should not give out any foul odour.

(v) It should not cause any splashing or scattering of sewage over ground surface.

(vi) It should keep out dogs, pigs, rats, cows, buffaloes and other animals.

(vii) It should not contaminate the source of water supply such as streams, wells, etc.

(viii) It should require the least quantity of water, should this be necessary either for its cleaning, dilution or purification.

(ix) It should be automatic in action. No constant attention should be required for its maintenance.

(x) It should be fool-proof and if anything sometimes goes wrong at all, it should give a fair warning but should not cause immediate adverse effects.

(i) The condition is self-evident in view of the abject poverty of the average Indian cultivator.

(ii) The condition regarding simplicity of construction is obvious. There may be complicated installations constructed on strict scientific principles, but if anything slightly goes wrong, an expert will have to be called for from cities.

(iii) On account of the familiarity, the havoc played by the common house fly is not properly appreciated. Not only is it one of the dirtiest animals but it is no exaggeration to say that it is a messenger of Death. It is more fond of putrefied things such as fæces, blood, pus, etc., than clean sweats and dairy products. A fly cannot eat solid substances such as sugar. It, therefore, liquefies such things by dropping its saliva on it and then swallows it to its heart's content. It is so voracious that when it cannot eat any more it vomits and empties its bowels on the food and when the latter is wetted starts eating it again. It has six legs each full of thick hair growth as shown in Fig. 48 and there are two pads of hair, soft like velvet, at the bottom of each leg upon which it rests. Thus, when it sits on filth, innumerable particles of it are bound to stick to the pads and the hair, and when it settles on food in this condition millions of disease germs are introduced into the food. Whenever filth is exposed in latrines

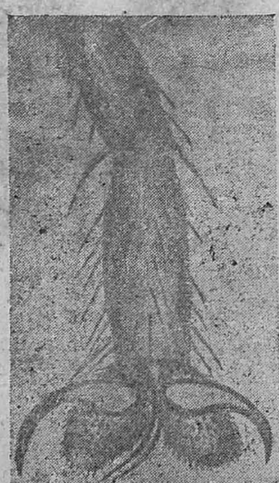


Fig. 48.
Leg of a house fly
(magnified)

there are invariably swarms of flies sitting on it, and these, when tired of feeding on it and want a change, enter the house directly and sit either on food in the kitchen or on the lips and eyes of infants. The germs left on the lips enter the mouth with the saliva and diseases like diarrhœa are produced, to which, very often the innocent babies succumb on account of their low vitality. That is why it is a messenger of Death.

(iv) Foul odours indicate that the system is not working properly.

(v) If sewage is allowed to be splashed or to lie scattered about on the ground surface, the hook-worm is likely to spread and troubles from flies also will arise.

(vi) If dogs and other animals get a chance to eat the filth they are likely to spread disease by contaminating food or water with the filth sticking to their mouths.

(vii) If sewage be allowed to soak into the ground, the sub-soil strata are soon saturated with it and if there be a well or stream nearby, the liquid sewage passes in course of time, unfiltered and enters the wells or streams.

(viii) There is a great scarcity of water in a large number of Indian villages. In some of them water even for drinking has to be brought from long distances. Hence, the condition that the system of disposal should not require any water, and that if it cannot do without it, it should need a minimum quantity, is very important.

(ix) and (x) In view of the caste and social prejudices, that none except a person of the sweeper class should touch such disposal installation, it is necessary to lay down the condition that it should be automatic in action, and should require least attention for its maintenance.

Let us now discuss the various systems and verify how far each one of them satisfies the above requirements: The various systems in vogue at present are (1) Using open space (2) Conservancy or Basket system and Hand removal (3) Water carriage or Flushing system (4) Earth closets (5) Bore-hole latrines (6) Trench latrines (7) Septic tank.

(1) *Using open space* for answering the call of nature is the most primitive system. It was not so objectionable when in primitive days houses were scattered. Even then the aged, the sick and children used the premises of the house out of necessity. But gradually the grown up people in health also, on account of their slovenly habits, found it convenient to follow suit and this continued even though the houses were built close together. This has given rise to general insanitary conditions in and around villages with consequent spread of diseases. This system is most objectionable even from the point of view of privacy, particularly, amongst women folk. Lastly, the material which would have been very useful as manure for agriculture which is suffering for want of it is converted into poison!

(2) *Conservancy or Basket system*:— This system has been tried for a long time and has been found to be equally bad, nay, even worse in some respects. In the first place, in the areas under local authorities more than 50% of the houses have no latrines of their own, and the public free latrines if provided at all, are too few to cope with the demand In consequence, conditions worse than the above prevail there. For, in villages there is at least ample space round the houses, but in towns it being very scarce, streets are made use of, by young children, any time by day, and by adults, during small hours of the morning or after dark. Even where latrines are built, the baskets

usually overflow, the liquid sewage flows into open street gutters with swarms of flies breeding and feeding on them. The latrines themselves are very insanitary with mud walls and mud floor, which is scarcely or never cleaned. Often times no paving either of concrete or flagstones is provided even below the basket. At some places, the basket is unserviceably broken or often altogether missing!

All this is very bad indeed, but there are still graver problems involved in it. Firstly, it is a mistake to leave the most vital question of our health to the mercy of the sweeper and to depend entirely on a class of people who do not know the value of sanitation. He does not care for the house owner and would not tolerate any remarks from him for unsatisfactory work. Very often he sets aside the orders of his superiors, makes unreasonable demands and if they be not fulfilled, goes on strike. How often do we hear of sweeper's strike and the sanitation of whole city thrown into ruinous condition?

Secondly, there is a social aspect to the problem. The sweeper is a human being, made of the same flesh and blood as we. Why should he then remain perpetually in bondage, do such filthy work and remain for his whole life "untouchable" and "unclean"? He has served us all these days, badly or well, but faithfully according to his lights. Instead of rewarding him for his services, with education we have condemned his whole class as untouchable. It is a shame to us, fellow human beings! It is only in India amongst the nations of the world that a large part of the human population — several million people are selfishly held in servitude to do the filthy work. It is a curse to India and the sooner it is removed the better.

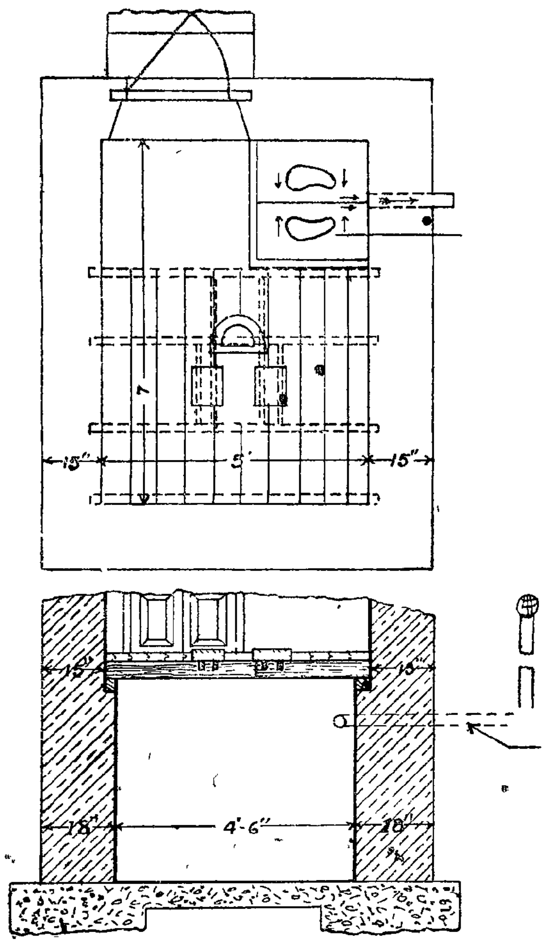
Thirdly, howsoever efficiently the system of hand removal be organised, the nuisance of foul odour and flies, while cleaning latrines, emptying baskets and carrying the sewage in carts through streets and finally emptying the carts into trenches, cannot be avoided. It is impossible to maintain the whole system so scrupulously clean to be absolutely harmless.

Lastly, one who has examined the municipal budget will tell how expensive it is to maintain the necessary establishment and equipment and still the result is disappointing.

(3) *Water carriage or Flushing system*:- This is the most satisfactory system so far known. But it requires a number of facilities for providing which, a great outlay of expenditure must be made. First of all there must be plenty of piped water supply under sufficient pressure. Then a network of underground sewers on sanitary lines must be built and thirdly the question of the disposal of the entire sewage must also be adequately solved. If there be sea or large river with flow even in the hot weather season, sufficient to dilute the sewage, it may be introduced there, away from human habitation. This is most economical, otherwise, additional large capital must be spent on pumping the sewage and distributing it for irrigation of crops or treating it suitably as to make it harmless.

(4) *Earth closet*:—In India on account of two disabilities, viz., that on account of heat, putrefaction starts very early and that lot of water is used for ablution, the problem of earth closets becomes a little more difficult than in the Western countries. However, if an earth closet is built on scientific lines and arrangement is made to separate liquids from the solid excreta or at least to reduce the quantity of water to a minimum, it must give perfect satisfaction.

The type of an earth closet shown in



Figs. 49 and 50.
Plan and Section of Earth Closet.

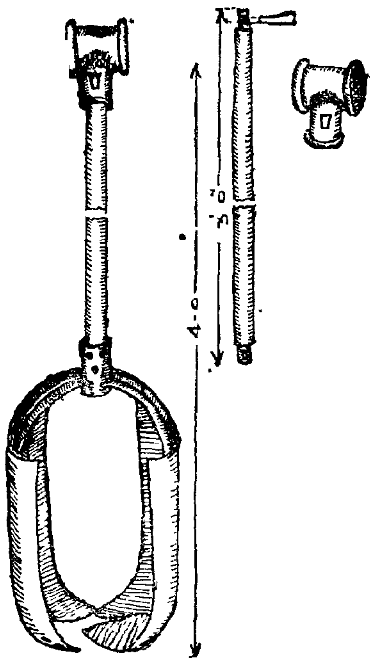
Figs. 49 and 50 has been found by experience to give excellent results. It consists of a pit 4′–6″ × 4′–6″ and 4 to 5 ft. deep with 6″ of lime concrete at bottom and 18″ thick side walls. The pit is lined at bottom and sides with cement plaster. At the plinth level the thickness of walls is reduced to 15″, leaving a step or an offset of 3″ inside all round. On this ledge, a wooden frame is placed and a rigid platform is made of 1½ inch boarding, leaving a gap 7″ wide with foot rests on both sides for squatting and a suitable basin with a hole at bottom for the urine. On the front side near the right hand corner there is a sink with foot rests with good slope towards a central channel for ablution purposes. As soon as the closet is used a mixture of dry earth and ashes placed in a pail near the seat is to be spread by the person to cover the excreta and then the ablution should be done in the corner sink. The water from the latter is diverted from the earth closet and treated separately in a soak-pit about 3 ft. deep filled with rubble-stones, brick-bats, gravel etc. and covered with 6 inches of earth at top. There is a ventilating pipe provided. But this is not absolutely necessary.

As only the urine is admitted into the pit the quantity of earth required to treat the liquid portion is small and if sufficient quantity of it is used there are absolutely no foul gases produced.

(5) *Bore-hole latrine* :—This is much cheaper and more convenient than the earth-closet, but its chief requirement is, that there should be deep soil for the bore. Rock, *murum*, or even sand are of no use. The soil should be at least 4 ft. deep, if it is 10 to 15 ft. deep or more, it is an ideal condition. Heavy clay soil (not black cotton soil, which cracks) is the best. Sub-soil water level even in the rainy season should be as low as possible.

The site selected for the bore should be on an elevation and if such a site is not available one should be made artificially by filling earth and making the surface, slope down on all sides, as shown in Fig. 54.

A hole of from 9 to 16 inches diameter is drilled vertically into the soil by an instrument of steel called an earth-auger. It consists of four fan-shaped fins about 12 inches long with a vertical rod rivetted at the top, as shown in Fig. 51. The total length of the auger is 4 ft., but by means of a junction piece rods 3 ft. in length as shown in Fig. 52

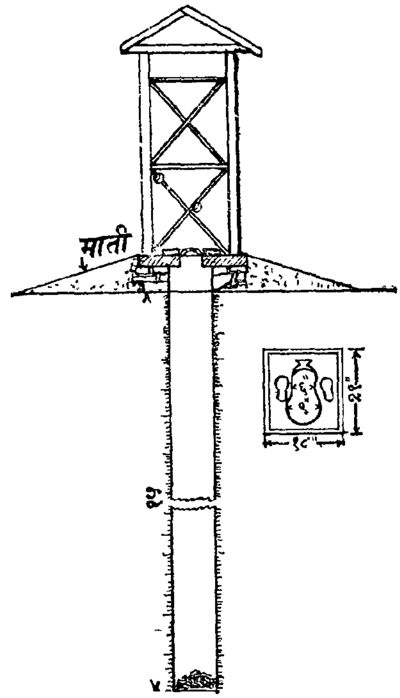


Figs. 51, 52 & 53.
Earth Auger and its parts.

can be joined to it by means of a cotter pin and thus it can be lengthened to any extent. First a small pit, about a foot deep is excavated by a pick-axe, and the auger held vertically in it and by inserting a wooden handle or a steel rod horizontally into the 'eye' at the top to apply leverage, it should be turned by two men going round and at the same time exerting some pressure on the instrument. The instrument should be lifted from time to time and the earth core collected by the auger removed and the auger introduced again and rotated. Incidentally, this earth core serves to show the samples of the strata below. When about 2½ ft. depth is reached, a 3 ft. lengthening rod should be connected and further work resumed. Four able-bodied men are required for a bore-hole. While one pair is working the other takes rest. In this way 8 to 10 ft. deep hole can be bored in one day.

When the bore is completed a seat either of wood, stone or brick masonry, or specially moulded concrete as shown in Fig. 55 with 7″ wide hole in the centre should be fixed for squatting and a small chamber with walls of bamboo matting or coarse cloth, and a roof formed on top as shown in Fig. 54.

Bore-hole latrine does not require earth



Figs. 54 & 55.
Section of a Bore-hole latrine and
Plan of the seat.

and ashes to be sprinkled on the fæces, nor is it necessary to exclude ablution water from it. In these respects it is more convenient than an earth closet.

The cost of the auger together with extension rods is about Rs. 80/-. It can be purchased on a co-operative basis. For a family of 7 or 8 souls, a bore 15 ft. deep provides a capacity sufficient for one year.

When filled upto two ft. below the top, it should be completely filled with earth and a heavy stone kept on its top. After 2 or 3 months, the bore-hole should be emptied by the same instrument. This time the drilling is very easy and two men can do it in one day. The cost of a bore-hole including a rent of one rupee for the auger amounts to Rs. 5/– and the valuable manure is easily worth Rs. 10.

The bore-hole is automatic in action and if not used by more than 10 persons at a time does not give out any foul odour. Even though the sub-soil water rises, say, upto ¾ths of its depth in the wet season, it gives satisfactory work. The only precaution required, if it is infested with a kind of blue flies called "Blue Bottle" flies, as sometimes happens when the bore-hole is filled upto 2 or 3 ft. below the surface, is to put about 2 lb. of fresh quick lime into the hole.

The bore-hole satisfies all the requirements of an ideal system except one, viz., it is likely to contaminate the supply from a well. It should not, therefore, be drilled within at least 30 ft. from a well and further, the same bore-hole, after it is once filled and emptied, should not be used again if it be near a well, but another should be drilled away from the first.

(6) *Trench latrine* :—This works on the principle of the earth–closet and in essential particulars does not differ from it. This is specially suited to Village Associations. For a village with a population of 500 a trench latrine of 10 seats is sufficient. The latrine should be arranged in two rows, one for men and the other for women. A trench not more than 4 ft. deep and 3 ft. wide at top and of length, at the rate 2′–9″ per seat should be excavated just outside the village away from the direction of the prevailing wind and either dry earth should be provided in kerosene oil empty tins open at top in each latrine for being spread by each user, or a special man should be appointed to do this.

An improvement over this can be made by building brick–lined trenches and placing either portable or folding latrines on their top. There should be two sets so that while one is being used, the other, which is already filled, is given some rest

Fig. 56

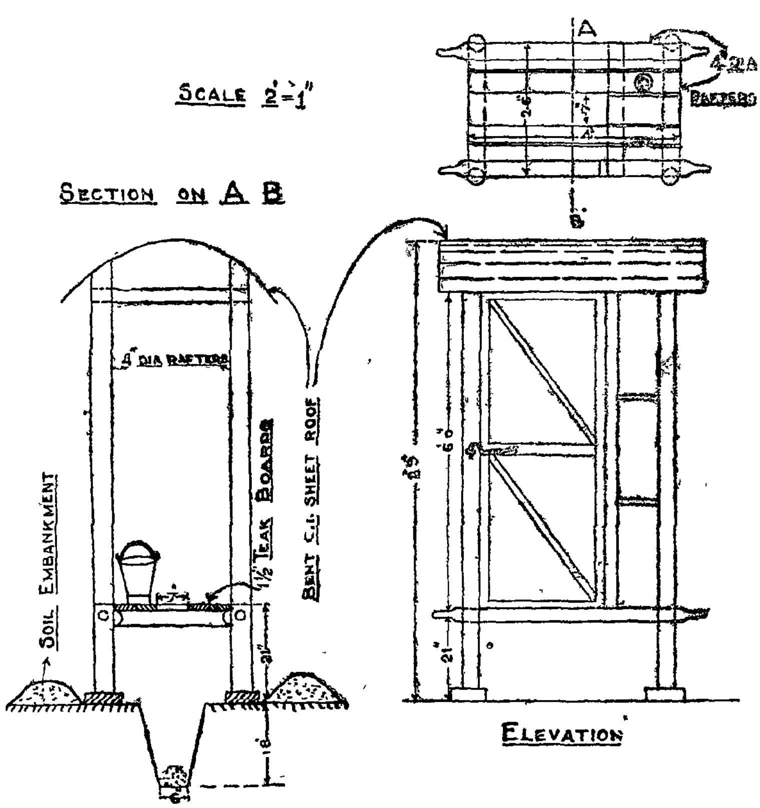


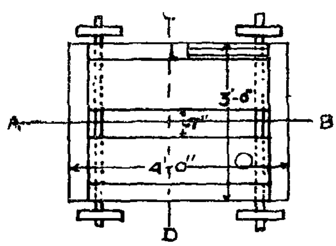
Fig. 57. Fig. 58.

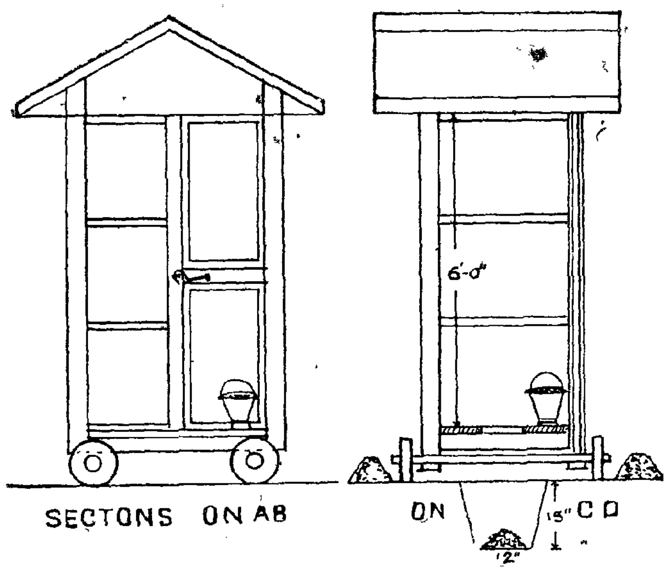
Plan and Section of a Stretcher type portable Trench Latrine.

for the contents being converted into harmless manure. Use of clean waste papers should be encouraged by supplying them instead of water for ablution which requires more earth and makes the problem difficult.

For domestic use a portable trench latrine is very convenient. Figs. 55 to 61 show a suggestion of a cheap design which the writer suggested a few years ago and has since been adopted by several Village Uplift Associations and a large number of them have since been giving perfect satisfaction. The squatting platform (Fig. 56) consists of a frame, made like that of an ambulance stretcher but only half as long, with projecting handles, of two 4 ft. and two $2\frac{1}{2}$ ft. long pieces of wood. Upon these are nailed $1\frac{1}{2}''$ boards so as to leave a lengthwise gap 7" wide and 2 ft. long in the centre. The platform should then be fixed between four vertical posts about 8′ long, at 2 ft. from the bottom. The frame thus formed should be enclosed either by bamboo matting or hessian cloth nailed on to it and on one side a door should be provided preferably with a self-closing spring. A suitable roof may be provided on the top.

Fig. 59





Figs. 60 & 61.
Plan and Section of a Truck type portable Trench Latrine on wheels.

This portable latrine should be placed centrally above a trench 6″ wide at bottom and sloping sides, and with the top 18 to 24 inches wide and of the same depth. The earth excavated from the trench should be heaped in long ridges on both sides to exclude surface flow a rain water.

A bucket, full of ashes and dry earth mixed together with an iron scoop in it, should be kept inside the latrine. The user of the latrine should spread the mixture with the scoop on the fæces so as to completely cover them.

When the portion below the trench is nearly filled upto the ground surface, the portable latrine should be lifted by means of the handles and placed a few inches forward or backward and some earth from the side ridges drawn to fill the portion previously used.

A trench 10′ long would last for over 8 months for a family of six souls.

Instead of a stretcher-like frame with posts resting on the ground, if four wooden wheels with axles, are fitted as shown in Fig. 59, it would be easy to push the portable cart latrine without much effort. A complete latrine, which costs Rs. 11/- is shown in the photograph in Fig. 62.

Precautions :—

(1) Choose a site, the wind from which will not blow towards the home to preclude the possibility of a nuisance, should anything go wrong at all.

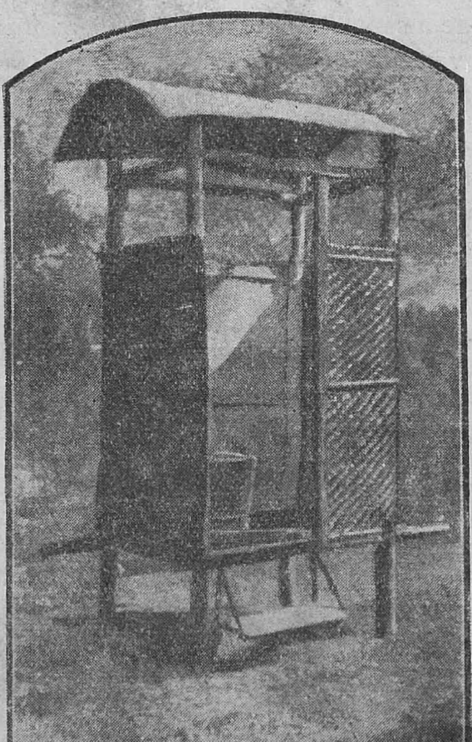


Fig. 62
Photographic view of a Stretcher type Trench costing Rs. 11/-

(2) The site should be as far away from a well as possible. As a further precaution, if a well is close by, the trench should not be more than a foot deep and more earth should be used, so that the sewage will not concentrate at one place and the chances of contamination of water would be reduced to a minimum.

(3) Proper precautions should be taken that rain-water will not enter the trench, at least will not form a pond on its top.

(4) Once a week, crude oil should be sprayed by means of a 'Flit' or 'Poysha' pump over the trench and floor of the latrine to prevent flies sitting. If trouble from Blue Bottle flies is experienced, quick lime should be spread on top of the trench.

Advantages :—

(1) If the above precautions are taken and earth is regularly spread, the system is most satisfactory.

(2) It affords the best privacy. Even the *purdah* ladies, children and sick people would find it convenient.

(3) It is very cheap both in the first instance and also in maintenance.

(4) The construction is very simple; materials required for its upkeep, *viz.*, dry earth, ashes and crude oil are all handy. One gallon of crude oil costs five annas and will last for a year. There is nothing likely to go wrong.

(5) The capacity of an earth-closet is limited; that of this trench is unlimited, since the bed and sides are all absorbent and so, less earth is required than in an earth-closet. There is no necessity of doing ablution in a separate sink.

(6) As the latrine is moved from place to place the concentration of sewage is prevented and thus there is very little chance of contamination. The excreta are converted into harmless humus within 8 days.

(7) It is not necessary to empty the trench as in the case of the earth-closet or the bore-hole and still the benefit of the valuable manure is fully derived, since, whatever crops or vegetables are grown on or near the trench their roots will obtain the nourishment.

(7) *Septic Tank*:—There are two wrong notions, which are opposed to each other, prevalent among people ,about the septic tank. There are some people who believe that a septic tank is a very complicated affair and that it requires a large quantity of water for purification and that if that is not available it is bound to be a failure. The other people, who are enthusiastic advocates, maintain that they have found a very cheap and easy method of disposing of sewage. Both are partially wrong and partially correct. Septic tank is a very simple natural process and there is nothing complicated in it. Domestic sewage is very simple and easy to treat as compared with sewage from a city which contains trade wastes, acids, grease and many other things difficult to digest, and can be easily purified by the installation of a septic tank. However, it costs a minimum of Rs. 60/- exclusive of the cost of the latrine and does require some water for proper working. However, if it is suitably designed it can function very satis factorily even with a supply of one gallon per head per day. The supply can be supplemented if the waste from the bathroom is led to the septic tank.

What is a septic tank ? It is a cistern either of masonry or concrete, built mostly underground, filled with water and provided with a cover. The sewage, including the solid excreta, is allowed to enter it at one end and after it undergoes certain chemical changes during the period it remains inside the tank, is allowed to escape from the opposite end.

The action of Septic Tank:—The word 'septic' is derived from *sepio* 'to rot' and the primary function of a septic tank is to allow the sewage to rot or putrefy. Now, when a substance rots—take for instance, a mango, either raw or ripe, it first becomes soft, and as time passes on becomes still softer and softer, and if it be opened at this stage, the liquid formed in it flows out. This liquid stuff also rots and is, in course of time, reduced in quantity by the formation of gases which escape, giving out bad odour, until finally a very small quantity of solid matter, mostly the rind and stone, remains out of the large and fairly heavy mango in the beginning. Exactly the same thing happens of the solid contents of sewage, inside a septic tank, which, on account of the very favourable artificial conditions, hastens the process.

This process of rotting or putrefying is caused by the growth of a sort of very minute germs, or bacteria, which very rapidly multiply and feed on the organic matter. These bacteria abhor air, the oxygen in which kills them. Hence, they are called "Anærobic". bacteria. Darkness, humidity and warmth which are all present in a septic tank, help their growth.

The septic tank does one more function besides that of *liquefaction* mentioned above. It is *precipitation* or *sedimentation*. The solid contents of sewage are composed of about 65% of mineral matter and 35% of organic matter. The mineral matter not only consists of sand, dust, ashes, etc., which find their way to the drain leading to a septic tank, but various salts such as chlorides, sulphates, carbonates, phosphates, etc., which are consumed with food and which after undergoing a number of chemical changes inside our body, pass out. The anærobic bacteria have no action on these and so they remain in the sewage intact. The heavier particles of mineral matter sink down or precipitate to the bottom of the septic tank and the lighter ones float and ultimately pass out of the tank. Out of the 35% of the solid organic matter, the heavier particles temporarily sink to the bottom and lighter ones accumulate at the top in the form of "scum." It is on these particles of organic matter that anærobes feed and breed. Thus this function of precipitation is also very important.

