

Post tsunami reconstruction

MANUAL FOR SUPERVISORS AND PROJECT STAFF

SOUTH INDIAN FEDERATION OF FISHERMEN SOCIETIES
AUGUST 2006

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Benny Kuriakose

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By **Benny Kuriakose**

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Edited by

Dr. Ahana Lakshmi

Designed by

C.R.Aravindan, SIFFS

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FOREWORD

SIFFS has taken the responsibility to construct around 2300 houses in Tamil Nadu as part of its post-tsunami reconstruction work. Nearly 1800 of these houses are in Tarangambadi and Chinnangudi villages of Nagapattinam. The SIFFS project in Tarangambadi with over 1200 houses will probably end up as the largest tsunami reconstruction project at a single location in Tamil Nadu. Right from the beginning, SIFFS opted for a participatory model of construction with the tsunami affected households having a lot of say in the type of houses they wished to have and also an important role in monitoring the construction itself. An important implication of such a participatory approach is that contractors do not easily fit into such a system. Hence SIFFS opted to develop its own team of engineers, supervisors and local volunteers to manage the construction which is being done by labour teams on piece rate basis or on plinth rate basis.

The large team involved in supervising the construction required periodical training and orientation. Benny Kuriakose, our architect and technical advisor,

who has developed the SIFFS construction programme in Nagapattinam, prepared a set of notes to help in this training and orientation of site engineers, supervisors and volunteers. We found these notes very useful and felt that it might be of help to others involved in the tsunami reconstruction as well. Hence we are bringing this out as a small manual for wider circulation. Though mainly targeted at tsunami reconstruction projects, this might find uses in other contexts as well.

V. Vivekanandan

Chief Executive, SIFFS
Trivandrum

PREFACE

This construction manual has been prepared for the engineers, supervisors, masons, contractors and others who are involved in the reconstruction project for the tsunami victims in the villages of Tarangambadi and Chinnangudi in Nagapattinam District. They are the people who are in the field and their skill upgradation and conviction about the “whys” are important to ensure the quality of construction. The basis for much of the information for the manual was the in-house training programme for engineers, supervisors and house-owners involved in the SIFFS project.

The biggest challenge the building industry in India is facing today is to ensure good quality in construction. The durability of a building is highly dependent on the quality of workmanship and the design details. Many of the modern buildings have maintenance problems. It is not because Reinforced Cement Concrete was used, but the way in which it was handled during the construction.

The quality of workmanship has come down drastically during the last two decades. Waterproofing the toilets or waterproofing the RCC roof was not at all common when I started practice twenty years ago. Now it has become the

order of the day. Using these construction materials as a short cut to good workmanship is not at all right for the durability of the buildings.

This manual deals with the construction techniques and materials which are being used in the SIFFS tsunami housing reconstruction projects. Thus, for example, there is no mention about stone masonry, although it is an important part of any construction manual.

I have tried to make the manual as simple as possible so that even a non-technical person can understand and follow most of the things. This is a reference book of guidelines. It is no way intended to replace the detailed specifications and the engineers should be aware of these specifications.

I would like to thank my colleagues in the project especially Sathya S, Nandhini T, Jeeva Jayadas, Prakasham, Rejitha R P, and Sheeja P for their assistance and co-operation in the preparation of the manual. Also, without the help of V. Vivekanandan, Chief Executive, SIFFS and others in SIFFS, this report would have been impossible.

Benny Kuriakose

bennykuriakose@gmail.com

CHAPTER I

QUALITY IN CONSTRUCTION

Reinforced cement concrete structures need a lot of care in construction and maintenance especially in a highly corrosive coastal environment. If the quality of construction cannot be ensured, over a period of time, it can jeopardize safety as well as tremendously escalate maintenance costs.

Poor quality of construction is not due to the fault of building materials, but the way in which they are used. The quality of construction and the attention to detail assume great importance in India, where standards and specifications are not strictly followed in the residential building construction scene. It is therefore essential to understand some fundamental issues with regard to various aspects of construction.

1.1 Durability of buildings

Among building materials, only mortar increases in strength over time. A building exposed to the elements of weather is constantly decaying. Every building material has a definite life. For example, roofs with coconut thatch last for one year while those with palm thatch last for four years.

Once the minimum quality of the materials is assured, the durability of a structure is dependent on the quality of workmanship and the design details. There is no short cut to quality workmanship. Take the case of plastering, for example. The separation of plaster from backing occurs due to the following reasons:

1. Water penetration inside the wall, which may be due to plumbing leakage or other reasons.
2. Finishing coat being stronger than undercoat.
3. Lack of suction control during application.
4. Excessive thickness of coats.
5. Inadequate raking out of the joints.

Of the above, the last four are controlled by the mason at the site. If there is inadequate understanding of the procedures to be followed, the correct steps will not be followed. In other words, it is because of poor workmanship. Of greater concern is that a building with poor workmanship is not durable.

1.2 Quality of workmanship

Architecture can be conveyed in words and by drawings: workmanship cannot. The architect hopes that the workmanship will be good but it is the worker who finally controls the quality. The

engineer or architect can point out and correct the major defects of workmanship, but they cannot make bad workers produce good workmanship.

*When defects in brickwork are pointed out to a mason, he will say that the defects will be covered in the plastering. When there are defects in plastering, he will say that they will be covered in painting. **There is no short cut to good workmanship.***

Society is accustomed to pay for quantity, not quality. Labour contracts and overtime lead to reduction in quality. In labour contracts, the labour cheats by reducing the quality. The owner thinks that he has gained because of the apparent increased output. Building owners don't realize that they are cheated in this manner. The additional cost in attaining quality is actually only marginal, whereas ensuring quality pays off in the long run in lowered maintenance costs.

Today, there is little incentive for the worker to do quality work. Manual labour is no longer respected. There seem to be only workers, no craftsmen. A craftsman understands the technology of his craft and he can provide leadership to do good quality work.



Buildings in poor condition due to bad quality of construction

CHAPTER II BUILDING MATERIALS

2.1 Bricks

Good bricks have a compact structure, are reasonably free from cracks, lime, stone and pebbles.

2.1.1 Soil for making bricks

Good bricks are mainly made from sandy clay. An optimum mix of sand and clay gives the best quality bricks. If the soil is too clayey, sand will have to be added and vice versa.

Bricks with higher proportion of sand will give good compressive strength, but their weathering quality is poor. If the proportion of clay is high, there is likelihood of greater warping and loss of strength.

The clay mix prepared should not contain large aggregates because they would cause splitting and disruption when the clay is fired. In the case of factory made bricks, the clay mix is passed through a pug mill to get clay mix of uniform consistency.

The soil or the water added to make the bricks must not contain any of the water-soluble salts such as sulphates and chlorides as their presence can lead to the problem of salt crystallization or efflorescence.

The soil used for making bricks should not contain any water soluble salts. Also, no salt water should be used in the process of making bricks. Both are detrimental to the durability of the buildings.



Large aggregates causing splitting and weakening of the brick



Too much sand content will erode the bricks

2.1.2 Firing

The firing process gives the bricks their characteristic properties. Primitive firing conditions produce inconsistencies that give attractive and subtle variation in colour and texture.

Only fully burnt bricks should be used for the construction of buildings. Half burnt bricks will have only a bit more strength than sun dried blocks and will not stand up to the vagaries of weather.

In the case of country burnt bricks, the bricks are not uniformly burnt. While a large proportion maybe satisfactory, those on the outside are often under-burnt and those in the heart of the kiln and over the fire holes are over-burnt. If so, they may be misshapen and cracked owing to the excessive heat. Bricks that are over-burnt to a blackish colour but not to the extent of losing their shape can be used.

2.1.3 Manufacturing defects

Cracking and warping, which create weaknesses in the bricks, may be due to the following reasons:

1. Exposure of green (freshly made) bricks to direct sunlight or rapid drying winds.

2. The placing of green bricks too soon inside the kiln.
3. Low sand content.

Dipping the moulds into water each time to prevent clay sticking to them will also lead to surface cracking. Dipping in sand generally produces better bricks with sharper profiles.

2.1.4 Wire cut bricks

Clay that is fairly soft and of a fine texture is extruded as a continuous ribbon and is cut into brick units by tightly stretched wires spaced at a height or depth for the required brick. Allowance is made during the extrusion and cutting for the shrinkage that will occur during firing. Wire cut bricks do not have frogs and on many, wire cutting marks may be seen.

