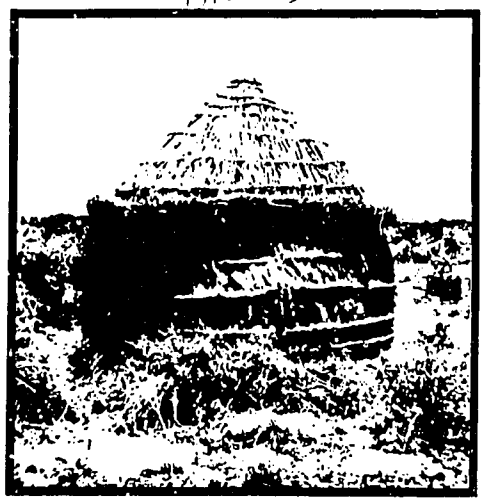
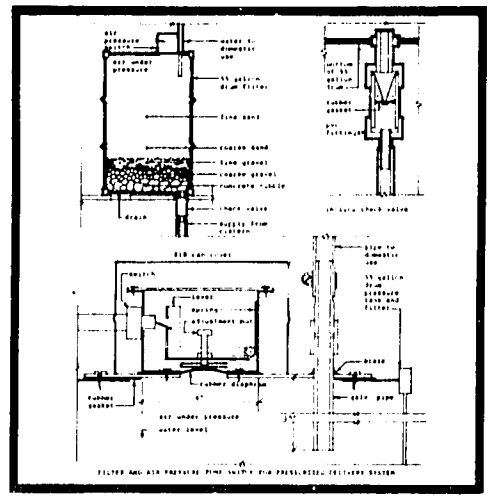
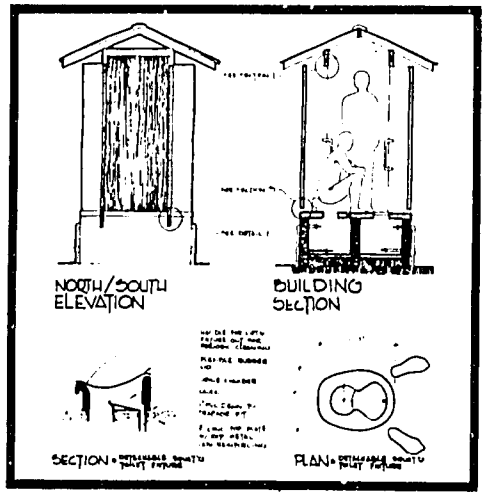
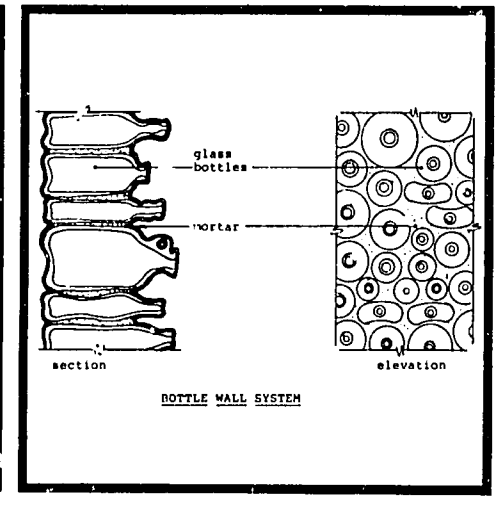








[redacted]

EXPERIMENTAL LOW-COST CONSTRUCTION UNIT

FLORIDA A&M UNIVERSITY
P.O. BOX 597, TALLAHASSEE, FL 32307

SCHOOL OF ARCHITECTURE

This manual was prepared in support of the Construction Training Program for the Pilot Housing Project in Kurtunwaare, Somalia, conducted by a team from the Experimental Low Cost Construction Unit, School of Architecture, Florida A&M University, from June to December of 1980.

Team Members:

School Superintendent . . . . . James Blakeley Bruce

Instructor of Masonry . . . . . Millard M. Wright

Instructor of Carpentry . . . . . David Tod Hollister

Administrative Coordinator . . . . . Lawrence E. Birch

TEXT AND ILLUSTRATIONS . . . . . James Blakeley Bruce

EDITOR . . . . . Deborah Rolfes

TYPIST . . . . . Vickie B. Anderson

CONSTRUCTION TRAINING MANUAL FOR THE
PILOT HOUSING PROJECT, KURTUNWAARE, SOMALIA

Publication #4 July, 1981

FUNDING AGENCIES:

USAID, East African Mission
Washington, DC, USA

Government of Somalia
Mogadishu, Somalia, East Africa

SUB-CONTRACTOR

Florida A&M University, School of Architecture
Experimental Low Cost Construction Unit
P. O. Box 597, Tallahassee, Florida, USA

Work performed in support of the Low Cost Housing Project for Kurtunwarre, Somalia. Prime Contractor: Louis Berger International Inc., 100 Halsted Street, East Orange, New Jersey, USA

Other documents available from the Experimental Low Cost Construction Unit include:

Publication #1: Energy Efficient Technologies and Methodologies for Low Income Rural Housing, 1978

Publication #2: Training Program in Low Cost Energy Efficient Technology, 1979

Publication #3: Construction Training Program for the Kurtunwaare Pilot Housing Project, Kurtunwaare, Somalia, 1981

Publication #5: Investigation of Alternative Roofing Systems Available for Use in the Kurtunwaare Pilot Housing Project, 1981

Publication #6: Design of Alternative Housing Units for the Kurtunwaare Pilot Housing Project, 1981

CONSTRUCTION TRAINING PROGRAM FOR THE

KURTUNWAARE PILOT HOUSING PROJECT

KURTUNWAARE, SOMALIA

PROJECT TEAM	All team members were provided by the School of Architecture, Experimental Low Cost Construction Unit, Florida A&M University.
TEAM MEMBERS	School Superintendent — James Blakeley Bruce
	Instructor of Masonry — Millard M. Wright
	Instructor of Carpentry — David Tod Hollister
	Administrative Coordinator — Lawrence E. Birch
FUNDING AGENCIES	USAID, East African Mission Washington, DC, USA
	Government of Somalia Mogadishu, Somalia
PRIME CONTRACTOR	Louis Berger International Inc. 100 Halsted Street, East Orange, NJ, USA
SUB-CONTRACTOR	Florida A&M University, School of Architecture Experimental Low Cost Construction Unit P.O. Box 597, Tallahassee, FL, USA
TRAINING PROGRAM BUDGET	$99,183.00
APPROXIMATE PROJECT BUDGET	$4,000,000.00

PROJECT SUMMARY

Background - Somalia was one of the many African nations affected by the 1973-1975 drought. In response to the thousands of refugee nomads produced by the drought, the Somali government set up 21 temporary relief camps in the drought-stricken areas, most of which are still in use today.

In an effort to provide the nomads an opportunity to rebuild their lives based on an alternative life style, the government's Settlement Development Agency (SDA) set up six permanent villages that were to have an economic base in agriculture or fishing. One of those villages, Kurtunwaare, located on the Shebelli River, was established as an agricultural village.

PROJECT SUMMARY continued

Kurtunwaare - The village of Kurtunwaare was founded in 1975 with 4000 nomad families. The primary crops produced by the village are rice and corn. In exchange for labor in the fields or village, settlers are provided with a food ration, clothing, education, health care, 2 shillings (13¢) a day, and housing.

Most of the village development effort, until recently, has been aimed at the village's economic base, farming and its infrastructure. There was little opportunity to upgrade the temporary housing and infrastructure, which were all quickly set up when the village was established. Existing houses in the village consisted of one room munduuls (round) and arishes (rectangular), constructed out of mud and wattle, with open pit latrines, a communal water supply and with little attention given to site drainage.

Project Description - Because of these problems, the SDA aided by the local USAID mission developed a prototype house unit and developed a site plan that calls for 4000 new houses with appropriate site infrastructure which includes a water standpipe and cistern for every 25 houses, a composting toilet for each house, and adequate site drainage. The first phase of the project was the construction of a portion (400 houses) of the complete project. The houses were constructed using the following systems:

Concrete grade beam foundations.
Masonry walls of hand-made cinva-ram brick and cement mortar.
Conventional wood frame roof structures.
Coconut palm leaf thatched roof membrane improved with tar paper.

CRAFTS TRAINING PROGRAM SUMMARY

Crafts Training Program - The workforce that was to build the project was to consist of Kurtunwaare settlers. This required that a crafts training program be set up for their training. The primary objective of the training program was to train the approximately 100 skilled laborers that it was estimated would be required for the project. In addition, leadership training, was provided to produce the necessary crew chiefs and foremen.

The Florida A&M Team was responsible for organizing and setting into motion the Crafts Training Program and the training of the School Staff of Somalis to whom the day-to-day management would be gradually turned over. This was done by the Team between June and December 1980.

CRAFTS TRAINING PROGRAM SUMMARY continued

Organization of the Crafts Training Program - The program was divided into the following instructional divisions:

- Unskilled Labor Experience
- Crafts Training Components
  - Foundations
  - Masonry
  - Carpentry
- Leadership

The Crafts Training Components -- Foundations, Masonry, and Carpentry, represented the backbone of the program by producing the skilled labor crew. The unskilled labor experience provided each trainee with a minimum one month weeding out, introductory period that lead to promotion to the Training Program. The Leadership Training was provided for likely candidates that had completed the Crafts Training Program and at least two months of experience with the production crews.

Training Method - The method of training was based on providing the trainee with highly supervised, on-the-job construction experience by constructing houses from the ground up that were identical to houses being built by the production crews. This method avoided wasting time and materials on practice structures and provided the trainees with the most realistic experience possible. This basic training concept was applied not only to crafts trainees but also to leadership trainees. They were trained by assigning them a crew of trainees, a plot to build on, and by giving them decision-making responsibility.

School Site - The training was conducted at the school site which consisted of one of the sites of ten houses (called a Xubin). The Florida A&M Team established the site which included the training houses, an administrative office, storage for materials, and a large equipment operation and storage area. Once all the plots were used, the program was to be relocated on the next Xubin.

RESULTS

By the time the Florida A&M Team left Kurtunwaare in December 1980, the following results had been achieved:

School Staff - A staff consisting of a School Superintendent, Instructors of Foundations, Masonry, and Carpentry, a general Labor Foremen, and assistants for each (10 personnel) had been trained to operate the program. This was the most important task because it insured the continuation of the program.

RESULTS continued

Training Program Curriculum - A curriculum was developed and documented in a manual for use by the school staff.