The bacteria live both in the scum of organic matter floating at top and also in the particles of heavier organic matter precipitated at the bottom. They act upon and disintegrate it. The chemical action involved is very complicated, but the result is that complex compounds such as proteins, carbohydrates, fats, etc. are chemically split up into simpler elements such as carbon, hydrogen, oxygen and nitrogen. The process of splitting up is called "hydrolysis" or "denitrification" in chemistry and liquefaction or putrefaction in common language. These simpler forms are either gases or liquid acids; the gases pass off through the ventilation and the liquids through the effluent, and thus, just as in the example of a mango discussed above, the bulk of the organic matter in the sewage, which otherwise would have formed large heaps, giving out offensive smell, is reduced by about 70 to 80% in volume in the septic tank through the agency of the anærobic bacteria.

The heavier particles of both the mineral as well as organic matter precipitate to the bottom. The mineral matter, on which the bacteria have no effect, accumulates and is known as the "sludge". There is organic matter also in the sludge but the bacteria soon split it up into liquid and gases and continually reduce it. The sludge goes on accumulating year after year and progressively reduces the useful capacity of the septic tank, until a time comes when the incoming sewage does not get sufficient time, on account of the reduced capacity, to be properly digested by the anærobic bacteria and passes out in a raw state giving out foul odour. The time has then arrived of once emptying the tank. In the case of a scientifically built domestic septic tank, this might occur once in 10 to 12 years and the inconvenience caused is just for one day. The sludge is a dark liquid and gives no more offensive smell than waste water from kitchen or bathroom flowing into open gutters. The tank can be emptied either by buckets or a small hand pump in a few hours. It may then be washed and filled with water and re-used from the next day.

It has been stated above that the quantity of organic matter present in the raw sewage is reduced by nearly 70 to 80% in the septic tank. This means that there is 20 to 30% of it still remaining in the effluent which passes out of the tank. Besides, it contains a vast number of anærobic bacteria floating on the surface and also a number of gases dissolved in it which are formed in the process of denitrification of the sewage. The latter are unstable. All these, if the effluent be left alone, would, not only give out foul odour but also prove positively harmful to health by contaminating food and water supply. The effluent must, therefore, be suitably treated and this treatment consists of bringing it into contact with fresh air, the oxygen in which combines with the unstable gases and converts them into harmless compounds like nitrates, carbonic acid gas, water, etc. This process of oxidation takes place through the agency of another set of bacteria, which live where there is free supply of air and are, therefore, called "*Aerobic*" bacteria.

There are a number of methods of utilizing the services of these bacteria to purify the effluent, but for treating domestic sewage the easiest and simplest ones are

(1) Surface Irrigation and
(2) Soak Pit.

Both these, particularly the soak pit, requires very little attention.

For surface irrigation the soil must be of a porous nature, in the innumerable pores or voids of which, myriads of ærobic bacteria live and do their work silently. Light, sandy soil is the best. The soil which is most suited for plant growth is good also for this purpose.

If a piece of ground with such a soil is available on the back side of the house the effluent may be led to it through a half-round stoneware pipe drain and allowed to spread in furrows of loose soil, and vegetables may be grown on the top of ridges. As far as possible, leafy vegetables which are eaten raw should not be grown. Two plots should be made side by side and the effluent diverted to each alternately. The soil at surface should be mulched or loosened from time to time. In America excellent lawns are also grown.

For the second method also, *viz.*, soak pit, the sub-soil which is capable of absorbing or draining water is the best. A pit of a size depending upon the porous nature of the sub-soil, should be excavated, say about 4 ft. deep and filled with stone-rubble having rough surface, over-burnt bricks, lumps of furnace or boiler-slag, etc., very loosely in a layer of about 1′-6″ to 2′; above it should be spread a layer of gravel or unscreened sand and the top 9″ to 1′ should be filled with loose porous soil. The effluent should be led so as to flow on the top of the gravel or sand. Care should be taken to cover the drain suitably so that the earth at the top does not choke the drain. The voids in the loose material contain air and so ærobic bacteria make their abode on the rough surface of stones or bricks, or in the voids of gravel and do their work efficiently. If, instead of a pit, a trench is excavated it should be about 18″ wide at bottom, 4′ deep with sloping sides and 2′ to 3′ wide at top. If it be *murum*, laterite, sand, or such other very porous sub-soil, even 10′ to 15′ length will suffice. At the other extremity a 50 ft. length may be required in sticky clay material.

Surface irrigation does require some attention for diverting the flow to alternate plots and also for loosening the soil. But the soak pit is an automatic and fool-proof arrangement.

The writer has built a large number of such domestic septic tanks with soak pits with excellent results without a single failure.

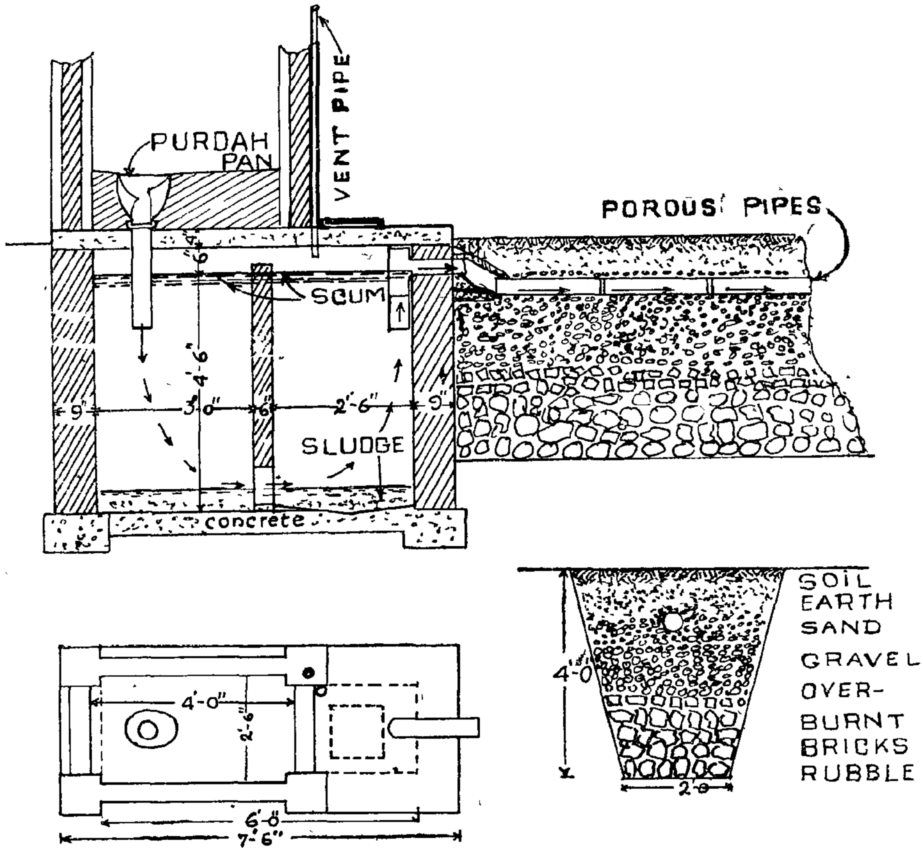
From the foregoing discussion of the principles of a septic tank it will be seen that a good design should incorporate the following features:—

(1) The contents should remain as quiet as possible, *i. e.*, there should be no disturbance or churning action caused as the latter will dislodge the anærobic bacteria both from the scum and the sludge. This can be accomplished by (a) making the tank deep (b) arranging the openings of the inlet and outlet pipe about mid-way and (c) providing one or more baffle walls or scum boards to damp waves caused by disturbance.

(2) The incoming sewage should remain as long as is conveniently possible, inside the septic tank. This could be arranged by (a) making the tank long and narrow, so as to increase the length of travel (b) providing a larger capacity consistent with economy.

(3) The whole arrangement should be air and water-tight. To attain this (a) the bed should be of at least 6″ of concrete and sides of 9″ brick-in-lime masonry and both should be plastered smooth with cement. (b) There should be an air-tight cover—either of brick-jack-arches or R. C. C. slabs with an opening for inspection closed with cast iron cover at the top. (c) A ventilating pipe of at least one inch diameter should be provided and carried to such a height as would not cause any nuisance.

Three separate designs of septic tanks, each suitable for a family, of members upto 12 in number, are given below :



Figs. 63, 64 & 65. Plan & Sections.
Design of a cheap Septic Tank.

*Design No. 1** : This is the most economical design, and as it requires a very little quantity of water to maintain it, it would be very suitable for areas where there is scarcity of water. In fact the water normally used for ablution, plus a bucketful poured every night for flushing and cleaning the floor and pan, should suffice. It is, however, advisable to take advantage of the water from a bathroom, after straining it through a suitable grating to exclude mineral matters such as sand, ashes, etc., and utilise it in the septic tank to dilute the sewage. For this the bath must be at a higher level than the septic tank.

The septic tank (See Figs. 63-65) occupies an area of 7′-6″ × 4′ including 9″ brick walls on all sides so that its inner capacity is 6′ × 2′-6″ × 5′ and has a reinforced concrete cover 4″ thick. The latrine is erected just on the top of a part of the septic tank. This has resulted in economy of foundations and one wall, drain and a

* With acknowledgment to Ushagram School Colony, Ushagram, Asansol, Bengal from whose design the main idea is taken.

trap below the pan. The pan is of a special kind called "Purdah Pan". It is white glazed on the inside and has two steep slopes on opposite sides as shown in Fig. 63 which cause the excreta to slide down with very small quantity of water for flushing. Fig. 66 shows an enlarged view of the

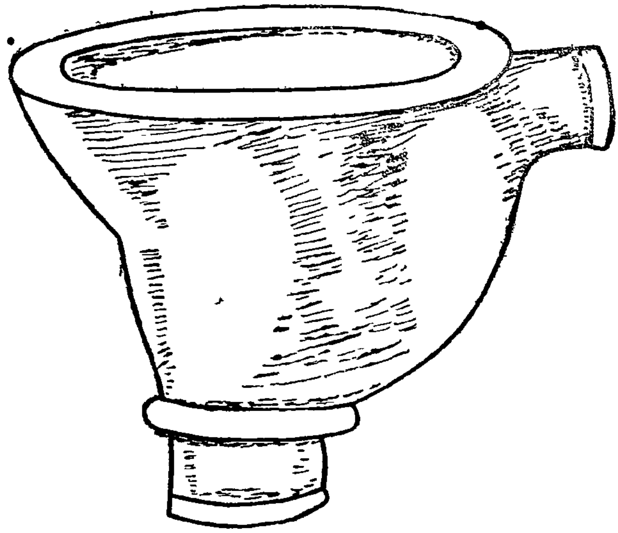


Fig. 66. Purdah Pan.

pan. A 4″ diameter stoneware pipe 2 ft. long is joined vertically below the pan and as it dips about 12″ in the water it forms a very good water seal. This dispenses with the necessity of a trap which

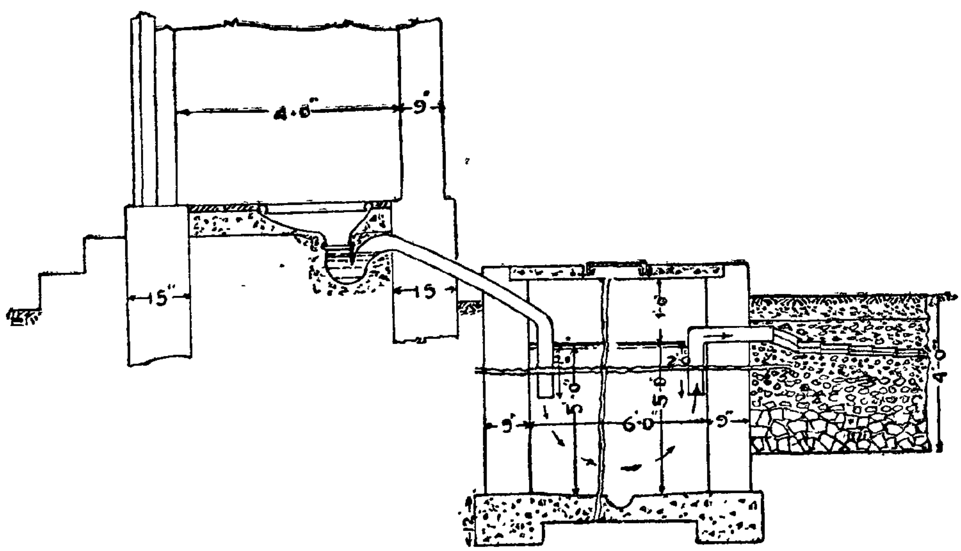


Fig. 67.

A Design for converting an existing lateine on Basket systrm into one suitable for a Septic tank.

is normally required. The outlet pipe consists of a 4″ diam. stoneware T-junction pipe with its longer leg dipping completely into the water. The horizontal portion of the T-pipe is placed at 4′-6″ above the bottom, so that there is a 6″ air space above water surface. A ventilating pipe is inserted to project about three inches below the under surface of the R. C. C. cover. A partition of 4′-6″ bricks in cement mortar is provided with a number of holes in a horizontal layer at 6″ and 2′-6″ above the bed. This wall which need not be plastered, is necessary to check the disturbance caused by the solid excreta dropping down vertically. A cast iron cover is provided on the top of of the second chamber for facilities of inspection and emptying the tank when filled with sludge.

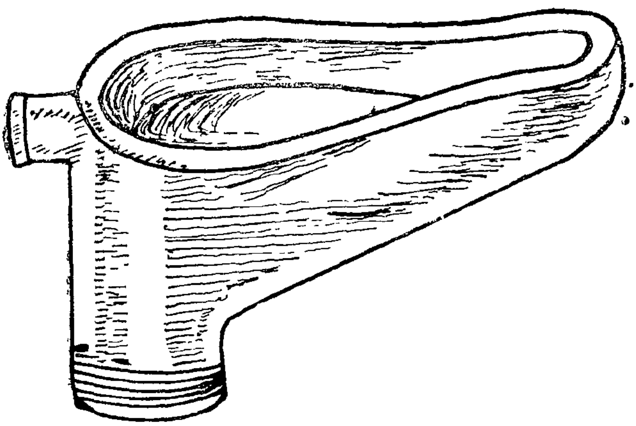


Fig. 68. Indian Pattern W. C. Pan.

The effluent is led through ordinary baked porous clay pipes with the smaller end simply inserted into the larger one

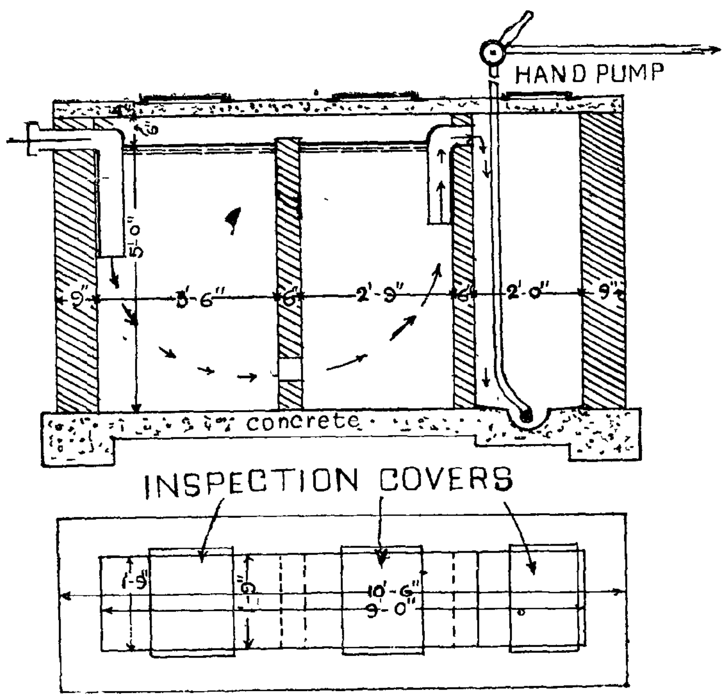
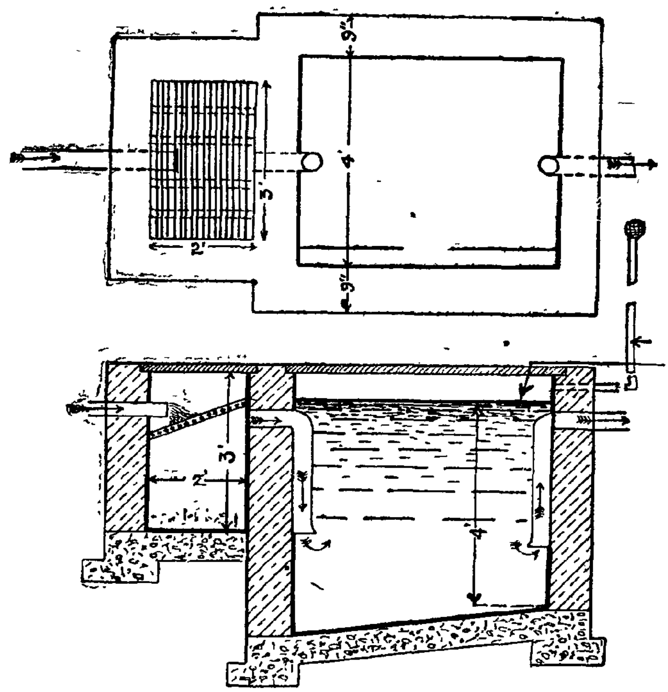


Fig. 69 & 70. Section & Plan of Design No. 3 of Septic Tank.

and these rest on the top of a trench 2′ wide at bottom 3½′ at top and 4′ deep (see Fig. 65) filled with materials shown in the section. The total cost of this installation including the walls and roof of the latrine is about Rs. 100/-.

Design No. 2 : This is a design suitable for an existing latrine which is built for the hand removal system, but is to be converted into one suitable for a septic tank. (See Fig. 67). The space below the seat formerly occupied by the basket is filled with rubble or brick-bats and a W. C. pan of the ordinary type with trap is fitted at top in concrete. Fig. 68 shows an enlarged view of the pan. A pipe connected to the trap is extended so as to dip about 2 ft. below the surface of water in the septic tank built close to the latrine. The septic tank is 6 ft. long, 1′-9″ wide and 5′ deep inside the walls. There is no necessity of a partition as in Design No. 1. The outlet pipe should start from 2 ft. below the surface of water and should have either a T-junction pipe or an elbow joined to it at the top. The soak pit or soak trench should be similar to that for Design No. 1. A pit or a depression about three inches deep should be made in the centre and a fall to the surface at bottom should be given towards it. An opening about 12″×18″ should be left in the cover at the top and closed by a cast iron manhole cover. It is desirable to provide a ventilating pipe, but septic tanks without it have caused no nuisance.

Design No. 3: This is rather expensive. The whole house is first provided with suitable drains with the drain from the bathroom at the top of the whole system, as laid down in the Chapter on House Drainage, so that all the waste water from kitchen, bathroom, and all other sinks is collected and led into the drain carrying sewage and finally admitted into the septic tank, which may be built on the back side of the bungalow away in a corner. The septic tank consists of two chambers, 3′ 6″ and 2′-9″ long respectively, 1′-9″ wide and 5′-6″ deep as shown in Fig. 69. The openings in the partition are left at two levels, *viz.*, at 6″ and 3′ above the bottom. There is a third chamber 2′ long in which the outlet pipe from the septic tank discharges the effluent. A sump is formed in the bottom of the latter in which the foot valve of a one inch hand pump rests. The delivery pipe of the pump is connected to a perforated pipe laid on the surface of ground where a hedge is grown. At a certain fixed hour of the day the pump is worked for a few minutes and the effluent is forc-



Figs. 71 & 72
The Grit Chamber is shown on the left hand side with the Grating in Plan & Section.

ed through the perforations, so that it falls in fine spray near the roots of the hedge and being exposed to air is partially oxidised. It is further absorbed by the soil and assimilated by the roots of the hedge.

All the three chambers are provided with cast iron inspection covers.

When the entire drainage from a house is collected together for being treated in a septic tank it is quite necessary to provide one more chamber called *grit chamber* 2′ long, 1′-9″ wide, and 3′ deep with a grating of iron rods as shown in Figs. 71 and 72 which is an old design of a septic tank. This chamber serves three purposes: first, that all the silt such as ashes, sand, earth, brick-dust, etc., used for burnishing utensils falls through the grating and collects at the bottom of the grit chamber. This would, otherwise, have entered the septic tank; the second, that shreds of paper, rags, loose coir, etc., used for burnishing utensils, which do not easily rot are arrested by the grating and excluded from the septic tank, and the third, that the solid excreta are also arrested by the grating and broken up by the jet of sewage which falls on their top and thus the work of the septic tank is simplified.

The following table gives the minimum inside sizes of septic tanks suitable for domestic purposes:-

Members of family including servants	Length	Width	Depth of Water	Cubic Contents	Allowance per head
10	5′-6″	1′-6″	4′-6″	36·2	3·62
15	6′-0″	1′-6″	5′-6″	49·5	3·33
20	6′-0″	1′-9″	5′-6″	57·25	2·88
30	7′-6″	1′-9″	6′-0″	78·00	2·60

Upkeep of Septic Tank Installation:—

(1) If there is scarcity of water and therefore Design No. 1 is adopted, the bucketful of water used once at night for flushing and cleaning should not be poured all at once, but the floor and pan should be first cleaned with a brush and a little water and the bucket poured slowly to wash away the dirt. This precaution is necessary for preventing a churning action inside the tank.

(2) In the case of Design No 1 it is possible that the solid excreta might accumulate at times in the vertical pipe and choke it, causing bad smell also. The obstruction should be removed by pushing it down with a rod.

(3) As far as possible strong disinfectants or acids should not be used for cleaning sanitary wares and flushing drains. These kill the germs. However, if white glazed surfaces are stained yellow, a rag dipped in weak Muriatic acid may be rubbed against it occasionally.

(4) It is the custom in some houses to allow young children to answer the call of nature on a piece of paper and to throw the paper with the contents into a W. C. pan. This is a very bad practice particularly when the sewage is treated in a septic tank. Paper and rags take a very long time to rot; besides, they are likely to choke drains.

(5) If a ventilating pipe is not fixed on the top of a septic tank, it is possible that inflammable gases like the marsh gas (CH_4) might accumulate in the empty space below the cover. Hence, when the manhole cover is opened, a lighted cigarette or a candle should not be brought near it, which might cause an explosion.

(6) If only the water from latrines be admitted, into the septic tank, and no extra quantity is used for flushing, it is possible that the losses by evaporation might exceed the incoming quantity of liquids. This might cause the level to sink causing foul odour; to remedy this one or two buckets of water may be poured into the latrine.

The same thing might happen if the latrine remains unused for some length of time. In such circumstances a bucketful of water should be poured once a week into it.

Disposal Of Urine

We now come to the question of the disposal of human urine. The usual practice of committing nuisance indiscriminately in the premises of the house is to be strongly condemned. It is forbidden by sanitary law even to abuse a street corner in this way, and one who misuses such places is liable to be prosecuted before a magistrate. Some people make use of sinks in the bathroom for the purpose. Though this is better from the point of view of privacy, it is also objectionable unless there is a flushing system with under-ground drains, or copious water is used by hand on every occasion for flushing, and further, the water is treated suitably. The best way is to build a small urinal in a corner of the compound outside the house with an earthenware half round channel at least 6 ft. long to carry the urine diluted by a flush of water into an underground soak-pit consisting of a trench about 2 ft. deep filled with rubble at bottom and graded gravel and sand above. The coarser material should be laid at bottom and finer at top.

Another way is to keep china or enamelled pot with a large mouth and a close cover with some saw-dust in it. Each time use is made, some ashes should be sprinkled on the saw-dust. At the end of the day the pot should be emptied in the manure pit, washed and kept for use again. Saw-dust holds its own volume of urine and prevents any possibility of its being spilt, and ashes check putrefaction and have also a deodorising effect.

Disposal of Horse and Cowdung

Then comes the question of the disposal of other excremental matter viz. that of domestic animals such as cows, horses etc. The question of collection and disposal of it in rural districts and in dairies, stables of horses kept for public use, etc. where the dung of a large number of animals has to be dealt with, requires special consideration, which is outside the scope of this book. It is only of an animal or two which are usually kept by middle class men, that is proposed to be discussed here.

The usual practice is, in municipal areas, to throw the waste fodder and litter into the municipal dust-bin and utilise the cowdung for preparing dung cakes to be burnt as fuel. In small towns and villages, where there are no municipalities, the former is thrown into a muck heap close to the house and the latter used for the same purpose viz. preparing cowdung cakes for fuel. The latter is a very bad practice both from the economical and sanitary point of view; because, its value as a manure is several times greater than that as a fuel. Again, considerable time is wasted on the preparation and drying of cowdung cakes, which can be better utilised for more important work. When agriculture is starving for want of manure and is yielding a very poor or no crop, it is a pity that we should burn cowdung which is an excellent manure. Everyone, no matter whether he is an agriculturist or not, must regard the burning of cowdung cakes for fuel as a national waste and a sin against agriculture.

The best way of treating dung of domestic animals is to store it in a pit in the compound as far away from the house as possible, situated in such a place that the wind will not blow from it towards the house. The ideal conditions are, that instead of an underground pit a masonry chamber lined with cement on the inside should be constructed above the ground with a roof over it. The door for throwing the dung into the chamber should be self-closing. There should be another door for removing the manure and a ventilating pipe carried high above the ridge for letting out foul gases; but the middle class people of India cannot afford this. Hence, we must be content with a pit excavated in a distant corner.

The danger in this arrangement consists of contamination of the water supply of wells if situated at hand by the sewage percolating through such pits. When such a manure pit is started, the unpolluted soil surrounding it is able to filter the liquid portion, which thus reaches the water-bearing stratum in a fairly pure condition, but as the strata forming the filtering media become polluted by soakage of the sewage, they lose their power of filtration and the liquid sewage passes unfiltered to a lower and lower level until it ultimately reaches the water-bearing stratum from which the wells derive their water supply.

To guard against this danger, the following precautions must be taken :—

(1) No liquids should be thrown into the pit. Every possible precaution should be taken to divert rain-water flowing towards the pit. In other words, the contents of the pit must be kept as dry as possible.

(2) The pits should not be very deep; but this is possible only if the space is ample.

(3) The pits should be lined on the sides and bottom with brick or stone masonry and plastered with cement if the substrata are very pervious.

(4) Ashes, dry earth, and similar deodorising agents should be occasionally spread in sufficient quantities in the pit.

(5) The pit should be emptied at short intervals and the manure utilised for agricultural purposes.

(6) Some sort of roof though not absolutely water-proof—sav even of thatch —should be erected to prevent rain from falling into the pit.

To keep off flies feeding and breeding on the heap in the pit, it should be covered with waste fodder from the shed or stable on which should be sprinkled crude oil from time to time.

Disposal of Slop Water

The next thing to be considered is the disposal of the waste water which goes under the general name of sullage water as distinguished from sewage. It consists of slop water from the kitchen, sink and waste water from the bathroom. The present practice, in municipal areas where there is no water-carriage system, to allow it into the open street gutters, is very pernicious. The channel leading thereto, from the sinks is often not well graded, nor constructed of water-proof material, in consequence of which, the water generally soaks into the ground close to the house, causing damp to rise and mosquitoes to breed. Even if it finds its way to street gutter, the latter are generally choked with debris, which obstructs it and the same result follows if only a little further away from the house.

In non-municipal areas no attempt is made to lead the water away from the house at all and, in consequence, it soaks into the foundation of the wall and the floors of the house, causing damp and stink to rise and mosquitoes to breed.