2.1.5 Stacking bricks

The following steps should be taken while stacking bricks.

1. Brick should not be dumped at the work site.
2. Brick stacks should be close to the site of work so that least effort is required to unload and transport the bricks again by loading on pallets or in barrows.
3. Bricks should be stacked on dry firm ground.

2.1.6 Identification of under-burnt bricks

If the bricks are soaked in water for a few hours, the half-burnt bricks will weather easily (the surface can easily be scratched with finger nails). Hence soaking the bricks for a minimum of one hour before using will ensure that under-burnt bricks are not used for construction.

2.1.7 Characteristics of good quality bricks

1. Good bricks should be hard, sound and well burnt.
2. A brick should give a metallic ringing sound when struck with another brick or with a hammer.
3. Bricks should have uniform colour and fine compact texture.
4. When a brick is dropped from a height of one metre on another brick, it should not break.
5. The brick should not absorb water more than 20 percent of its own weight.
6. The bricks should be free from any water soluble chlorides or sulphate. The source of salts could be from the soil or from the water used for brick making.



Under burnt bricks will not have enough strength and weather over a period of time

A good brick of 2 kg should not weigh more than 2.4 kg if immersed in water for 24 hours

2.1.8 The need for a “Frog”

The indent or sinking in the brick is termed a frog. Some bricks have no indent or frog at all, some have on one face only and some have indents on both long faces. They are formed to facilitate the bedding of bricks in mortar. All bricks should be placed with their frogs on top so as to provide good bonding with mortar.



Frog in bricks

2.2 Cement

2.2.1 Ordinary Portland Cement

Ordinary Portland Cement (OPC) is a material that sets hard when in contact with water. When mixed with water, its molecules combine with water molecules to form crystals. These crystals interlock with each other and with the surfaces of any aggregate added to the mix. The material possesses an early set, known as the initial set, which can be made use when OPC is mixed and

used quickly in small quantities, and a final setting time of not more than ten hours. Further hardening is brought about by continued reaction, and is rapid in the early stages but slower with the passage of time.

Portland cement is a wonderful building material that has many specific good qualities. But it has come in for some criticism on the following grounds¹:

- ♦ Its use is not reversible.
- ♦ It is unnecessarily strong (designed for reinforced concrete structures).
- ♦ It is impermeable (causes frost damage to stone).
- ♦ It shrinks (causes cracks and moisture penetration).
- ♦ Its colour is cold (unpleasant, lacks colour harmony but white cement is obtainable).
- ♦ It is not plastic (lacks thermal elasticity, it cracks on settlement because it sets too quickly).
- ♦ It is attacked by sulphates.

¹ Adapted from "Guidelines for Conservation – A Technical Manual" by Bernard Feilden, published by INTACH, New Delhi, 1989.

Indiscriminate use of cement has led to many serious problems over the years. On the other hand, the advantages of lime are becoming more evident as a result of the recent research reports from various countries. Lime is a time-tested material with many good qualities.

2.2.2 Different types of cement available in the market

1. Ordinary Portland Cement (OPC): Its rate of gaining strength, drying shrinkage and resistance to cracking are moderate.
2. Portland Puzzolana Cement (PPC): The rate of development of strength is lower than that of OPC. The advantages of using this cement are the increased workability, water tightness, more resistance to cracking and greater resistance against sulphatic action. The cost is also lower than OPC.
3. Sulphate Resistant Cement (SRC): If water soluble sulphates are present in the soil or in water, OPC disintegrates. When the presence of sulphates is more than the prescribed limit, SRC should be used. Special orders will have to be placed with the cement manufacturer to procure this cement.

2.2.3 Difference between PPC and OPC

Puzzolana Cement attains strength slowly and Ordinary Portland Cement attains strength very quickly. But both the cement types attain same strength at the end of 90 days. Puzzolana cement is better for plastering. It emits less heat, produces less cracks and improves impermeability and strength. It has more resistance towards sulphate attack.

2.2.4 Different grades of Cement available

Different grades of cement available in the market are known by their grade number and include 33, 43 and 53 grades of cement. The grade number indicates the minimum compressive strength of cement and mortar in N/mm² at 28 days, under standard test and conditions. 43 grade cement is most commonly available.

2.2.5 Storage of cement

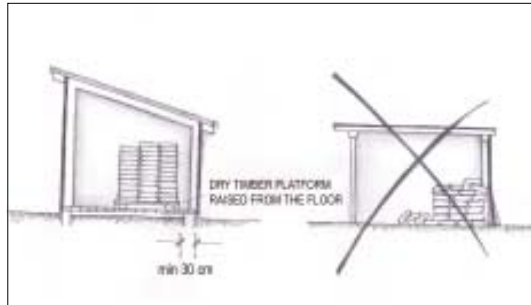
Cement has great affinity for moisture and hence it should be stored in such a way that moisture may not reach it.

1. Cement should be stored in the driest place possible.
2. Cement should be kept off the floor by placing the cement bags on timber planks, and away from the walls by at least a foot (30 cm)

3. More than 12 bags should not be stored one atop the other. Otherwise stacking/removing the cement bags becomes cumbersome.
4. Cement should not be stored for long periods during the rainy season.
5. Bags should be kept close together in the stack to reduce circulation of air as much as possible.
6. Bags should be stacked in a manner to facilitate removal and use in the order in which they are received. The principle of first-in and first-out should be followed in removing bags.
7. Bags should not be stacked on the ground for temporary storage at work site. They should be on top of a dry platform and covered with tarpaulin or polythene sheet during the night or if there are any chances of rain.

Cement loses its strength gradually while in storage and should be used as early as possible. Cement which is stored for more than 3 months loses its strength by 20%.

Lumps may be formed in the cement bag when the bags are stored for long periods. If lumps formed are so hard that they cannot be pressed to powder between the fingers, then the cement can be considered useless and should not be used for any critical works such as concreting.



Cement storage

2.3 Sand

Sand is the aggregate whose particles pass through 4.75 mm mesh sieve but are completely retained on 0.075 mm mesh. Particles that are finer than 0.075 mm come under silts and clays and are considered as harmful ingredients.

2.3.1 Qualities of sand used in construction

1. The sand should be clean and free from impurities such as clay, salts and vegetable matter. Clay and silt content should not exceed 10%, otherwise the sand needs to be washed.

2. The sand should be well-graded.
3. Sea sand or sand containing saline impurities should never be used.

Sea sand should not be used for the construction of buildings. Also the sand should not contain any water soluble salts or excessive clay in it.

2.3.2 Bulking of sand

If the fine aggregate is damp or wet, the volume of the sand will increase by up to 25%. This increase in volume is called bulking. It can be detected by taking a level bucket of sand and stirring it slowly into a similar bucket filled with water. If the saturated sand does not reach the top of the bucket, there is deficiency in the quantity of sand. This deficiency should be allowed for in proportioning.

2.3.3 Checking sand quality at the site

The sand to be used has to be checked for impurities such as organic materials (mud, leaves, roots etc.) When a sample is rubbed between damp hands, clean sand will leave the hands only slightly stained but if the hands stay dirty, it indicates the presence of too much silt or clay.

A simple test is to fill half a bottle with the sand and add clean water until the bottle is three-quarters full. After shaking it vigorously, leave it to settle for about an hour. Clean sand will settle

immediately, silt and clay will settle slowly on top of the sand. The thickness of the clay and silt layer should not exceed one-tenth or 10% of the sand below.

2.3.4 Sea-sand in construction

The sand which is used for the building construction should not contain any water soluble salts. Also the sea-sand is uniformly graded and will not give strength to the cement mortar or the concrete for which it is used.

2.3.5 Identifying presence of salts

A sample of the sand should be added to a bottle of distilled water, filtered and tested for any dissolved salts such as sulphates and chlorides.

Manufactured bricks can also be tested for the salt content by applying paper pulp soaked in water over the bricks after making sure that the pulp that is being used does not contain any salts by conducting the above test. Newspaper sheets can be used for the above purpose. The brick is allowed to dry after the paper pulp is added. The water in the paper pulp goes into the bricks and the salts present will dissolve in this water, which then rises to the surface and evaporates. If there are any salts in the bricks, they will be left behind in the paper pulp. The dried pulp is soaked in salt free water. After filtration, the water is tested for the salt content.