60 Apprentice Craftsmen Trained - These apprentice craftsmen (including about 20% women) were trained and promoted to the production crews. Additionally, about 40 trainees were still in the program to be replaced by new trainees once they were promoted.

Construction of 13 Houses - 25%, or 13, of the total of 50 houses started by December 1980 had been started by crafts trainees in the training program. Of the 13, 7 were completed.

Establishment of a School Site with Facilities and Equipment - In December, the second school site was established with the layout of its first foundation.

ADDITIONAL SERVICES

Construction Supervision - Each team member provided general construction supervision to aid in project mobilization.

Set Up and Daily Operation of Cinva-ram Block Plant

House Unit Design - Eleven alternative house units were designed and built.

Roofing System Investigation - Investigation and limited testing of alternative roofing systems was carried out.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

ADMINISTRATION

Introduction: Objective of the Manual 3
Training Objectives 3
Area of Training 3
Target Population. 3
Method of Training 3
Organization of Work. 4
School Superintendent. 4
Instructor of Foundations. 5
Instructor for Masonry 5
Instructor for Carpentry 6
Labor Foreman. 7
Training Facilities 7
Area Location. 7
Training Equipment 8
Training Materials 8
Training Program. 8
Time Schedule. 8
Selection Criteria 9
Methods of Instruction 9
Evaluation Criteria. 10
Training Rewards 11
Graduation 11
Leadership Training. 11
Staff Meetings 12
Records and Files 13
Construction Plans. 15
Training School Site 16
Proposed Site Plan 17
House Plan 18
Building Details 19

FOUNDATIONS

Daily Operation 23
Tools 24
Foundations Layout. 28
General Location 28
Batter Boards. 29
String Placement 32
Piles 41
Location and Spacing 41
Digging the Pile Holes 41
Pile Reinforcing Steel 42
Placing the Concrete 43
Perimeter Beam. 44
Location 44
Setting up the Forms 44

Reinforcing Steel Cage 46
Partition Beam Connection. 47
Placing the Concrete 48
Stripping the Forms. 50
Partition Grade Beam. 54
Location and Connection. 54
Setting up the Forms 54
Steel Reinforcing. 55
Subfloor Fill 55
Floor 56

MASONRY

Daily Operation 63
Tools 64
Mortar. 68
Building Layout 69
Centering the Walls on the Foundation. 69
Squaring the Foundation. 71
Leveling the First Course. 71
Locating the Door Openings 72
Completing the First Course. 72
Building the Corners. 73
Exterior Walls. 75
Laying a Mortar Bed. 75
Working to a Line. 76
Making Vertical Mortar Joints. 77
Wall Reinforcing 79
Tie Blocks 79
Scaffolding. 80
Gables 80
Doors and Windows 82
Door Opening 82
Window Openings. 83
Interior Walls. 84
Wall Finishes 84
Roof Anchor Blocks. 85

CARPENTRY

Daily Operation 89
Tools 90
Typical Roof Design 92
Roof Slope 92
Truss Spacing. 93
Truss Fabrication 93
Sizing the Truss Members 93
Truss Fabrication. 96
Top Chords. 96
Bottom Chord. 97
Ridge Plates. 99
Assembly. 99
Heel Cuts 101

Truss Erection. 106
Setting the Trusses in Place 106
Diagonal Bracing 107
Ridge Beam 108
Roofing 110
Palm Stalk Roof Battens. 110
Roofing Felt 111
Palm Thatch. 112
Temporary Door and Window Frames. 114
Wooden Doors and Windows. 115

LISTS OF ILLUSTRATIONS

Administration. 121
Foundations 121
Masonry 122
Carpentry 123

Administration

Introduction: Objective of the Manual

Training Objectives
- Area of Training
- Target Population
- Method of Training

Organization of Work
- School Superintendent
- Instructor for Foundations
- Instructor for Masonry
- Instructor for Carpentry
- Labor Foreman

Training Facilities
- Area Location
- Training Equipment
- Training Materials

Training Program
- Time Schedule
- Selection Criteria
- Methods of Instruction
- Evaluation Criteria
- Training Rewards
- Graduation
- Leadership Training
- Staff Meetings

Records and Files

Construction Plans
- Training School Site
- Proposed Site Plan
- Proposed House Plans

I. Introduction: Objective of the Manual

The Florida A & M University members of the expatriate staff think that the training of the Somali Nomads, who have been resettled in the Kurtunwaare Village, is essential to the ultimate success of the Kurtunwaare Housing Project. It is the intent of this manual to aid the Settlement Development Agency (SDA) employees responsible for the future operation of the technical training program.

The objective of this manual is to provide a detailed description of the construction process presently involved in the housing project. The general construction sequence is broken out into a series of detailed steps which form the core of the training program. This document will assist the craft instructors presently employed in this project and will act as an introduction or orientation document for future employees.

This manual is based on the experiences gained during three months of training and construction by the Florida A & M University team. The drawings and text describe construction processes and details which may (and most likely will) change during the duration of the project. It is, therefore, important that this manual be regularly updated to include in the training program the construction techniques used by the production crews.

II. Training Objectives

A. Area of Training

The Kurtunwaare pilot project is a low-cost housing project which has a training component involving the technical transfer of basic construction skills to the local Kurtunwaare settlers, and the training of counterparts for the expatriate team. The training program is designed to teach specific job construction skills as defined by the project management. Training programs have been set up and are in operation in the following areas:

1. Foundations
2. Masonry
3. Carpentry

B. Target Population

The training program was established to train ex-Nomads who have been resettled in the Kurtunwaare village. The training of the local settlers during this pilot project is seen as an opportunity to generate within the community the technical capacity to construct the remaining 4,000 - 5,000 housing units presently needed.

C. Method of Training

An on-the-job training system is the core of the program, as was called for in the contract documents. The ex-Nomads (settlers)

are instructed in various technical skills via the construction of the same types of housing units as those built by the production crews. Low-cost housing is by its very nature, simple and straightforward, therefore, no attempt has been made to further simplify the design of the houses on which the trainees work.

The settlers are first trained for one or two months so as to develop their physical skill levels to a minimum standard. Once this level is reached, they are turned over to the respective production crews, where they continue to learn and develop at their own rate. Additional training is provided for settlers who show exceptional potential, as well as those experiencing difficulty.

A clear distinction between the production crews and the training program should be noted. The training program needs a strong working relationship with the district authorities, separate from that of the production crews, in order to maintain a viable program. The district provided many essential components to the project, not the least of which is the trainee. The school superintendent must establish and maintain a close relationship with the key district officials and be aware of their long-range goals.

III. Organization of Work

A. School Superintendent

The school superintendent for the training program holds a key position with respect to the eventual success or failure of the school. The job is particularly difficult because it combines the standard organizational problems of construction (coordinating time, labor and materials effectively) with the low or non-existent technical skill levels of the trainees.

It is the responsibility of the school superintendent to:

Organize and operate the daily, weekly and monthly functions of the training program.

Record, monitor and evaluate all training activities.

Establish and maintain a formal operational relationship with the district authorities.

Determine or establish the number and rate of trainees needed by the production crews.

Establish and upgrade criteria for candidate selection.

Readjust the training activities so that they conform to the work being done by the production crews.

Work with the leadership training candidates to develop settlers who can become craft instructors, labor foremen, crew chiefs, etc.

Recommend that additional staff be hired by SDA or that existing staff be dismissed.

Pick up new trainees from the district.

Organize staff meetings.

Purchase tools and needed supplies.

B. Instructor for Foundations

The instructor for foundations has one of the most critical jobs in the project, but one that has very little identification with the house that is finally built. The foundations of the house provide a basis upon which the success or failure of the masonry and carpentry work will rest. Because the physical size of the foundation is small (partially below grade), and because of the physical difficulty of the work, few settlers will want to be in the foundations training program. The instructor must be aware of this and take appropriate action to maintain an ongoing program. The training programs for masonry and carpentry can both be jeopardized by a bottleneck situation in the foundations training program.

It is the responsibility of the instructor for foundations to:

Determine special criteria required for candidate selection specific to foundation work.

Formalize construction techniques with the superintendent of foundations.

Establish training schedule which will stay ahead of the masonry and carpentry programs.

Issue and collect tools used on a daily basis.

Instruct trainees according to the technical steps described in this manual.

Determine whether additional staff is needed.

Determine appropriate skill evaluation criteria.

Evaluate trainees weekly.

Recommend trainees for graduation.

C. Instructor for Masonry

The instructor for masonry has the job of teaching the skill most identified with these houses. The masonry training program is the backbone of the training school and will require assistant instructors to work with the masonry instructor. Because masonry

skills are highly regarded (due to the potential for increased employability), little difficulty will be experienced in obtaining candidates for this program. Conversely, it will be difficult to keep trainees in the program, once their skills are developed and employability increases.

It is the responsibility of the instructor for masonry to:

Determine special criteria required for candidate selection specific to masonry work.

Formalize construction techniques with the superintendent of masonry construction.

Establish a training schedule which will keep up with the foundations program and stay ahead of the carpentry program.

Issue and collect tools used on a daily basis.

Instruct trainees according to the technical steps described in this manual.

Determine whether additional staff is needed.

Determine appropriate skill evaluation criteria.

Evaluate trainees weekly.

Recommend trainees for graduation.

D. Instructor for Carpentry

The carpentry skills needed for this project are simple and straightforward, making the carpentry instructor's position one of the easier jobs within the crafts training school. The carpentry training will include basic carpentry skills, rough carpentry, form carpentry and roofing. Like the masonry program, the carpentry training program offers a marketable skill outside the settlement, creating a potential problem for keeping skilled trainees and tools in the program.

It is the responsibility of the instructor for carpentry to:

Determine special criteria required for candidate selection specific to carpentry work.

Formalize construction techniques with the superintendent for carpentry construction.

Establish a training schedule which will keep up with the foundations and masonry training programs.

Issue and collect tools used on a daily basis.

Instruct trainees according to the technical steps described in this manual.

Determine whether additional staff is needed.

Determine appropriate skill evaluation criteria.

Evaluate trainees weekly.

Recommend trainees for graduation.

E. Labor Foreman

There are many aspects of the construction process in which the trainees need not be involved. The transport of water, cement, blocks, lumber, etc. all tend to take the trainee away from the tasks they are learning. Still, there is a constant need for quickly available, common labor around any construction site. The training program needs to have its own supply of common labor and a labor foreman to supervise the work. Because of the tedious and physically demanding nature of the laborer's job, the foreman should expect a high turnover of settlers who are placed in this program. To offer an incentive, the training program should limit the settlers' work in the labor crew to one month or less, and then move them into either the masonry or carpentry programs.