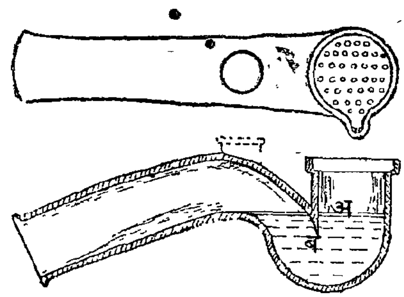
The proper way of disposing of the sullage water is given below.

At the outset it must be remembered that water from latrines, which contains pure sewage of a dangerous character, must in no event, be allowed to enter the drain meant for sullage water. The sewage requires quite a different treatment which has already been described in a previous chapter. The slop water from kitchen sinks and the waste water from the bathrooms, the composition of which is different, require slightly different treatments in the earlier course; because the slop water from the kitchen contains some oils and fats, cream rising at top in the *congee* (gruel) while boiling the rice, peels of onions and vegetables etc., which must be first separated. Otherwise, they are not only liable to choke the drains, but the fats in them render the problem of disposal of the water more difficult. The waste water from Indian bathrooms is, in most cases, likely to contain urine. Hence, it is safe to take some precautions to prevent foul gases from entering the house.

A sink in the kitchen need not be larger than 2 ft. by 2 ft. If it is to be used only as a kitchen sink, i. e. not for occasional bathing, even 18 in. by 18 in. will suffice. The flooring should be of a flagstone in one piece with a slope towards a corner and not towards any side. A piece of pipe at least 2 in. in diameter should be laid for leading the water to the outside. The pipe which should not be provided with an elbow, should drop the water on to the top of grass put into an iron bucket or half cut kerosene oil tin with perforations at the bottom. Thus all the solids including fats, will be arrested by the grass allowing only the slop water to trickle down. There should be another small chamber, lined with cement on the inside, just 6 in. deep below the perforated tin for collecting water and allowing it to run through a drain of half round 4 inch earthenware pipes starting from it. The drain should be open throughout and as long as the space will permit. The water should finally be led to the roots of vegetable or flower plants by turn.

In the absence of any flower or vegetable garden, the water should be collected in a cement lined masonry cistern, from which it should be daily taken out by hand-bucket and sprinkled over open ground for being purified by the action of the soil and the sun's rays.

the surface of the ground be limited in extent, some sort of vegetation—even grass may be grown on it. Roots of living vegetation very quickly absorb and assimilate the impurities and render them harmless. The same treatment is required for waste water from bathrooms except that a *nhani* trap illustrated in Figs. 73 and 74, should be fixed in a



Figs. 73 & 74

corner of the sink, towards which the floor should slope. This trap has a water seal which prevents foul gases from the drain rushing back into the bathroom.

The object of the long open drain for carrying slop water is, that by exposure to the air, sun-heat, cold and drying winds, the putrefaction is checked and the production of foul gases is rendered impossible.

Subsoil irrigation and pit filtration are other remedies for the purification of the slop water, but are not recommended in consideration of the habits of the Indian people. For, unless carried out on strict sanitary principles, they are very likely to prove a greater evil by becoming the breeding grounds of mosquito-larvæ.

Disposal of Dry Refuse

We next come to the question of removal and disposal of dry refuse such as sweepings from the house, rags, pieces of paper, peels of fruit, leavings of food, plantain or other leaves used as plates etc., etc.

For perfect success in this respect a radical change in our habits must be effected. Even the young children must be trained not to throw carelessly about pieces of paper, peels and stones of fruits, shells of ground-nuts, chewings of sugar-cane etc., not only inside the house but also outside. They should be trained systematically to put them into small receptacles provided with lids and placed in a corner of every important room. Even grown-up people are in the habit of throwing, through windows or door openings, that sort of litter in-tothe compound, and the idea scarcely enters their minds that they are doing even a greater harm than by throwing it inside the house. For, if the litter be scattered inside the rooms of the houses, it gets a chance of being swept once or twice a day, but if such waste things are thrown into the compound they decompose, vitiate the air surrounding the house with foul gases, which are inhaled by the inmates. Such rubbish attracts flies, which transfer disease germs from its surface to the articles of food. For this purpose, the premises of the house must be kept as scrupulously clean as the inner apartments. It would be a great advance upon the existing state of things if the plan were universally adopted, and every one in the household would do his, or her bit, not necessarily in cleaning, but in preventing dirt, by acquiring cleanly habits.

The receptacles in which dry refuse is collected, should be emptied at least once a day into dustbins in municipal areas, and where municipalities are not existing, they should be treated as described later on.

The public dustbin in India is an abominable nuisance. It is never used properly, for fear of the user, particularly of the Brahmin Community, being defiled, if one happens to touch it. The contents of the receptacles are thrown in from a distance, with the result that hardly half the *kutchera* falls into the bin while the remaining half falls outside it. The next person, especially if she be a female, is afraid of touching the rubbish scattered outside by the previous person for the same religious prejudices as above, and empties her basket from a still longer distance. Ultimately the middle of the street is reached by the heap of the refuse meant for the dustbin, leaving the latter practically empty. Such a scene affords a suitable place for the young children of the adjoining house to commit nuisance. If a dinner or a feast was given in any of the houses in the street, on account of the celebration of a marriage or of like festive occasions, the plantain or other leaves used as plates for the dinner are thrown near the dustbin with remnants of food sticking to them. Stray dogs, cows, pigs, cats, and fowls stir up and scatter the rubbish with a view to feeding on it; wind further helps and thus the entire street often presents an appearance of a muck-heap until the weary and indifferent municipal sweeper comes with a bullock cart to collect and remove it haphazardly with no special mission, to confer the boon of sanitation upon the locality.

In moffusil areas, where there are no municipal organisations, it is advisable to sort out the rubbish coming from the homesteads. The portion which is capable of rotting, should be put into the manure pit, and covered with ashes or dry earth, and that which is capable of drying easily, should be burnt in a pit and the ashes so obtained used for covering the manure pits or trench latrines. Those who can afford to spend more should build simple types of incinerators which burn such rubbish efficiently in a short time without producing volumes of smoke.

Prevention of Damp.

We next proceed to the second principle of domestic sanitation viz. that the house should not hold damp anywhere. Enough has already been said about the prevention of damp while building a new house. We shall now confine our remarks to the question of how to remedy the existing one. For this, the root cause of the damp must be first found and remedied. Very often it will be found to be due to defective drainage. If it be due to the choking up of a drain somewhere, the obstruction should be detected and removed. If it be due to very insufficient slope given to the drain, the latter will have to be regraded. It may perhaps be due to a leaky joint which should be traced and mended.

If the damp be due to a leaky roof, the water of which soakes into the wall, the leak should be located and set right. Sometimes it is very difficult to find the exact spot of the leak in a pitched roof if there is a ceiling below it ; because the water drops on the ceiling and finds its way somewhere else through it. If it be a flat terraced roof with concrete on the top, a search should be made for cracks, and they should be filled with a water-proofing compound. Sometimes there is no crack distinctly visible, but there are innumerable hair cracks spread over the surface through which water percolates. This can be remedied by giving one or two coats of a water-proofing paint such as hot bitumen.

The damp may, perhaps, be due to rain-water collecting near the house in a depression. This should be drained off, and arrangements should be made so that rain-water runs fast away from the house before it gets time for accumulation and soaking in. The cause of the damp oftentimes lies in the mud or earth used for the flooring of rooms, containing salts which absorb moisture from the surrounding soil or even from the air. To remedy this, at least one-foot layer of the earth at the surface should be removed and replaced by good earth which does not contain any moisture-absorbing salt, and the floor remade. Or, the old earth should be washed to leach out the salts from it (vide p. 30).

Often, the site slopes sharply, causing the plinth of the part of the house to be at lower level than the ground surface on the other side, so that damp necessarily rises in the floors and walls in that part. This can be remedied in either of the two following ways :—

If the difference in level is considerable and also damp serious, excavate a trench close to the outer wall on the side of the high ground, down to the foundations, wash the face of the stone masonry, rake out joints and point them with cement mortar, and in addition to this, fill the trench with clay of the nature of black cotton soil (*Regur*). If the clay has to be brought from a long distance, cover only 6 in. width of the trench touching the wall with it, and remaining width with the earth excavated from the trench, side by side, in 6 inches layers, as shown in Fig. 75, and ram well up to the ground surface. The black clay is impervious to water, and effectually blocks the passage of water towards the house. If the wall be built in burnt brick, the portion below ground, in which damp has appeared, must be plastered with cement before filling the trench with black clay.

Another remedy is to excavate the floors of rooms to a depth of about 15 in., remove the stuff, and fill in pebbles and gravel from river bed of sizes, varying from 4 in. to 1 inch to a depth of 9 in., and re-make the floor on top of this ; this would make it free from damp. If a layer of about 4 in. of concrete is laid at top, as an additional precaution, it ensures perfect protection from damp.

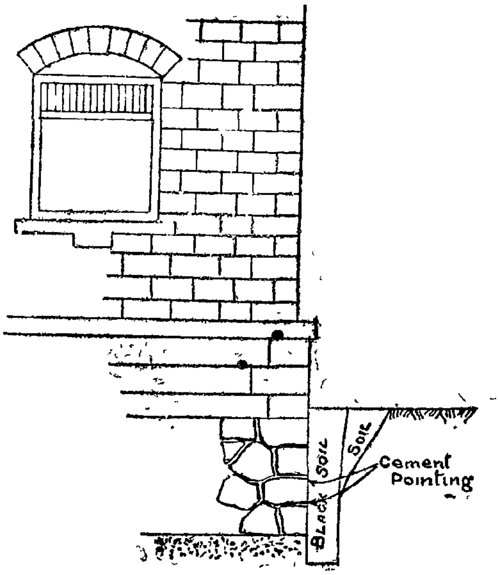


Fig. 75

Sometimes, there is a large source of water-supply at a higher level, and the ground below it is permeable, through which water percolates and rises in the form of damp. Very often, a whole village is affected in this way. The only remedy is to excavate a trench on the upper side of the house or village, deep enough to cut through the water bearing stratum such as *murum*, sand etc. A suitable bed-fall should be given to the trench, and it should be made to join a *nalla* or a river. The trench should be filled with boulders of stone, and the top portion made good by filling earth. The trench will cut off and carry to the river, the water which would otherwise have caused damp.

Prevention of Dust & Dirt

We now come to the third principle of domestic santitation viz. avoidance of dust. To what extent the atmosphere is charged with dust needs no demonstration. One can actually see the particles lit up by a beam of the sun entering a dark room in a house. How the cloud of dust rising behind an automobile running on roads suffocates, for a few seconds, the passing pedestrians, is a matter of every day experience. Part of this dust cloud unfailingly finds its way in dry weather through every chink, door and window opening in the house walls and settles in a thick layer on the horizontal surface of every article in the house. It mingles with the food we eat, and with the liquids we drink. One would be startled to find what a large quantity of dust one must be sucking into ones lungs during the process of breathing, when it is considered that an average man inhales 16·6 cu. ft. (or 33 average sized pitcherfuls) of air per hour.

The street dust has become so familiar to us that we have lost the sense of appreciating the incalculable evil in it. Street dust when examined under a microscope is seen to be composed of powdered mud, particles of human excreta, powdered droppings of horses and bullocks, particles of decaying bodies of dead animals, such as cats, dogs, rats, etc., particles of soot, fibres of cotton, hair, etc;etc.; all contributing their quota in forming the savoury compound called dust.

Every particle carries with it hundreds of microbes of disease. Fortunately, we are provided with a delicate apparatus which prevents even a single particle from finding direct access to the lungs proper. Otherwise, untold calamity would have been the result. The particles are driven back to the throat from where they are swallowed in the stomach. Still, they affect the throat and cause irrition; bronchitis is said to have its origin very often in dust. Sore eyes especially of children is another result.

Again, the dust produced by certain trades is poisonous. Thus, the dust produced while manufacturing lead and arsenic paints, grinding metals etc., is full of poison. The dust in the ginning factories is full of microscopic particles of fibres of cotton which are found to clog the passage of lungs.

If it is realised that dust and dirt mean disease, all that lies in our power must be done to minimise the harm due to the evil. There must be no recesses or ledges, no cornices of complicated designs, no *jalis*, carvings and other ornamental work, no furniture except that with plane surfaces, no fluffy carpets of wool nor cotton that hold dust and yield a cloud of dust when shaken etc. Even nitches and open shelves, in which things are likely to be stowed away and left undisturbed for months together, are objectionable. It is desirable even to go to the extent of making the bottoms of windows on the inside, sloping, instead of flat, to preclude the possibility of any articles being put there. For, not only do they obstruct ventilation, but are, in addition, sure to catch dust. There should be an ample provision of cupboards in walls, and all of them should be closed by close-fitting shutters, no matter of whatever cheap material.

Some people are very fond of crowding the rooms with unnecessary furniture or lumber. They make the task of the housewife or servants very difficult, and if the latter are slack in carefully dusting them every day, which they are sure to be in nine cases out of ten, the articles are bound to accumulate dust and dirt.

In short, strictest attention should be paid while designing and building a house that the labour of keeping it clean would be the minimum.

Ventilation

Air is a prime necessity of life which becomes extinct if the air supply is cut off even for a few minutes. In a closed room, the effect of animal respiration is doubly adverse on the air enclosed. For, when we inhale, we consume oxygen from it, and when we exhale again, we render it impure by filling it with carbonic acid gas and water vapour. Impure air causes head-ache and sickness, and ultimately devitalizes the person; because, with the deficient supply of oxygen, the process of purification of blood is checked. The man looks pale, loses vigour, activity and the power of resistance to the germs of disease, and thus falls an easy prey to it.

This is what exactly happens in India. The reason, why Malaria, Cholera, Plague, Small-Pox etc., take such a heavy toll of human life in India, will be found in the most devitalizing conditions caused by deficiency of adequate light and ventilation, and prevalence of general insanitary conditions in the dingy and stuffy rooms in the houses, especially of the lower classes. The high death rate particularly amongst infants and women, has its origin in the over-crowding of rooms and deficiency of fresh air and light in ill-built, congested houses. Men go out into the open air at least for some part of the day, but the females of the middle classes and especially those in *purdah*, have to confine themselves for 24 hours in the house. The young and innocent infants whose strength and power of resistance are naturally very low, are further devitalized by want of sufficient oxygen, and consequently succumb to diseases, even with a slight change in the atmospheric conditions.

In many towns, the depth of houses, front to back, is excessive, and the houses in most cases touch each other with the side walls in common between two. In rare cases, where a small passage or gully exists, it is generally not more than 2 ft. in width which is quite inadequate to supply fresh air and light to rooms; on the contrary, it is so full of filth and decomposing matter thrown from windows on either side that to exclude the foul gases, the windows have to be normally closed. As a result of this, the buildings are deficient in ventilation and light, the central rooms being often in absolute darkness requiring a candle to light them when required even by day. They are dependent for ventilation upon the passages within the house.

In villages and small towns, one or two small square holes, scarcely exceeding one or two square feet in area, are provided in the walls, even though the entire wall surface may be exposed to light. These holes are also closed by night for fear of draught and burglars, sometimes by permanently fixing gunny cloth, by nails against the closed shutters, and in the small space enclosed within the walls, all the members of the family sleep on the ground by night. It is a common practice to allow in the same room calves, goats, poultry, the latter covered under a loaded wicker basket. Were it not for the chinks in the ill-fitting doors, and the crevices in the crude form of the tiled roof, through which some air enters, they would certainly die of sheer suffocation. Nevertheless, the bad effects must be there especially on the health of infants.

The remedy consists in educating the public mind in domestic sanitation and personal hygiene by every means possible. Aid of legislation, if possible, may be taken in the beginning.

With this slight digression for which no apology is required, let us turn to the subject in hand. Ventilation connotes much more than mere providing of fresh air. The old theory that carbon-dioxide (CO_2) is a poisonous gas, and that if its proportion in the air exceeds a certain limit it proves fatal, has been exploded. It has been recently proved by experience and experiments that it is not a poisonous gas, and that breathing of air containing percentages of CO_2 which at one time would have been thought dangerous, has practically no injurious effects. On the other hand, it is now held in scientific circles that the more important factors, in rendering the air impure, are the organic matter continually given out with exhalation of breath and the humid emanations proceeding from the skin surface. One can verify these facts if one only brings to one's mind how foul the matter deposited on teeth is, which is nothing more than a part of what comes with human exhalations, and how offensive the stink of clothes, worn for a long time, is. Thus not only the respiratory organs but the whole body is continually breathing. There are also other factors viz. the heat produced by warm breath and the water vapour contained in the exhalation, which increase the temperature and humidity respectively of the air in a closed room ; because, upon them wholly depends the sensation of stuffiness or otherwise which one usually experiences, in a crowded place. When we enter, for instance, an occupied railway compartment with windows closed during night, the warmth experienced is due to the rise in temperature of the air ; the bad odour is due to the organic matter in the form of microscopically small particles emanating from breath and skin surface of the occupants ; the perspiration caused, is due to the excess of water vapour present in the air, and the general uneasiness experienced is due to the deficiency of oxygen and all other above mentioned causes combined together.

Movement of air or *lack of movement of air* is conducive to a feeling of well being or discomfort, leading in the latter case to serious results. Lack of movement of air leads to increase in temperature, increase in humidity, which lead to hindrance of evaporation from the body surface, heat accumulation and finally heat stroke.

Despite the fact that the purpose of ventilation is the promotion of a healthy and comfortable atmosphere in our rooms, the latter is often deceptive. The ventilation of a room may produce an agreeable and pleasant sensation to an occupant, and still the condition of the air in it may be far from the standard sanitary requirements. The sensation of the pleasantnêss or oppressiveness depends upon the relative temperature and humidity of the air and also on the physical conditions of the occupant. A man who has just taken a brisk exercise may find the air in a room with good ventilation to be quite stuffy; which a man in health at rest may find quite agreeable, but which to a third anæmic person, cause a sensation of draught in the same room.

The composition of average air is as follows :—

Component	Parts per 10,000	
	Fresh air	Respired air
Oxygen ...	2,026	1,620
Nitrogen ...	7,800	7,500
Carbon-dioxide ...	4	400
Water vapour (variable) ...	150	500
Dust and other impurities ...	(variable)	(variable)

Though according to the theory of ventilation the presence of a small excess of carbon-dioxide is not viewed with apprehension so far as its injurious effect on health is concerned, still, its proportion is taken as a guide for the computation of the standard requirements. With its rise in a certain system of ventilation, the proportions of the injurious bacteria in the form of the organic matter and water vapour also increase, and the oxygen contents proportionally decrease. Hence, certain limiting proportions of carbon-dioxide are taken as a basis for designing standard requirements of ventilation which are, from 5 per 10,000 parts in hospitals, 6 or 7 in residential buildings, to as much as 10, in theatres and public halls, which are crowded for a short length of time.

On the basis of this and on the assumption that an average man gives out 0·6 of a cu. ft. of carbon-dioxide per hour, it is easy to calculate that 3,000 cu. ft. of fresh air must be supplied per man per hour. If the room he occupies be 10 ft. by 10 ft. by 10 ft. the air in it must be renewed three times an hour. This is, however, not strictly correct. It is not practicable to change the air completely.

It was held a few years ago that the outlet openings must be larger to cope with the larger volume of air, expanded by heat. But according to the modern sanitary opinion, if this is done, reverse currents are produced; therefore, it is urged to provide larger inlets.

A considerable fetish, is made by sanitary authorities in the Western countries, of draughts. So far as their cold climates are concerned, it is all right, because there is a considerable difference between the temperatures of air inside and outside their houses. The outside is very cold and the inside, heated by fire-places, is hot. Hence, the effects of draughts are immediately felt. Here, in India, however, the difference is much less. Hence, draughts need not be so much feared while contemplating the provision of the means of ventilation.

From the foregoing discussion, it will be seen that ventilation consists in setting up movement in air so as to induce circulation between the fresh air outside and the used up air inside, with the ultimate object of either diluting or removing the impurities and at the same time producing air conditions which ensure comfort to the body.

This is effected in one of the following three ways:—

(1) By taking advantage of the law of nature viz., a motion is started by particles made light by heat, rising to the top to be

replaced by heavier ones sinking to the bottom.

(2) By atmospheric winds or air in motion.

(3) By mechanical means of artificial ventilation, such as fans or pumps which either extract air from a room or force it into it under pressure.

In residential buildings, the first two methods are employed. In the tropical climates, like that of India, where, except perhaps, on a few hill-stations and during winter at some places on the plains, no fires are lighted inside the rooms, the difference in temperature of air inside and outside of rooms is, therefore, not much. On the other hand, there is almost always some wind blowing. Hence, the action of wind is the main factor to be depended upon in the regulation of ventilation. This is often rather an uncertain factor. For, whereas during a high wind especially in cold weather, a draught is likely to be produced, on still days, when the movement of air is negligible, a sensation of stuffiness is sure to be experienced. Hence, the scheme of ventilation must be so designed that even on days of dull atmosphere, when the motion in air is practically nil, sufficient air-exchange between outside and inside of rooms should take place through the window space provided, and when, on the other hand, there is a high wind, the draught can be prevented by partially closing the windows, as necessary.

While providing window openings for ventilation in residential buildings, the habits of the people who are to occupy them must be taken into account. Many people, especially the illiterate ones of the lower classes, are in the habit of closing all the windows or even further sealing them by tacking gunny cloth on the closed shutters. For such houses the ventilation must be fool-proof i. e. additional openings of such sizes and at such places should be placed that even though the windows are closed, the former will normally charge the room with sufficient fresh air. Sky ventilators in the roof, clerestory windows, bulls' eyes, floor ventilators are some of the suggestions for this. If the last-named openings are to be provided, they should be done judiciously so as to avoid a direct draught on the body of the people sleeping on the floor. The latter is the practice of people in Southern India and part of the Deccan. Where, however, *charpoys* are used, no special discrimination especially in the position of the floor ventilators is required. Still, such openings, intended to be kept permanently open, should be introduced at such parts of the room, where, they would not cause a sensible draught.

While providing ventilation, the following points should be noted :—

(1) The exhaled hot air is light, and therefore, rises to the top i. e. collects near the ceiling. If it is allowed to accumulate there for a long time, it cools again and sinks down towards the floor to be breathed again into the lungs. Hence, it is absolutely necessary to provide exit openings near the ceiling level to remove the exhaled air, as rapidly as possible, while it is still hot.

(2) The scheme of ventilating a house should be so designed that the fresh air entering through the windows or other openings on the side of the house in the direction of the prevailing wind, should pass through the exits provided in the outer wall on the opposite side. This means that the rooms shall have all its ventilators in direct communication with the outside air space. Verandahs are considered as outside air. This is called "Through Ventilation." For the successful operation of it, windows must be provided also in the internal walls abuting against verandah specially meant for ventilation, though they might admit

borrowed light also. For the sake of privacy of the rooms, it may be desirable to place them high up near the ceiling.

(3) Always remember that while over-ventilation is harmless, under-ventilation is a positive evil. For the climatic conditions normally prevailing in India, rules of ventilation framed to suit the conditions of the Western countries are of no use. *We want more free ventilation. Draughts need not be feared so much by a person in health in this country.*

(4) The area of inlet openings should be 20 to 30 per cent. in excess of the area of the outlets.

(5) Although carbon-dioxide diffuses into the fresh air admitted, more or less freely, the organic emanations from the breath and skin surface, do not. They hang about in corners and near the ceiling, where obstructions to a free flow of air are met with.

(6) If provision of ventilation is based on the capacity or the cubic contents of a room, the tables, sofas, movable wardrobes etc. which reduce the capacity must be taken into account.

(7) It is a fallacy that because a room is high, it must provide efficient ventilation. For the latter, the openings or orifices must be dotted, here and there, over the entire exposed wall surface. Otherwise, on a still day, the respired air diffuses in the large volume of the air in the high room, which causes it to cool down, and thus tends to check the circulation between the inner and outer air. However, a lofty room is to be preferred to a low one in hot countries, first, partly for the reason that it contains more volume of air; second, to prevent radiation, or rather minimise radiation of heat from the ceiling, also keeping the room cool. The statement, often found in English books on ventilation, that a height of over 14 ft. is of no value for ventilation, is also partly explained by the fact that ventilation and heating in such cold countries are inseparable, and there is always much difficulty in heating adequately rooms higher than 14 ft., with consequent trouble with ventilation.

Light

We now come to the fifth principle of Domestic Sanitation viz. providing ample light in the entire house and dispelling darkness even from every nook and corner. The importance of light cannot be stressed too much. It is ingrained in every healthy mortal to love light. An infant, before the age of reason, instinctively loves light and abhors darkness. Even those having sedentary habits and unfitted for an outdoor existence, prefer well-lighted and cheerful surroundings to darkness and gloom. Light, life and laughter synchronise, so do darkness, depression and death. Darkness is the symbol of sin. Darkness is sought by criminals for the perpetration of sinful acts. Light is indicative of piety and purity.

Even plants become pale, droop and ultimately die if they are deprived of light——instinctively they turn to light. Similar is the case of human beings. Those who are doomed to spend a considerable time in darkness, grow pale and anæmic, lose vitality and the power of resistance to disease.

The sun's rays are the best disinfectant. Even the diffused light of the sun has this power though to a less degree. It has been proved that direct sunlight will kill even virulent bacilli of typhoid within ½ to 2 hours, and diffused light, within about five hours.*

The visible light rays of the sun are, as is well known, composed of seven colours. At one end of these is the red and at the other, the violet. In addition to these, there are invisible rays—those at one end

* *Hygiene and Public Health* by B. N. GHOSH.

are called infra-red, and those at the other ultra-violet. The infra-red include the invisible dark rays of heat. The ultra-violet rays are very powerful in destroying bacteria and possess therapeutic value to a remarkable degree. The cells of the skin and corpuscles of the blood, circulating in the veins and arteries close to the skin surface, absorb these rays, and as a result, the blood is purified and its circulation accelerated, which causes a feeling of vigour and health to be experienced.

Dr. Rollier of Switzerland has, of late years, proved beyond a shadow of doubt, the wonderful healing power possessed by the sun's rays, by treating successfully hundreds of cases of tubercular affection, which were declared to be beyond hope of cure by the usual means. He has built special sun pavillions called " Solaria " on the top of a hill, at Leysin, Switzerland, with special means of regulating the intensity and dosage of the sun's rays.

These rays are absorbed by the water vapour, smoke, dust, etc. present in the atmosphere. Hence, it becomes often difficult to make full use of the sunlight as a therapeutic agent, especially in crowded cities. Again, many countries in Europe, as for example, England, are not blessed with sunshine for any considerable period of the year. Hence, ultra-violet rays are produced artificially by passing electric current through mercury vapour or by some such suitable devices; but the expense is pretty high. In India, however, we are blessed by Providence with so much free sunlight almost all the year round. Hence, there should be no necessity, especially for those who cannot afford it, of resorting to the artificial means of producing ultra-violet rays.

The ancient custom of annointing the body with cocoanut or mustard oil and basking in the sunshine has almost sunk nto oblivion with the advance of modern civilization. But it possesses a good many virtues to commend itself for a revival, especially for the benefit of the young children, particularly suffering from rickets, which are wonderfully cured by exposure to sun's rays or ultra-violet rays. The annointment with oil, serves a treble purpose. Firstly, the vigorous massage which is usually done with the application of oil, tends to accelerate the circulation of blood; secondly, the oily surface prevents sunburns by reflecting away the heat rays, and thirdly, it absorbs the ultra-violet rays.