Test for sulphates: The filtered solution is treated with barium chloride solution. If sulphates are present, insoluble barium sulphate is precipitated.

Test for chlorides: The filtered solution is treated with silver nitrate solution. If any chlorides are present, insoluble silver chloride is precipitated.

2.4 Coarse aggregate

The aggregate whose particles completely pass through 75 mm mesh sieve and are entirely retained on 4.75 mm mesh sieve is referred to as coarse aggregate.

2.4.1 Storing coarse aggregate

1. The aggregate should be stored in such a way as to prevent mixing with foreign materials.
2. Aggregate can be unloaded separately to avoid the segregation of bigger size materials at the bottom and smaller at the top
3. The heaps of fine and coarse aggregate should be kept separate.

2.5 Steel

Steel reinforcements should ordinarily be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. It is a good practice to coat reinforcements with cement wash before stacking to prevent scale and rust.

Table 2.1
DIFFERENT SIZES OF REINFORCEMENT AND THEIR WEIGHTS

Diameter of the reinforcement in mm	Weight per kilogram
6	0.22
8	0.39
10	0.62
12	0.89
16	1.58
20	2.47

2.6 Water

2.6.1 Quality of water required for construction

Water used for mixing mortar and concrete, and for curing should be clean and free from materials like oil, acids, alkalis, vegetable matter etc. Potable water is generally considered satisfactory for mixing and curing all concrete and masonry works.

1. Water should not have dissolved chlorides or sulphates.
2. Salinity of water should be checked. The best method is to taste the water.
3. The pH of water should be close to neutral, i.e. between 6 and 8.5.

Salt water should not be used for construction at all. Problems that can be created include salt crystallization and the fast corrosion of reinforcement.

2.7 Mortar

2.7.1 Necessity for mortar

1. Mortar is used as a bed to even out the irregularities of the individual masonry units. The more even the surface of the individual stone or bricks, the thinner will be the mortar bed.

2. Mortar should provide some adhesiveness between the individual stones or bricks.
3. Mortar must transfer the compressive, tensile and shear stresses between adjacent units and it must be sufficiently durable to continue to do so.

2.7.2 Gauging mortar mixes

1. The mortar or the concrete should be mixed only on a proper platform made either with bricks, tin or steel sheets.
2. The volume of material in each batch should be accurately proportioned.
3. When all the volumes of the materials for the mix have been measured, they are blended together dry. For thorough mixing by hand, the dry mix should be turned over three times. Turning over takes the form of moving all the material to one side with a shovel, moving it back and then moving it to one side again. At this stage the mix should be of uniform colour with no lumps or pockets of aggregate or binder.
4. A hollow like a volcano crater is made in the middle of the pile.

5. The dry material is then mixed with the water, starting with the inside of the ring. When enough water has been incorporated to make the mix of the right workable consistency, the process of turning over is again performed three times wet.



Dry mixing of cement and sand



Water is added by making hollow in the top of the pile

- *Water should not be added until the sand-cement mix is uniform in colour.*
- *If water is added to the sand-cement mix, then it should be consumed within an hour, because the initial setting time of cement is about 30 minutes.*
- *The mortar or the concrete should be mixed only on a steel or timber platform. Otherwise the cement will be washed away with water.*

2.7.3 Shelf life of mortar

Mortar should be used as soon as possible once water is added. In any case, it should not exceed 30 minutes.

2.7.4 Mortar in relation to brick and stone

1. It is the combination of the brick and the cement mortar that is important. For any particular strength of unit, there is optimum mortar strength. A stronger mortar will not increase the strength of the brickwork.
2. If the mortar mix is too strong for the stones or bricks, the evaporation of moisture, instead of taking place over the whole wall including the joints, can only take place through the external face of the brick or stone. The exposed faces will then tend to flake off, through the crystallization of salts, resulting in a wall in which the mortar stands out.
3. A weak mortar will retain the cracking within the numerous bed and perpendicular joints between the bricks.
4. A correct relationship between the mortar and the brick will result in the total effects of the movement being distributed amongst numerous fine cracks. Such cracks are largely concealed and can easily be pointed over without becoming unsightly.

2.7.5 Weathering of mortar over time

Weathering of mortar occurs due to a variety of reasons including the following:

1. Scouring actions of wind-borne grit and rain.
2. Spalling action of salt crystallization because of the use of unsuitable materials such as sea sand.
3. Defects in design details such as inadequate overhangs to copings and absence of drips.
4. Excessive dampness caused by defective rainwater pipes.
5. Vegetation growth penetrating mortar joints.
6. Industrial pollution of the atmosphere by acidic gases carried by rain water is an important cause of deterioration. Sulphur dioxide forms sulphuric acid when dissolved in water and damages lime mortar and anything containing calcium carbonate, calcium oxide or calcium hydroxide.

2.7.6 Mortar and concrete mixes for various works

The mortar and concrete mixes used for various purposes may vary depending upon the final strength required. The more commonly used mixes are suggested in Table 2.2.

Table 2.2
MORTAR AND CONCRETE MIXES FOR VARIOUS WORKS

Item of works	Cement	Sand	Coarse aggregate	Mortar mix
Brickwork in Foundation	1 Part	6 Parts	–	1:06
Brickwork in Superstructure	1 Part	6 Parts	–	1:06
Plain Cement Concrete	1 Part	4 Parts or 5 Parts	8 Parts or 10 Parts	1:4:8 or 1:5:10
Reinforced Cement Concrete ²	1 Part	2 Parts or 1.5 Parts ³	4 Parts or 3 Parts	1:2:4 or 1:1.5:3
Interior Plastering	1 Part	5 Parts	–	1:05
External Plastering	1 Part	5 Parts	–	1:05
Flooring	1 Part	5 Parts	–	1:05

- ◆ *Only the mix specified for each purpose should be used.*
- ◆ *More cement does not necessarily give more strength.*
- ◆ *The way the mortar is prepared and used determines the final strength achieved.*

² The minimum recommended as per the ISI specifications is M20 Grade Concrete. You may have to use 1:1.5:3. But a leaner mix than 1:2:4 should not be used for any structural purposes.

³ In practice, more sand will have to be added for bulking of sand.

2.8 Curing of cement mortar and concrete

If curing is not done, complete hydration of cement will not take place and the full strength will not be achieved. Proper curing results in:

1. Increased strength,
2. Improved wear resistant and weather resistant properties, and
3. Increased impermeability and durability.

Salt water should not be used in construction, even for curing.

2.8.1 Need for curing of mortar and concrete

Cement hardening is a complex reaction with water which takes place over a long period of time. Curing is done to prevent the water which has been mixed in the mortar or concrete from evaporating.

Reinforced cement concrete columns are cured by covering the columns with jute bags or straw to retain the water for a longer time period.

Best results are obtained by not allowing the brickwork, concrete or plaster to dry rapidly. Alternate drying and wetting may be harmful.

2.8.2 Curing: Points to remember

1. Fresh concrete should not be not exposed to sun or rain or drying winds.
2. Concrete should be covered with tarpaulin while it is drying if the weather is hot and dry.
3. 24 hours after laying the concrete, the surface should be cured by flooding with water.
The columns should be covered with gunny bags for curing.
4. Curing should continue for a minimum of fifteen days after the concreting is done.
5. Water used for curing should be of the same quality as that used for mixing the concrete.

- ◆ *Any work done with cement should be cured properly. The final strength is dependent on proper curing.*
- ◆ *Brickwork should be cured for a minimum of seven days.*
- ◆ *Reinforced cement concrete work should be cured for a minimum of 15 days.*
- ◆ *Curing is not required during the heavy rainy season.*



Wet Gunny bags wrapped to keep the concrete wet



Curing of the brickwork



For roof slabs, water should be stagnated by constructing small bunds



Curing of the sunshade

CHAPTER III

BUILDING ELEMENTS

3.1 Foundation

3.1.1 Settlement

There are various possible ground movements under the foundation of a building that may cause one part of the foundation to settle at a different rate and to a different extent compared to another part of the foundation. This different or differential settlement must be limited to avoid damage to the superstructure of the building. Some structural forms can accommodate limited differential movement of the foundation of the structure by slight movement of the small brick units and mortar joints, without affecting the function of the wall, whereas a rigid framed structure with rigid panels cannot do so to the same extent. On clayey soils, settlement is generally greater and continuous over time.