It is the responsibility of the labor foreman to:

Acquire and organize labor crews to assist the training program.

Issue and collect tools used on a daily basis.

Establish the type and frequency of needed labor through consultations with the craft instructors.

Turn laborers over to masonry and carpentry training programs after one month or less.

IV. Training Facilities

A. Area Location

The crafts training program presently has a small two-room building which is being used for an office and equipment storeroom. This building will be the central facility for the program until such time that the school needs to relocate. At that time, the school superintendent will move the school's base of operation over to a new site, located more centrally to where house construction is taking place. As the training program completes the houses around its location, it will then have to move to a new site and begin training activities there. It is not anticipated that any training structure larger than 35 square meters will be needed by the training program; therefore, the same house plan can be used for the training program's office, less some of the interior partition walls.

B. Training Equipment

The program is based upon teaching specific construction skills and techniques to the Kurtunwaare settlers. An on-the-job training program has been established with little or no specialized training equipment other than the actual tools used to construct the houses. The use and control of the tools is critically important because they are both construction and training tools. All tools should be counted out and checked in each day in order to reduce the chance of tools being lost or stolen. The small hand tools should be locked inside the storeroom at night, and the wheelbarrows should be chained up neatly outside the storeroom. In addition to the tools used in the training program, a supply of tools must be reserved so that sets of tools can be given to each graduate.

C. Training Materials

Like the training equipment above, the only training materials used by the program are the common materials of construction. A supply of certain materials must be maintained at the site if a steady training schedule is going to be achieved for the masonry and foundation programs. Supplies of sand, gravel, lime, cement, water and blocks are all necessary. The carpentry program requires lumber, nails, roofing felt, palm stalks and thatching to function normally. All of these materials must be ordered and stored in an orderly manner at the training school's site. For security reasons, all the sawhorses and timbers used for scaffolding should be stored next to the storeroom when not in use.

V. Training Program

A. Time Schedule

The training program is designed to operate on a six to eight week cycle, depending on the individual trainee's rate of development. This time frame gives the trainee several chances to do specialized tasks while developing his/her general skill level. If fewer trainees are used, or if additional staff is used, the period can be reduced because of the increased student-teacher interaction. If no labor support is provided and the trainees must stop to help with other tasks, then their training period will be longer.

The school superintendent should know when new trainees are needed from district offices, and request them a week in advance. New trainees should be picked up after breakfast (10:00 a.m.) on Saturday morning, and taken to the job site. The first day's activities for all new trainees should provide orientation to the program. The school superintendent should walk the new trainees through the block plant, the different production crews, and the different training programs, explaining the general background of the project.

The training day begins at 6:00 a.m., when the labor transport trucks leave the staff compound for the site. Training should begin

immediately at the site after the roll has been taken and tools checked out. A thirty-minute breakfast is taken at 9:00 a.m. The instructors should be sure that the trainees leave the training area in a neat and orderly manner so that training can be started promptly after the break is over at 9:30 a.m. After breakfast, the roll is taken again and training is continued until 1:00 p.m., which is the end of the work day. The last thirty minutes of each day should be spent reviewing the work and cleaning up and storing the tools.

The project is operating on a six day work week with a total of 40 hours per week. Saturday through Wednesday are 7-hour days with Thursday being a light 5-hour day.

B. Selection Criteria

The training program can produce more effective graduates if the candidates or recruits are selected to meet minimum standards as to basic education, physical fitness, construction experience and leadership ability. The school superintendent must place a strong emphasis on the importance of this aspect of recruiting when requesting new trainees from the district.

A typical recruit should meet the following criteria:

Age: 20-30 years old (emphasis on the young).

Sex: Male and female (instructor's recommendation).

Health: Good general condition with no physical disabilities.

Motivation: Candidate should want to learn a skill.

Residence: Candidate must live in Kurtunwaare.

C. Methods of Instruction

The intent of the training program is to instruct and train local settlers in simple construction techniques for building low-cost housing in Kurtunwaare. The instruction is done through simple demonstrations by the instructors and through practice and review sessions by the settlers. The craft instructors must be qualified in their respective trades and should be able to communicate simple, technical information clearly.

In this project, there are no practice or demonstration structures used for training purposes only. The trainees learn through the construction of actual project houses. For this reason, close supervision by the instructors is necessary to identify and correct mistakes being made by the trainees before they become too critical or permanent. If a trainee builds a corner out of square, sets foundation forms up that are not level, or fails to put diagonal bracing on the roof trusses, then it is the responsibility of the craft instructors to spot the problem and correct the condition.

Any such condition creates an excellent training situation and the instructor should collect the trainees together, explain the problem, and demonstrate the work necessary to correct the problem. Learning through experience is the key to the training program. There will be mistakes made by the trainees every day that they are learning. This is normal and to be expected. It is the instructor's responsibility to catch the inevitable mistakes, so that the appearance and quality of the houses are not compromised.

Review periods are a good way for the instructors to look for mistakes with the trainees and to demonstrate how to correct the mistakes. The instructors should not let new trainees work too long without review because large mistakes will accumulate and too much time will be lost correcting the mistakes.

D. Evaluation Criteria

The Kurtunwaare settlers have little or no background knowledge of traditional masonry and carpentry skills, and surely have no understanding of the tools involved in the construction process. Therefore, all aspects of the construction process need to be taught to the settlers. There are three areas of development which the instructors need to observe in order to evaluate the skill development and progress of the trainee.

1. Physical Ability

The trainees will be slow and awkward in their work at first. As their training continues, they will become more accustomed to and feel physically more comfortable with the work and the tools. As their physical ability improves, the instructors should notice an increase in the amount and quality of work performed.

2. Mental Ability

At first the trainees will have no understanding of the work to be done, and will only imitate what they see. With time, as they continue to work and learn, they will begin to understand why things are done in a particular manner. As the trainees develop an understanding of each step of the construction process, they will begin to make fewer mistakes and will work more efficiently.

3. Motivation

Initially, the work and training will be hard and physically exhausting for the settlers. This fact, combined with the low living allowance provided to settlers, guarantees certain motivational problems. As the settlers gain the physical and mental ability to do the work, their attitude and motivation should improve, especially as they realize that they are learning a skill or trade that has significant economic reward outside the village.

As motivation increases, so also will the amount and quality of work completed.

Monitoring and recording the progress of each trainee is very important, and should be done each week by the school superintendent and the craft instructors. See Figure 1.1 for a typical trainee evaluation form.

E. Training Rewards

The most significant reward system available to the training program is to recommend increases in pay for the trainees as their skill and understanding of the work increases. It is the responsibility of the school superintendent to recommend to the district office increases in pay for the trainees, and to then ensure that the increases are paid.

In addition to cash rewards, there are also material rewards which can be used. Upon final completion of the training program the settlers are given tools of their trade, which have a significant value. This should be made clear to the new trainees to encourage them to stay with the training program.

Without a reasonable reward or incentive program, it is very unlikely that the training program will be successful.

F. Graduation

Graduation of the trainees out of the program and into one of the production crews is the ultimate goal of the training program. The training program is designed to graduate new trainees in six to eight weeks after they begin training. It is the responsibility of the school superintendent to coordinate the number of trainees needed by the production crews with the number of graduates produced by the school. As stated earlier, the trainees are given tools of their respective trades upon graduation, then turned over to the production crews.

G. Leadership Training

While the settlers are in the initial stage of the training program, their progress will be monitored by weekly evaluations and a final evaluation upon graduation. Those trainees who show rapid development in the physical, mental and motivational areas should be considered as candidates for the leadership training program. The leadership candidate should be graduated and turned over to the production crews, just like all the other graduates, and allowed to work for two months. After obtaining work experience, the candidate can be recalled for further training in more complex areas of construction. The candidates will learn foundation layout, masonry layout, roof layout, materials scheduling, labor management, etc. while working on one building lot set aside for leadership training purposes. It is the purpose of the leadership training program to develop skilled trainees who have the ability to organize complex job

responsibilities. The settlers who graduate from the leadership program can then become crew leaders or foremen for the production crews. In addition, the graduates can be used by the training program as assistant instructors to assist the primary craft instructors.

H. Staff Meetings

Formal staff meetings will be necessary to efficiently manage and operate the training school. A specific day every two weeks should be set aside for staff meetings; the trainees will have that day off while the instructors discuss current problems and plan activities for the next two weeks.

The purpose of the staff meeting is to openly discuss current problems in the program, to anticipate future problems, and to plan for their resolution. Both problem-seeking and problem-solving are critically important to the success of the daily operations of the school. Emphasizing the need for total commitment to the success of the program will help to reduce tensions and hard feelings among staff members as efforts are made to identify problem areas.

Identifying the problem areas is less than half the job. The truly difficult part is organizing a plan of action to solve or correct the problem.

Staff meetings should cover many issues, with both forward and backward glances at the following areas:

Trainee Attendance and Progress

Construction Progress

Materials Supply

Staff Attendance and Performance

Graduates

Need for Additional Trainees

Expected Problems and Accompanying Plan of Action

Training Schedule (Foundations, Masonry, Carpentry)

Tool Supply

Staff meetings are only as productive as the involvement of the staff members. Without the desire to identify and solve the problems of operating a training program, little will be gained by having staff meetings. It is the responsibility of the training staff, and primarily the school superintendent, to identify and solve such problems.

VI. Records and Files

The paper work that goes along with this project is as important as the actual construction training. It is necessary to maintain close control over SDA employees, district trainees, tools and materials supply, etc. The school superintendent should record the progress of the school on a daily and weekly basis, and maintain up-to-date files on all aspects of the school's operation.

The following records must be maintained:

A monthly time sheet for the district, to include all foundation workers, masons, carpenters and laborers. A copy of the time sheet should be retained for the files, along with a weekly list of names of people who have missed two or more days. Record excuses.

A monthly time sheet for SDA employees. Keep time on craft instructors and Merka labor office employees, checking the time sheet against that of the timekeeper. If they are the same, sign approval for their time, retaining a copy for the files. Record excuses.

Daily attendance.

Requests for new trainees.

Notices of returning settlers who are not acceptable.

Pay grades of settlers.

Requests for pay increases.

Tool inventory.

Requests for additional tools.

Monthly progress reports.

A simple system for keeping track of the trainees was developed for the program using file cards. All pertinent information regarding the trainees while in the training program was kept on these cards. The information stored fell under the following overall headings: (1) Personal Information, (2) Craft Skill and Tools, (3) Salary Information and (4) Weekly Review and Final Evaluation.