"The sun's magic rays heal all that they come in contact with. They repair broken-down bone tissue; they dry up running sores and ulcers and cause new skin to grow over; they cause swellings to subside; they alleviate pain; they bring down temperature, diminish the drenching sweats and decrease cough. The sun is the greatest of all natural healing agents in consumption."*

The foregoing facts, specially mentioned rather in detail, will convince the reader of the vital importance of natural light on the health of human beings; therefore, a house should be so built that every room should receive the sun's rays in some part of it, some time or other during the course of the day; and there should be no corner in the entire house which is not sufficiently lighted. Darkness is synonymous with dirt. If a room is generally dark, it is sure to be dirty. Even in a room lighted moderately well, the darkness in the corners and recesses is sure to conceal dirt and dust. A housemaid's broom is bound to fail, in its circular sweep in corners, to penetrate into the depth of the recesses to clear the dust and dirt away. All sorts of visible vermin and microscopic bacteria breed there

* Dr. EDWARD PARISKY, M.D., Brooklyn, New York, by acknowledgment to '*Health*' Sept. 1934.

with unchecked activities as the darkness envelopes them. If, on the other hand, there is light in such corners and recesses, it makes the dirt visible and none but the most careless person will consciously allow it to accumulate there.

Domestic Water Supply

Next in order of importance to air, water is another prime necessity of life. Life cannot be sustained even for a few minutes without air; without water, it can be sustained for a longer period, still death is sure to ensue.

Water, from whatever source it may come e. g. a river, a lake, a spring or a well, is all originally derived from the rain. The water as it comes from rain is distilled by nature and is very pure, but as it falls on the ground and flows along, or under it, it collects impurities. The latter are either suspended or dissolved. The suspended impurities can be removed by treatment with alum or filtration.

The dissolved impurities in water are again of two kinds:—

(1) Mineral

(2) Organic.

The latter, again, are subdivided into vegetable and animal.

The mineral impurities render the water hard. This is due to certain salts of Sodium, Calcium, and Magnesium dissolved in it. The hardness due to chalk or Calcium Carbonate can be removed either by boiling or by mixing lime water in it. But hardness due to other salts cannot be so easily removed. The disadvantages of hardness are that *dhals* (cereals) and vegetables cooked in it do not become tender; hard water is, again, bad for washing purposes, because, a lot of soap is wasted first for removing hardness before it cleans dirt. It is believed that stone and gravel in the bladder are produced by it. Hard water does not dissolve soap freely without curdling; that is its test.

Palatibility, or the sparkle of water, is not due to the presence or absence of any salts but to the oxygen and carbonic acid gas dissolved in it. All waters which are pleasant and sparkling to taste are not necessarily pure. The waters which are brackish contain mostly sodium chloride or common salt and to a certain extent other salts. Common salt does not, in itself, make the water hard, but it is generally associated with other salts which render it so. Hence, brackish waters should not be used, especially, by the dyspeptics and generally by those suffering from any intestinal disorders.

So far about the mineral impurities some of which though harmful to health are not, on the whole, dangerous. But the effects of organic impurities are very serious, and often lead to the outbreak of diseases in the community, which are called epidemics. By far the most common source of organic impurities is sewage either by soakage from leaking drains, manure-pits, muck-heaps, latrines etc., getting into the source of supply, whether it be a well, or a stream. Often, bodies of dead rats, mice, cats, dogs, etc., float and decompose in water. All these make it very dangerous for drinking purposes.

When a disease in an epidemic form breaks out, it must be due to some poison either in food or water. Poison in food may affect one isolated family sharing it commonly, but as it spreads to different families, it is a sure indication of the common water supply of the community having been contaminated. Such spreading diseases are Diarrhoea, Cholera, Typhoid, Dysentery, diseases of certain parasites, e. g. guinea worm etc. The latter enters the body with drinking water, remains inside it for a year, after which, it breeds and makes itself felt in a swollen foot or leg.

Sources of supply and how they are contaminated.

Household supplies of water are derived in India either from a river or a small stream, a tank, wells or springs. In very rare cases it is derived directly from rain and stored for household use in any large quantities.

Water from rivers and streams, should always be looked upon with suspicion. In many instances, the sewage from large towns is let into them. Hence, smaller the volume of water in the river, the greater the quantity of sewage contamination, and the nearer the place from where the water is drawn for use to the source of contamination, the more dangerous the water becomes for domestic purposes. Even small streams and *nallas* or surface water from fields, though they do not receive sewage directly, are still likely to be contaminated by the excreta of animals including human beings, dead bodies of fish, decomposing vegetation etc. which are likely to contaminate it.

However, as the rivers and *nallas* flow, the contamination decreases ; because a process of self-purification goes on in the running water.

This might be due to the fish and other living organisms in water eating out the organic matter, or to the process of "oxidation" or the destruction by oxygen in the air with which the water comes in contact in the course of its flow. But it is a fact that some miles below the place where sewage is let into the river, the quantity of water improves. This, however, cannot be entirely relied upon as we do not know what other sources of contamination in the intermediate length there might be.

Tanks and reservoirs collect only rain-water flowing along the ground surface, and therefore, so long as we are not sure that there is no source of contamination from human habitations or cattle in the entire catchment area, from which the rain-water flows into them, purity of supply cannot be guaranteed. On the contrary, the smaller the tank the greater the chances of contamination.

Wells:—Wells are classified into two divisions :—

(1) Shallow Wells,

(2) Deep Wells.

A well is called deep, not necessarily because it is deep, but because one or more impermeable layers, such as black earth or clay, intervene and prevent the water percolating through the ground surface from reaching it. A shallow well is one which derives its supply from such percolation. In India, with the exception of some of the larger towns, the supply of water for domestic purposes is derived from wells. In some towns and villages, there is a well in every house, some inside the house, and some a little away from it, mostly in the backyard. When these wells are first excavated the supply is pure, but gradually sewage and the sullage water, which from the surrounding houses are allowed to soak into the ground, filter through the soil and find their way to the well. It is at this time pure, but as the underground strata are gradually polluted and saturated with the organic impurities in the sewage, the filtering media lose their power of filtration and the liquid sewage passes unfiltered to the lower and lower level, and ultimately reaches the water-bearing stratum from which the well draws its supply, in the form of pure sewage,making the whole supply dangerous for human consumption. If the well is deep in the above sense, the intervening impermeable layer or layers effectively bar the sewage from entering the water-bearing strata and contaminating the supply.

Even if a well is deep with an assuredly pure water supply, the latter is likely to be contaminated by one or more of the following causes:—

(1) Very often, there are trees overhanging or in close proximity of the well, and the leaves, flowers and fruit from it either drop directly or are blown by wind into it, which decompose and contaminate the supply.

(2) Very often, washing or bathing is done quite close to the well and the dirty water splashes and flows into it.

(3) There is no well-built properly graded gutter for the waste water to flow away from the well. This causes the water to stagnate in a pond quite close to the well and it percolates into it.

(4) Very often, steps are provided to reach the water in the well. People using them indiscriminately pollute the water by washing hands and feet and even by spitting or gargling mouth in it. Burnishing copper or brass pots with ashes, earth and often road scrapings, and washing them in the well, is also a common practice.

(5) The village urchins often bathe and swim in the wells.

Thus, wells in the midst of human habitation should be looked upon with suspicion unless they are deep, in the technical sense of the word, and vigilantly guarded against the above common sources of impurities.

Wells which are open to the sun and air are perferable, no doubt; but when it is considered that open wells are likely to be polluted in the way mentioned above. it is always advisable to close the wells and leave an aperture just sufficient for drawing water or close them altogether, and instal hand pumps for drawing water. This will incidentally prevent mosquito-breeding. Means should, however, be provided for opening the cover for occasional cleaning and repairs to the well and pump.

Deep bore holes drilled into the ground to tap underground water have always a supply of pure water.

A spring is an outflow of supply of water situated somewhere at a higher level, from which it flows or percolates by gravity to a lower level, through a subterranean path. During its passage it is filtered and hence it is invariably pure. Unlike water from deep bore-holes, it gets a chance of æration and is also palatable.

Purification of Water

The dangers attendent on the indiscriminate use of water from rivers, *nallas* and wells situated in the midst of human habitation, have been dealt with in the previous chapter. Prevention is always better than cure. Hence, it is safe to use water from doubtful sources for cooking and drinking purposes only after it is purified. We are discussing here only the methods on a small scale suitable for domestic supply.

The best and surest method is distillation. But it is expensive and also impracticable. It is possible, however, to collect rain-water in the monsoon season sufficient at a time for two or three days' requirement to meet the breaks in the rain-fall. It may be either collected directly from house roofs as is done at Broach, or similar large surfaces, or from fairly pure ground, such as sand or unmanured field or rock, as is done at Aden, away from human habitation. This should be done after the roof or the ground has been thoroughly washed away. For, the first flow from rain, collected from roof surfaces, besides containing impurities, such as particles of dust, soot, droppings of birds, leaves of trees, pollen of flowers etc., also holds acids and ammonia in the atmosphere dissolved in it. To remove the former the water collected must be well strained through several folds of cloth or better through a sand filter. The latter impurities are harmless.

Rain-water is very soft and is specially useful for washing purposes. A very small quantity of soap is required. In some countries, notably in Holland, concrete or masonry tanks of several months consuming capacity are constructed and rain-water is stored in them.

The second best method which is more practicable for every household, is to boil the water required for drinking purposes. For perfect purification, the boiling water must actually boil for at least 5 minutes. Though the living organisms in water stand much higher temperature than that of the boiling water, they are killed by the moist heat or saturated steam at the boiling temperature. Hence, boiling is an effective remedy. We have already seen, mere boiling is not effective in removing hardness of water, except that due to the presence of chalk. The third remedy is to filter the water. Filters, if working efficiently, remove both the suspended and the dissolved impurities. In respect of the former the action is purely mechanical, the voids in sand or the pores in other material, such as coal, etc., offer resistance to the suspended matter which is arrested by them, and only the pure water is allowed to pass. In respect of the organic matter the action is chemical. The upper layer of the filtering material holds a sort of bacteria which eat out all the organic matter in the water, but in the course of a few days the layer becomes clogged and the filter does not work. The sand or whatever other material it is, must then be washed for re-working of the filter. When the pores in the upper layer are clogged, not only does the filter not work well, but it forms a positive danger; because the growth of fungus occurs on it which makes the water worse than before. Hence, absence of a filter is better than a dirty filter.

The materials commonly used for filtration are sand, gravel, iron filings, charcoal, animal coal, porous stone, ground slag etc. Sand is by far very common. For efficient working three grades should be used. The lowest should be of shingle of ½ inch size, the middle layer of gravel of ¼ inch size, and the upper layer of very fine sand. All these should be carefully washed separately and then used. Ordinarily, filters should be washed once a week. After washing, the material should be exposed to sun for a day and fresh material used instead. The old material should be screened, graded, and used again next week.

Not only the sand or the other filtering material, but the containers used for holding the filtering material and the filtered water, should also be scrupulously cleaned, the former, every week along with filters and the latter every day.

Purification by Chemical and other Agents.

Alum :—This has no germicidal action ; it combines with the alkaline carbonates present in water to form aluminium hydrate, which being insoluble in water precipitates to the bottom.

A sort of fruit called the "clearing nut" (*Nirmali*) is frequently used in India for the same purpose. The fruit is rubbed against the inner sides of the vessel holding muddy water for a minute and in a few minutes the suspended impurities settle down at the bottom leaving clear water above.

Potassium Permanganate:—This does not directly kill bacteria, but destroys the organic matter on which the bacteria live. Still, this is a very sure, cheap, and simple remedy of disinfecting well-water during periods of epidemics. When dissolved in water it produces nascent oxygen which oxidises organic matter.

There are two methods of using it. The first is to calculate the quantity of water in the well or the cistern to be disinfected, and put potassium permanganate into it in the proportion of five parts of P. P. per million parts of water. The other depends on the colour test only. A sufficient quantity is said to have been added, when after half an hour a red colour is still present. If not, add more. In all cases, enough should be added to produce a faint pink colour lasting 24 hours.

The mode of mixing P. P. is as follows: Put the crystals of P. P. in a bucket and fill it nearly half with the water to be treated. Stir it up and pour the red solution thus produced into the well, leaving the portion of the P. P. that is not yet dissolved in the bucket at the bottom. Lower the bucket into the well, fill it with water, draw it up, stir it, and pour back the red solution as before. Repeat the process till all the P. P. has been dissolved. One to six ounces will be generally found to be sufficient for average wells. If the P. P. is added at night the water will be fit for drinking on the following morning. If, at this time, the water has a red colour, it will have a slightly unpleasant taste, but it is perfectly harmless. The unpleasant taste will go away automatically in course of time as water is drawn from the well.

Bleaching Powder:—This is a whitish grey powder with a characteristic smell. It consists of slaked lime saturated with chlorine, and is a powerful sterilising agent. The powders available in the market are of varying strengths in respect of the chlorine contained. Again, the dose of the powder required to sterilise a certain quantity of water depends on the amount of the organic matter present. Roughly, one part of bleaching powder of 25 per cent chlorine strength is required to sterilise one million parts of average water. According to this, one ounce of bleaching powder (25 per cent strength) would be required to sterilise water five feet deep in a well of 8 ft. diameter.

Make a solution of one ounce of powder dissolved in one pint (20 ozs.) of water, and keep it in a well-stoppered bottle in the dark. The well treated with it should be allowed to stand for 24 hours for its action.

The test of the sufficiency of dose is that there should be a free chlorine in it which should be appreciable to the taste. The presence of free chlorine can be tested also chemically by adding Potassium Iodide and starch to the sample of water when a bright blue colour will appear.

The advantage of using bleaching powder for disinfecting water is that its disinfecting action is completed rapidly in about 20 *minutes*, and that complete disinfection can be obtained *without* taste or smell or colour. The taste and smell usually experienced in chlorinated water is more due to chloramines resulting from the action of chlorine on organic matter of polluted waters than to the presence of pure chlorine, which may be demonstrated by other means than taste and smell. Excess chlorination will produce taste and smell of chlorine, but it is unnecessary to proceed to such excess.

Chlorogen:—This acts in the same way as the bleaching powder, by liberating chlorine and nascent oxygen which are both very powerful sterilising agents. Chlorogen deteriorates in strength on keeping for a long time. The amount of chlorogen required depends on the degree of contamination. Hence, a rule of thumb cannot be applied for its use. The method of determining the quantity of chlorogen to treat a certain well is rather complicated. Roughly, if a perceptible taste of chlorine is felt after 12 hours in the water treated, we err on the safe side.

House Cleaning

If one starts to clean a house from one end, before one reaches the other, the former is again ready for cleaning. We have thus to wage a war continually against dirt, and our enemy is such that it is impossible to completely vanquish him. At the most, we can keep him under control. The moment of our rest is the moment of our defeat. Nevertheless, if a habit of perfect cleanliness is once acquired it becomes second nature and the very sight of dirt becomes unbearable. There is some indescribable pleasure—a sense of supreme satisfaction arising from cleanliness, and the person who has once realised it, becomes so sensitive to it, that he feels a sort of positive discomfort at the sight of dirt.

A house may have been designed and built on the most up-to-date hygienic principles, with the best of materials, and supplied with every ultra-modern appliance of comfort and convenience, but if it is not maintained in a clean state, it may soon be rendered unfit for human habitation. Hence, cleaning the house both inside and outside is a matter of utmost importance.

Prevention is always better than cure. If, therefore, every one in the house would do his or her bit, not necessarily in cleaning, but by preventing dirt by the practice of cleanly habits, it would go a long way towards success. Even young children should be trained to do so from their early age, which then becomes a part and parcel of themselves.

Method and system are, as in everything else, the key-note to success in this matter also. They consist in having a clear idea of what is exactly to be done, and in pre-arranging as to when, how, and by whom exactly it has got to be done. If the person concerned is made to feel his or her responsibility, success would be guaranteed. An important point is the division of labour. There is nothing derogatory or undignified in doing part of it oneself. On the contrary, if the important person in the household shows occasionally a keenness on doing it personally, every one else in the house catches the spirit of dignity of labour, and the servants, too, do not get an opportunity to scamp work.

In order to maintain a house and its premises in a perfectly clean state, certain rounds of duties have to be done daily, weekly, monthly, and periodically. As a general rule, daily work must be directed towards removal of fresh dirt, which is continually collecting on surface, and the weekly and periodical cleaning must aim at restoration to that condition of perfect cleanliness, from which everything around us tends continually to depart.

Out of the daily duties, sweeping dust, and collecting, removing and disposing of the refuse produced inside and outside the house is an important one. Dust must be removed not only from the floor, but from every surface which is likely to collect it, such as wall surfaces, picture frames, furniture etc. First, take the door mats and carpets away from the house, shake and beat them with a stick, then close all the doors of the room to be cleaned so that the dust may not enter other rooms, sweep the floor, then spread the carpet again in position, wait for a few minutes for the dust to settle down and then dust the pieces of furniture etc. The usual practice of doing the latter consists of beating the surface briskly with a piece of cloth tied to the end of a rod. This does not remove the dust, but helps distribute it evenly on the surrounding articles in the room. The proper way of doing it is to wipe the dust off, gently and carefully with a piece of moist cloth which should be shaken frequently out of the window.

The rooms used most are likely to be most dusty. The main entrance passage is thus the worst in this respect, then comes the staircase, if there be one in the front, because, it is the only thoroughfare for going up. It was formerly the custom enjoined by the Hindu Shastras to wash one's feet with water before entering the house. For, if we walk out of doors we are sure to bring in with our feet, some of the dirt on the street. What this dirt shows itself to be under a microscope, has been already described on p. 93. It is pity, however, that many of us, in blind imitation of the Western people, enter even the innermost apartments with shoes on. With the proper use of a scraper at the front door, and a mat in the front passage, the danger is considerably reduced. However, it is the best custom to remove shoes near the entrance and then enter inner apartments with indoor slippers, if necessary. The dust from the entrance passage and stairs which is full of harmful bacteria, must not be allowed to enter other rooms. These rooms should be cleaned first in the morning after closing the doors of the adjoining rooms.

As a general rule, all living rooms should be cleaned daily. The bedroom in which we pass nearly one-third of our life should be kept particularly clean. This should be sunned every day by opening out windows and admitting sun's rays especially in the morning if this be possible.

The stairs should be started from the top downwards, but not in a manner as to push the dust by a brisk sweep of the broom. Every step should be wiped gently with a broom, or better still, with a round brush which penetrates into corners better, and the dust from it collected in a pan held below the edge.

All the ledges in doors, windows, etc., should be wiped clean ; lamps, flower-pots, ornaments forming articles of decoration etc., should be wiped, rubbed, and polished.

Bedding and coverings should be aired every day for a few hours and sunned once a week, together with the bed taken to pieces. A searching examination should be occasionally made of joints, folds, etc. to search if any bugs have intruded, and if so, prompt action should be taken to inject kerosene oil emulsion ;* then close the joints with wax, and blow on insect powder to destroy their eggs.

Emptying slop basins or cisterns should also form one of the daily rounds of duties. All the open drains should then be examined, and obstruction, if any, removed.

* Add 8 parts of bar soap by weight to 15 parts of water, and while it is being boiled add gradually 100 parts of kerosene oil to make kerosene oil emulsion.

Among the weekly duties come the sweeping of the wall surface, corners and ceiling etc., removing cob-webs and dust, washing floors, urinals, and sinks with a disinfectant, and scrubbing and washing shelves in the kitchen cupboards.

Household dustbins should preferably be of iron and they should be disinfected by burnning waste paper in them.

Bath and toilet rooms should be white-washed twice a year. If freshly slaked lime is used, it behaves as an excellent disinfectant. If trouble of bugs is apprehended, the bedrooms should be given a buff wash made of freshly slaked lime mixed with *Multan Mitti* or some such cheap colouring pigment, so that it can be renewed at a small cost from time time, with a view to kill all the vermin.

Kitchen walls of the houses of the middle classes, in which fire-wood is mostly used for fuel, are likely to be dark on account of the smoke. The best plan is to give a cheap yellow lime wash, or better still, two coats of a paint prepared in the following manner :—

Pour water on freshly burnt Surat lime (lime prepared by burning sea-shells in a kiln) to make a wash of the consistency of cream, mix boiled linseed oil with it in the proportion of one part of linseed oil to 8 parts of the milk of lime, and give a wash with it by means of a vegetable fibre brush, as lime will act on animal bristles and soon destroy the brush. The surface, when dry, can be frequently washed with a disinfectant without losing the colour. This paint lasts for a long time.

A Few Chief Disinfectants and their Use

From personal knowledge, the writer is led to believe that even many educated people have got a wrong notion about disinfectants. Many people think that a substance which conceals or destroys an offensive stink emanating from decomposing matter is a disinfectant, and with this mistaken idea, they entirely rely upon them under a delusion which gives them a sense of false security. It is therefore proposed to close this section after making a brief reference in this chapter to a few cheap and reliable disinfectants.

Disinfectants are agents which destroy the germs, or the carriers of the germs, of disease, and should be distinguished from the *antiseptics* which merely check the growth of the germs and prevent animal or vegetable substances from decomposing, and from *deodorants* which oxidise the products of decomposition as soon as they are produced, and so absorb or destroy offensive smells.

It is not enough to know that a certain substance is a disinfectant; the quantity to be used and the degree of concentration necessary for its successful operation are also important factors.

(1) *Fresh air* and *sunlight* are the natural disinfectants and kill germs of most diseases. The only disadvantage is that whereas clothes, mattresses, pieces of furniture and other movable articles can be exposed to sunlight, and disinfected, the corners and recesses of rooms cannot, for which some other convenient disinfectants have to be sought for. For

systematic disinfection by sunlight the following rules should be observed.—

Select a flat piece of ground with no cracks in it. It should preferably be sandy, or else, sand may be sprinkled on its surface.

Let it get hot by exposure to sun. Thus sun disinfection should not be attempted before 11 o'clock in the morning.

Spread clothes on it evenly in a single layer. If they are left exposed to sun in this way even for an hour that is enough. Thick padded clothes, such as quilted coats, mattresses etc., must be turned over once or twice so that both the sides are well heated. Beds and pieces of wooden furniture should be taken to pieces, if possible, and exposed to sun for several days.

(2) *Quick lime* is the next best agent for disinfection. It is cheap, and has a very high germicidal value. Water should be sprinkled on freshly burnt *kunker*, till it falls to powder, which is called slaked lime. This may be used either in a dry state or formed into a liquid of the consistency of milk by dissolving it into water, and then used in that condition. It can be used to purify water, to disinfect floors, stables, drains, gutters etc. The powder soon absorbs carbon dioxide from the air, and deteriorates in quality. Hence, stale dry lime is useless.

(3) *Phenyle*:—This and carbolic acid are both obtained from coal-tar, but phenyle is twice as powerful as carbolic acid, besides being much cheaper. It is, however, poisonous and irritant to the skin. One part of it, in 50 parts of water forms a good disinfectant.

(4) *Izal* is also obtained from coal-tar. It is non-irritant, non-poisonous and cheap, and is thus superior to phenyle in every respect. 1 part of it in 500 of water disinfects even the stools of a Typhoid patient in 15 minutes. (Dr. Klein).

(5) *Pesterine* is a strong disinfectant and comparatively cheap. It does not mix with water, but does so freely in soap solution. The objection to its use is that it stains fabric. 1 part in 100 of water makes a sufficiently strong disinfectant.

(6) *Fumigation by Sulphurous Acid*:—This is also very effective and comparatively cheap method, and possesses some special advantage over other disinfectants in so much as it kills all the germs floating in the atmosphere contained in a room. But as it is a poisonous gas it cannot be used when the room is occupied. There are special machines designed for this purpose but the pot method is the cheapest and easiest for household use.

First take powdered sulphur in the proportion of 2 lb. per 1000 cu. ft. capacity of a room, moisten it with methylated spirit, and put it into an iron pot. The latter should be placed into a tub containing water. The tub should be placed high up in the centre of the room, say at 5 or 6 ft. above the floor. Before igniting the sulphur, all the doors and windows etc. should be closed. Even the chinks and cracks in them should be closed by pasting paper on them. Then ignite the sulphur, and let the smoke emanating from it fill the room for six hours, when the doors and windows should again be opened.

The water is required for supplying the necessary moisture to produce hydrated sulphur dioxide (SO_2) and it is to be burnt at a high level because, the sulphur gas being heavier than air will sink to the bottom and will not reach the higher parts of the room.

Ready-made sulphur candles can now be had in the market for this purpose which are very suitable.

While using sulphur as a means of disinfectant it should be noted that its gas bleaches all colouring matter of vegetable origin, acts on cotton and linen fabric, and attacks all metals especially silver, which it stains very badly.

As a general rule, disinfectants act better at high temperature. The water to be used should therefore be hot. Hard water interferes with the property of disinfection. Hence, only soft water should be used. Again, an emulsion is more powerful than a mere solution.

A bucket spray pump does the work of disinfecting very satisfactorily and economically.

Repairs and Alterations

The subject of repairs is so vast that in order to do full justice to it, a volume, perhaps bigger than the present one would be required. In the present chapter it is proposed only to touch on the aspect of remodelling a building, which is in need of repairs with a view to improve the general sanitation connected with it.

From this point of view, an examination of the existing drainage system occupies the first place of importance. A defective drainage, whether closed underground or open at surface, makes itself visible, first in the evidence of damp, and then in that of a stink caused by the emanation of foul gases. This may be due to a crack in the drain, or some obstruction in the passage of the water flowing through it, which causes the water to head up, soak in the ground and overflow, if it gets an outlet. The stink even inside bathrooms in some Indian homes is so bad sometimes that it is an ordeal to stand there for a few minutes. Even flushing the bathroom with a copious supply of water does not remove it. The reason is that the obstruction which chokes the drain is in a state of decomposition, and the foul gases given out by it enter the room and cause the stink.

The first precaution against this is to provide traps at every drain in the house, so as to cut off the connection between the interior of the house with the outside drain. A *nhani* trap has already been illustrated on p. 90. In places where water-carriage system has been also introduced, the municipal authorities compel the owner by law to provide systematically designed drains with traps, ventilating pipes, etc., but even in places where a system of open surface drains exists, provision of traps would go a long way towards improving the general sanitation. The next thing is to give a suitable fall to the drains so as to create a self-cleansing velocity in the flow; and the third essential is the provision of means of access to the drains for inspection or repairs, if the drains be wholly or partially covered underground. This subject has been treated at considerable length in the author's *Build Your Own Home.*

Eighty per cent. of the damp is caused by defective drainage, 15 per cent. by leaky roofs, and only 5 per cent. by all other causes combined. In the case of flat roofs, a not uncommon cause of damp is the neglect of the periodical inspection and repairs of the cracks on the surface of the terrace or valleys and roof gutters and in the brickwork and coping of the parapet walls. The damp due to these causes is visible by stained patches on the surface near top of walls.

The following are the remedies suggested for this :—

(a) If the roof be of mud, and if impervious white earth be not available, leep the surface with a mixture of 12 parts of roofing earth, 4 of cowdung and one of cement, mixed in water, and moderately rub the surface with the mason's trowel. This will, in most cases, be found to be effective, but if it does not stop the trouble, apply, when the surface is dry, a coat of the paint prepared of sodiumised clay* mixed with boiled linseed oil.

(b) If the roof be of cement or lime concrete terrace, and if the cracks are very fine, called 'hair cracks', then,

(i) Give a coat of cowdung, cement, and fine sand, mixed in equal proportions in water, with a brush. This should be applied in the evening so as to give it a chance of setting slowly.

(ii) Paint the cracked surface with hot bitumen, or cold "Colas." The remedy is effective but it stains the surface dark.

(c) It the cracks are wide,

(i) Take linseed oil two lb. and while it is being boiled add one lb. of resin crushed to powder and then powdered bath brick or very fine sand one lb., and apply the mixture with a brush while hot.