3.1.2 Excavation and filling of basement: Points to remember

1. The bottom of foundation pits should be dressed level in all directions before any concrete is put in, and should be well watered and thoroughly rammed.

2. The surface to receive the filling should be first cleared free from all roots, vegetation or spoil; and thoroughly wetted.
3. Filling up to plinth level should proceed in layers with the construction of the building so that the earth filling may be thoroughly consolidated by the trampling by the workers.
4. Filling in basement should have optimum moisture content and should be well consolidated in layers of 15 cm by ramming with iron rammers and butt ends of crowbars.



Excavation



Ramming the foundation pit

When filling reaches finished level the surface should be flooded with water for at least 24 hours, allowed to dry and then rammed and consolidated in order to avoid any settlement at a later stage.

5. Protection against slides and caving should be provided if necessary.

3.2 Plain cement concrete

The width of a concrete strip foundation depends on the bearing capacity of the subsoil and the load on the foundation. The greater the bearing capacity of the subsoil, the lesser will be the width of the foundation for the same load. The minimum width of a strip foundation is 450 mm, which gives a reasonable bearing area for most two storey houses on most sub soils and provides space in the trench to lay the foundation work.



Plain cement concrete

The least thickness for concrete for strip foundation is generally 100-150 mm and the concrete should be at least as thick as the projection of the strip on each side of the wall where the concrete is not reinforced.



Coping



Centre line marking to fix the mat
and column reinforcement

3.3 Damp-proof course

The purpose of damp-proof course in a building is to provide a barrier to the passage of moisture from an external source into the fabric of the building or from one part of the structure to another. The movement of moisture or water may be upwards in the foundation of walls and ground floors, or downwards in parapets. Damp-proof courses may be either horizontal or vertical.

There should be a continuous horizontal damp-proof course aboveground in walls whose foundations are below ground, to prevent moisture from the ground rising through the foundation to the wall above ground, which otherwise would make all surfaces damp and damage wall

finishes. The damp-proof course above ground should be continuous for the whole length and the thickness of the wall and be at least 150 mm above the finished ground level.

Damp proofing layer is not required where a plinth beam is constructed. The plinth beam will act as the damp-proof course.

3.4 Brickwork

Masonry structures are highly durable. Many historic buildings and engineering structures provide proof of this quality. If the masonry buildings are designed and built with competence and care, they should last much longer than their required life.

The maintenance costs of masonry are quite minimal. A well designed building will contain the majority of damage within the mortar and movement joints.



**Bonding in brickwork
avoiding vertical joints**

3.4.1 Brickwork: Points to remember

1. Bricks required for masonry in cement should be thoroughly soaked in clean water for not less than an hour before use.
2. At the time of laying, the bricks should not be too wet.
3. All the walls should be taken truly vertical. The courses should be laid horizontal and vertical joints in two adjacent courses should be avoided.
4. Bricks with frogs should be laid with frogs upwards.
5. Mortar should be pressed into all the vertical joints using a trowel. Properly filled joints ensure maximum strength and resistance to penetration of moisture which takes place mainly through joints.
6. When new brickwork is started, the surface over which the brickwork is to be started should be slightly wetted.
7. When the brickwork is to be plastered, the surface should be raked out to a depth of 12-15 mm. so as to give adequate key for plastering.
8. The thickness of a mortar joint should not be more than 12 mm.

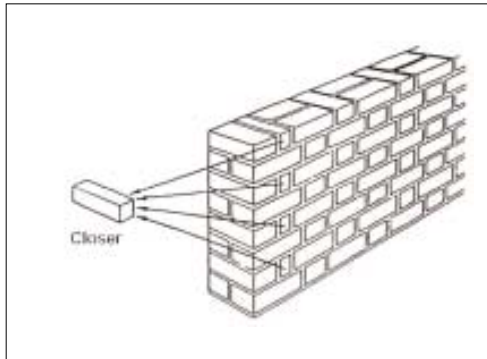
9. Broken bricks should not be used unless they are essential from good-bond point of view.
10. In the case of brick masonry, the wall should be constructed to a height of not more than one metre per day.
11. The brickwork should be cured for a minimum period of seven days.
12. The verticality of walls and horizontality of the courses should be checked frequently with plumb bob and spirit level respectively.

Bricks are soaked in water before use for the following reasons;

- ◆ *The brick should not draw/absorb the water from the mortar.*
- ◆ *By soaking bricks in water, under-burnt bricks can be identified.*
- ◆ *The appearance of a white patch on the surface of the brick indicates the presence of water soluble salts in the brick.*

Broken bricks should be used where it is necessary for bonding. The common habit among the masons is to break one full brick even when many half bricks are available. This kind of wastage can be avoided.

Mortar should be properly filled in between the bricks and at each joint (Vertical and Horizontal). The thickness of the mortar should not exceed 12-18 mm ($\frac{1}{2}$ - $\frac{3}{4}$ inch). The greater the thickness of mortar, the weaker the strength of the brickwork.



Using closers to avoid vertical joints and ensure proper bonding of bricks



Soaking of bricks



Using string to ensure the horizontality of brickwork



Checking the plumbness of the wall at regular intervals

3.4.2 When is a wall unsafe?

If the wall is out of plumb for more than 25 mm in a normal storey height, then professional advice should be sought for rectification.

3.5 Formwork and concreting

3.5.1 Formwork & shuttering: Points to remember

1. The formwork should be erected in such a way that it can be dismantled easily without causing damage to the concrete.

2. The shuttering coming into contact with concrete should not permit leakage of cement grout.
3. Where the centering posts rest on soft ground, the load should get distributed by means of thick planks or otherwise, as required.
4. The centering posts should be truly vertical and should not be placed at an angle.
5. The levels of the formwork should be checked and they should be as per the drawings.
6. No gaps should be there in the formwork before concreting.
7. The centering should be designed and arranged so that the sequence of removal is: sides of columns followed by the sides of beams, boarding under the floor slabs and finally the soffits of beams.
8. The joints of the formwork should be made and maintained tight and close enough to prevent the squeezing out of grout or sucking in of air during vibration. Absence of this precaution may cause honeycombing on the surface of concrete, impairing the appearance and sometimes weakening the structure.
9. Normally gaps larger than 1.5 mm between the boards should not be permitted. The number of joints should be made as few as possible by making shutter sections large.

10. Any fan clamps or hooks should be provided after the shuttering is completed.
11. Suitable wooden plugs may be placed in the centering for electric fittings.
12. Similarly, clamps for hanging ceiling fans or other purposes should also be fixed in their correct positions.
13. In any event the top of any conduit should be at least 18mm below the finished surface in order to prevent cracking.
14. To avoid sticking of concrete, mould releasing oil should be applied on the formwork.



Grade beam formwork



**Roof slab formwork with
reinforcement**

3.5.2 Removal of formwork

Formwork should be left in place until the concrete has hardened enough to hold its own weight and any other weight it may be carrying. Where the temperature is above 20°C and ordinary cement has been used for concreting, formwork may be removed after the periods given below.

Columns, vertical sides of beams and slabs	:	1-2 Days
Slabs of spans less than 3.6 metres	:	08 Days
Slabs of spans more than 3.6 metres	:	14 Days
Beams upto 6 metres span	:	14 Days
Beams more than 6 metres span	:	21 Days

3.5.3 Reinforcement Placement: Points to remember

1. All reinforcement should be clean and free from mill scales, dust, loose rust and coats of paint, oil or other coatings which may destroy or reduce bonding.
2. The bars crossing one another should be tied together at every intersection with two strands of binding wire of 16 to 20 SWG twisted tight so as to make the steel work rigid. This will ensure that it does not get displaced during concreting.

3. Joints in reinforcement bars should be avoided as far as possible. But where lapping is unavoidable, it should be staggered so that only a small part of the total reinforcement at any particular section is lapped. The minimum lapping length should be 50 times the diameter of the bar.
4. Stirrups may be staggered, after ensuring that the corresponding stirrups form a uniform pattern in elevation.
5. All laps of reinforcements should be a minimum 50 times the diameter of the bar.
6. Stirrups should be bent to 135° and hooks should not be placed on the same side.
7. Cover blocks as per the required thickness should be tied to the reinforcement.
8. No one should be allowed to stand or walk on the reinforcement bars once they are placed in position.
9. Surface for placing concrete which is the formwork should be prepared according to the requirements and thoroughly soaked with water.