The purpose of the card file system was twofold. The information made up the core of the data kept by the Training Program on the trainees. In addition, the cards were to become a part of the records of the District Authorities for their reference when trying to identify personnel for a village construction job other than the housing project or for future phases of the housing project.

The card is illustrated on the following page.

TRAINEE EVALUATION CARDS

front

NAME: _____

LOCATION: _____ BIRTH DATE: _____

SEX: _____ STUDENT: _____ WORKER: _____

TRAINING PROGRAM ENTERED: _____

DATE ENTERED: _____ DATE COMPLETED: _____

TOOLS ISSUED: _____

LEADERSHIP ABILITIES?: _____

SALARY RECEIVED & DATE:

2 _____ 4 _____ 6 _____ 8 _____ 10 _____ 12 _____

SALARY REQUESTED & DATE:

2 _____ 4 _____ 6 _____ 8 _____ 10 _____ 12 _____

rear

WEEKLY WORK REVIEW:

1 _____
2 _____
3 _____
4 _____
5 _____
6 _____
7 _____
8 _____
9 _____
10 _____
11 _____
12 _____

FINAL SUMMARY STATEMENT: _____

_____

_____

FIGURE 1.1
TRAINEE EVALUATION CARD

VII. Construction Plans

A. Training School Site

The training school site (Figure 1.2) consisted of ten lots measuring 11 meters by 16 meters, providing 176 square meters per family. On the first training site (XUBIN A-2) ten different houses were designed and constructed, for the purpose of generating cost and affordability information. By establishing and maintaining affordability standards for the target population, the potential that additional housing units would be financed by other lending agencies was significantly improved. The affordability factor, or the ability of the users to repay the cost of the house directly affects the size and complexity of the house. The first training site consisted of ten different house plans that ranged from 26 square meters (Lot #1, Figure 1.2) to 43 square meters (Lot #7, Figure 1.2), and included different numbers and arrangements of rooms. A rectangular floor plan for all ten houses was maintained to simplify both the foundations and roofing systems. The house on Lot #2 of XUBIN A-2 was used as a site office and tool storage area for the training program.

B. The Proposed Site

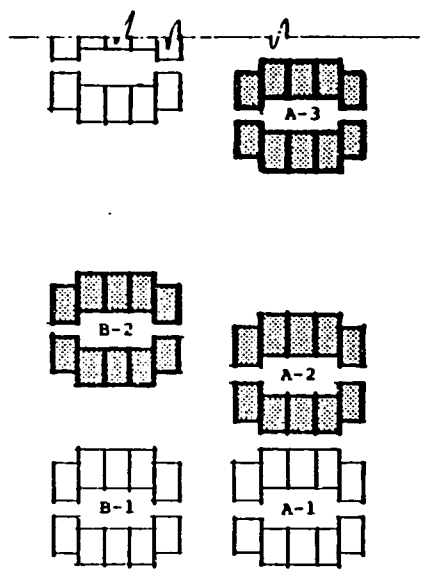
After all ten houses had been completed at the first site (A-2) work could begin at the second site (XUBIN B-2, Figure 1.3). The first ten houses were evaluated according to their cost, affordability, user requirements and Settlement Development Agency requirements. The house on Lot #7 of the first site was selected to be used on all remaining lots built by the training program.

C. The House Plan

The house plan consists of two enclosed rooms approximately 12.5 square meters each, and a covered area of 12.5 square meters between them (see Figures 1.4 and 1.5). The foundation is a rectangle 4.94 meters wide and 8.90 meters long with a grade beam under the two partition walls. The grade beams are reinforced concrete and are 20 cm wide and 25 cm deep. The grade beams rest on eight reinforced piers which are at each corner of the foundation and extend down one meter below the exisitng grade.

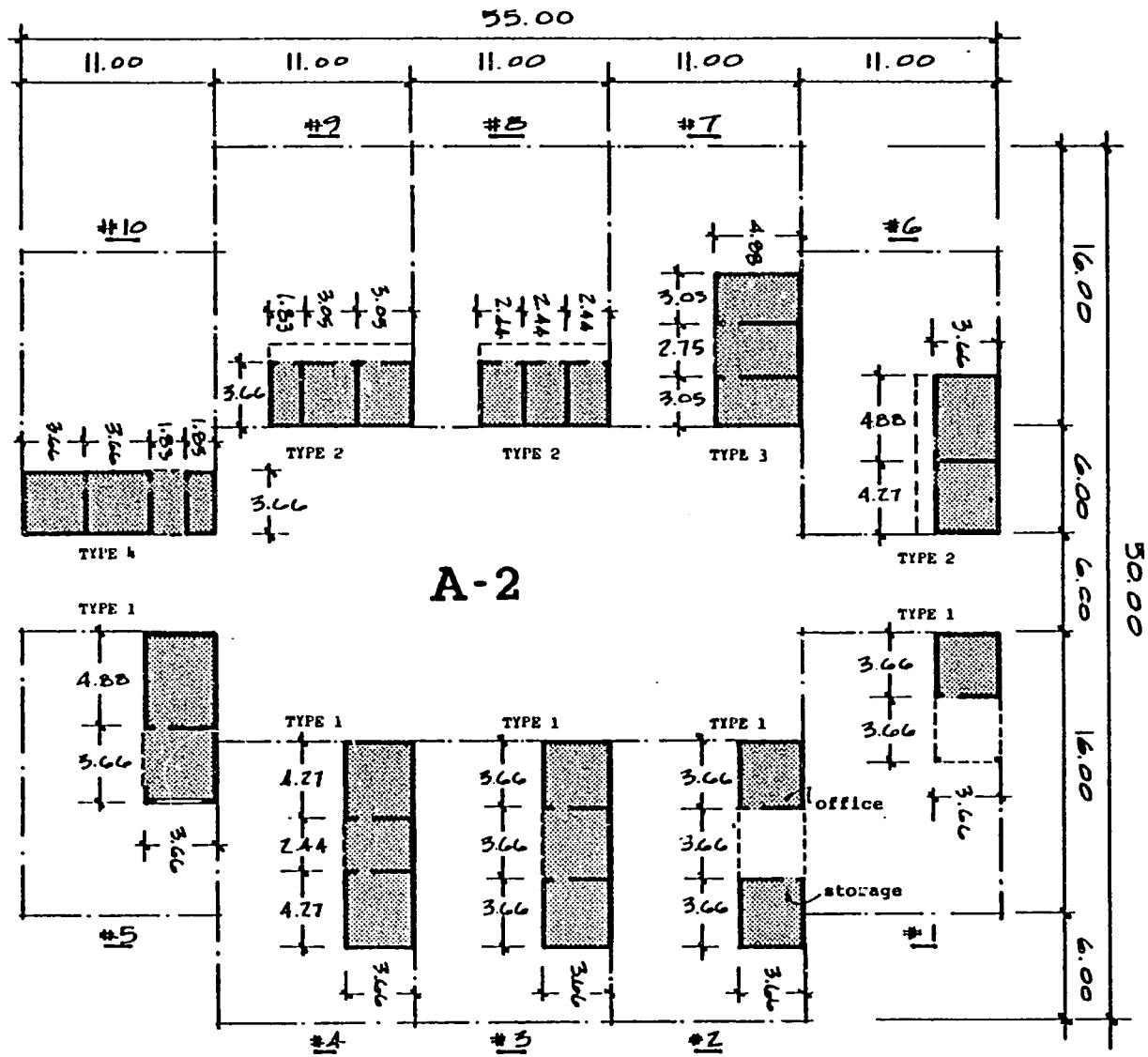
For further details of the site plans, house plans and their evaluation, which were used in this project see Publication #6: Design of Alternative Housing Units for the Kurtunwaare Pilot Housing Project, available from the Experimental Low Cost Construction Unit.

FIGURE 1.2
TRAINING SCHOOL SITE



SCHEMATIC SITE PLAN

NO SCALE (PARTIAL PLAN)

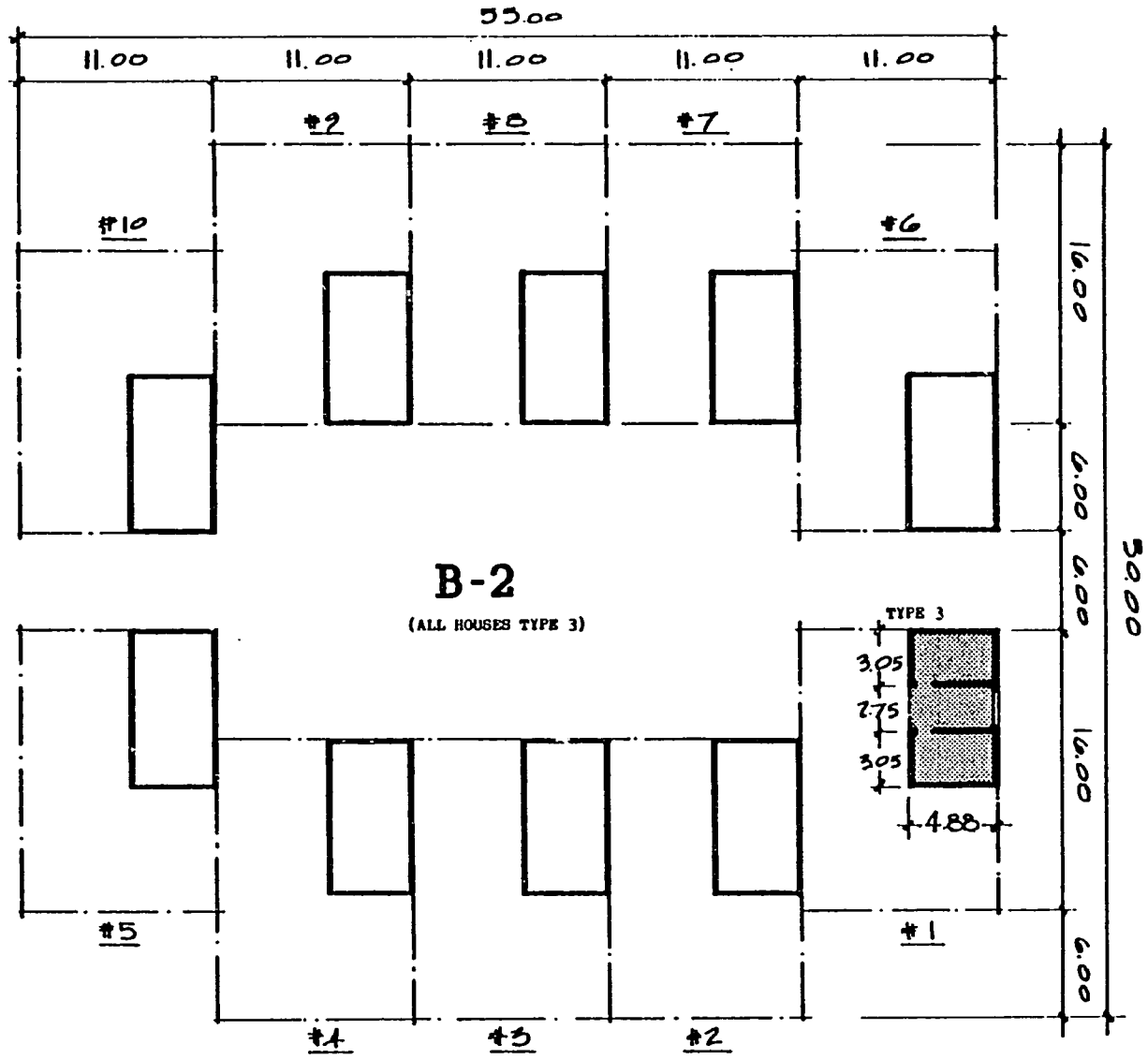


XUBIN A-2 SITE PLAN 1:250 NORTH

SITE PLAN
TRAINING SCHOOL SITE

EXPERIMENTAL LOW-COST CONSTRUCTION UNIT
FLORIDA A&M UNIVERSITY
P.O. BOX 597, TALLAHASSEE, FL 32307
SCHOOL OF ARCHITECTURE