(d) If the cracks are big, widen them further by means of a chisel, remove every bit of loose matter and wash them clean with water. After this, fill in by pushing hard by the edge of a trowel, a mixture composed of cotton, cut to pieces, thoroughly soaked in hot asphalt or bitumen, spread some sand on the surface and wipe it off.

Another item of frequent repairs is the plaster. If it be of lime, a very careful treatment is required, because, it is very difficult to make a proper junction between the old mortar which has already set and the fresh one. Open all the loosened patches, rake out the joints, soak them freely with water and then apply lime mortar, in which cement is mixed in the proportion of 5 of mortar to 1 of cement. This would make the surface sufficiently hard in about 6 to 8 hours, when it should be tamped closely with an edged instrument and then coated finally with a mixture consisting of cream of lime and fine sand in equal proportions ground to a workable paste with a pestle on a flat piece of stone, applied with a trowel and polished.

If the plaster be of mud, dismantle the patch which sounds hollow, moisten the portion with water and replaster it with sodiumised clay or brick clay, in which is mixed, cement in the proportions of one of cement to 12 of clay. This should be indented as described above and finished on with a final coat of the same material.

Another item of repairs, which is often very troublesome, and causes damp and consequent ill-health is the leak through the walls and floor in the cellar or basement floor. The entire surface of the wall and floor should be minutely examined under the light of an electric torch, if the daylight be insufficient in such a room, to see whether any cracks are visible and whether water leaks through them, and if so, they should be treated in the manner described for repairing leaky terraced roofs. If there be no cracks, and if the water is seeping through the pores of the permeable concrete, the remedy suggested on page 92 viz., excavating a trench on the outside of the wall, in the portion

* Vide pp. 11 to 13.

through which water leaks, pointing the joints with cement, and in addition, filling the trench with black cotton soil well rammed, may be resorted to, or a coating of cement plaster may be applied.

If the floor of the basement is seeping, it is rather a difficult job to set right, because, the water coming inside is in most cases under pressure. Any surface treatment, therefore, is of no use. The only satisfactory remedy is to construct a new floor on the top of the old one, with cement concrete, taking all the precautions to ensure a compact and water-tight surface.

Type Economical Plans.

A few economical type plans are given below illustrating some of the principles of economy mentioned in the foregoing pages. Economy consists of two sorts: first in planning, and the second in construction. Economic planning consists of grouping of the different apartments in such a way that no space under the roof is wasted, a minimum possible being allotted to passages and lobbies in order to make every room (except perhaps the drawing room), and particularly, the bathroom and services, independently approachable. This has been attempted to be done in the few plans given below.

The plans are self-explanatory, still, for the guidance of laymen who have never seen building plans, explanation of the details is supplied in the key plan in Fig. 76.

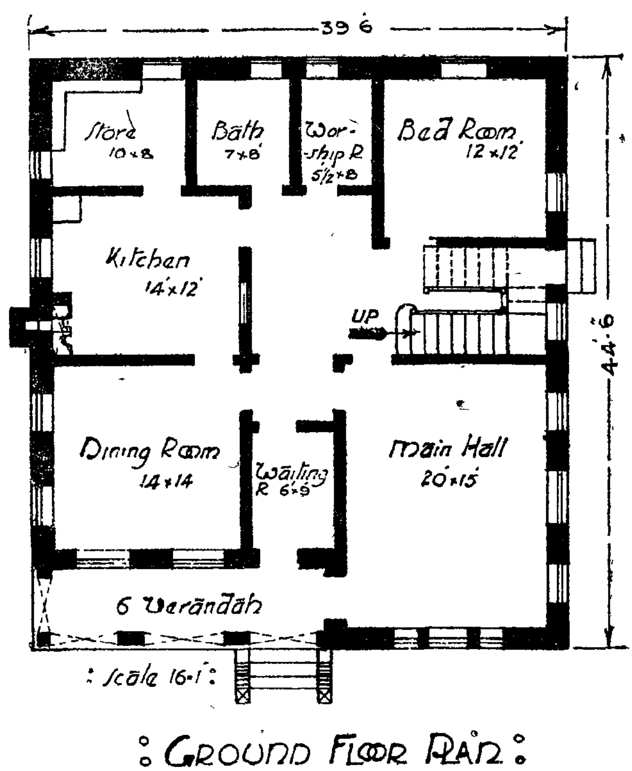


Fig. 76.

Diagonal dotted cross lines indicate arches; Double lines along walls near the outer edge, windows; Recess in walls, cupboards; Breaks in walls, doors; Steps with arrow, staircase; CH. chulla; S, sink; SF, Shelf; Rectangular fig. in bedroom, position of bed. N, (The arrow on the right, in the front) shows the North direction.

The costs given at the head of each plan are based on average rates of different provinces and may not entirely tally with those at any one place. When the rates in average towns in the different provinces are compared, it is found that these are 5 to 10 per cent. in excess of those in the Central, United Provinces and the Punjab, and about 15 per cent. of those in the Madras Presidency. •An idea of the rates assumed can be had from the estimates of two buildings given. Another purpose of the estimates is to give a layman an idea of the various items in building construction in order to enable him to pre-arrange for materials and funds.

Wherever pitched roof is indicated, roof lines have been shown in dotted lines on the plans. As the plans are intended for upcountry places, latrines are expected to be built a little away from the main building. They are therefore not shown. The cost includes the main building only. Site, outbuildings, compound wall, etc., would require an extra amount.

PLAN No. 1.

Plinth Area 1170 Sq. Ft.] [Cost Rs. 1800

Very often, the sites for buildings, lining streets in towns are long with a very narrow frontage, and further, the side walls of the houses, either touch each

Fig. 77.

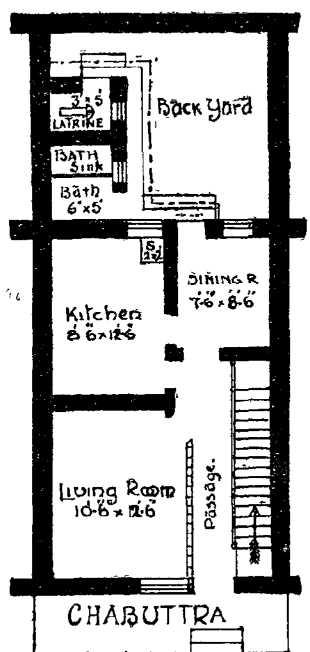
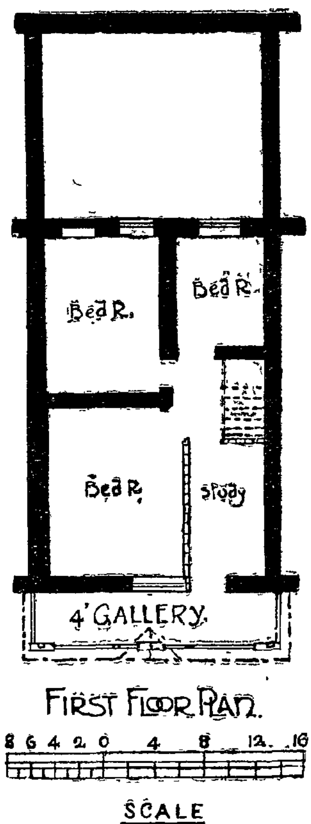


Fig. 78.



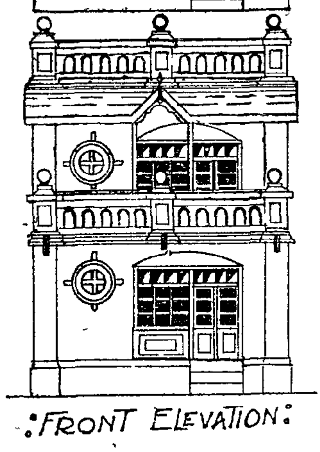


Fig. 79

other, or there are no separate side walls to each house, but one wall serves the common purpose of two adjacent houses. Under such circumstances, it is impossible to derive light from the sides. The plan in Figs. 77 to 79 shows how this difficulty is overcome, and how by skilful designing maximum light and ventilation can be secured.

There is an open porch or *chabuttra* in front. If this is enclosed by a low compound wall, it can be used as an excellent conservatory. Of course, only dwarf varieties of plants must be grown, otherwise they will darken the drawing room by shutting off light partially. As one enters the front door, there is, on the left side, a drawing room well lighted by the large window on the front side. Behind it, is the kitchen which has to be contracted a little to make room for the dining room. The kitchen is lighted by a window from the back side. On the rear side there is a closed bathroom and a latrine, the latter has an opening on the opposite side in order to lessen the trouble of flies, should the door remain open by chance. The staircase in the front is 3 ft. wide and is very easy to ascend.

Upstairs (Fig. 78) are three bedrooms, a study room, and a projecting gallery in front. All the rooms are so skilfully grouped that each has an independent entrance, and the gallery, which is an excellent sitting-out place, is independently accessible from every bedroom. Thus, every inch of the space available has been utilised for living accommodation.

The elevation (Fig. 79) is smart and attractive, but if there are a number of such houses on the street, many alternative forms in pleasing diversity, can be adopted in order to break the effect of deadening monotony.

PLAN No. 2.

Plinth Area 1088 Sq. Ft.] [Cost Rs. 1560

This small but simple and attractive countryside building combines economy, comfort and convenience in one place. The verandahs are an Indian institution, and no house, though small, is complete without them. The present cottage has them both in the front and rear, and as they are closed by trellis work which admits light and breeze, they constitute delightful sitting-out places affording the best privacy. The study-room in the front can be used also as a bedroom. The two central rooms are spacious, and the very wide windows provided in them give them a feeling of light and airiness. The elongated kitchen, with two windows, a sink, a shelf and a cupboard with a wide verandah in front, should prove a thing of constant pride and joy to the housewife. It would ordinarily provide the necessary accommodation for the members of the household to dine together. The

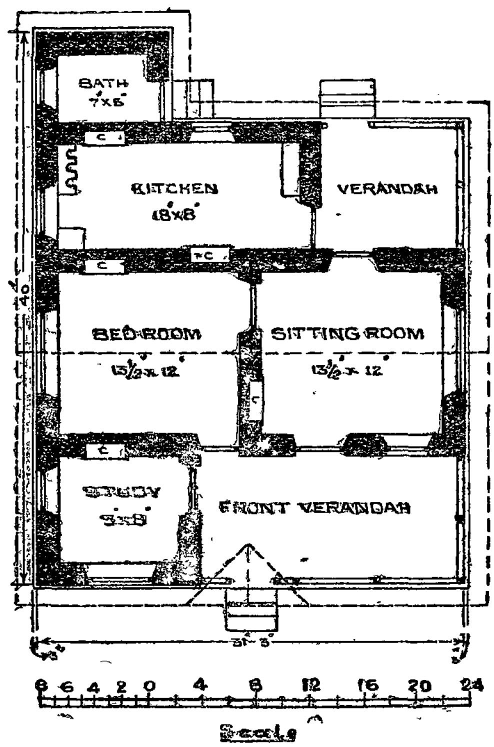


Fig. 80

front verandah which is 9 ft. wide, would accommodate at least five beds and still leave sufficient room for a passage.

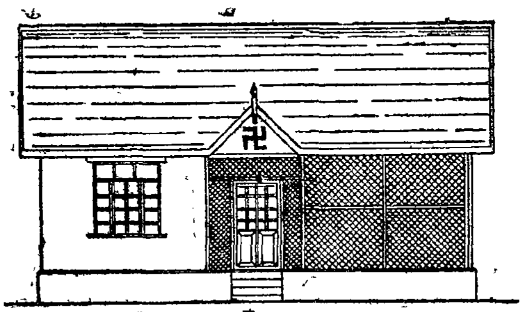


Fig. 81.

The distinguishing feature of the cottage is its cheapness. In spite of the provision of a damp-proof course, rat-proof construction, fully glazed windows, concrete floor throughout, leak-proof roof of corrugated sheets, etc. the building costs only Rs. 1,500 and odd. The detailed estimate attached will convince the reader of it. The rate per sq. ft. of plinth area works out to Rs. 1/8. For preventing heat of the roof, one of the remedies suggested in the chapter on Roof might be adopted.

IMPORTANT SPECIFICATIONS

Item No. 1. Excavation for Foundation:-

The widths given are at the bottom of trenches. The excavated material to be stacked not nearer than 3 ft. from the edges of trenches. The excavation to be taken down to hard, incompressible, and stable material.

Item Nos. 2 & 3. Uncoursed Rubble Masonry in Foundation and Plinth:—

Please see page 24 in respect of headers, bedding of stones, and precautions against hollows in the wall, etc.

Item No. 4 Damp-proof Course:—

This is to consist of a ¾ in. layer of concrete of gravel, sand and cement with a layer of coal-tar on it, laid on the top of the plinth masonry in the centre of the wall. (vide page 53).

Item No. 7. Concrete Flooring:-

The space below the plinth to be filled with any earth except the black cotton soil (*Regur*), and should be thoroughly rammed and watered. On the top of this is to be laid, a 3 in. layer of concrete consisting of stone pebbles from river bed below 1½ in. size 4 parts, unscreened sand free from earth 2 parts, and lime mortar 1 part. If metal or pebbles are not available, broken brick bats should be used. This layer to be rammed hard, and while yet green, a ½ in. layer of mortar prepared of 32 parts of sand, 8 parts of lime mortra, and one of cement should be applied on top and moderately polished as the mortar sets. This is to be kept moist by spreading wet grass, frequently watered for 15 days.

Item Nos. 9, 10 and 12. Doors and Windows of Teak or Salwood:—

The frames to be made of R. C. C. as described in Appendix No. 3.

Light doors:—The frames to be of R. C. C. as above. The shutters to be of a frame of teak wood ¾ in. thick with panels of waterproof canvas stretched and screwed on to it by means of wooden fillets. (vide page 45.)

The shelves to be of whole piece flagstones such as Shahabad, Tandur, Yerraguntla, Katni, Rewari etc., with the front edge rounded.

Item No. 18. Wire-netting for 18 in. Skirting:—

The lower end to be embedded into concrete floor at least 2 in. and only when the concrete has set, should the upper end be stretched well and the netting fixed on the surface of the wall by means of U-shaped staples, 1½ in. long, driven into the wall. The surface to be plastered over with mud again and leeped over with cowdung. (Page 42).

*Abstract of Quantities and Cost of Plan No. 2

Item No.	Name of Item	Quantity	Rate Rs. a.	Per unit	Amount Rs.
1	Excavation in average soil ...	1667 cu. ft.	0–12	cu. ft. 100	12·51
2	Filling foundations with boulders and rubble in mud ...	1250 cu. ft.	5—0	„	62·50
3	Rubble stone in mud masonry for plinth including cement pointing to the outer surface above ground	1375 cu. ft.	7—0	„	94·71
4	Damp-proof course of ¾-inch cement, sand and coal-tar. ...	338 sq. ft.	9—0	sq. ft. 100	30·42
5	Filling earth in plinth ...	1831 cu. ft.	0–8	cu. ft. 100	9·16
6	Superstructure of *pise* earth ...	3449 cu. ft.	3—0	„	103·50
7	Flooring of broken brickbats and lime concrete surfaced over	750 sq. ft.	9—0	sq. ft. 100	67·50
8	One inch flagstone paving in lime	108 „	10—0	„	10·80
9	Doors teak or sal wool, plain planked with iron fixtures ...	100 „	1—4	sq. ft.	125·00
10	Light doors on inside ...	42 „	0–12	„	31·50
11	Flagstone slabs one inch thick set in mortar for window sills...	74 „	10—0	sq. ft. 100	7·40
12	Teakwood windows iron barred and fully glazed complete with iron fixtures	93 „	1–12	sq. ft.	162·75
13	Cupboards with light shutters ...	56 „	1—0	„	56·00
14	R. C. C. lintels over doors, windows and cupboards ...	49cu. ft.	1—0	cu. ft.	49·00
	Total Carried Forward ...				822·74

Item No.	Name of Item	Quantity	Rate Rs. a.	Per unit	Amount Rs.
	Total Brought Forward ...				822·74
15	Cut teak or sal woodwork including fixing	10·8 cu. ft.	4—0	cu. ft.	42·00
16	Expanded metal trellis work in varandahs	408 sq. ft.	25—0	sq. ft. 100	102·00
17	Cement plaster to walls ...	104 „	10—0	„	10·40
18	Gauze wire netting 3 feet wide one inch mesh fixed as skirting to walls by iron staples for rat-proofing	193 Rft.	6—0	Rft. 100	11·58
19	Whitewashing three coats ...	2432 sq. ft.	0–12	sq. ft. 100	18·24
20	Round teak wall plates 3 inch diameter	243 Rft.	0—3	Rft.	45·56
21	Corrugated iron sheet roofing complete with purlins, ridge, eaves boards etc.	1920 sq. ft.	24—0	sq. ft. 100	460·80
22	Sinks in bathroom & kitchen complete with *nhani* traps, pipes etc.	2 Nos.	5—0	each	10·00
23	Sets of pegs	5 Nos.	1—0	„	5.00
24	Oiling woodwork; painting ironwork	Lump	1—0	„	15·00
25	Loft in kitchen	Do	1—0	„	15·00
26	*Dhandies* of bamboos for drying clothes, cradle hook, swing hooks, etc.	Do	1—0	„	5·00
	Total ...				1563·32
	Say Rs. ...				1560

* The rates adopted here are average of rates obtaining in different provinces.

Measurement Schedule

No.	Description of Item	No.	Length	Breadth	Depth or Height	Quantity	Total Quantity
			F. i.	F. i.	F. i.		
1	*Excavation for foundation in average soil*						
	Side walls on the left & right...	2	34–0	2–6	3–0	510·00	
	Cross walls ...	4	27–0	2–6	3–0	810·00	
	Partition walls in verandah ...	2	6–6	2–6	3–0	97·50	
	Partition central ...	1	11–0	2–6	3–0	82·50	
	Side walls of bathroom ...	2	6–6	2–6	3–0	97·50	
	Rear walls of bathroom ...	1	6–0	2–6	3–0	45·00	
	Steps front and rear ...	2	4–0	3–0	1–0	24·00	
	Total ...					1666·5	cu. ft. 1667
2	*Filling foundations with boulders and rubble in mud ¾ of the above* ...	¾	of	the	above	1250	
	Total ...					1250	cu. ft. 1250
3	*Rubble stone in mud masonry for plinth including cement pointing on the exposed surface above ground*						
	Side wall on the left ...	1	33–6	2–0	3–3	217·75	
	Side wall on the right, middle portion	1	15–0	2–0	3–3	47·50	
	Side wall on the front and rear portions	2	9–0	2–0	3–0	108·00	
	Cross wall middle	2	27–6	2–0	3–3	357·50	
	Cross wall rear of kitchen ...	1	19–6	2–0	3–3	126·75	
	Cross wall rear of verandah ...	1	8–0	2–0	3–0	48·00	
	Cross wall in front of study ...	1	10–9	2–0	3–3	70·25	
	Cross wall in front of verandah	1	16–9	2–0	3–0	100·50	
	Partition walls in verandahs ...	2	7–0	2–0	3–3	21·00	
	Partition walls central ...	1	11–6	2–0	2–9	74·75	
	Side walls of bathroom ...	2	6–6	2–0	2–9	71·50	
	Rear walls of bathroom ...	1	6–6	2–0	2–9	35·75	
	Steps ...	2	3–6	3–0	0–9	15·75	
	Steps ...	2	3–6	2–0	0–6	7·00	
	Steps ...	2	3–6	1–0	0–6	3·50	
	Total plinth masonry ...					1375·50	cu. ft. 1375

No.	Description of Item	No.	Length	Breadth	Depth or Height	Quantity	Total Quantity
			F. i.	F. i.	F. i.		
4	*Damp-proof course of ¾ inch cement and sand with coal tar on top*						
	Side walls ...	2	33–0	1–6		99·0	
	Cross walls ...	4	28–0	1–6		168·0	
	Partitions in verandahs ...	2	7–0	1–6		22·5	
	Partitions central ...	1	12–0	1–6		18·0	
	Side walls of bathroom ...	2	6–6	1–6		19·5	
	Rear walls of bathroom ...	1	7–0	1–6		10·5	sq. ft.
	Total damp proof course ...					337·5	338
5	*Filling earth in plinth*						
	Front verandah ...	1	17–6	6–9	2–6	295·00	
	Study-room ...	1	8–9	7–9	2–6	170·00	
	Bedroom ...	1	13–3	11–9	2–6	390·00	
	Sitting room ...	1	13–3	11–9	2–6	390·00	
	Kitchen ...	1	17–9	7–9	2–6	342·00	
	Rear verandah ...	1	8–6	6–9	2–6	197·00	
	Bathroom ...	1	6–9	4–6	1–6	47·00	cu. ft.
	Total earth filling ...					1831	1831
6	*Superstructure of pise earthwork*						
	Side walls of study and kitchen	4	9–0	1–6	(8·25+12·75) / 2	567·00	
	Side walls of bed and sitting R.	2	15–0	1–6	13–1½	590·6	
	Middle partition ...	1	15–0	1–6	13–1½	259·3	
	Middle cross walls ...	2	28–0	1–6	13–1½	1100·0	
	Side walls of bathroom ...	2	6–6	1–6	(8·75+7·25) / 2	156·00	
	Rear wall of bathroom ...	1	7–0	1–6	7·5	79·00	
	Triangular portions ...	2	15–0	1–6	(0+6·37) / 2	143·0	
		1	15–0	1–6	(0+6·37) / 2	71·50	
	Total superstructure ...					3802	

Item	Description	No.	L	B	H/D	Quantity	Total
	Deduct						
	(a) Doors ...	2	3–0	1–6	6–6	58·50	
	Doors ...	4	2–6	1–6	6–0	90·00	
	Doors ...	1	2–0	1–6	6–0	18·00	
	(b) Windows in study, kitchen and in sitting-room	5	2–0	1–6	3–0	45·00	
		2	5–0	1–6	6–0	90·00	
	in bed and sitting-room	1	2–6	1–6	1–0	3·75	
	in bathroom	2	5–0	1–6	0–6	7·50	
	(c) Lintels over doors ...	3	4–6	1–6	0–4	6·75	
	Lintels over doors ...	1	2–6	1–0	0–4	0 83	
	Lintels over doors ...	1	4–0	1–6	0–4	2·00	
	Lintels over windows ...	5	4–0	1–6	0–4	10·00	
	Lintels over windows ...	2	7–0	1–6	0–6	10·50	
	Lintels over windows ...	1	4–6	1–6	0–4	2·25	
	Lintels over cupboards ...	5	4–6	1–0	0–4	7·50	
	Total deduction ...					352·58	
	Total Superstructure ...					3802	
	Less deductions ...					353	cu. ft.
	Net Superstructure ...					3449	3449
7	*Flooring of broken brick bats and lime concrete*						
	Study room ...	1	9–0	8–0		72·0	
	Bed and sitting rooms ...	2	13–6	12–0		324·0	
	Kitchen ...	1	18–0	8–0		144·0	
	Front verandah ...	1	18–0	7–6		135·0	
	Rear verandah ...	1	10–0	7–6		75·0	sq. ft.
	Total concrete flooring ...					750	750
8	*Flagstone paving on lime concrete including cement pointing*						
	For coping of front verandah ...	1	18–0	1–9		31·50	
	For coping of front verandah ...	1	7–0	1–9		12 20	
	For coping of rear verandah ...	1	10–0	1–9		17·50	
	For coping of rear verandah ...	1	7–0	1–9		12·20	
	Bathroom ...	1	7–0	5–0		35·00	sq. ft.
	Total flagstone paving ...					108·4	108
9	*Doors teak or Salwood plain planked with shutters complete with iron fixtures*						
	Front verandah ...	1	4–0		7–0	28·0	
	Rear verandah ...	1	3–0		6–6	21·5	
	Inner doors ...	2	3–0		6–0	36·0	
	Inner doors ...	1	2–6		6–0	15·0	sq. ft.
	Total doors ...					100	100

Item	Description	No.	L	B	H/D	Quantity	Total
10	*Doors with light frames and shutters* ...	2	2–6		6–0	30·0	
	...	1	2–0		6–0	12·0	sq. ft.
	Total light doors ...					42·0	42
11	*Flagstone slabs one inch thick set in lime mortar for window sills* ...	5	2–6	2–0		25·0	
	...	2	5–6	2–0		22·0	
	...	1	3–0	2–0		6·0	
	on top of steps ...	6	3–6	1–0		21·0	sq. ft.
	Total ...					74	74
12	*Windows iron-barred and fully glazed as per (b) under deductions from Item 6 above* ...					93	sq.
	Total ...					93	ft.93
13	*Cupboards with light shutters* ...	5	2–6		4–6	56	sq.
	Total cupboards ...					56	ft.56
14	*R. C. C. lintels over doors and windows as per (c) under deductions in item (6) above* ...					48·7	cu. ft.
	Total R. C. C. lintels ...					48·7	49
15	*Cut teak or Sal woodwork including fixing*						
	verandah posts	5	0–4	0–4	9–0	5·0	
		3	3–4	0–4	9–0	3·0	
	Post plates ...	1	19–0	–3	0–4½	2·8	cu. ft.
	...	1	11–0				
	Total woodwork ...					10·8	10
16	*Expanded metal trellis work in front and rear verandah* ...	1	18–0		8–0	144	
	...	1	10–0		8–0	80	
	...	2	9		8+12·5	184·5	sq. ft.
	Total ...				2	408	408
17	*Cement plaster to walls*						
	Bathroom ...	2	7–0	4–0		56	
	...	2	5–0	4–0		40	
	Sink in kitchen ...	2	2–0	2–0		8	sq. ft.
	Total ...					104	104

Measurement Schedule—*Contd.*

No.	Description of Items	No.	Length	Breadth	Depth or Height	Quantity	Total Quantity
			F. i.	F. i.	F. i.		
18	*Wire netting 3 ft. wide one inch mesh to be tacked to wall by iron staples at bottom of walls for rat-proofing and plastered over with mud* ...	1	39			39	
	...	2	51			102	
	...	1	52			52	Rft.
	Total wire netting ...					193	193
19	*Whitewashing inner surface of walls 3 coats including dressing and leeping surface previously*						
	Front verandah ...	1	9–0		8+12·5	92·5	
					2		
	Study room ...	2	7–6		8+12·5	153·5	
					2		
		1	9–0		8·25	74·25	
		1	9–0		12·5	125·5	
	Bed and sitting rooms ...	4	13–6		13·6	728·0	
		2	12–0		13·6	324·0	
	Triangular portions ...	2	12–0		0+6·5	78·0	
					2		
	Kitchen ...	1	18–0		8·25	148·5	
		1	18–0		12·5	225·0	
	Rear verandah ...	2	8–0		8+12·5	164·0	
					2		
		1	8–0		8+12·5	82·0	
					2		
	Bathroom ...	1	10–6		12·5	131·0	
		2	5–0		7+9·5	82·5	
					2		
		1	7–0		7·0	49·0	
		1	7–0		9·5	66·5	sq. ft.
	Total whitewashing ...					2431·7	2432

No.	Description of Item	No.	Length	Breadth	Depth or Height	Quantity	Total Quantity
			F. i.	F. i.	F. i.		
20	*Wall plates of round teak rafters 3 in. diameter*						
	Side walls of study and kitchen	4	11–0			44·0	
	Front of study room ...	1	11–0			11·0	
	Front and rear walls of bed and sitting room ...	2	30–0			60·0	
	Side walls of bed and sitting room ...	6	14–6			87·0	
	Rear wall of kitchen ...	1	20–0			20·0	
	Side walls of bathroom ...	2	6–0			12·0	
	Rear walls of bathroom ...	1	9–0			9·0	Rft
	Total wall plates ...					243·0	24.
21	*Corrugated galvanised iron sheet roofing complete with purlins, ridge, eaves boards etc.*						
	Front and rear wings ...	2	34–0	27·0		1836	
	Bath projection ...	1	14–0	6–0		84	sq. ft.
	Total roofing ...					1920	1920
22	*Sinks in bath and kitchen complete with nhani traps, pipes etc.* ...	2				2	Nos. 2
23	*Sets of pegs* ...	5				5	No. 5
24	*Oiling woodwork and painting iron work* ...						No. 1
25	*Lofts in kitchen* ...	—Lump—				—Lump—	No. 1
26	*Dhandies of bamboos for drying clothes below ceiling and cradle hook, swing hooks etc.* ...						Lump.