Corrosion resistant coating is not very important for the steel apart from being quite expensive. If the steel is covered properly and the concrete is of good quality, then the durability will be quite good.



Footing mat



Stirrups bent to 135°



Gaps closed with tape



Beam main bar bent at the end to have column to beam connection

3.5.4 Water-cement ratio and the strength of concrete

The materials used for making concrete are mixed with water for two reasons.

1. To cause the reaction between cement and water - this results in the cement acting as a binding agent.
2. To make the materials of concrete sufficiently plastic to be placed in position.

The ratio of water to cement used in concrete affects its ultimate strength and only a particular water-cement ratio produces the best concrete. If too little water is used the concrete is so stiff that it cannot be compacted and if too much water is added the concrete does not develop full strength.

A general tendency of masons is to use more water so the concrete may become easily workable. This practice should be firmly discouraged. Excess amount of water not only produces low strength concrete, but also increases shrinking tendency. This also causes decrease in density and durability of the concrete.

Water-cement ratio also depends upon the method adopted to secure compaction of the concrete. If compaction is to be done by vibrators, less water/cement ratio is required.

The amount of water required to make concrete sufficiently plastic depends on the position in which the concrete is to be placed. The extreme examples of this are concrete for large foundations which can be mixed with comparatively little water and yet be consolidated, and concrete to be placed inside form work for narrow reinforced concrete beams where the concrete has to be comparatively wet to be placed.

For higher strength of concrete, it is better to use the minimum amount of water required that permits workability

3.5.5 Cover for reinforcement

An appropriate concrete cover of the steel reinforcement is absolutely essential to protect the steel members from corrosion. As soon as humid air comes in contact with the steel reinforcement inside the concrete, corrosion begins. This leads to rusting and eventually disintegration of the affected part. This can lead to weakening of the concrete beam or slab, eventually leading to collapse.

3.5.6 Cover requirements for concreting

Table 3.1
SUGGESTED COVER REQUIRED FOR VARIOUS WORKS⁴

Item of works	Cover required (mm)	Cover required (inches)
Column Footings	40	1.5
Columns	25-30	1 – 1.25
Beams	20-30	1 – 1.25
Roof Slabs	15	0.63

Quality control in concrete

- ▶ *Slump cone test should be carried out at the site before concreting.*
- ▶ *A minimum of three concrete cubes should be cast at the site and tested on a regular basis to see whether the required strength is achieved.*
- ▶ *Tests for moisture content and bulkage of sand should be done before the concrete mix is prepared.*

⁴ The cover required for various works may vary depend on the specifications by the structural engineer.

3.5.7 Making cover blocks

Cover blocks are generally square or rectangular in shape with or without binding wire embedded in them which will be tied to the reinforcement at the time of placement. Rings with suitable hold at the centre may also be used.

The mortar or concrete used for the cover blocks or rings should not be leaner than the mortar or concrete in which they will be embedded. To provide necessary cover for reinforcement at any section only single cover blocks should be used.



Cover blocks



Cover block for footing

3.5.8 Machine mixing of concrete

1. About 10% of the mixing water should be poured into the mixing drum before dry materials are added.
2. Water should then be continuously added along with the dry materials, keeping about 10% to be added after all the dry materials have been fed.
3. Mixing should be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency.
4. In no case should mixing be done for less than two minutes.
5. The concrete should be discharged from the mixer quickly in one operation.

Normally, water requirement per bag of cement is 20-28 litres. The requirement is lower if the sand and the aggregate are wet.

During machine mixing, water should be measured and added. Once water is added, the concrete should be used within 45 minutes.



Concrete cubes cast at the site
for testing the compressive strength



Timber boxes for measuring fine
and coarse aggregates



Measuring box



Machine mixing



Slump cone test



Concrete cube tested for compressive strength

3.5.9 Hand mixing of concrete

Hand mixing is adopted where quantity of concrete is very small. Cement and sand are mixed dry on a clean, hard and impermeable platform. Dry mixing is continued until the mix attains uniform colour. This is mixed with the coarse aggregate to attain a uniform colour. A hollow is made in the centre and 75% of the required quantity of water is added. Mixing is done and the remaining quantity of water is added to acquire uniform workability.

There are many chemicals called admixtures that can be added to cement, water and aggregate during mixing in order to modify or improve the properties of concrete for a required application. Adding them does not mean that it is at the cost of quality workmanship.

Remember!

There is no short cut for good quality concrete and workmanship.

3.5.10 Concreting: Points to remember

1. Concreting should be done continuously and finished in one stretch.
2. Concrete should be placed in position gently and not thrown from a height. This is to prevent the segregation of aggregates.

3. Concrete should be deposited as near as practicable to its final position.
4. Concrete should be laid in layers not exceeding 15 cm in thickness and thoroughly compacted before the next layer is laid.
5. Only sufficient quantity of concrete that can be laid within twenty minutes should be mixed at a time. This is to ensure that the setting action has not commenced.
6. Concrete should not be mixed in the rain.

Concrete should not be dropped from a height while placing.



Batching



Loading machine with materials



Pouring concrete at lower height



Vibrator is used for compacting the concrete

3.5.11 Compaction of concrete

Air gets trapped in the plastic concrete. In order to make the concrete impervious and attain its maximum strength, compaction is done. If the trapped air is not removed completely, there is considerable loss of strength.

Compaction of concrete can be done either manually or mechanically. When it is done manually (with steel rods) it is called hand compaction or tamping. When mechanical vibrators are used, it is termed as machine compaction.



Compacting concrete using the vibrator

If there are 5% voids in the concrete, the strength is reduced by about 30%.

3.5.12 Compacting Concrete: Points to remember

1. The water content of the mix should be reduced when vibration is adopted.
2. The vibrators should be used by skilled and experienced workmen only.

3. Hand compaction should be done by tamping using rods.
4. Concrete must not be over tamped, as this will bring to the surface not only the water but also the cement paste which is required to act as the matrix.
5. Both excessive compaction and under compaction are harmful for concrete.

3.5.13 Vibrators: Points to remember

1. Care should be taken so that the vibrating head does not come into contact with hard objects like hardened concrete, steel and timber.
2. When the space for introduction is narrow, the vibrator should be switched on only after the vibrator head has been introduced into the concrete.
3. Formation of watery grout on the surface of the concrete due to vibration is an indication that the concrete is too softly made and unsuitable for vibration; a close textured layer of viscous grout may, however, be allowed.
4. For vibrated concrete, the formwork should be stronger than that used for hand compacted concrete and greater care must be exercised in its assembly.

5. The vibrator may be used vertically, horizontally or at an angle depending upon the nature of work. But needle vibrators should be immersed vertically in beams and other thick sections at regular intervals.

Walking on freshly laid concrete should be avoided for at least ten hours (final setting time).

3.5.14 Finishing: Points to remember

1. The voids left on the top surface should be filled with concrete and the process repeated till uniform surface is obtained.
2. Floating with a straight edge board of timber can ensure the levelling of concrete; this serves the dual purpose of compacting and bringing the excess water to the surface so that it can evaporate.
3. In the case of roof slabs, the top surface may be finished smooth by plastering with a mix of 1:3 cement mortar, while it is still fresh.
4. The workmen should walk over the concrete by placing planks on top while doing the plastering.

5. Projections due to defective workmanship on the concrete surface should be removed either by rubbing down with carborundum stones or by careful chiseling.
6. Honeycombing of a minor nature on the surface should be made good by applying cement mortar of the same proportion as in the concrete.
7. The exposed surface which is specified to receive plaster should be properly roughened by hacking, immediately after the shuttering is removed.



Column concrete with good finishing



Leveling of roof concrete

Two very common mistakes in concreting

1.The strength of the concrete will be weakened because of the segregation of the coarse aggregate particles. This occurs because of two reasons;

a. Too much water has been added

b. Concrete has been allowed to fall from a height.

2. There is a tendency of water to rise to the surface of the freshly placed concrete. The water rising to the surface carries with it particles of sand and cement which on hardening form a scum layer popularly known as laitance. Due to this effect, homogeneity of concrete is disturbed, which results in weak and porous concrete.