FIGURE 1.3
PROPOSED SITE PLAN

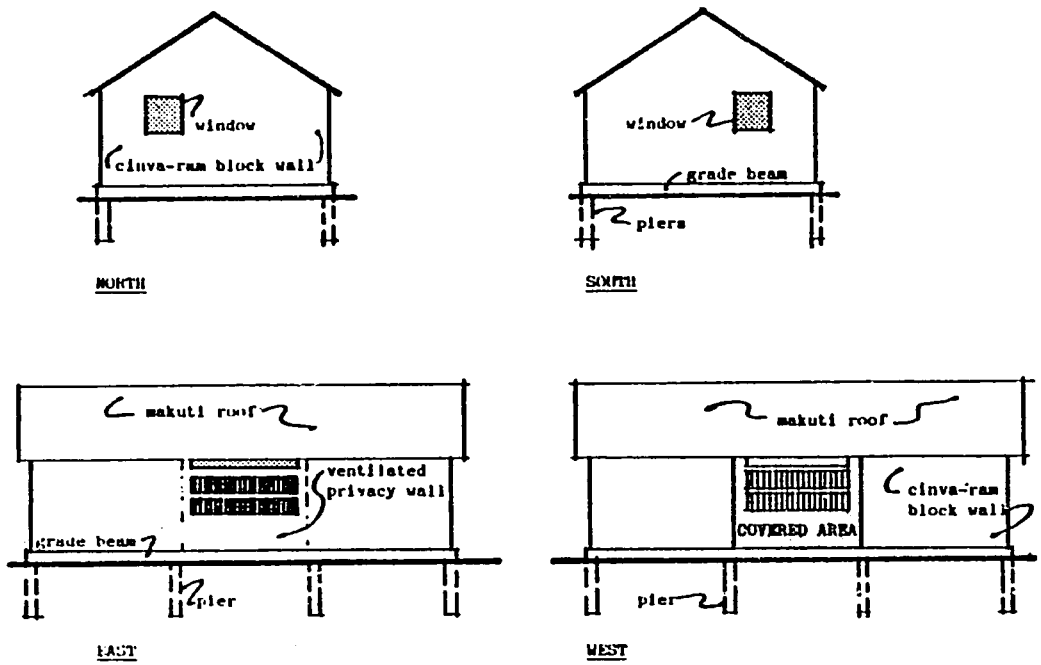


XUBIN B-2 SITE PLAN 1:250

SITE PLAN

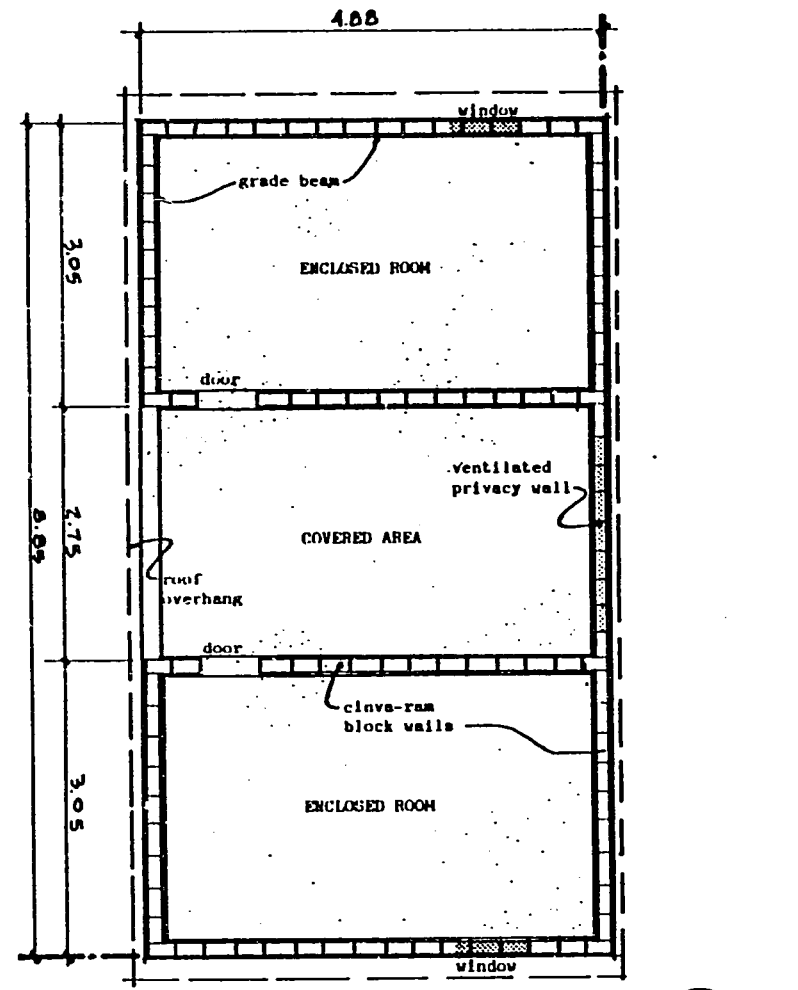
EXPERIMENTAL LOW-COST CONSTRUCTION UNIT
FLORIDA A&M UNIVERSITY
P.O. BOX 597, TALLAHASSEE, FL 32307
SCHOOL OF ARCHITECTURE

FIGURE 1.4
HOUSE PLAN



ELEVATIONS

1:100



PLAN

1:50

DATA

ROOF AREA

Total	56.4 SM

FOUNDATION

Grade Beam	36.0 LM
Piers	8

FLOOR AREA (GROSS)

Enclosed	29.8 SM
Covered	13.4 SM
Total	43.2 SM

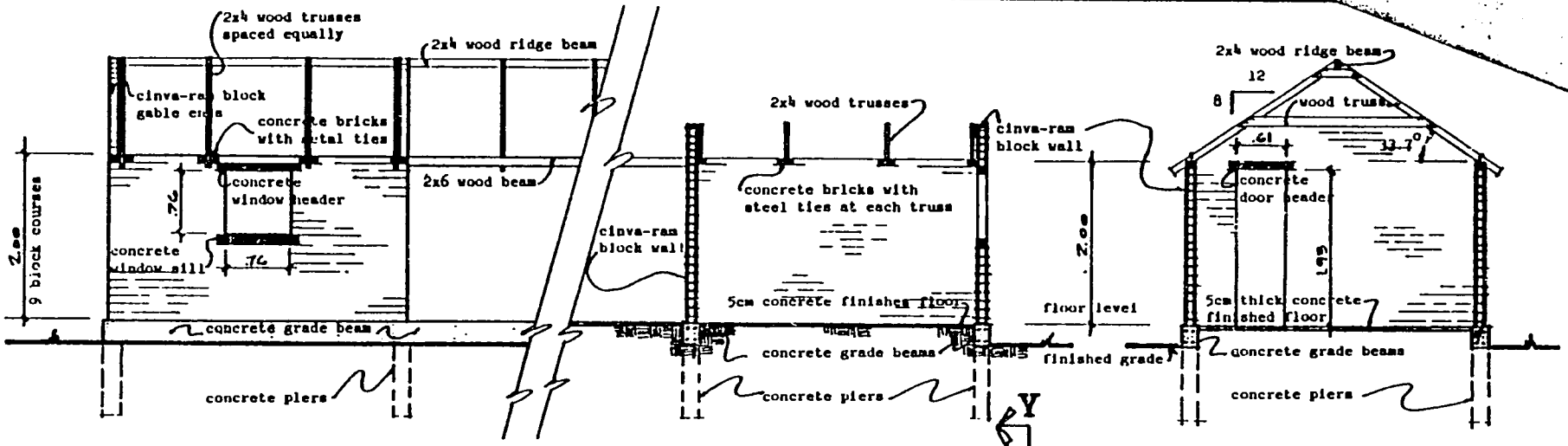
WALL AREA

Exterior	78.1 SM
Partition	0.0 SM
Total	78.1 SM

HOUSE UNIT ALTERNATIVES
TYPE 3 LOCATION A-2, #7 & B-2 #1-10

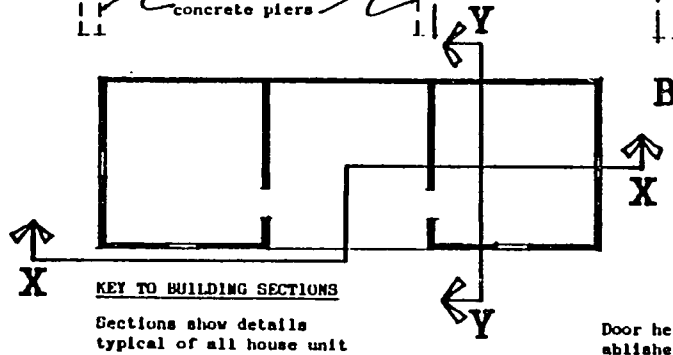
EXPERIMENTAL LOW-COST CONSTRUCTION UNIT
FLORIDA A&M UNIVERSITY
P.O. BOX 597, TALLAHASSEE, FL 32307
SCHOOL OF ARCHITECTURE

FIGURE 1.5
BUILDING DETAILS



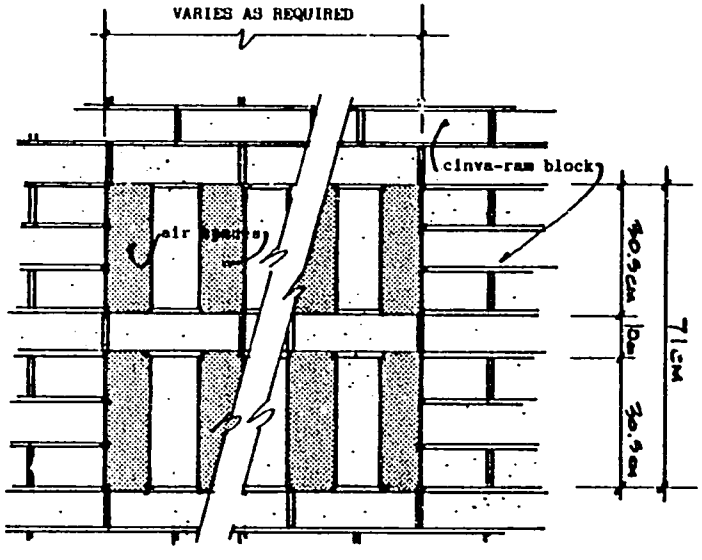
BUILDING SECTION X-X

BUILDING SECTION Y-Y



KEY TO BUILDING SECTIONS

Sections show details typical of all house unit alternatives.