PLAN No. 3.

Plinth Area 1326 Sq. Ft.] [Cost Rs. 2290

This snug little cottage, on account of the broad, low sweeping lines in the elevation gives an appearance of roominess. The deep verandah in front is most inviting. It gives a feeling of a little out-of-doors, and yet the dwarf wall on its edge affords a touch of privacy. The drawing room centrally situated will give the necessary warmth in winter and coolness in summer. The bedrooms are commodious and are provided with separate bathrooms—a modern necessity. The kitchen is not only sufficiently spacious but the provision of a separate store-room, with rows of shelves, adds to its convenience. The wide verandah enclosed by trellis on the rear side would provide an excellent dining-room. The bathroom is very conveniently situated.

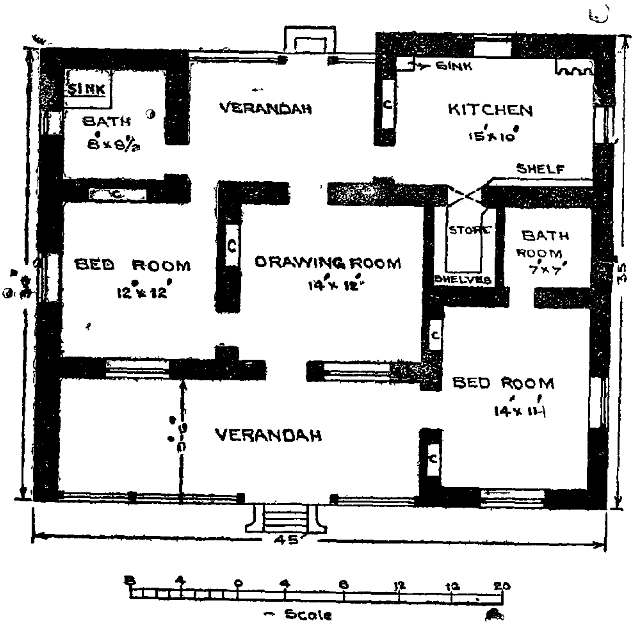


Fig. 82

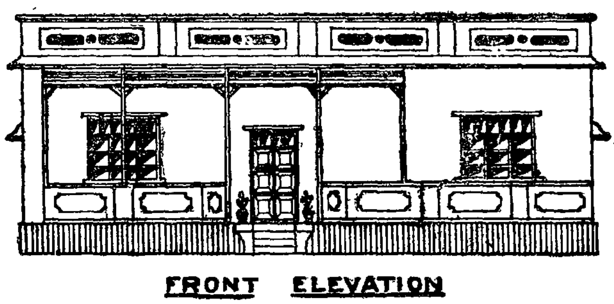


Fig. 83.

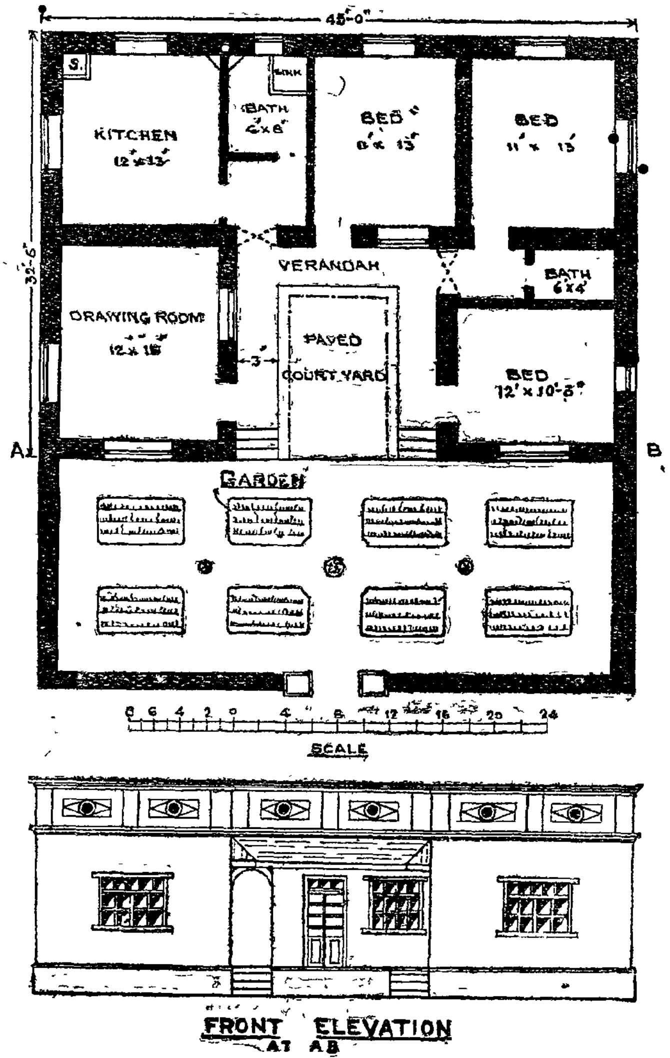
This bungalow should be built on a slight elevation and should be in a setting of a garden in front, which would then command a view from the verandah and the front bedroom. An ample provision of cupboards has been made in every room.

PLAN No. 4.

Plinth Area 1462 Sq. Ft.] [Cost Rs. 2545

This charming little cottage which is designed on the principles of the Indian architecture possesses all the advantages of the latter, without sharing a single disadvantage. The open space in front is enclosed by a high compound wall and is entered through a massive wide gate (not shown in elevation). There is, again, an open paved court-yard in the centre, round which runs a corridor to give an independent access to every room of the house. Light and breeze pervade the entire house, and with them, health and cheerfulness must predominently rule, because, there is not a single room even including the kitchen which is not open at least on two sides, still the house possesses the best privacy from the highways and byways. Imagine the front garden to be bristling with roses and an exhuberant vine trailing on the arch in front of the open paved court-yard and you have to picture to yourself how the cottage would look in this best setting.

The interior arrangements fully synchronise with these exteriors. The sizes of all the rooms are very good for a small cottage like this. There are two bathrooms, each of which is independently accessible from any room. The drawing room and the bedroom opposite to it enjoy light and breeze on three sides. In spite of this all, the cost is only Rs. 2545 ; the garden and compound wall would cost extra.



Figs. 84 & 85.

PLAN No. 5.

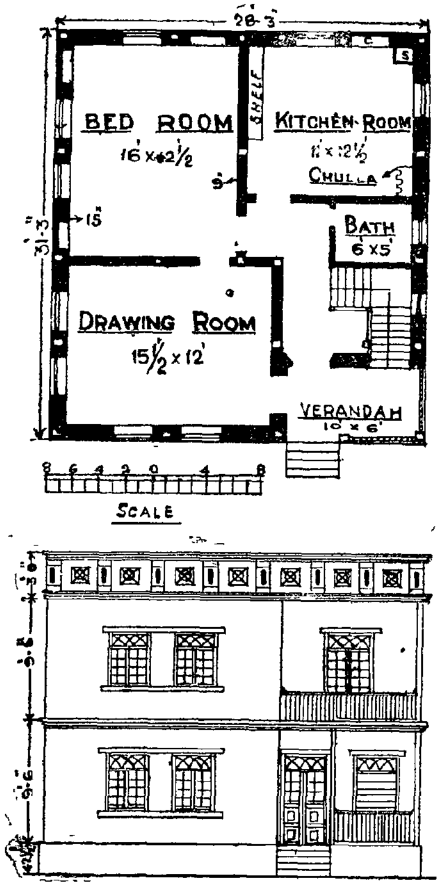
Plinth Area 1766 Sq. Ft.	Cost Rs. 3255

To one of limited means, who has spent years of his life in cities in the course of service, etc. in palatial buildings, but who now wants to lead a life in retirement with his large family in a town on the country side, this design will make a strong appeal. Because, it combines economy with refinements of arrangements and comforts, almost amounting to luxuries. It illustrates the principle that simplicity and straightforwardness of design make not only for economy but also for comfort and health.

It is a storeyed building with a flat roof on. But a pitched roof would give the elevation even a better effect of simplicity and homelike appearance as the plan is a straightforward rectangle.

Ascending the flight of steps, one enters the verandah. If space permits, it is worth while projecting the verandah a little more so as to make it 8 ft. wide at a little extra cost. The good-sized drawing room is provided with four large glass windows which command a view of the landscape on two sides. Behind it is a bed room with three large windows and two fixed wardrobes. It is of such a size that one living even in mansions should envy. The spacious kitchen on the right hand side possesses every modern convenience. If necessary, a back door may be provided in it in the corner of the shelf. The bathroom entered through a lobby is accessible independently from every room. The space below the staircase can be utilised for storing bicycles or a pram. There is a large-sized loft provided (shown in the cross section in Fig. 89) above the bathroom for depositing lumber or storing fuel.

The entrance to the staircase is through the verandah and it lands one in the lobby



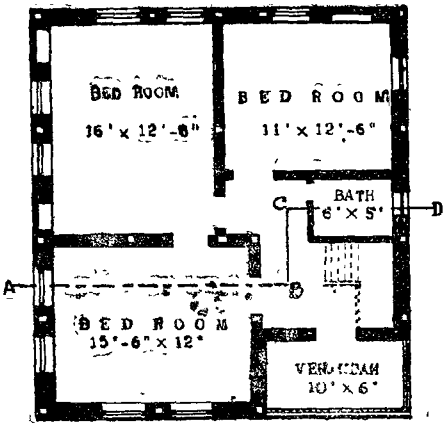
FRONT ELEVATION

Figs. 86 & 87.

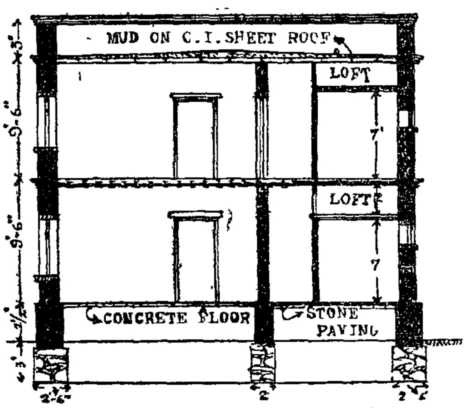
on the first floor. This may be optionally altered and the entrance may be made through the lobby on the ground floor with a landing in the verandah upstairs. This would save a door on the ground floor.

On the first floor there are three bedrooms a bathroom, with also a loft on its top, and a verandah. There is an independent passage to every bedroom through the lobby, and the front verandah and the bathroom are common and independently approachable from every bedroom.

The roof, which consists of a 6 inch cover of mud on top of corrugated iron sheets, is bound to remain cool, absolutely eak-proof, and free from the danger of being blown away by a storm. Not only the staircase, but also the posts, floor,



FIRST FLOOR



SECTION ON ABCD

Figs. 88-89.

ceiling are all of fire-proof material. In fact, no wood is used in the building except for the shutters (not even for frames) of doors and windows. The upper floor and the roof are supported on a framework of steel girders embedded in the walls, the white square dots shown in the walls on the plans denote their positions. All this makes the building so strong that with the usual attention to the annual maintenance, the building can be guaranteed to last at least 150 years.

Still, the cost of the building does not exceed Rs. 3255 in Bombay and should be much less in Northern and Southern India. This has been made possible only by adopting some of the measures of economy suggested in the foregoing pages. A reference to the detailed estimate attached is invited for verification of this fact.

IMPORTANT SPECIFICATIONS FOR PLAN NO. 5

Please refer to the specifications given for Plan No. 2 with the following addition :—

Item No. 6 Cement Concrete Blocks :—

These are to be cast *in situ* with concrete made of 5 parts of stone metal $2\frac{1}{2}$ parts of sand, and 1 of cement. In places where stone metal and sand are not available at a cheap rate, metal of over-burnt (vitrified) bricks may be used, or even whole vitrified bricks may be laid in cement mortar of 4 of sand and one of cement.

Items No. 7 and 31 Steel Framework :—

For posts which are to be embedded in walls and which, therefore, will get a lateral support on all sides, joists $4'' \times 1\frac{3}{4}''$ size weighing 5 lbs. per foot to be used. Elsewhere, i. e. in partition walls and at other places, where they are to have small or no support, $4'' \times 3''$ joists weighing 9 lbs. per running ft. to be used. The flanges of both the sorts of joists to be filled with cement concrete of 6 : 3 : 1 proportions. Vertical posts to be joined to the horizontal joists on their tops by means of an angle iron piece on one side bolted to both where the posts are embedded in wall and by means of two pieces on both sides in places where the posts will have no lateral supports. If the posts are crooked or bent they are to be straightened and tested for plumbness before concrete is filled in.

Item No. 8 Superstructure of burnt brick in lime facing and unburnt brick in Mud Backing :—

The burnt bricks to be kept immersed in water for two hours before being used. The lime mortar to be spread in a width of two inches from the face and the joint finished off neatly, straight and uniform in width and rubbed hard after 24 hours with a *nahila*. The face to be watered frequently for at least a week. The mud mortar to be used on the inside must be a little stiff.

Continued on page 131.

Abstract of Quantities and Cost of House in Plan No. 5.

No.	Name of Item	Quantity	Rate Rs. a.	Per unit	Amount
1	Excavation in average soil for foundations ...	cu. ft. 1295	0—12	cu. ft. 100	9·75
2	Filling foundations with rubble and boulders in mud ...	cu. ft. 971	5—0	"	48·55
3	Rubble in mud masonry for plinth including cement pointing on the exposed surface above ground ..	cu. ft. 1124	8—0	"	89·92
4	Damp proof course ...	sq. ft. 311	9—0	sq. ft. 100	28·00
5	Filling earth or *murum* upto plinth level ...	cu. ft. 1287	0—8		6·44
6	Cement concrete blocks below posts of rolled steel	cu. ft. 11	70—0	cu. ft. 100	7·70
7	Steel framework to be embedded in walls ...	cwts. 19·5	9—0		174·60
8	Superstructure of burnt brick in lime on the exposed face and sun-burnt bricks of same size in mud on the inner (*Jibbi* work) ...	cu. ft. 948	15—0		142·20
9	Partition walls of sundried bricks in mud ...	cu. ft. 235	3—0		7·05
10	4½ inch brick nogging in lime for partitions (*Dhujji* work) ..	sq. ft. 166	30—0		49·80
11	Doors of teak or salwood half glazed and half panelled and windows full glazed ...	sq. ft. 209	4-12		365·75
12	Light doors on the inner side ...	sq. ft. 51	0-12		38·25
13	Cupboards with wooden frame and light shutter ..	sq. ft. 45	1—0		45·0
14	R. C. C. lintels over doors and windows ...	44	1—0		44·0
	Total Carried Forward...				1047·01

No.	Name of Item	Quantity	Rate Rs. a.	Per unit.	Amount
	Total Brought Forward ...				1047·01
15	Flagstone paving on 3 inch lime concrete including cement pointing ...	sq. ft. 162	203-0	sq. ft. 100	32·40
16	Indian Patent stone floor ...	523 "	15—0	"	78·45
17	Cement plaster to walls ...	247 "	10—0		24·71
18	Mud plaster to walls ...	1536 "	3—0		46·08
19	Railing in verandah ...	12 Rft.	1—0		12 00
20	Loft for lumber ...	1 No.	10	each	10·00
21	Sink complete in kitchen ...	1 No.	6	"	6·00
22	*Nhani* trap and pipe in bath room ...	1 No.	2	"	2·00
23	Shelf with brackets ...	1 No.	4	"	4·00
24	Sets of pegs .	3 Nos.	1	"	3·00
25	Steps complete with brick work and stone paving on top...	Lump.			5·00
26	Suspended flooring on walls ...	sq. ft. 779	40	sq. ft. 100	311·60
27	White or buff wash 3 coats ..	1783	0—10	"	11·15
28	Oiling woodwork and painting ironwork ...	Lump.			10 00
29	Sunshades as per specifications ...	5	6	each	30·00
	Total cost of the Ground-Floor ...				1633·16
	say				1633 00
	FIRST FLOOR				
30	Fire-proof staircase as per specifications ...	15 steps.	5—8	per step	82·50
31	Rolled steel frame-work of posts and beams ...	cwts. 17—8	9—0	cwt.	160·50
32	Superstructure of burnt brick masonry in lime on face and sundried bricks in mud on inner surface ...	cft. 976	15	cu. ft. 100	146·25
	Total Carried Forward ...				389·25

Abstract of Quantities and Cost of House in Plan No. 5—(*Contd.*)

No.	Name of Item	Quantity	Rate Rs. a.	Per unit.	Amount
	Total Brought Forward ...				389·25
33	Partition walls of sundried bricks ...	cu. ft. 235	4—0	cu. ft. 100	9·40
34	4½ inch brick-nogging in lime (*Dhujji* work) ...	sq ft. 166	30—0	sq. ft. 100	49·80
35	Doors half glazed and half panelled and windows fully glazed complete with fixtures ...	sq. ft. 187	1-12	per sq. ft.	327·25
36	Light doors on the inner side ...	sq. ft. 51	0-12	per sq. ft.	38·25
37	Cupboards with light shutters ...	sq. ft. 45	1—0	per sq. ft.	45·00
38	R. C. C. lintels over doors windows and cupboards ...	cu. ft. 41	1—0	cu. ft.	41·00
39	Indian Patent stone floor (surfacing only) on lime concrete already laid ...	sq ft. 685	10—0	sq. ft. 100	68·50
40	Cement plaster to walls ...	sq. ft. 247	10—0	sq. ft. 100	24·70
41	Mud plaster to walls ..	sq ft. 1536	3—0	sq ft. 100	46·08
42	Railing in verandah ..	16 Rft.	1—0	Rft.	16·00
43	Loft above bathroom ...	1 No.	10—0	each	10·00
44	*Nhani* trap and pipe in bath room ...	1 No.	2—0	Lump	2·00
45	Sets of pegs ...	4 Nos.	1—0	each	4·00
	Total carrid Forward ...				1071·23

No.	Name of Item	Quantity	Rate Rs. a.	Per unit	Amount
	Total Brought Forward ...				1071·2
46	Roof of galvanised iron corrugated sheets on top of rolled steel joists with a covering of 6 inches of mud ..	sq. ft. 883	40—0	sq. ft. 100	353·20
47	Brick in lime string course below and above parapet wall ..	Rft. 238	0—3	Rft.	44·62
48	Parapet wall of brick in lime masonry cement pointed on the inner side ...	cu. ft. 274	25—0	cu. ft. 100	68·50
49	Lime plaster on the outer face of parapet wall ...	sq. ft. 366	7—0	sq ft. 100	25·62
50	Rain water spouts ..	6 Nos.	2—0	each	12·00
51	Sunshades for windows ...	5 Nos.	6—0	each	30·00
52	Oiling woodwork and painting ironwork ...	Lump			10·00
53	Bamboo *dhandies* hung below ceiling in passages for drying clothes, cudle hook, swing hooks etc. ..	Lump			5·00
					1620·17
	Cost of Ground Floor ...	1633			
	Cost of First Floor ..	1620			
	Total Cost ...	3253			
	Say Rs. ..	3255			

Measurement Schedule for Plan No. 5.

S. No.	Item	No.	Length	Breadth	Depth.	Quantity.	Total
			F. i.	F. i.	F. i.		
1	Excavation in average soil for foundations						
	Long walls ...	2	32 6	2 6	3	486·0	
	Short walls	2	24 6	2 6	3	367·5	
	Wall on the rear of verandah ...	1	10 0	2 6	3	75·0	
	do do side of do ...	1	3 6	2 6	3	26·2	
	Partition wall between Bed R. and Dr. R. ...	1	16 3	2 0	3	97 5	
	Partition wall between Bed R. and Kitchen ...	1	14 9	2 0	3	8·85	
	Partition wall between Dr. R. and Staircase ...	1	5 6	2 0	3	33·0	
	Partition wall between kitchen and bathroom ...	1	11 3	2 0	2	45·0	
	Partition wall round bathroom ...	1	10 0	2 0	2	40·0	
	Below steps ...	1	4 6	4 0	2	36 0	
	Total excavation in average soil ...					1295	cu. ft. 1295
2	Filling foundations with rubble and boulders in mud ...						
	Three-fourth of excavation in (Item 1) ..	1	1295		3/4	9 71/9 71	cu. ft.
	Total ..					971	971
3	Rubble stone in mud masonry for plinth including cement pointing on the exposed surface above ground level ...						

S. No.	Item.	No.	Length	Breadth	Depth	Quantity.	Total.
			F. i.	F. i.	F. i.		
	Long walls ...	2	32 0	2 0	3 3	416	
	Short walls ...	2	25 0	2 0	3 3	325	
	Wall on the rear of verandah...	1	10 0	2 0	3 3	65	
	do do side of do ...	1	5 3	2 0	3 3	34	
	Partition wall between Bed R. and Dr. R. ...	1	16 3	1 6	3 3	79	
	Partition wall between Bed R. and Kitchen ..	1	15 3	1 6	3 3	74 33	
	Partition wall between Dr. R. and Stairs ...	1	5 9	1 6	3 3	27·03	
	Partition wall between Kitchen and bath .	1	11 9	1 6	3 0	52·50	
	Partition wall round bath ...	1	9 3	1 6	3 0	41·50	
	Below steps ...	1	4 6	4 3	0 6	9·75	
						1124·1	
	Total ...					1124	cu ft. 1124
4	Damp proof course of 3/4 in. cement concrete and coal tar and sand above, through all the walls						
	Long walls ..	2	32	1 3		80·0	
	Short walls ...	2	25	1 3		62·5	
	Back wall of verandah...	1	10	1 3		12·5	
	Side wall of do ...	1	5 3	1 3		6·5	
	Wall between Bed R. and Dr. R. (central portion only.) ...	1	16 3	0 9		12·0	
	Wall between b~~e~~droom and kitchen ...	1	15 3	0 9		12·0	

Measurement Schedule for Plan No. 5—(*contd.*)

S No.	Item	No.	Length	Breadth	Depth	Quantity.	Total
			F. i.	F. i.	F. i.		
	Wall between Dr. R. and stairs partition only ...	1	5 9	0 9		4·5	
	Wall between Kitchen and bath partition only ...	1	11 9	0 6		6·0	
	Round bath ...	1	9 3	0 6		4·5	
	Total ...					200·5	sq. ft. 200
5	Filling earth or murum inside walls upto plinth ...						
	Bed room ...	1	15 3	11 9	2 6	450	
	Kitchen ...	1	10 3	11 9	2 6	300	
	Drawing room ...	1	14 3	11 3	2 6	240	
	Bath and the space opposite to it ...	1	4 3	11 9	2 6	125	
	Stairs room ...	1	8 9	5 3	2 6	110	
	Verandah ...	1	3 7½	6 7½	2 6	62	
	Total Filling ...					1287	1287 cu. ft.
6	Cement concrete blocks below posts of rolled steel joists for frame work in 15 inch walls ...	22	1 6	1 0	0 4	11	
	Total ...					11	11 cu. ft.
7	Rolled steel joists with cement concrete filled inside their flanges erected as posts of frame work in 15 inch walls including jointing ...	14	9	4'' 5 lbs.	1¾'' per ft.	630	
	do in partition walls or without wall supports ...	8	9	4'' 9·5	3'' or lbs. per ft.	674	

S. No.	Item	No.	Length	Breadth	Depth	Quantity	Total
			F. i.	F. i.	F. i.		
	Horizontal joists on top of vertical posts joined by pieces of angle iron complete with cement concrete between flanges, each 4'' × 1¾'' 5 lbs. per ft.	2 3 1 1	30 6 27 6 18 0 12 0	173.6'' 5 lbs. per ft.		867	
	Total Steelwork ...					2171	2171 lbs. or cwt. 19.
8	Superstructure of burnt brick in lime on the exposed face and sundried brick in mud on the inner face (jibbi work)						
	Side wall on left ...	1	31 3	1 3	9 0	351·5	
	do on right ..	1	25 3	1 3	9 0	284·0	
	Front wall of Dr. R. ..	1	16 9	1 3	9 0	184 0	
	Side wall of Verandah ...	1	6 0	1 3	9 0	67·5	
	Rear wall of do ...	1	8 9	1 3	9 0	96 0	
	do of kitchen and Bed R.	1	25 9	1 3	9 0	289·5	
	Total ...					1272·5	
	Deduct ...	3	3 0	1 3	7 6	84·4	
	(a) Doors ...	9	3 0	1 3	4 6	151·9	
	(b) Windows ...	4	2 0	1 3	2 0	10·0	
	(c) Cupboards ...	4	2 6	0 9	4 6	33·7	
	(d) Lintels						
	over doors ...	3	4 6	1 3	0 6	8·4	
	over windows ..	9	4 6	1 3	0 6	25·2	
	Cupboards ...	2	3 6	1 3	0 6	4·4	
		4	4 0	0 9	0 6	6 0	
	Total Deduction ...					324·0	

Measurement Schedule for Plan No. 5—(*contd.*)

S. No.	Item	No.	Length	Breadth	Depth	Quantity	Total
			F. i.	F. i.	F. i.		
	Total Superstructure Masonry ...					1272	
	Deduction ...					324	
	Net Superstructure Masonry.					948	Cuft. 948
9	Partition walls of sundried bricks between Dr. R. and Bed R. ...	1	15 6	0 9	9 0	105·7	
	do Bed R. & Kitchen ...	1	16 0	0 9	9 0	108·0	
	do Dr. R. and Stairs ...	1	6 6	0 9	9 0	43·9	
	Total ...					257 6	
	Deduct for Doors ...	2	2 6	0 9	6 0	22·5	
	Net Partition Wall Masonry ...					235·1	Cuft. 235
10	4½ in brick nogging in lime for partitions (*Dhujji* work) between Kitchen and bath ...	1	12 6		9 0	112·5	
	Round bathroom ...	1	11 6		7 0	80·5	
	Total Brick Nogging ...					193·0	
	Deduct Doors ...	1	2 6		6 0	15	
		1	2 0		6 0	12	
	Total Deduction ...					27	
	Net Brick Nogging ...					166	sq. ft. 166
11	Doors of teak or sal wood half glazed and half panelled						
	Front ...	3	3 0		7 6	67·5	
	Bathroom ...	1	2 0		6 0	12·0	

S. No.	Item	No.	Length	Breadth	Depth	Quantity	Total
			F. i.	F. i.	F. i.		
	Windows iron-barred and fully glazed complete with brass fixtures ...	9	3 0		4 6	121·5	
		2	2 0		2 0	8·0	
	Total Doors and Windows glazed ...					209	sq. ft. 209
12	Doors of light frames and light shutters complete with iron fixtures on the inner side ...	2	3 0		6 0	36	
		1	2 6		6 0	15	
	Total Light Doors ...					51	sq. ft. 51
13	Cupboards with wooden frames and light shutters complete ...	4	2 6		4 6	45	
	Total Cupboards ..					45	sq. ft. 45
14	R.C.C. lintels over doors, windows and cupboards as shown under deductions in Item 8 (d)	1				44	
	Total R. C. C. Lintels					44	Cuft. 44
15	Shahabad, Yerraguntla, Katni, or similar slab paving on 3 inch lime concrete including cement pointing	1	6 0	5 0		30	
	Bath room	1	10 0	6 0		60	
	Verandah	1	7 0	6 6		45	
	Passage	1	4 0	6 6		27	
	Total Paving ...					162	sq. ft. 162