The parapet of the roof slab should be done only after ensuring that there is no leakage in the slab. It is very difficult to find the location and correct the leakage once plastering is done or parapet walls are constructed.



Honeycomb in column concrete



Finishing the roof slab by plastering

3.6 Plastering

Plastering is the process of applying a covering on the surfaces in order to obtain a smooth, even, regular and clean surface of ceiling, walls, and columns. This thin covering is known as plaster.

The following are the objectives of plastering;

1. To protect the exposed surfaces from harmful effects of atmospheric elements.
2. To develop decorative effect or to improve the appearance.
3. To conceal inferior materials or defective workmanship.

3.6.1 Plastering: Points to remember

1. Plastering should not be started until all the wiring conduits have been finished.
2. The sand used for plastering should be sharp, angular and free from impurities to the greatest extent possible.
3. The aggregates should be properly washed, so that there is no more than 5% of clay in the sand. If sand mixed with clay is used for mortar, the clay tends to prevent the cement or lime binding the sand particles together.

4. The aggregates and the binder should be thoroughly mixed.
5. The water content in the mortar should not be too high. If so, crazing will develop on the plastered surface.
6. The plaster should not be allowed to dry very rapidly such as by exposure to hot sun. If so, crazing will develop on the plastered surface.
7. There should not be any soluble salts in the aggregates or in the water used. This will lead to salt crystallization and the plastered surface will start crumbling or powdering.
8. The projections extending beyond 13 mm from the general surface of the masonry should be knocked off so as to maintain thinner plaster layer. This will reduce the consumption of the plaster mortar.
9. All the joints in the masonry face should be raked out for a depth of about 20 mm. These joints should be cleaned from all loose dust and mortar. This is very essential to obtain a good key for the plaster; otherwise separation from backing or separation between coats will take place.

10. The thickness of a single coat should not be more than 15 mm. Both the above will lead to separation from backing.
11. The wall surface should be wetted properly prior to being plastered. If the wall is dry, it will suck water from the mortar and proper adhesion will not take place.
12. The plaster should be laid over the full length of the wall or upto natural breaking points such as doors or windows.

3.6.2 Defects in Plastering

An impervious layer of plaster works well provided it is faultless. However, cracks through which rain water can penetrate always form due to movements in the structure.

Moisture which has penetrated has difficulty in getting out again due to the imperviousness of the plaster and therefore accumulates behind it, causes the wall to become damp and is a menace to the plaster itself.

3.6.3 Crazeing

The appearance on a finished plaster surface of a number of fine hair cracks in an irregular pattern is called crazeing. It may be due to one or more of the following reasons:

1. The plaster surface was allowed to dry very fast such as by exposure to hot sun.
2. The finish was applied before backing had set.
3. The shrinking of an undercoat after application of the finish (probably caused by using poor quality clayey sand in cement/sand mixes).
4. Due to poor application such as insufficient pressure applied to the finish.

3.6.4 Loss of adhesion

The loss of adhesion of plaster can occur due to the following reasons:

1. Due to water penetration.
2. Finishing coat stronger than undercoat or wall.
3. Excessive thickness of coats.
4. Lack of suction control during application (dry backing out of wet application)
5. Lack of adequate raking out of the joints.

Adequate key must be ensured by raking out the joints to 20 mm minimum depth or by hacking the background or scoring the undercoat.

3.7 Flooring

3.7.1 Thickness of the floor screeds

A screed laid on a concrete base, within three hours of placing concrete will bond strongly to the concrete and dry slowly with the concrete so that drying shrinkage and cracking of the screed are minimized. For this monolithic construction of screed a thickness of 12 mm will suffice.

A screed laid on concrete base that has set and hardened should be cleaned and dampened and then covered by a thin grout of water and cement before the screed is laid.

3.7.2 Points to be remembered: flooring

1. All the inside walls, ceiling and outside walls should be plastered before the flooring is done.
2. The top layer should consist of a uniform layer of cement plaster of specified thickness and of mix 1:4 cement mortar, unless otherwise specified. The top is finished with a floating coat of neat cement.
3. Screeds should be mixed with just sufficient water for workability.

4. The plaster flooring may be thread-lined, in squares or diagonals, to the sides of the room.
5. The screed should be cured for at least seven days and allowed to dry slowly over the course of several days to minimize rapid drying shrinkage and cracking.

3.8 Painting

Painting of the walls, woodwork and the metal grillwork are done to give a good appearance to the surface besides protecting it from corrosion and decay.

3.8.1 Application of cement based paints

Cement paints are applied on the masonry walls of the house. These are available in powder form.

3.8.2 Application of cement based paints: Points to remember

1. The dry paint powder is added to water and not the other way around.
2. Two parts of dry powder are added to one part of water by volume in a clean container and mixed thoroughly till a uniform paste is obtained.

3. One part of water is again added by continuously stirring to get a paint of uniform consistency.
4. Before applying the paint, the walls have to be saturated with water.
5. The whole quantity prepared should be consumed within one hour.
6. Two or three coats of paint may be applied to get the required finish.

3.8.3 Curing period for cement based paints

Any paint made out of cement with different pigments needs curing for at least five days.

3.8.4 Application of enamel paint: Points to remember

1. It should be ensured that the timber is properly seasoned before it is painted.
2. The surface of the woodwork should be cleaned and all the nail heads should be punched to a depth of 3 mm.
3. A priming coat (the first coat of paint) is applied whose main function is to fill the pores of the wooden surface by penetrating into the surface. It also acts as the foundation for subsequent coats of the paint.

4. When priming coat is dry, the nail holes, cracks, dents etc on the surface of the woodwork are filled up with putty. The surface is then sanded.
5. Next, the undercoat of the paint is applied.
6. Each coat should be applied after the coat applied previously has sufficiently dried. For superior works, each coat is rubbed before applying the next coat.
7. Generally 2-3 coats of finish paint give satisfactory results.



CHAPTER IV DESIGN DETAILS

4.1 Rising damp

If a porous walling material such as brick or stone is in contact with damp soil, moisture will be drawn into the pores by a physical process called capillary action. The absorbed moisture will rise in the wall to a height at which there is a balance between the rate of evaporation and the rate at which it can be drawn by capillary forces. The height will vary in accordance with the level of the water table of the soil.

Rising damp usually contains salts carried up from the soil or dissolved from the walling material. Some of these salts are hygroscopic; i.e. they absorb moisture from the air. Their presence will maintain dampness even after the rising damp has been eliminated.

The effects of rising damp usually extend from 3 cm to 100 cm above floor level and exhibit a sharp change from wet to dry on the wall. Moisture will be present throughout the wall thickness. Contaminating salts may be seen as white deposits or crystals.



Rising dampness and salt crystallization leads to weathering

4.2 Salt crystallization

Salt crystallization is the precipitation of salts such as chlorides, sulphates and carbonates in the building material. The salts are activated only when a suitable agent is present. Water plays a key role as an agent either in the form of moisture, which causes dampness, or subsoil water rise in the structure or percolation; or seepage of water accumulated in the structure due to cracks and crevices. When water is drawn from soil, it always contains solution of salts present in the soil.

When evaporation takes place on the surface, the salts get deposited near the surface and the mechanical forces exerted during crystallization cause the plaster or brick to disintegrate over a period of time. In Nagapattinam District in Tamil Nadu, for example, the ground water table is quite high and the water is salty and hence this has to be given special consideration while building houses there.



Cement plaster at the bottom leads to further rise of rising damp and salt crystallization



4.3 Coping

A top is needed for a wall to throw off rainwater and protect the brickwork below from being saturated. This is called coping. Traditional copings have a slight overhang on each side of the wall face with a groove called a throating on the underside. Rainwater drips off the edge without running down the face of the brickwork.



Coping to protect the brickwork below



Sunshade throughout building helps to protect both the walls and windows

4.4 Sloping Sunshades

Sunshades should be provided to protect walls, windows and doors against sun and rain. Sloping sunshade is advisable rather than a flat sunshade because flat sunshades can collect water which may lead to dampness of the wall over a period of time.