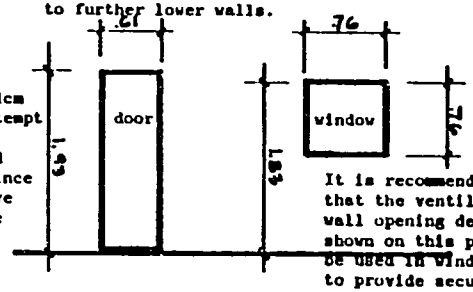


TYPICAL DETAIL OF VENTILATED WALL OPENINGS

DETAIL

Door heights were established at 193cm (6'-4") in an attempt to lower the wall heights. Doors were located in gable end walls to further lower walls.

Door widths were established at 61cm (2'-0") in an attempt to minimize the material required to make a door since wood, an expensive material, might be used.



It is recommended that the ventilated wall opening detail shown on this page be used in windows to provide security.

TYPICAL DOOR AND WINDOW OPENING DETAILS

DETAIL

BUILDING SECTIONS AND DETAILS

EXPERIMENTAL LOW-COST CONSTRUCTION UNIT
FLORIDA A&M UNIVERSITY
P.O. BOX 597, TALLAHASSEE, FL 32307
SCHOOL OF ARCHITECTURE

Foundations

Daily Operation

Tools

Foundations Layout
- General Location
- Batter Boards
- String Placement

Piles
- Location and Spacing
- Digging the Pile Holes
- Pile Reinforcing Steel
- Placing the Concrete

Perimeter Beam
- Location
- Setting up the Forms
- Reinforcing Steel Cage
- Partition Beam Connection
- Placing the Concrete
- Stripping the Forms

Partition Grade Beam
- Location and Connection
- Setting up the Forms
- Steel Reinforcing

Sub-Floor Fill

Floor

I. Daily Operation

A smooth daily operation is crucial to the success of the training program. The training of the settlers takes time, and decreasing time lost due to an inefficient daily operation increases the productivity of the program. In addition, if the settlers view the program as disorganized, there will be a greater chance that tools and equipment will be stolen. It is the responsibility of the foundations instructor to organize each day's activities and to coordinate those activities with other training instructors.

The following practices will help to ensure an efficient daily operation:

Check attendance as soon as all the trainees have arrived in the morning, and again after they return from breakfast. The instructor should have the day's activities clearly planned by the time the roll is called so that the trainees can be quickly divided into groups and the day's training begun.

Make a checklist of all items or materials needed each day and check the list before leaving the compound for the site. Much lost time and needless confusion can be avoided by doing so.

Issue tools and equipment to only those trainees who will be needing them. Pick up all tools at the end of each day, and make sure that they are clean and in good working order. It is the responsibility of the instructor to check tools out and to make sure that they are returned.

Use review periods to evaluate the work done by the trainees, catch mistakes, and explain problems to the group-at-large. Review periods should be frequent at first and can also be used as rest periods. Remember, physical endurance must be developed along with construction skills, and the trainees will tire quickly at first. As the trainees continue in the program, review periods will be needed less often; but to begin with, each batter board nailed up and each hole dug should be monitored. The review should include discussions of how to use the tools, how to stand while working, and how to correct mistakes. There should be a final review at the end of each day in which the day's achievements are discussed and trainees are given an opportunity to express any problems they may be having.

Make sure that the necessary materials and supplies are on hand. It is the responsibility of the foundations instructor to make certain that lumber and nails are available for batter boards and that cement, aggregate and water are available for the foundations.

Communicate ways that work can be done in a safe and orderly manner. The best way to achieve this goal is to maintain a clean and orderly area around the training site.

Always have a supply of clean drinking water available.

Plan ahead. Because the foundations are made of reinforced concrete, special precautions must be taken when some jobs are started. Once a concrete pour is started, for example, it is best to finish it without

stopping. Always make sure there is enough time to finish the pour once it is started.

Coordinate work activities carefully. For example, pile holes should not be dug too far in advance of filling them with concrete since, if it rains, they will have to dug out again--a difficult and time-consuming process.

II. Tools

Instruction in the care and use of the following tools is an essential aspect of the foundations training program:

Digging Bar

FIGURE 2.1
DIGGING BAR

The digging bar is a heavy steel rod that is used to break up the soil and rocks so that a hole can be dug in hard ground. The bar has a pointed end for penetrating and a flattened end for cutting into the soil. Normally, the digging bar is used to loosen up the soil, which is then shoveled out of the hole.

Shovel

FIGURE 2.2
SHOVEL

The shovel is used to dig foundation holes, spread sand and gravel, and perform a variety of other jobs around the construction site.

Pick

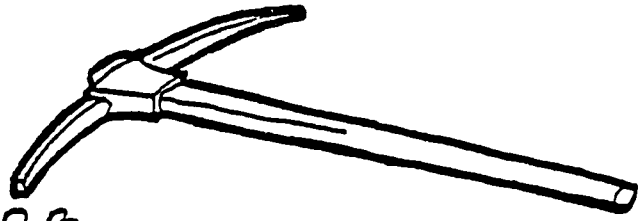


FIGURE 2.3
PICK

The pick is a tool specifically used to break up hard soil which is too difficult to dig with only a shovel. After the pick has loosened the soil, a shovel can be used to clear the soil away.

Sledge Hammer

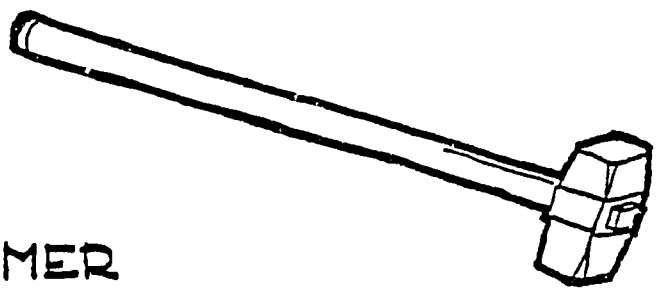


FIGURE 2.4
SLEDGE HAMMER

The sledge hammer is a very heavy steel hammer that weights 5 or 6 kilos. It is primarily used by the foundations program for driving wooden stakes into the ground. As with any hammer, always make sure that the head of the hammer is securely attached to the handle.

20-Meter Tape Measure

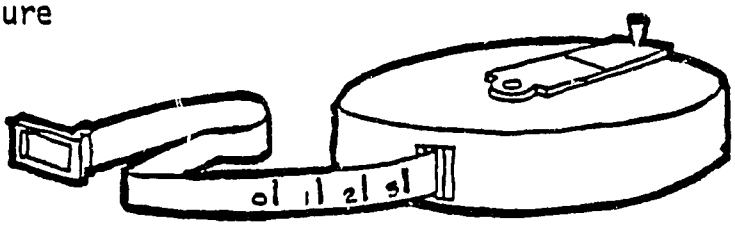


FIGURE 2.5
20-METER TAPE MEASURE

The tape measure is used to lay out the location of the batter boards, check the exact placement of the strings which locate the foundations, and for a variety of similar jobs. The markings on the 20-meter tape do not start at the end of the tape, but begin about 20 cm from the end. This provides enough room to get a firm hold on the tape. Normally, it takes at least two people to use any long tape measure in order to pull it tight between the points being measured. If it is very windy, a third person may be needed to hold the tape in the middle.

Hammer

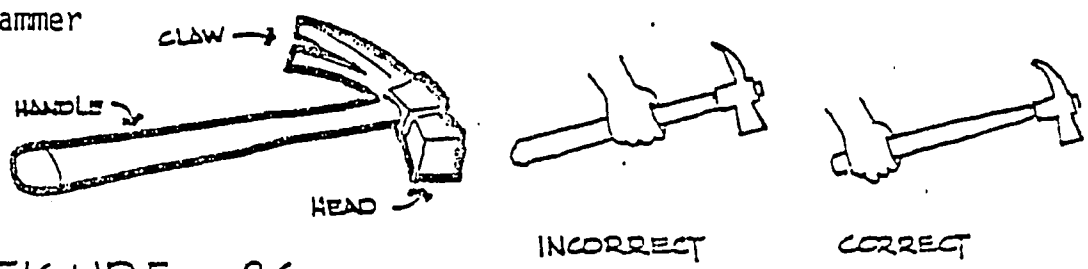


FIGURE 2.6
CARPENTERS HAMMER

A simple carpenter's hammer is frequently needed when setting up the batter boards and forms. For a full description of how to use a hammer, see the section on carpentry tools.