Measurement Schedule for Plan No. 5—(*contd.*)

S. No.	Item	No.	Length	Breadth	Depth	Quantity	Total
			F. i.	F. i.	F. i.		
16	Indian Patent stone floor on 4 inch lime concrete						
	Drawing Room ...	1	15 6	12 0		186	
	Bedroom ...	1	16 0	12 6		200	
	Kitchen ...	1	11 0	12 6		137	
	Total Indian Patent Stone Flooring ...					523	sq. ft. 523
17	One inch cement plaster to walls for one foot skirting all round at bottom for fat proofing						
	Drawing room all round	1	55 0		1 0	55	
	Bedroom all round ...	1	57 0		1 0	57	
	Kitchen ..	1	47 0		1 0	47	
	Bath (also for water proofing) ...	1	22 0		3 0	66	
	Passage ...	1	15 0		1 0	15	
	Verandah ...	1	7 0		1 0	7	
	Total Cement Plaster ...					247	sq. ft. 247
18	Mud plaster to walls on the inner side						
	Drawing Room all round	1	55 0		8 0	440	
	Bedroom do	1	57 0		8 0	456	
	Kitchen do	1	47 0		8 0	376	
	Bath do	1	22 0		4 0	88	
	Passage do	1	15 0		8 0	120	
	Verandah do	1	7 0		8 0	56	
	Total Mud Plaster ...					1536	sq. ft. 1536
19	Railing in Verandah	1	12			12	
	Total Railing ...					12	R. ft. 12

S. No.	Item	No.	Length	Breadth	Depth	Quantity	Total
			F. i.	F. i.	F. i.		
20	Loft above bathroom 6×5×2′ high ...	No. 1				1	No. 1
21	Sink, in Kitchen with paving, pipe, parapets and cement plaster on sides complete with nhani trap	No 1					
22	Nhani trap and pipe in bathroom ...	No. 1				1	No. 1
23	Shelf with brackets in Kitchen ...	No. 1				1	No. 1
24	Sets of pegs ...	Nos 3				3	No. 3
25	Steps complete with brick bats set in lime, with 1½ inch flag stone paving on top, of rounded edges projecting ½ inch ...	Lump					No. 1
26	Suspended flooring of 4″×1¾″ steel joists 5 lbs. per foot length laid as detailed in the specifications ...	1	27 0	30 0		810	
	Total ...					810	
	Deduct for Staircase Wall	1	3 0	7 6		22·5	
		1	3 0	3 0		9 0	
	Total deduction ..					31·5	
	Net Suspended Flooring					779	sq. ft. 779
27	White or buff washing 3 coats on the plastered surface (Items 17 & 18 together.)					1783	sq. ft. 1783
28	Oiling wood-work, painting iron-work ..	Lump					No. 1

Measurement Schedule for Plan No. 5—(*Contd.*)

S. No.	Item	No.	Length	Breadth	Depth	Quantity	Total
			F. i.	F. i.	F. i.		
29	Sunshades for windows ...	No. 5					No. 5
	FIRST-FLOOR						
30	Fire proof staircase complete as per specifications ..	Steps 15				15	No. 15
	Total Steps ...						
31	Rolled steel joists for frame work. Posts in 15 in. walls as on ground floor ..	14	4″ × 9 ×	1¾″ 5 lbs. per ft.		630	
	Do. in partitions or without wall supports,	6	4″ × 9 ×	3″ 9·5lbs. per ft.		505	
	Horizontal joists 4″ × 1¾″ on top as on ground floor					867	lbs. 2002 or 17·8 cwts.
	Total steel frame work ...					2002	
32	Superstructure of burnt bricks in lime on outer face and kacha bricks of same size in mud on the inner ...						
	The same on ground floor ...					1272·5	

No.	Item	No.	Length	Breadth	Depth	Quantity	Total
			F. i.	F. i.	F. i.		
	Deduction. The same as on the ground floor. Viz. 324 Cft. less 28 Cft. for one door less in the rear wall of verandah ...						
	Total deduction ...					296	
	Net Superstructure masonry .					976	976 Dft.
33	Partition walls of sun-dried bricks						
	The same net quantity as on the ground floor, 4½ in. brick nogging ..						235 Cft.
34	Same as on ground floor						sq. ft. 166
35	Doors half glazed and half panelled and windows fully glazed-one door less than on the G. F. 209-22					187	sq. ft. 187
36	Light doors on inner side complete with iron fixtures—same as on G.F.					51	51 sq. ft.
37	Cupboards with wooden frames and light shutters-same as on the G. F. .					45	45 sq. ft.
38	Lintels of R. C. C. as on G. F. less for one door ..					41	41 Cft.

Measurement Schedule Plan for No. 5—(*Contd*)

S. No.	Item	No.	Length	Breadth	Depth	Quantity	Total
			F. i.	F. i.	F. i.		
39	Indian Patent stone flooring-the same as for items 15+16 on the ground floor estimate .. (32+523)					685	sq. ft. 685
40	Cement plaster to walls same as on the G. F.					247	sq. ft. 247
41	Mud plaster same as on G. F. ...					1536	sq. ft. 1536
42	Railing in Verandah ...	1 1	10 0 6 0			10 6	
	Total Railing ...					16	16 Rft.
43	Loft above bath room ...	1				1	No. 1
44	Nhani trap and pipe in bath-room ...	1				1	No. 1
45	Sets of pegs ...	4				4	No. 4
46	Roof of G. I. sheets 26 B. W. G. fixed flat on top of steel joists $4'' \times 1\frac{3}{4}'' \times 5$ lbs. laid 2 ft. apart with 6 inch covering of mud of white earth. ..	1	31 3	28 3		883	
	Total Roof ...					883	sq ft. 883.

S. No.	Item	No.	Length	Breadth	Depth	Quantity	Total
			F. i.	F. i.	F. i.		
47	Brick in lime string course all round below and above parapet wall ...	2× 119				238	Rft. 238
48	Parapet wall of burnt brick in lime cement pointed on inside ...	2 2	31 3 29 9	0 9 0 9	3 3	140·5 133·5	
	Total ...					274	274 Cft.
49	Lime plaster on the outer face including cornices ...	2 2	31 3 29 9		3 3	187·5 178·5	
	Total ...					366	sq ft 366
50	Rain water spouts ...	No. 6				6	Nos. 6
51	Sunshades for window ...	No. 5				5	No. 5
52	Oiling woodwork and painting exposed steel work ...	1	Lump				No. 1
53	Dhandies of bamboos for drying clothes, cradle hook, swing hooks etc. ...	Lump				Lump Lump	No. 1 No. 1

(*Continued from page 122*)

Item No. 26. Suspended Flooring :—

This is to consist of $4'' \times 1\frac{3}{4}''$ steel joists weighing 5 lbs. per ft. laid from left to right in one piece each i. e. of 27 ft. length on top of the bedroom and kitchen and bath as far as the partition wall and its continuation between the bedroom and drawing room. In the remaining portion, they are to be laid at right angles to those previously laid, i. e., from the central partition wall to the front wall, leaving an open space for the staircase well.

In the one ft. space between the two adjacent joists square flooring tiles $12'' \times 12'' \times 2''$ thick or any kind of flagstone slabs $1\frac{1}{2}''$ thick should be inserted from one end and the joints pointed with cement. The space above the slabs to be filled with either *murum*, brickbats or any other similar stuff not liable to decay, and rammed well. It is desirable to give two coats of coal-tar or oil paint to the joists previously.

If either tiles or any sort of flagstone slabs are not available at cheap rate, pieces of waste timber planed on the lower side one ft. long may be inserted from one end. They must be one inch thick at the thinnest side.

Item No. 30. Fire-proof Staircase :—

Please see pages 142 and 143.

Item No. 45. Roof of G. I. sheets on top of rolled steel joists with 6 inch covering of mud :—

The joists to be laid at 2 ft. distance c. to c. and to be given the inclination according to the local practice (usually $\frac{1}{4}''$ per ft.) from the central ridge towards both right and left sides and the corrugated sheets to be simply laid on them. They need not be fixed to the joists as the weight of the earth above them will hold them in position. Only a ridge capping is necessary. Two coats of coal-tar to be applied to them and then earth in the form of stiff mud to be spread in a layer of 6 inches and rammed hard. When dry, the surface to be leeped with sodiumised clay or at least white earth, cow-dung, and cement mixed in the proportions of 12 : 4 : 1 respectively.

Plan No. 6

Plinth Area 2704 Sq. Ft.] [Cost Rs. 7000

This plan is rather on a pretentious scale. It is given here not so much as an example of economy but to illustrate the principle that well conceived simplicity and attention to details in the internal arrangements are the key-note of a good design which makes for the comforts of a real home.

The delightful semi-circular front verandah enjoys a vista and breeze from three directions. On the left side there is a guest room with the modern necessary convenience of a bathroom attached to it. The drawing room is located in the heart of the house and occupies the spacious square room. On the right hand side there is a large verandah 11 ft. wide including the space occupied by the stairway. This verandah may, if necessary, be partly enclosed and a small study room formed out of it. The kitchen with ample cupboard space and two windows is compact and convenient and the additional feature of a smoke outlet in a corner adds much to its value. In front of the kitchen and behind the drawing room is placed the

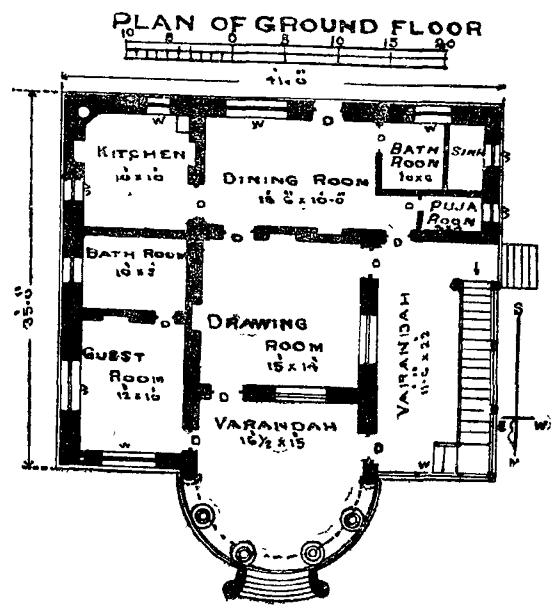
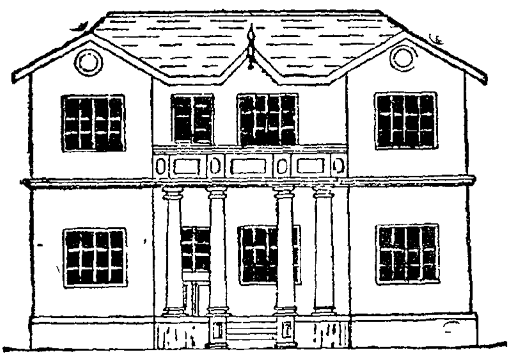


Fig. 90

commodious dining room and the right hand corner is occupied by a bathroom of convenient size. The small space between the bathroom and the verandah is enclosed and formed into a small *Puja* or Prayer room. Removed away from the hubub of the rest of the house, this small corner will not fail to give that Pleasure and peace of mind which the religious-minded person longs to seek in solitude in this materialistic world.

For reaching the dining room the guest need not pass through the drawing room, but through the verandah on the left side and enter through the door near the *Puja* room. If a separate bathroom is not required to be attached to the guest room, it would be an excellent plan to



FRONT ELEVATION

Fig. 91

turn it into a store room for the kitchen. All that is necessary for this is to close the door communicating with the guest room and open another in the wall between the kitchen and the store room.

The staircase is wide and easy to climb and all built of fire-proof material. Upstairs there are three bedrooms, the special feature of which is that each enjoys free breeze from three sides and that the small bathroom can be entered independently from every bedroom through the lobby, and further that the verandah and open terrace also can be made use of by the occupiers of the bedrooms quite independently.

PLAN OF FIRST FLOOR

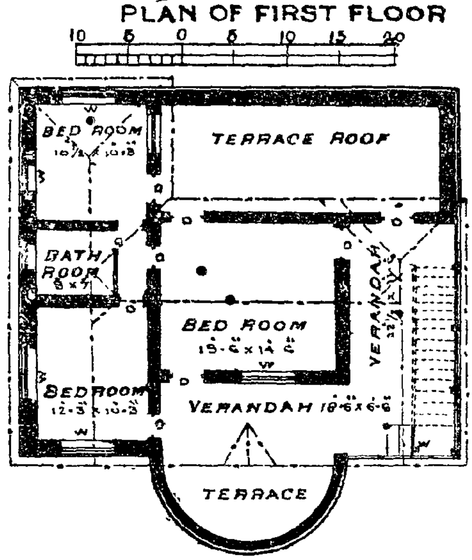


Fig. 92

If a small bed or study room is built on the right hand side of the open terrace on the rear side it would be open on all four sides.

If the same arrangement of rooms as on the ground floor is made upstairs and the latter flat let as a separate tenement the independent entrance to the staircase on the left hand side would admit even of this.

And with all these conveniences and special features the cost in an up-country town for a solid structure of stone or brick-in-lime walls, paving of Indian Patent stone floor in the entire house, R. C. C. suspended flooring, R. C. C. round posts in the front verandah, fully glazed doors and windows, Mangalore tiled roof etc. the cost does not exceed Rs. 7000.

Thus, this cottage rightly combines symmetry, simplicity, dignity, comfort and economy all in one. This is actually

Fig. 93

built at Nasik in the Bombay Presidency on the Bombay Agra Road, with a slight alteration in the roof. Fig. 93 shows a photographic view of the same.

More Practical Suggestions & Hints for Economy

(1) Cutting up timber by departmental agency should not be attempted by laymen, as it is a risky business. The purchase of logs requires experience. Then, the sawing requires experience, care, and constant supervision. The waste timber obtained cannot be economically utilised on such a small building work in hand and thus forms a cumbersome heap which ultimately fetches no more than its fuel value. Besides, for want of getting scantlings of the proper size in time the progress of work is hindered.

(2) When the work is small, and particularly of the nature of repairs it is often cheaper and more convenient to use a mixture of 7 or even 8 parts of sand to 1 of cement instead of lime mortar.

(3) Even in places where excellent stone is available at a cheap rate, cut stone steps prove to be a very costly item Unless finely dressed they do not present a neat appearance and dressing costs a good deal. Instead of this, if steps are roughly formed of lime concrete, brick or rubble masonry in lime, and flat flagstones with edges rounded in the front, are laid on their top, they are not only cheaper but also look clean and equally well, if not better.

(4) Verandahs and passages should, as far as possible, be paved with stone slabs, so also the door sills, if the floor is to be of *murum* or mud. These places are subject to considerable wear.

(5) The economical stock sizes of steel joists are 4″ by $1\frac{3}{4}$″ or $4\frac{3}{4}$″ by $1\frac{3}{4}$″ and if one dimension of rooms is kept 12 to 13 ft., great economy is caused by their use for upper flooring. Similarly, the stock size

of timber scantling is 6 ft. length. If the sizes of windows and cupboards are limited to that length, considerable economy results.

(6) Except, perhaps, in the exposed situations, wood should not be painted, as the paint has to be renewed at frequent intervals at great cost, and if it is not done in time the appearance looks shabby. Instead of this, if it is coated with some cheap mixture, such as Solignum or Ceaserot or simple lineseed oil and coal-tar boiled together and mixed in kerosene oil, to form a paint of dark colour, its appearance can be preserved for a long period very cheaply by occasionally wiping the surface with a rag dipped into kerosene oil.

(7) Painting and varnishing done in wet weather is useless. It should always be done in the hot weather.

(8) Lead paints are cheaper and better for iron work. Zinc paints are not spoiled by the action of smoke. At the most, washing the surface with a solution of washing soda gives it the appearance of freshness.

Check List of Questions on Health & Safety

Please see if you could answer these questions satisfactorily for the preservation of health and safety of your family.

(1) What is the average number of persons per bedroom?*

(2) Is there sufficient cross and through ventilation in the house particularly in the bedrooms? (Vide page 234).

(3) Does sunlight enter every room of the house particularly in kitchen and bedrooms in some part of the day or other?

(4) Is there any damp or mouldy odour anywhere in the house? If so, have you taken immediate steps to find out the cause and remove it?

(5) If there be a basement floor or a cellar, are there facilities of draining it?

(6) In what condition is the privy? Has it a water-tight floor and efficient provision of excluding flies?

(7) Is there any pool of stagnant water near the premises? If so, have you closed it? If it be not possible to do so, do you frequently put kerosene or crude oil so as to keep the surface of water always covered with its film?

(8) Do you, at frequent regular intervals, inspect the premises occupied and used by your servants, particularly the places where cooking utensils are burnished, to see that they are at all times kept clean?

(9) Do you frequently inspect open drains to see that they are not choked?

Food

(10) Is the floor of the kitchen made of some smooth and water-tight material, such as cement concrete or polished slabs or tiles laid with joints in cement, so that any soft food spilled may be scrubbed and washed.

(11) Have you provided a bin in kitchen, with a tight lid, for collecting garbage, food crumbs etc., and are persons working in the kitchen trained to wrap garbage and waste food in paper before it is thrown into them, so that it should not stick to the bottom and sides of the bin.

* The standard in England is 2·5 adults per bedroom, a child under ten being counted as half an adult.

Is the bin regularly emptied at least twice a day, scrubbed and washed ?

(12) How is the garbage disposed of ? Is it thrown into municipal bin, or if there be no municipality, thrown into covered manure pit away from home, or better still, burnt in an incinerator or on open ground away from the house ?

(13) Are food-stuffs kept covered from dust and other contamination ?

(14) Are fruits and perishable vegetables stored in well-ventilated cupboards provided with shutters of fine mesh wire gauze so as to exclude knats and mosquitoes ?

(15) Are milk, curds, butter and other dairy products stored in portable cupboards of fine mesh wire gauze sides or in wall cupboards with fine wire gauze shutters and air bricks on the back ?

(16) Is the cook careful to wash his or her hands before starting work and frequently afterwards during the process of cooking ?

(17) Are persons handling food particular about body cleanliness and personal hygiene ?

(18) Do you see that no dirty dishes are allowed to stand in sinks and cupboards.

(19) Are *chullas*, sinks, table tops, shelves and minor tools and equipment such as choppers, cutters, grinders, graters, egg-beaters, butter-churners, and the like washed thoroughly every time after their use ?

(20) Do you take care to wash green leafy vegetables in a solution of potassium permanganate before they are eaten as uncooked salads ?

Personal Hygiene

(21) Have all the members of the family including young children, been trained to brush and wash their teeth twice a day—first in the morning before any food or drink is taken and last at night before going to bed ?

(22) Have they all been trained to wash their hands before touching any food or other eatable things ?

(23) Are they using their individual towels and tooth brushes ?

(24) If an individual contracts eczema, itch, ring worm or other communicable disease is he or she careful to use his or her individual soap, towel, *dhoties*, or saries etc., and act in such a way as the disease would not spread to other members of the family ?

Safety in Homes

(25) Is the staircase of fire-proof material ? If not, are there sufficient number of exits for fire-escapes provided on each floor and are they at all times, kept free of boxes and lumber ?

(26) Do you periodically inspect the building and see that as a result of earth movements or uneven settlement of foundations no wall or part of a wall is inclined out of the plumb line, also see that no timber used in the building, particularly in positions of posts, beams, rafters etc., is attacked by white ants or dry rot ? (Vide page 22).

(27) If there is piped gas supply for cooking and lighting, do you frequently make yourself sure that no pipe or equipment is leaking ?

(28) Are poisons, loaded fire arms and other dangerous materials safely stored so that there is no chance of any danger left from them ?

(29) If the home is wired for electricity, are fuses and other safety devices provided to eliminate fire accidents ?

(30) Are the railings and parapet walls in galleries and roof terraces of sufficient height and of sufficiently small openings so that children may not easily climb over or fall through ?

APPENDIX No. 1

A Note on Clays Impervious to Water

There are four main types of soil which occupy the major part of India. They are :—(1) Alluvium, which covers an extensive area of the Indo-Gangetic Plain in Nothern India, and in Sind. (2) Black cotton soil or "Regur". (3) The black or red soils overlying the metamorphic rocks of Madras, and (4) The laterite soils which occupy the coastal parts of the Sahyadri and occur also at many places in Southern and Central India and the United Provinces.

Between these there are innumerable minor varieties caused by local conditions. Thus, though alluvium is yellow loam, in many parts it is sandy or even clayey, the latter is generally pink and sometimes even bluish green in colour. The stickiness of the clayey soils is due to the high percentage of alumina and iron they contain, and the impermeability of the soils is due to the alkali bases present in them, especially in the form of sodium.

Generally speaking all the varieties are alkaline in reaction. Exceptions to these may be found in certain small areas, where the rainfall is high and wind fierce. For instance, in Assam and in the Konkan of the Deccan the soil is distinctly acidic in character. The alkalinity is due to the presence of a strong alkali base, and comparatively a weak radical. The acid soils contain a high proportion of hydrogen ions, and the alkaline soils, that of hydroxyl ions. The bases in soils are either calcium, magnesium, potassium, or sodium. Of these calcium and magnesium bases tend to make the soil loose, and those of potassium and sodium, especially the latter, impervious.

The object in making the earth suitable for building purpose is just the opposite of what it is in making it fit for agriculture. For the latter we try to reduce alkalinity by mixing certain materials, whereas, for building purposes our aim is to render a neutral soil, alkaline by adding certain suitable soils to it. Both these are rendered possible on account of a certain chemical affinity which exists between a soil and a salt solution, viz.

When soils are brought in contact with solutions of salts, a chemical reaction takes place and the bases are mutually exchanged.

This phenomenon is called the Exchange of Bases.

Thus it is possible to reduce a soil containing a preponderence of a certain base to another of any other base. For agricultural purposes, soils containing potassium or sodium bases, which make them stiff, are sought to be reduced to those of calcium base, as the latter makes them more or less loose and porous. On the other hand the object to be aimed at, when rendering earth suitable for building purposes, is to displace other bases in a soil by sodium base, so as to make it impervious to water, or to "sodiumise" it, to speak in technical terms.

It is evident that it is comparatively easy to sodiumise a soil which is agriculturally poor, for, it already contains some sodium salts. In order to understand the exact chemical action involved, suppose we have got handy and in abundance a soil containing calcium as the base. When we treat a sample of this soil with solution of common salt (which contains sodium) what happens is this :—

$$\text{Ca-Clay} + 2Na_2Cl_2 \rightleftarrows CaCl_2 + 2\text{Na-Clay}^* \ldots\ldots(1)$$

We get calcium chloride and sodium clay. Instead of treating the soil with solution of common salt (sodium chloride), suppose we do so with sodium sulphate (Na_2SO_4), still the same result is obtained as far as sodium and calcium clays are concerned :—

$$\text{Ca-Clay} + Na_2SO_4 \rightleftarrows CaSO_4 + 2\text{Na-Clay} \ldots\ldots(2)$$

Sodium clay is produced again. That is, the original calcium base of the soil is turned into sodium base.

Now sodium clay, in presence of water hydrolyses producing hydroxyl ions of sodium

* This as well as the equation on the next page, are not strictly correct. The valency of clay is not definitely fixed. Besides, this is not a definite chemical change but a physico-chemical one.

(NaOH) which cause alkalinity. The chemical equation for this is :—

$$Na\text{-}Clay + H_2O = NaOH + H\text{-}Clay \ldots\ldots(3)$$

Even a trace of NaOH tends to render the soil impervious to water. The sodium clay formed has its particles highly dispersed; they remain for a long time in suspension in water, and thus make the soil sticky and impervious. This is entirely due to the high electrokinetic potential of Na–Clay which is $1\frac{1}{2}$ times that for the calcium clay.

The free sodium hydroxide (NaOH) renders the soil impervious to water and under suitable circumstances it further reacts on the aluminium hydroxide if present and forms sodium aluminate. When this happens, the aluminium hydroxide precipitates in a gelatinous condition and further helps to make the soil impervious to water.

Thus, when salts of sodium are mixed with any soil, and water is added to it, in course of time NaOH (sodium hydroxide) is formed which is responsible for causing the imperviousness.

The soil inside, and in the neighbourhood of village sites contains a lot of sodium salts, but it also contains potassium salts in the form of nitre (KNO_3) as a result of accumulation on it, of nitrogenous matter, such as urine, excreta etc., for a number of years. In fact, this nitre lends the white colour to it. When this 'white earth' comes in contact with rain water, for instance on the top of mud roofs, the potassium salts, are leached out especially from the surface, and the latter soon automatically becomes impervious and prevents penetration of water. The same thing happens, when water is mixed with such white earth, that is, most of the potassium salts are leached out and the sodium salts which remain in preponderence, impart impermeability to it.

One often sees that this white earth or *Khari Mitti* used for roofing or other purposes detoriorates in course of time. The reason is, that rain water, particularly in the beginning of monsoon, is charged with carbon-dioxide from the atmosphere dissolved in it. When white earth in position such as that on the top of mud roofs, is long exposed to such rain, the CO_2 dissolved in the rain-water, forms with the Na-salts in the earth, sodium-bicarbonate ($NaHCO_3$) by the reaction :—

$$H_2O + CO_2 = H_2CO_3 \ldots\ldots(4)$$

$$Na\text{-}Clay + H_2CO_3 = H\text{-}Clay + NaHCO_3 \ldots\ldots(5)$$

When this takes place Na is easily removed from the soil in the form of bicarbonate of soda, and the alkalinity and with it the imperviousness begin to disappear, because the process of hydrolysis is suppressed and free alkali is no more produced. In such circumstances, in order to render the roofing earth again impervious, the remedy is to mix fresh sodium salts with it and leach them out. It has been observed after experiments that when the concentration of Na–salts is 0·6 p. c. optimum impermeability to water is obtained. Further concentration than this tends to prevent hydrolysis of Na—Clay and reduce its impermeability.

APPENDIX 2

Duties of a House-Holder for Preventing or Fighting an Epidemic

If, in the centres called "Home", the foundations of health are laid, the task of Government and Local Bodies would at once be simplified. 'If the houses are taken care of", says the 'Sanitarian, "the towns will take care of themselves". If this were to take place, there would be no necessity of legislative acts in respect of sanitation to be enforced. But unfortunately in India, the ignorance even of the fundamental principles of hygiene, coupled with prejudices, peculiar religious and social customs, and domestic habits, so ingrained in the course of ages, as to become innate and form an integral part of the life of the individual and the community to which he belongs, come in the way and cause him to offer a passive resistance to any sanitary measure. What is required is the establishment of sanitary associations in every village and town to make co-ordinated strenuous efforts, (in co-operation with the Local Bodies), by every possible means to impress on the people the necessity of observing sanitary precautions with the ultimate object of gradually creating a desire on their part for healthier surroundings. The sense of responsibility must be developed; the inspiration must come from within. Then and then only would it be easy to keep under control or altogether stamp out any infectious disease before it gets time and opportunity to spread out in an epedemic form.

In order to be able to do this efficiently, one must understand intelligently how such infectious diseases are caused and spread, how they should be recognised, and what precautions must be taken and what dangers must be guarded against, to prevent their extension to the other members of the family and the community at large. With this object in view it is proposed to give a few brief notes on the principal diseases communicable from man to man.