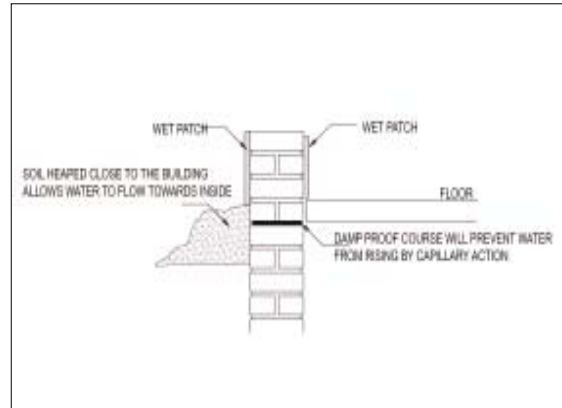


Wall below sunshade is in good condition

4.5 Sloping of ground away from the building

The ground should slope away from the building to ensure that rainwater flows away. All the soil and loose earth close to the external walls should be removed and maximum slope given away from the building. Dampness may enter a building from the ground. The difference between the finished ground level and the finished floor level was not even 150 mm in many of the existing buildings that were surveyed in Nagapattinam. The height of the plinth should be kept to a minimum of 450 mm in all the buildings.

Ground slope is a serious problem in the tsunami affected areas because of the high



Transfer of ground water above DPC in wall

water table during the rainy season. In many of the existing villages, it is one to three feet below the existing ground level. The rising damp in the building will become less problematic if the land is sloped away from the building.



CHAPTER V

FREQUENTLY ASKED QUESTIONS

- **What is the difference between a framed structure and a load bearing structure?**

An RCC (reinforced cement concrete) framed building would have concrete footings and concrete columns and beams. The load is transferred through the column beam frame to the RCC footings. The masonry walls do not take any load and are constructed only after construction of the frame is over.

Building with load bearing masonry transfers the dead and live loads of the building through the masonry walls and footings. In this case, the walls are structural members.

- **What are the advantages and disadvantages of an RCC framed structure?**

The advantages of an RCC framed structure are the following;

1. The whole building acts like a monolith in the event of a natural hazard such as earth quakes and cyclones.

2. The internal walls can be made in half brick thickness. This will allow a gain of some extra carpet area which is very critical for small rooms.

The disadvantages of the RCC framed structure are the following;

1. The quality of construction required for an RCC framed structure is very high considering the highly corrosive nature of the coastal environment.
2. The skill required for putting up an RCC framed structure is high and there may not be sufficient local know-how on the materials and the workmanship.

- **Is soil investigation necessary for the tsunami reconstruction projects?**

The soil in many of the areas in Nagapattinam district is inferior from a foundation point of view. It is very important to do the soil investigation by a suitable method to know the nature of the soil and the foundation required for the building. By knowing the exact nature of the soil, the structural engineer will be able to design the foundation accordingly. Doing a soil test in one place in an area and hence designing the right foundation will result in mass

savings when many houses are to be constructed in the location because even a small saving in one building, when it is multiplied by the number of houses, can become a substantial amount.

- **What should be the depth of the foundation required?**

The details such as the depth of the foundation, the type of the foundation (whether it is column footing, spread footing, under-reamed pile or pre-cast piles) and the reinforcement required will vary from project to project depending also on the design.

- **How can one construct strong buildings in low lying land or in agricultural fields?**

As explained earlier, the foundation has to be designed for each building and the design will vary from place to place. In Nagapattinam district, the soil is very silty in many places and a carefully designed foundation is essential.

- **Why are cover blocks for the reinforcement required?**

The steel bars used in RCC have a tendency to corrode when in contact with humid air. To prevent this, all the sides of the reinforcement should be covered with sufficient concrete. To

ensure this, cover blocks are placed to prevent the steel bars from getting exposed to the atmosphere. The blocks are tied to the reinforcement using thin steel wires called binding wires.

- **What should be the thickness of the roof slabs made of concrete?**

The minimum thickness of the concrete slab should be 10 cm. It may vary from one structural engineer to the other, but should not exceed 11 cm for the smaller span rooms of less than three metres in residential houses. The depth of the beam will vary depending on the span.

- **What is the reinforcement required for a concrete roof slab?**

Normally 8 mm diameter steel bars are used as the reinforcement for the roof slabs for spans less than three metres. The spacing should not exceed 250 mm and it will vary from one building to the other.

- **Why do concrete roofs leak?**

Concrete roofs can leak because of the following reasons;

1. Poor compaction of concrete resulting in a lot of air voids.

2. Improper proportioning of concrete constituents resulting in concrete becoming permeable.
3. Structural cracks because of loading conditions and failure of the structure to with stand those stresses.
4. Discontinuity in construction joints that may facilitate movement of water.
5. Thermal expansion and contraction which take place over a period of time.

- **How can leakages in concrete roofs be avoided?**

The following measures will help to avoid leakages:

1. Water should not be allowed to accumulate on the terrace. Good drainage with correct gradient must be provided.
2. Good quality materials should be used and good quality workmanship must be ensured.
3. Construction joints must be avoided as much as possible.

- **Do earthen buildings require maintenance?**

It is of fundamental importance to understand that earth walls and roofs need regular, if not constant, maintenance. Earth may be the most vulnerable of all the inorganic building materials being subject to rapid and often catastrophic erosion. Earth buildings are characterized by a worn and repaired finish. People who live in earth buildings have to accept that regular maintenance, repair and replacement are constant activities. Yet, there are many earth buildings around us which are more than 100 years old. For increased life, an earth house should have a good overhanging roof. The English proverb – “Give me a hat and shoe I will last forever” becomes quite apt in this context.

- **How durable are the buildings built with rammed earth?**

The rammed earth wall buildings which have been stabilized with cement are very durable and will not erode as rapidly as an earth building.

APPENDIX

SAFETY AND HEALTH IN CONSTRUCTION WORK

Sufficient attention is not paid to the health and safety aspects of construction works. Accidents are very common, although many of them may not be of a very serious nature. However, they result in the loss of work and income for few days for the workers. Though national laws have been passed for the health and safety of the workers, they are not enforced. In many cases, local circumstances and technical difficulties make it impracticable to follow the provisions of such laws and guidelines. Simple measures as detailed below can help improve safety at the construction site.

Workplaces

1. There should be sufficient ventilation and lighting in all workplaces.
2. All projecting nails should be removed or bent over to prevent injury.
3. Equipment, tools and small objects should not be left lying about where they could fall over a person or result in workers stumbling or stepping on them, thereby causing an accident.

4. No open flame should be brought near any flammable or combustible materials kept or stored in the workplace. Smoking should be prohibited in such places.
5. Special care should be exercised by all workers when they drop building materials, scaffold materials, waste materials and tools from heights so that they do not cause injury to others.
6. All used wood should be made free from nails, iron straps etc. before being reused.
7. First aid kits or boxes should be provided at the workplaces. The kit should not contain anything besides materials for first aid. First aid kits should be in the charge of a responsible person who should be trained to render first aid. Supervisors and workers should be given training in first-aid.

Scaffolding

1. Scaffolds must be provided for all work which cannot be safely done from the ground or from part of the permanent structure. Ladders may be used but only for light work that can be done by hand.

2. All scaffolding, shuttering, and bracing should be inspected for any damage or defects after any long idle period or heavy wind or rain.
3. Ropes used should not come into contact with lime, acids or other corrosive substances.
4. Loose bricks or other unsuitable material should not be used for the construction or support of scaffolds.
5. It should be ensured that the nails on scaffolds are of adequate length and thickness. They should be driven full length and not driven part way and then bent over.
6. No nail should be subjected to direct pull.
7. No sudden shock should be transmitted to the scaffold while transferring heavy loads on, or to a scaffold.
8. Care should be taken to ensure that the scaffold is not over loaded. The load on the scaffold should be evenly distributed as far as possible, and in any case, should be distributed so as to avoid any dangerous disturbance of the equilibrium.

9. Workers should not be employed on outside scaffolds in a high wind.
10. Scaffolds should not be used for the storage of material except those required for immediate use.
11. As far as practicable, clear headroom of at least 1.8 m should be maintained on working platforms.
12. Boards or planks, which form part of a working platform or which are used as toe-boards should be at least 2.5 cm thick and 15 cm wide.
13. The pole uprights should always be erected in such a way that they are either vertical or slightly inclined towards the building.
14. If pole uprights have to be extended,
 - (a) The upper and lower poles should overlap by at least 1.5 m.
 - (b) The two poles should be securely wedged together and lashed with wire or rope; and
 - (c) The extension pole should rest on a ledger, log or other adequate support.