Fluid Level

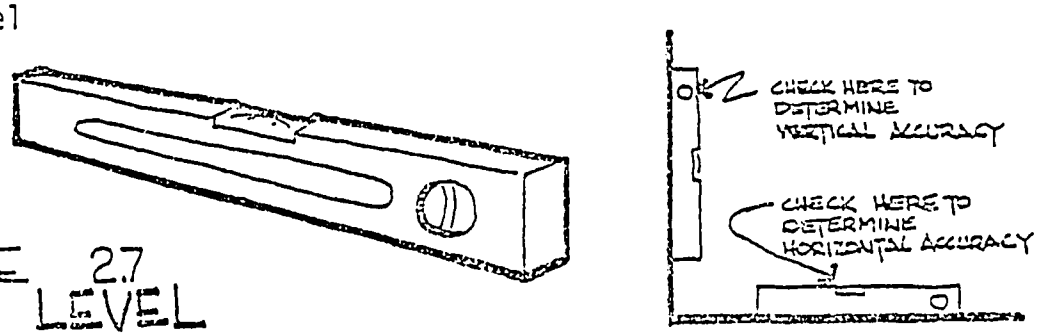


FIGURE 2.7
FLUID LEVEL

The fluid level is a tool used to determine points which are parallel with or perpendicular to the horizon. The fluid level has several uses in setting up the building's foundation; its principal use is to ensure that both the inside and the outside of the concrete formwork is level and of the same height.

Transit

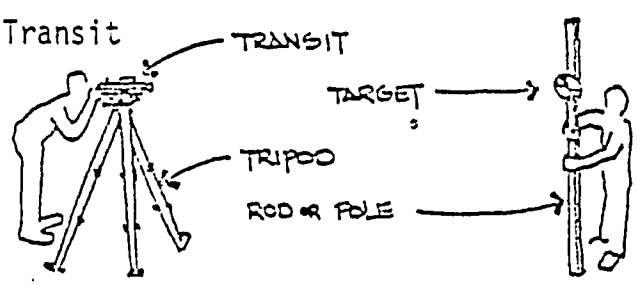


FIGURE 2.8
TRANSIT

The transit is an instrument which is used to determine the height (or elevation) of one point in relation to a set reference point. In foundations work, it is important to set the forms up straight and level, so that the building will not lean one way or the other. The transit is used to make the top of the foundations uniformly level. It rests on a tripod which must be set up first in the following manner:

- Unstrap the tripod and fully extend the three legs.

- Spread the legs apart and set the tripod onto the ground so that it is stable and will not tip over.

- Step on the foot of each leg to securely set the tripod into the ground.

Once the tripod is set up, the transit can be taken out of its case and leveled by the following procedure:

- Set the transit on top of the tripod and screw it into place. Be careful not to move or bump the tripod.

- Use the four threaded adjustment knobs to level the instrument. Line up the barrel of the transit with two of the knobs and adjust until the bubble is in the center. Rotate the transit 90^{0}, so that the barrel of the transit is lined up with the other two knobs. Adjust those knobs until the bubble indicates that the transit is level, regardless of the direction it is pointed.

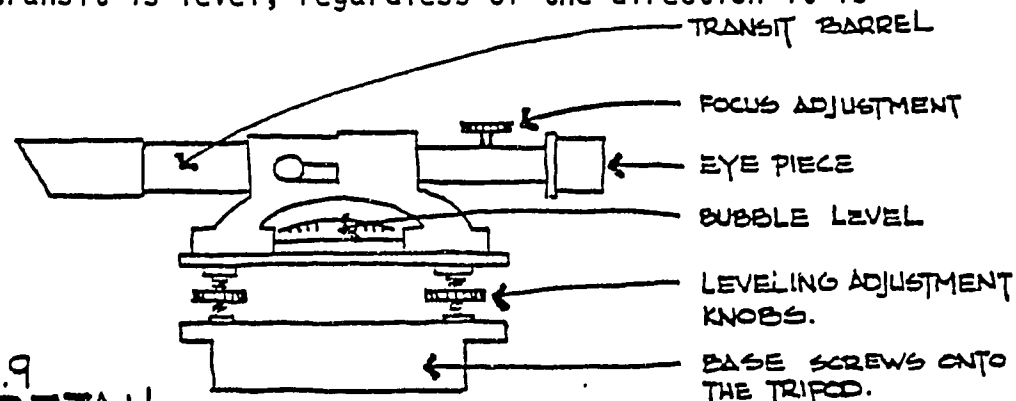


FIGURE 2.9
TRANSIT DETAIL

Metal Form Clips

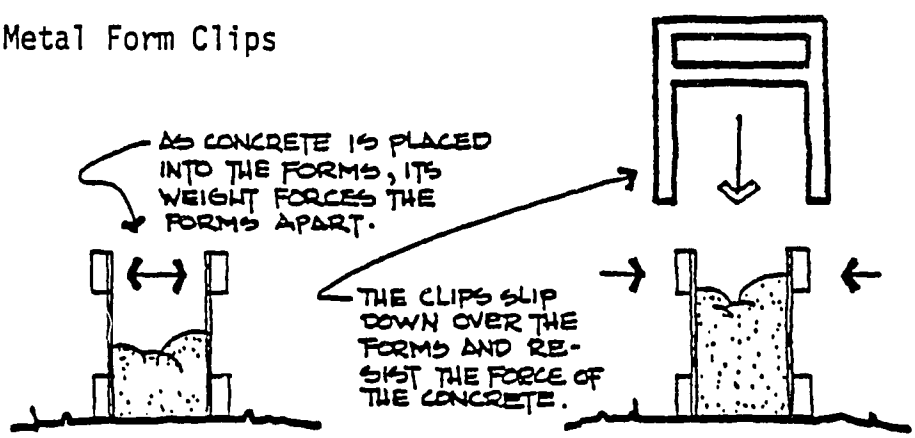


FIGURE 2.10
METAL FORM CLIPS

The metal form clips are used to hold the wood forms at the correct spacing (20 cm), so that the weight and force of the liquid concrete will not push the forms apart. They simply slip over the forms and hold them in place.

Wheelbarrow

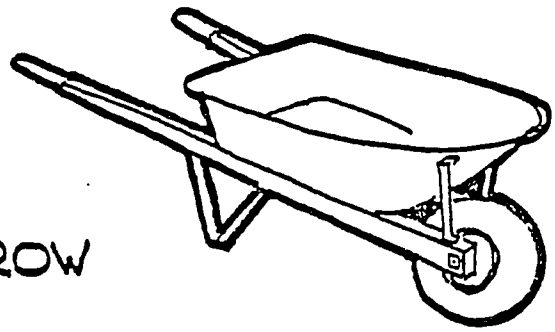


FIGURE 2.11
WHEELBARROW

The wheelbarrow is a small vehicle used to move small loads of sand, gravel, cement, blocks, water, or dirt from one place to another. The load is carried by a single wheel in front; two handles in the back are used for lifting, balancing, and guiding the load.

Crowbar

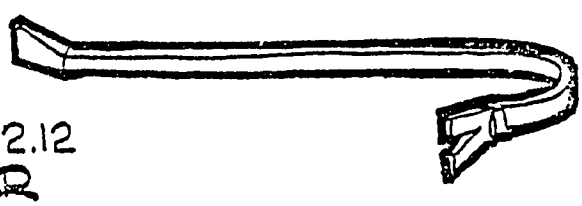


FIGURE 2.12
CROWBAR

The crowbar is a heavy metal bar with one curved and one wedge-shaped end. It is used to pry objects apart.

III. Foundations Layout

It is important to accurately locate each house in relationship to the other houses in the xubin and to the project in general. A site plan for each xubin should be provided to the training program by either the sites engineer or the foundations superintendent. Be sure that an approved site plan is used to lay out the foundations. The site plan will show the dimensions of the ten lots and the locations of the individual houses on each lot. In addition, the site plan will show the elevation of the top of the foundation.

Once the site has been cleared of small brush and the ten building lots have been set out, the foundations instructor is ready to begin. Once the general x bin layout is understood, the exact location and orientations of each individual house must be carefully determined.

A. General Location

The general location of the building is indicated by placing a marker (block or stone) in the approximate location of the corners of the building. The foundation plan will give dimensions indicating

the location of the corners of the building in relationship to the building lot.

B. Batter Boards

Once the corners are spotted on the ground, the batter boards can be set up. The batter boards are placed so that they frame in (or bracket) the general location and elevation of the finished foundation.

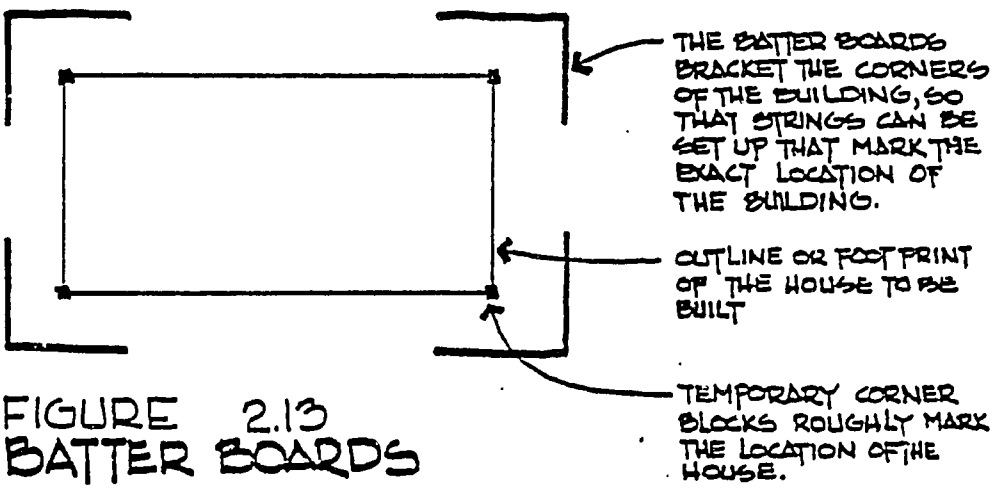


FIGURE 2.13
BATTER BOARDS

Each corner is made of three wooden stakes, driven firmly into the ground, and the two batter boards nailed between them. String is stretched over the batter boards, marking the exact location of the foundation forms. The sequence for setting up the batter boards is described below.

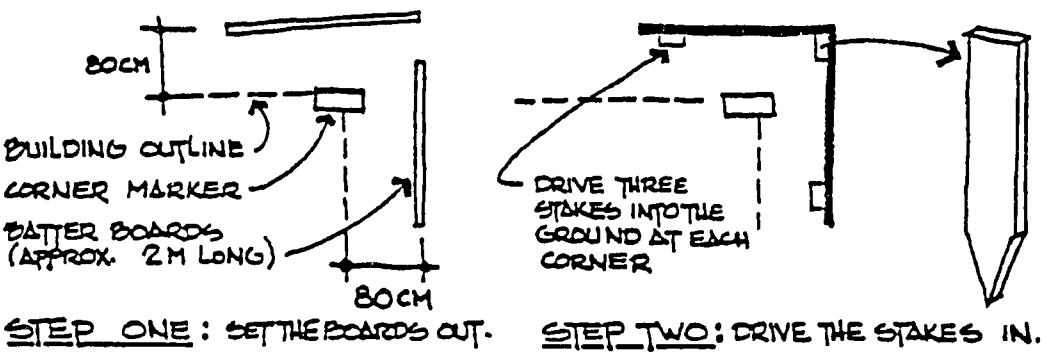


FIGURE 2.14
BATTER BOARDS - DETAIL

1. Lay the batter boards down on the ground, about 80 cm from the building line.

2. Drive stakes into the ground firmly with a sledge hammer, making sure that they are driven vertically, not sloping one way or another. The two faces of the stakes should be parallel with the line of the building. The batter boards will be nailed to the outside face of the stakes.