Cholera

Symptoms :—Profuse purging and vomiting of an almost colourless slightly whitish watery material; muscular cramps, especially in legs; suppression of urine: hollow sunken eyes; anxious look, and collapse. The onset of disease is sudden, and the symptoms very severe, from which the disease can at once be recognised. Time is an important factor in saving a life, and the prompt recognition of the symptoms is therefore extremely important.

Origin :—The poison consists of very very minute living organisms which enter the intestines and multiply there. A person can be attacked by cholera *only if he swallows these organisms* either with food or drink.

Mode of Spread:—(a) Water in a river, tank, or well is infected by washing of anything, such as hands clothes, utensils etc., infected by the living organisms. (b) Food including milk is infected by flies sitting on it, after they have settled previously on discharges of a cholera-infected person, or by the handling of it by hands or in utensils soiled by such discharges even in microscopically small quantities.

Prevention :—(a) Personal Prophylaxis :— Never drink water which is not previously boiled or sterilised in any other way. Observe this strictly even in the use of water for washing vessels and washing vegetables to be used in an uncooked state.

Avoid foods that may cause indigestion. Do not use stale food which is likely to be in a state of decomposition. Food-stuffs in a hot state are least likely to be contaminated by flies.

Avoid too much fruit when an epidemic is likely to break out, avoid especially both unripe and over-ripe fruit, avoid *shirbets* of all descriptions. The digestive juice of a healthy stomach is slightly acidic which destroys the germs of cholera. Eating too much fruit or unripe or over-ripe ones tends to make it alkaline and to destroy this resisting power.

Avoid even aerated waters unless they are carefully prepared at home. Soda water, unless allowed to stand for 3/4 days after it is manufactured, does not destroy germs of cholera, and it is doubtful if it does so even afterwards.

Avoid purgatives, particularly salines. The fact that a purgative was taken easily makes the symtoms of cholera, and the doctor may be easily deceived and valuable time lost for administering prompt treatment. Such cases are by no means uncommon and hence this emphasis.

Keep the surroundings scrupulously clean.

Get yourself and all the members of your family inoculated with cholera vaccine, or take anti-cholera Bilevaccine pills and 2 or 3 drops (only 2 or 3 and no more) of camphor oil to obtain immunity.

If there is a well in the compound of the house for supplying drinking water, sterilise its water in some suitable way.

Notify at the earliest opportunity to the Local Authority and isolate the patient even if it be in a separate room of the same house.

Disinfect every thing connected with the patient, including discharges, clothing, utensils, such as plates, cups, etc.

Let only one person attend on the patient at a time and he or she must wash his or her hands with carbolic soap before touching anything outside the patient's room.

As soon as an attack is suspected, get a doctor to treat the patient AT ONCE. Time is very valuable.

Plague

Symptoms—Slight shivering, strong headache and restlessness followed by a sudden advent of fever; blood-shot eyes, vacant look; the patient walks and talks like a drunken man.

In the pneumonic variety the lungs are seriously affected, and there is no glandular swelling. This variety, though rare, proves generally fatal. In the bubonic plague the glands or buboes appear in 1 to 5 days and are very painful.

Origin and *Mode of Spread* :—The following are some of the important conclusions of the Plague Commission :—

1. Bubonic plague in man is entirely dependent on the rat.

2. Pneumonic plague is highly infectious. It is, however, rare (3 p. c. of all the cases).

3. Infection is conveyed from rat to rat, and from rat to man *solely* by means of the rat-flea.

4. A case of bubonic plague in man is not in itself infectious.

The fleas attack rats first, but when they are deprived of their food by the death of rats they attack man. For this reason, one generally hears that rats die first of plague, and after an interval man is attacked.

Prevention :—Prevention and destruction of rats is therefore the only effective remedy. The measures to be adopted must be all directed towards this.

They are :—

(*a*) The building should be rat-proof and rat-free.

(*b*) Relieve over-crowding not only of men but also of lumber which favours the harbouring of rats.

(*c*) Destroy the rats either by poisoning or better still, by trapping.

(*d*) Disinfect the house by means of kerosene emulsion (see page 260) which is an excellent flea-destroyer.

(*e*) Keep the house and premises clean. Accumulation of rubbish provides food and shelter for rats.

(*f*) Get yourself and every member of your family inoculated with plague vaccine or take anti-plague Bilevaccine pills.

Enteric Fever or Typhoid

Symptoms:—This is rather a difficult disease to diagnose, even for a medical man, in the beginning. In a typical case the temperature during the first week is continuous and gradually rises to the maximum (103° to 105°) with diurnal remissions. During the second week it remains continuously high with slight diurnal remissions. During the third week the remissions are more marked. In the fourth week first the morning and then the evening temperature becomes normal. Convalescence is said to be established when the evening temperature is normal for two successive days.

Some diarrhoea is usually present with distension of stomach from the second week, and the stools are yellowish green. The tongue is coated and the eyes are bright and lustrous.

Origin :—The disease is caused by specific micro-organisms which infect the intestines, where they multiply and pass through the excreta and urine.

Mode of Infection :—The most common sources are (a) water, (b) milk and food and (c) flies and dust. The drinking water-supply is often contaminated by sewage, sometimes the excremental matter of a typhoid patient finds its way to wells, tanks, and rivers either directly or indirectly through soiled linen, vessels, etc., washed in or near them. Milk is infected by contaminated water directly or indirectly, or by flies alternately sitting on them and on the discharges of typhoid patients. It is also spread by flies and dust settling on slices of melons, *papais* etc., or sweets exposed to air. The last one is common near schools, bazaars, railway platforms etc.

Preventive Measures :—(1) Boilng of all water used directly for drinking or indirectly for buttermilk, rinsing utensils, and washing vegetables to be used uncooked. (2) Avoiding bazaar-made sweets and cut slices of fruit. This must be enforced in the case of school children during recess hours in particular. (3) Inoculation with anti-typhoid serum or the use of Bilevaccine pills, which give immunity for a year. (4) Disinfection of all clothing and articles used by the sick. (5) Disinfection of all discharges of the invalid. They should be first mixed with a disinfectant and then buried on an open ground under at least six inches of dry earth. The discharges of the patient even in the convalescent state contain germs of typhoid. (6) The attendant must keep his or her hands scrupulously clean, especially before taking or serving food, milk etc.

Small Pox

Symptoms :—A sudden onset of high fever with severe head-ache and a severe pain in the back and a flushed face. With characteristic eruption, which appears on the third day, first on the face and the wrists, the fever goes down. It is distinguished from measles by the absence of the catarrh of the nose, eyes, and lungs, which is very marked in measles. In the latter, again, the rash appears on the fourth day with it the temperature *rises*.

It is one of the most contagious diseases. The danger of infection is the greatest when the scales or scabs begin to fall off, and are carried by wind and flies etc.

Preventive Measures :—(1) Vaccination with a fresh serum, and revaccination afterwards every seventh year. (2) Rigid isolation of the patient. (3) Thorough disinfection of all discharges even of those from the nose and the mouth. Their collection on a piece of cloth and the burning of the latter is the best way. (4) Anointing the patient with carbolised oil and giving him after recovery one or two hot baths, with the whole body scrubbed well with carbolic soap before he is allowed to mix with other people.

Malaria

This disease is too well known to need any description. It is essentially a disease of the middle and poor classes ; because the latter do not get nourishing food, nor warm clothing and mosquito nets, nor do they afford to undergo the necessary prolonged treatment with rest, which the disease demands. On account of its very common prevalence, particularly amongst the poor population of the rural districts, it does not attract so much attention and cause a sensation as do the other spectacularly prominent diseases like cholera and plague, but when its far-reaching evil effects are considered, it is no exaggeration to say that it is by far the greatest destroyer of the human race.

It saps the vigour, lowers the vitality and makes the community unfit for the battle of life. It not only increases the death rate, but it also lowers the birth rate. It disorganises labour and seriously interferes with agriculture and commerce. It is estimated that it is responsible for over one million deaths per annum in India.

Symptoms :—There is invariably an attack of shivering followed by fever. If the latter be high there is a strong head-ache. The fever lasts for a few hours or sometimes even a day or two and it subsides with profuse perspiration. The subsequent attacks may come daily on alternate days, every third or fourth day, or irregularly at intervals. In course of time the spleen is enlarged, digestion is impaired, and the person affected loses power of resistance to diseases and falls an easy prey to them.

Origin:—The disease is caused by particular germs which live on blood and multiply in it. They are sucked by the mosquito with the blood of the affected person and when it bites another person in turn, the germs are injected into the blood of the latter. Thus the disease goes on spreading from man to man solely through the agency of the mosquito.

There are two varieties of mosquitoes. (1) Culex and (2) Anopheles. The former may disturb one's sleep, but is harmless as far as the propagation of the malarial fever is concerned. It is the latter which carries germs of Malaria. The process of breeding of both the varieties is the same, viz. the eggs are laid in a warm place on, or mostly near, the surface of water; in two or more days they are hatched and the larvæ come out. The latter dive in water feeding on other insects in the water. They come to surface for breathing air. After a week the larva becomes pupa which mostly remains on the surface. After two or more days the skin of the pupa cracks and the adult mosquito emerges. The male feeds on plant and fruit juice but the female sucks blood of some animals including man, and goes to a water surface only for the purpose of laying eggs once in three or four days.

Prevention;—There are three ways of prevention. (1) Preventing mosquito breeding, (2) Destroying mosquitoes, (3) Protecting oneself from their attack.

The first is by far the most efficient. In order that the effort may be directed in the proper way in destroying the malaria–carrying mosquitoes, namely, Anopheles, without wasting it in killing the harmless ones viz. the Culex, it is necessary to distinguish between the two varieties correctly. The following are the features which distinguish them.

Anopheles

(1) Wings spotted black and white.

(2) The anopheles sits straight making a definite angle with the wall surface as shown in Fig. No. 94.

Fig. 94.
Anopheles

(3) The larvæ of the anopheles float immediately below water surface in a position parallel to it, as shown in Fig. 96.

(4) When moving from its place the anopheles larva darts suddenly with a jerk.

(5) The anopheles lives only in clear water, and moves out and bites mostly by night.

Culex.

(1) Wings not spotted.

(2) The culex sits in a hunch-backed position with the head and tail thrown down and back raised as shown in Fig. 95.

Fig. 95.
Culex

(3) The larvæ of the culex float much below the surface with the head hanging down as shown in Fig. 97.

(4) The larva of the culex propels slowly.

(5) The culex lives in dirty water and bites at any time.

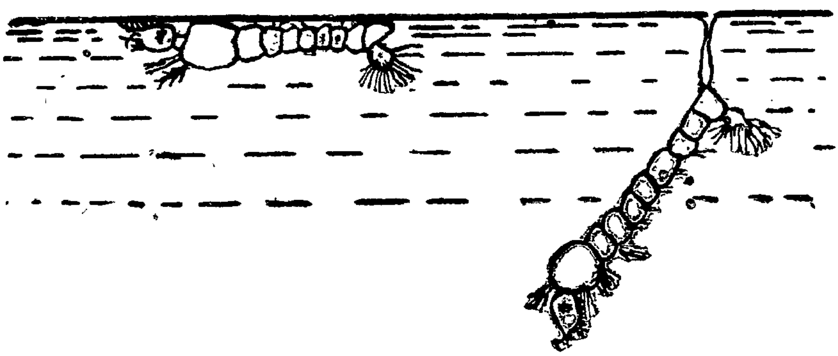


Fig. 96. Fig. 97

Some of the habits of the anopheles shown above give clues for applying remedies for preventing their breeding. Some of the practical methods are given below :—

The main principle to be observed is that in no event is water to be allowed to stagnate near the house; for this, small ponds and pools which are capable of being drained should be drained, and those which are not, should be either filled in with earth or suitably treated so as to prevent the breeding of mosquitoes.

Kundies or small cisterns for slop, or household water should be emptied regularly. Water from bathrooms etc. should not be allowed to stagnate on any account, or even to soak into the ground close to the house.

Weeds from *nallas* having sluggish flow should be removed from time to time as mosquitoes find in them an ideal place for laying eggs upon.

Water troughs for cattle should be emptied and cleaned regularly. Obstructions, if any, should be removed from surface drains and they should be scrubbed occasionally with a stiff cocoanut broom. The eaves gutters should be similarly treated in the wet season.

Hollows in trees should be filled with lime or cement concrete. Old iron tanks, cisterns, tin-pots, broken earthen pots etc., thrown outside, in which water is likely to accumulate, should be destroyed.

Wells in use should be kept clean of any rubbish accumulating on the surface or in hollows and recesses in the sides: as the water is likely to be constantly stirred up while being drawn, mosquitoes will not breed on the surface of wells with clear water.

Unused wells should either be filled up or efficiently closed. No rubbish should be allowed to accumulate in the corners and lanes or narrow gullies between houses as they are bound to retain rain-water and form breeding places.

Aroido and other aquatic plants should not be allowed to be planted near the house.

Waste motor lubricating oils, which are otherwise useless, sould be poured on the surface of ponds and wells not in use. This oil spreads on the surface in a thin film which prevents the larvæ of the mosquito from getting their air supply and in consequence of this, they die. The same purpose is served by kerosene oil but it soon disappears by evaporation and has to be renewed every third or fourth day.

Protection from the Attack :—(*a*) Using mosquito nets during nights affords considerable protection, but in the first place it is not within the reach of the poor, and secondly, for efficient protection, not only should the nets have no holes in them, but there should be no opening or door flap in them for entering in. They should be let down in position before dark and should be carefully examined for any stray mosquito that may have intruded inside before going to bed.

(*b*) Regular use of quinine is another remedy. But this is impracticable, because it entails expense which is often beyond the means of the very poor people though the Public Health Department have made arrangements to supply it in Post Offices for a trifling cost. Again, it does not agree with the health of many. It is, however, useful both as a preventive and a curative remedy. In malarial districts even occasional use of it may help in checking the predisposition to malaria.

Tuberculosis and White Plague

Tuberculosis is a chronic wasting disease caused by the bacillus called 'Tubercle'. The principal form in which it appears is the pulmonary phthisis, or consumption, in which the lungs are affected. But there are different varieties of tuberculosis each differently named according to the different parts of the body it affects. Thus, if glands are affected it is called 'Scrofula'; if the spinal chord is affected it is called, Meningitis, and so on. There may be in the same way intestinal tuberculosis, bone or joint tuberculosis, or even skin tuberculosis all caused by the same germ the tubercular bacillus (T. B.). Even lower animals with the exception of the goat are not free from this disease.

Causes :—Extreme poverty, ignorance and some peculiar social habits are responsible for the spread of tubercular infection, which has been distinctly on the increase during the last decade as revealed by the last Census Report. Over-crowding and want of nourishment are the direct results of poverty. Over-crowding compels the members of the family to occupy the same room as the one occupied by the consumptive patient. The already inadequate ventiliation becomes still less, and the risks of catching infection on the part of the healthy members of the family, increase. The evil is still greater in Northern India and other parts where the extreme cold requires the windows to be shut up during the night time.

The *purdah* system prevalent in most Mohammedan and a few Hindu communities further increases the incidence of deaths by the disease amongst women and children of these communities. The women folk have to shut themselves up in ill-ventilated, dark rooms on the rear side, which is generally insanitary Then again, on account mostly of poverty and partly of ignorance, the necessary precautions are not taken in the case of the females during and after confinement, particularly in respect of proper medical advice and nourishing food, and as a result, the incidence of deaths amongst females on account of this disease has, of late years, been very large. There is another reason viz., amongst the middle classes of today on account of unemployment and similar other reasons, purely economical, the age limit of the bridegrooms has increased in undue proportion to that of the brides. This naturally tells upon the health of the latter and creates a predisposition to this disease. At any rate the annual death rate on account of this disease in India is most appalling as compared with the most backward nation in the world. Hence, every effort must be made to educate the public mind in respect of the precautionary measures to be adopted.

Symptoms :—The individual affected looks anæmic and pale and lacks vigour. There is a gradual emaciation with decrease in weight and a rise in temperature during night. There are discharges from the parts affected, for instance, purging in the case of intestinal affection, expectoration, in that of the lung affection and so on.

Mode of Infection :—The germs are passed through the discharges from the affected part. Thus the sputum of the patient of pulmonary phthisis, and bowel discharges of the intestinal affection contain millions of T. B. These germs die out soon when exposed to fresh air and sun's rays, but they remain active and full of vigour for a long time, in stuffy, dark and damp places. Thus the sputum in a dark corner may have dried up, and still may contain thousands of germs in a virulent state for months together. The dust exposed to sun and open air rarely contains living germs, yet what settles in dark corners and recesses must contain a large number of them. Flies settle on the discharges of the affected person and transmit the germs to articles of food. Even crows and other animals eating sputum in streets, after picking it up fly to a vessel of milk or water and dip their beak into them full of germs, and so on. There are innumerable sources and ways of infection, but by far the most fertile is the sputum. A consumptive patient in open air where the germs are readily attenuated by breeze, is not so dangerous as the one who shuts himself up by closing windows for fear of draught.

Preventive Measures :—All the preventive measures must be based on two facts known from the life-history of the germ, viz. (1) that fresh air and sunlight are detrimental to the growth of the T. B. and (2) that the disease is disseminated from an affected person to an unaffected one by actual transmission of the T. B.

For personal prophylaxis strictly observe the ordinary rules of personal hygiene viz. (1) sleep with windows open. If draught is apprehended arrange a screen to break its force. (2) Take plenty of open air exercise and (3) Take sufficient nourishment in the food. Besides this observe the following 'Don'ts' :—

(*a*) Don't occupy the same bed with a consumptive patient.

(*b*) Don't occupy the same room with a consumptive patient unless there is a strong current of air coming inside.

(*c*) Don't partake of the milk or food remaining after feeding him : don't use his utensils such as cups, glasses, plates etc., before they are sterilised. It is highly advisable that the patient should have a separate set of utensils for his own use.

(*d*) Don't spit at all. The habit of spitting is very bad. Even an apparently healthy man may be passing T. B. (tubercular bacilli) in his spit or other discharges for years together before he is aware that he has been doing so. The best policy to be observed even on the part of a healthy person is not so spit at all, except into receptacles which can be washed in the ordinary course of household cleaning.

(*e*) Don't eat sweets, slices of cut fruit, pastry etc., exposed to air and dust of the streets and to flies.

(*f*) Don't cough, or sneeze into another man's face, always hold a handkerchief against the mouth or nose and turn your face aside.

(*g*) Don't kiss in the lips.

(*h*) Don't blow with your mouth on the surface of milk to keep back cream. Don't blow on hot tea or hot food meant to feed another person, in order to cool it.

(*i*) Don't drop a particle of food or sweets on the floor, and if you happen to drop it, don't pick it up and use it.

(*j*) Don't drink water or any other beverage from the same glass as others before it is throughly cleansed with water. The usual way of cleaning such glasses viz., rinsing the bottom and leaving the part actually held in the lips, untouched, is useless.

(*k*) Don't use ends of garments or the cloth you are wearing for wiping the mouth or hands. either of yourself or those of others.

(*l*) Don't allow dogs or cats to contaminate your food or milk.

(*m*) Don't use road scrapings or dirty earth for scouring or burnishing utensils. Use only ashes from the *chulla* or earth specially brought from field.

(*n*) Don't forget to wash your hands with soap, once you have entered the patient's room and touched anything there, before you touch anything outside.

Measures to be Adopted by the Consumptive Patient :—

These are necessary not only for safeguarding the health of those dear ones who attend on and who come in contact with the patient, but even to a greater extent, in the interest of the patient himself to avoid the risks of fresh infection from his own sputum etc., which is bound to retard or even prevent his recovery.

Tuberculosis is a lingering disease and in most cases the purse of a middle class family is overtaxed, often causing them to run into debts. Hence, for their benefit only very cheap but efficient and practical methods have been suggested below :—

(1) The expectoration when indoors should be received into paper bags, and the latter should be burnt on fire afterwards. It would do if it is received into a glass or china receptacle containing ashes, provided it is emptied into an open pit and covered with at least 4 inches of dry earth, or the contents thoroughly burnt on fire, but the former method is simple and more efficient.

(2) The expectoration out of doors should be received into a kerchief of tough paper (sold cheaply in the market) and the latter should be burnt on fire afterwards as above ; or into a large-mouthed bottle with a close-fitting stopper which should be emptied as above and washed 2/3 times with boiling water.

(3) If an ordinary handkerchief is used both indoor and outdoor, it should be kept immersed in boiling water for five minutes *before it gets dry*, and then washed with ordinary soap. If it is allowed to dry, even a slight shaking causes the dry particles of the expectoration to fall off and spread with the wind; and as the latter contain millions of germs there is every risk of the infection spreading to others who get that air into their lungs.

(4) The individual should scrupulously avoid sharing a bed or food with another person. Very often, others do not keep themselves aloof in this way for fear of offending the invalid or to smother his feelings arising out of segregation or boycott. If she be a mother of a young baby she should stop feeding her on the breast in the interest of both.

(5) It is generally not possible for a middle class family to allot an independent room to the tubercular patient prticularly in urban area. The member of the family who will attend on the patient (and only one in perfect health should do it) need not be afraid of occupying the same room provided the room has a sufficient cross ventilation i. e. there are large windows in the walls on the opposite sides, and that they are kept open during night. If the patient is covered with warm clothing, draught need not be feared unless the health is very delicate. In the latter event a screen should be arranged some distance away from the window on the inner side to break the force the draught.

(6) The patient's clothing, cups and other utensils etc. should not be mixed up with those in household use before they are kept immersed in boiling water or are thoroughly exposed to direct sun's rays for several hours every day.

(7) No opportunity of admitting suns' rays—no matter if it be possible only in a corner of the patient's room—should be lost. As far as possible the patient should spend most of his time out of doors under the shade of a tree etc. or at least in an open verandah.

(8) The bedroom should be cleaned with a wet broom dipped into a disinfectant, or if the floor be of concrete or paved with stone slabs, it should be wiped with a cloth dipped in a disinfectant. In no event should it be swept dry, as the germs in the particles of sputum etc. are likely to be beaten up in the atmosphere of the room and spread.

APPENDIX 3.

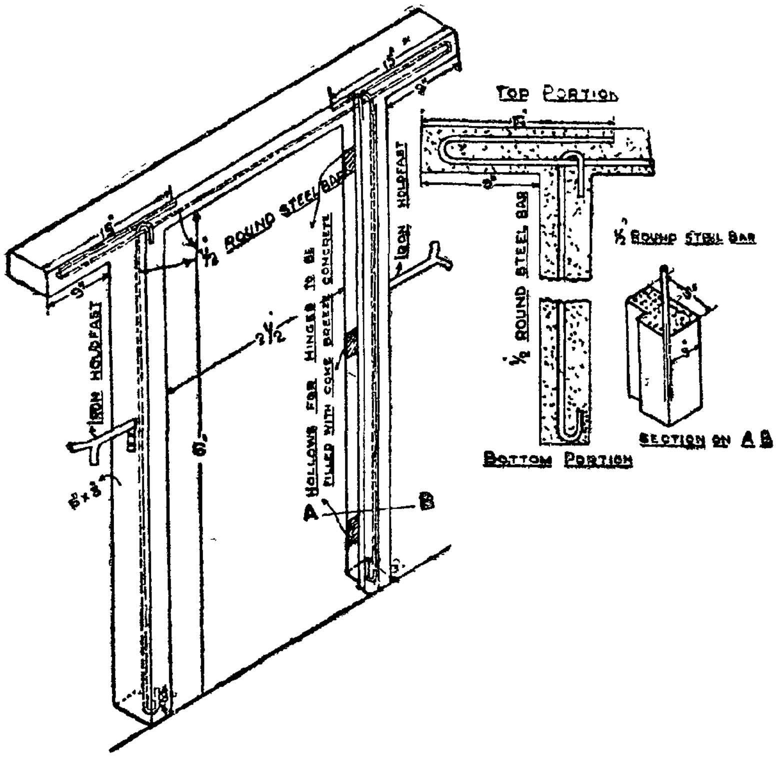
A Note on Preparing Door and Window Frames of Reinforced Concrete.

Wooden frames of doors and windows, as they have necessarily to be partially embedded into wall, are subject to the danger of being attacked by white ants and dry rot, particularly when the walls are built either wholly or partially in mud. Again, they are susceptible to being destroyed by fire, if any breaks out. Under these circumstances, reinforced cement concrete frames prove to be ideal ones. In some stone districts in India, frames for door consisting of two vertical side pieces and a horizontal lintel above them, all of finely dressed stone 7 to 9 in. square in section, are being used from very old times ; but as the shutters cannot be hung on to the stone frames by hinges they are provided with tennons at ends which move in holes in the stone still at bottom and the lintel at top for opening or closing the door. Another disadvantage of stone door frames is that as snfficiently long stones for the sides cannot be had at a cheap cost the height of the frames has in most cases to be restricted to from 5 to 5½ ft. it causing great inconvenience.

Not only can all these defects be overcome by using R. C. C. frames but the latter can be prepared at a less than 1½ the cost of the teak wood frames. The process is so simple that any layman can prepare them at home.

It would be convenient if all the doors were made of one standard size, say, 2½ ft. by 6 ft. so that one strong mould prepared of stout boards 1½ in. thick would serve the purpose. It is economical in the long run if careful attention is given for preparing the mould, which should be of only well seasoned teak wood.

Figs. 98, 99 and 100 show an isometric view of such a frame just removed from a mould. It is 5″ by 3″ in section. Any village carpenter should be able to prepare such a mould so as to enclose a space of the section shown in Fig. 100. The surface on the inside should be smooth.



Figs. 98, 99 and 100

The reinforcement consists of mild steel round bars, ½ inch dia., with hooks formed at ends as shown in Figs. 98 and 99. It is necessary that the hooks at the ends of the top member should be 15 in. long. The two side pieces should be laid flat on ground parallel to each other at the requisite distance apart and the top piece should be inserted into the hooks and bound to them by means of a thin steel wire.

The mould should he placed flat on the ground and crude oil should be smeared with a rag on the inner surface. Then the inverted U of steel bars prepared as above should be laid inside it resting at bottom temporarily on something so as to lie all round centrally in it. Then concrete, prepared of 4 parts of gravel, 2 parts of clean sand, and one part of cement, mixed twice in a dry state and twice again with water, should be poured into its end and rammed by means of a small wooden handle so as to push the material evenly in every corner and recess. Stone metal and gravel above the size of ½ inch are unsuitable as they do not penetrate into corners and assume a flat surface. The excess material should be removed and top made flat by wiping the top with a straight metal edge. There is no necessity of a covering plank for the top of the mould. After 6 hours the mould should be covered with moist gunny cloth, and left for 24 hours, when the sides of the mould could be taken apart to piece. After another 24 hours the frame could be bodily lifted up and the bottom plank of the mould removed and used for preparing another frame. If sand and gravel of small size are used, the surface becomes smooth obviating the necessity of plastering it. Should the surface present a rough appearance, a coating of cement one part and fine sand 2 parts mixed in water should be applied with a flat brush. The frame thus prepared should be kept covered under moist gunny cloth for one week. If possible it should be preferably kept immersed in water in a tank or a pond for that period.

For fixing the hinges, rough wooden lugs should be nailed inside the frame at the places of hinges, before concrete is poured so that there would be hollows left at those places in the frame. These may be filled afterwards with concrete made of 4 parts of coke breeze and one part of cement; when this sets it admits of hinges being fixed by means of ordinary screws, as if in wood.

Whereas a teak frame costs about Rs. 6 per cu. ft. including labour, the above frame costs Rs. 1-14 per cu. ft. including labour and the cost of the mould distributed over 16 frames, besides being permanent and proof against fire, white ants and dry rot.

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