15. Two consecutive ledgers should overlap at least for 1 m.
16. The distance between two consecutive putlog on which a platform rests should not exceed 1 m with planks less than 4 cm thick, 1.5 m with planks less than 5 cm thick and 2 m with planks at least 5 cm thick.

Excavation

1. Before excavation begins on any site, the location of all underground installations such as sewers, water pipes etc. that may cause danger during the work should be ascertained.
2. Sides of excavation should be thoroughly inspected after heavy rain.
3. No person should work on loose ground if the slope is such that a safe foothold cannot be ensured.
4. The ground should not be undermined without adequate support.
5. Trenches in unstable ground such as loose sand should be close-timbered.

6. No person should enter a sewer, shaft, or other underground space or chamber unless it has been tested and found free from dangerous levels of harmful gases.
7. If workers have to enter an underground chamber or other place to test for gas, they should be provided with a safety belt, safety line and breathing apparatus.
8. A barrier should be provided to every accessible part of an excavation into which a person could fall.
9. The safety of the persons employed below should be considered while stacking or placing any material near the edge of any excavation.

Demolition

1. Unstable parts of the building should be made secure before demolition operations begin. The power on all electric service lines should be shut off and the lines cut or disconnected at, or outside the property line.
2. Demolition operations should be in the reverse order of construction.

3. Demolition operations should begin by the removal of:
 - (a) glass in doors, windows etc.;
 - (b) loose objects; and
 - (c) projecting parts.
4. Where and when necessary, parts of the structure should be adequately shored, braced or otherwise supported.
5. Structures should not be left in a condition in which they could be brought down by wind pressure or vibration.
6. Water should be sprayed at suitable intervals to keep down dust.
7. Workers employed in demolition operations should wear safety boots, safety helmets and gloves.

[From: Safety and Health in Building and Civil Engineering Work, International Labour Office, Geneva, 1972]



GLOSSARY

Aggregate	Broken gravel, stone or sand used with cement to form concrete or mortar. Aggregate can be coarse or fine, and is measured by the size of the mesh through which it is passed.
Arch	A curved structural member, which spans openings or recesses.
Bond	The way in which bricks are laid producing a pattern of stretchers and headers on the face of a wall.
Ceiling	Internal covering of a roof of boarding or plaster concealing or set between the structural members.
Cement	A general term denoting a binding material of plastic consistency with adhesive properties and hydraulic setting action. Especially Portland cement: a powder made from crushing the clinker resulting from burning lime and clay, producing a fast and hard set when mixed with water.
Centering	Temporary structure for support of arches and lintels during construction.
Coping	A cap or finish, either flat or sloping, on top of a wall, pier, chimney or other structures serving to protect masonry below.

Course	Continuous layer of masonry or brick work in a wall.
Crazing	Hairline cracks on a plaster surface.
Damp Proof Course	A stratum of water - resistant material placed within a wall slightly above the ground level, to prevent humidity from rising within the wall structure.
Efflorescence	A powdery white stain on a wall surface and seen when the wall dries out, caused by deposition of water - soluble salts.
Elevation	Any face of a building
English Bond	A method of laying bricks so that alternate courses or layers on the face of the wall are composed of headers or stretchers only.
Float	Small handheld tool used by masons to finish the plaster surface.
Flemish Bond	It is a method of laying bricks so that alternate headers and stretchers appear in each course on the face of the wall.
Form Work	Temporary construction of wood within which concrete is cast.
Framed Building	The structure is carried by a framework – e.g. of steel, reinforced concrete, and timber – instead of by load-bearing walls.

Frog	A depression on the bed surface of a brick.
Gable	Head of wall at the end of a double-pitched roof, usually triangular.
Gravel	Collection of small rounded stones.
Grout	A cementitious component of high water – cement ratio, allowing it to be poured into small spaces.
Gutter	A channel placed along eaves of a roof or edge of a path for removal of rainwater.
Header	A brick laid so that the end shows on the face of the wall.
Lime	Limestone (Calcium Carbonate, CaCO_3) is burnt to get quicklime (Calcium oxide or CaO). after slaking it becomes calcium hydroxide ($\text{Ca}(\text{OH})_2$). We use this as the mortar. This absorbs carbon dioxide from the air and becomes calcium carbonate again.
Lime Putty	The plastic material resulting from slaking quick lime with an excess amount of water, or by adding hydrated lime powder to water.
Lintel	A beam placed over an opening in a wall.

Masonry	Walls built of building blocks of stone, brick, concrete, laterite, or any other material.
Mix	The various materials, and their relative proportions used in a mortar.
Mortar	The initially plastic material used in masonry to provide even bedding and jointing.
Off – set	The part of a wall exposed horizontally when the portion above it is reduced in thickness.
Parapet	A low wall placed to protect any spot where there is a sudden drop, for example, at the edge of a bridge or house – top.
Pillar	Free – standing upright member of any section, that is slender in proportion to its height.
Plinth	Projecting block beneath a column, or projecting courses at the foot of a wall.
Pointing	The outer face of a mortar joint.
Pozzolanic	A term used to describe a fine aggregate which, when incorporated in a mix, gives that mix the ability to set in damp conditions.

Precast	Any component cast in a factory or on the site before being placed in position.
Prefabrication	The manufacture of whole buildings or components in a factory or casting yard and transported to the site.
Rammed Earth	Clay or earth kneaded or mixed with gravel, rammed between boards or formwork, which is removed as the earth hardens.
Retaining Wall	A wall, usually sloped, which supports or retains a weight of earth or water.
Riser	Vertical face of a step, between the two treads.
Sand	The usual filling material in mortar.
Scaffold	Any temporary structure supporting one or more platforms used for supporting workmen or materials in the course of any type of construction work, including maintenance and demolition
Screed	A wooden beam used by masons, roughly six feet in length, used for striking off the plaster surface.
Shuttering	See form work
Sill or Cill	The lower horizontal member of a window, door – frame, or screen.

Soffit	Underside of an arch or lintel.
Spalling	The chipping or flaking of concrete, bricks, or other masonry
Stretcher	The long face of a brick.
Tamping	A board used for consolidating concrete within its forms and for leveling the concrete.
Tread Board	Horizontal element of a step

About SIFFS

SIFFS is a leading non-governmental organisation in fisheries. It functions as the apex body of over 120 primary fish marketing societies of artisanal fishermen in Tamil Nadu, Kerala, Pondicherry and Andhra Pradesh, which are in turn affiliated to District federations that are the members of SIFFS. The village level primary societies take care of the local fish marketing, credit and saving needs of over 6000 fishing units which benefit 30,000 fishermen. The total fish sale by this network was around Rs.450 million in 2005-06. The district federations provide various support services to the societies including monitoring, input supply, credit services and welfare measures. SIFFS as the overall apex has a wide range of activities, both commercial and developmental. These include running a network of boat yards manufacturing marine plywood/fibreglass boats for artisanal fishing, supply of out board motors, a network of motor service centres, ice plants, a large micro-finance programme, R&D in fishing technology, promotion of fishermen societies in new areas, policy research and advocacy. SIFFS also provides technical, professional and financial support to fisherwomen's organisations. Some of the SIFFS services are available in Karnataka also.

SIFFS has played a major role in relief and rehabilitation after the December 2004 tsunami, especially on the Tamil Nadu coast. In addition to providing immediate relief, it has worked on restoring and further enhancing fisheries livelihoods in many areas. Repairs of boats and motors were followed by supply of new boats and nets. Livelihood restoration support was also provided to fisherwomen and male fish vendors. The opportunity has been seized to strengthen the marketing, credit and technical support activities and expand the fish marketing society network along the east coast. A community based fisheries management programme has also been launched in select locations. Given the scale of the destruction, SIFFS also felt compelled to get involved in activities for which it had no previous experience like housing. SIFFS is committed to constructing 2500 houses with the technical support of a number of institutions and with the participation of the affected communities. The SIFFS tsunami work also involves livelihood support to neighbouring agricultural and labouring communities. Finally, SIFFS has partnered with other organisations including the UNDP to set up coordination mechanisms for tsunami rehabilitation.