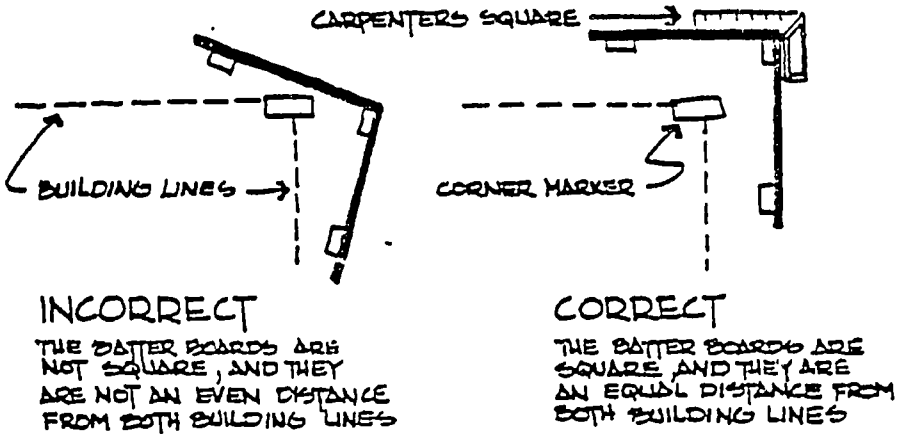


FIGURE 2.15
BATTER BOARDS - DETAIL

3. Once all the stakes have been set in place, the elevation of the top of the foundation can be established:

   Set the transit up and read the elevation of an existing foundation (or ask the sites engineer for the elevation).

   Mark one stake where the top of the foundation will go. Then, make a second mark 9 cm above the first mark; read the elevation of that mark. (This distance of 9 cm is arbitrary. The intent is to raise the batter boards and the string which stretches across them to a point which will allow sufficient clearance for the trainees to set the forms in place without moving the string.)

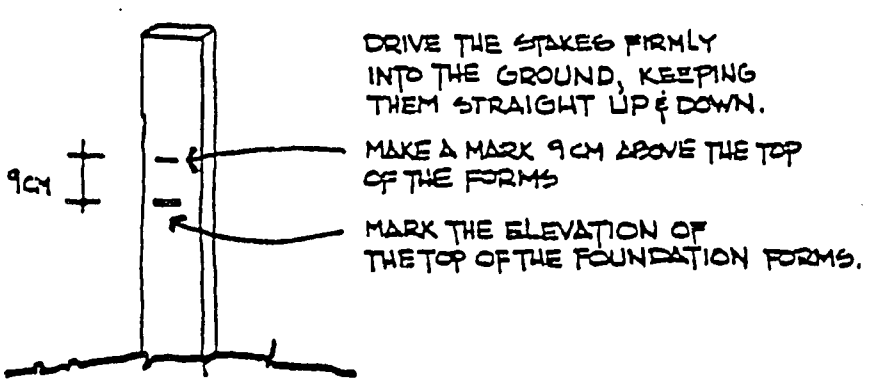


FIGURE 2.16
SETTING THE FOUNDATIONS ELEVATION

Using the transit, carefully mark all the stakes at the elevation that is 9 cm above the top of the foundation. Be sure to mark the stakes on the side away from the building, as this is the side to which the batter boards will be nailed.

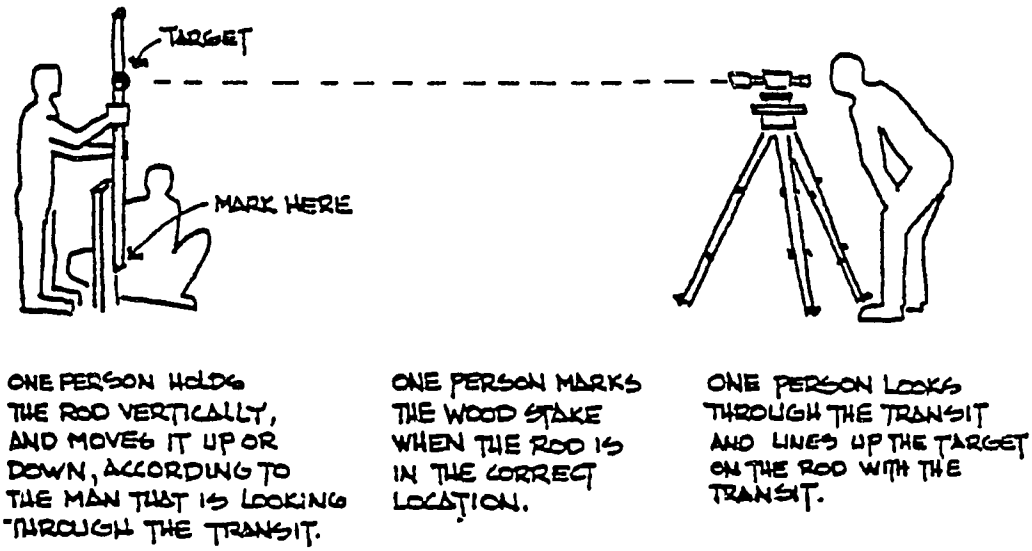


FIGURE 2.17
USING THE TRANSIT

4. Nail the batter board to the stakes, lining them up with the marks. Have someone hold the stake while the batter board is being nailed to it so as to prevent the stake from moving and becoming loose in the soil.

5. If you marked all the stakes accurately, all the batter boards should be at the same elevation. This can be quickly checked by setting the surveying rod on the batter boards and checking the elevation around the building with the transit.

6. When the strings are being laid out and set, you will sometimes find that the batter boards are not in the correct place and need to be extended. To do so, drive an additional stake into the ground and nail on the additional length of batter board. Use the liquid level to get the correct height.

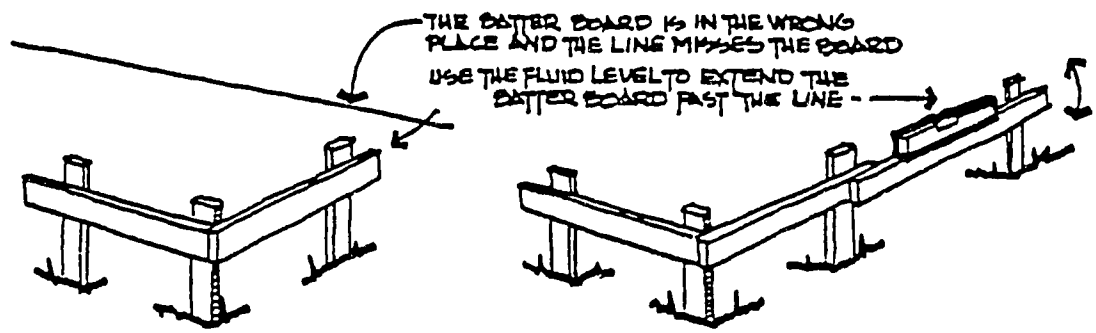


FIGURE 2.18
BATTER BOARDS - DETAIL

C. String Placement

After the batter boards are set up and have been checked, the strings marking the exact location of the foundation can be set in place. The strings will mark the inside of the foundation, the forms for which will be set in place first.

1. The First String

The location of the lot line must be found and marked on the batter boards first. To do so, stretch a string past the two steel pins set in concrete which mark the corners of the lots. Mark each batter board where the string crosses it. (Use a level to find the point on the batter board just above the string.) Once the property line is marked on the two batter boards (points A and B in Fig. 2.19), measure 20 cm to the inside and make a second mark on each board (points C and D in Fig. 2.19). Set a tight string over these two marks (points C and D) to locate the inside face of the foundation. You have set the first string.

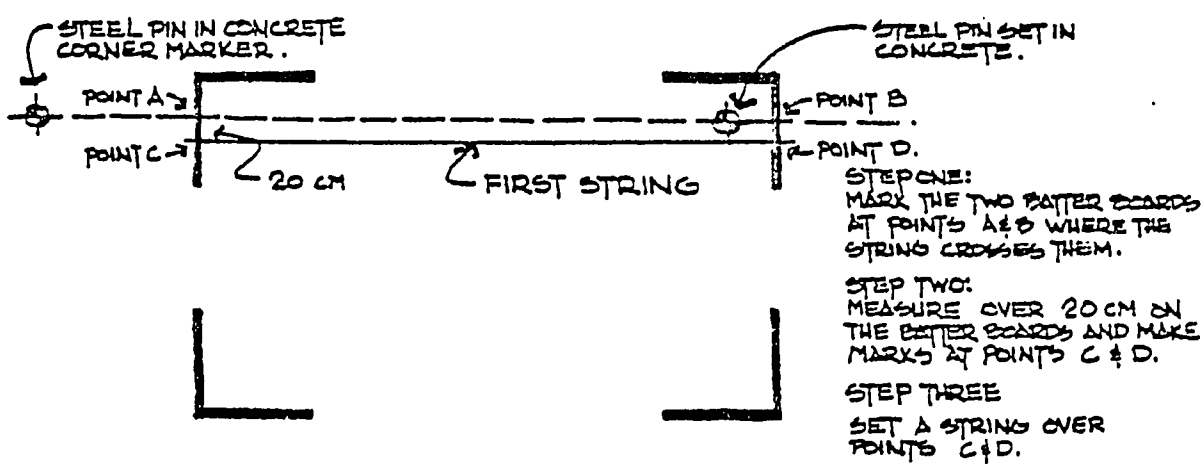


FIGURE 2.19
THE FIRST STRING

2. The Second String

The location of the second string is also found by first marking the location of the lot line on the batter boards (points E and F in Fig. 2.20). Once the lot line is marked on each board, measure 20 cm to the inside and make a second set of marks (points G and H in Fig. 2.20). Set a tight string over the marks (points G and H) to temporarily locate the inside face of the foundation.

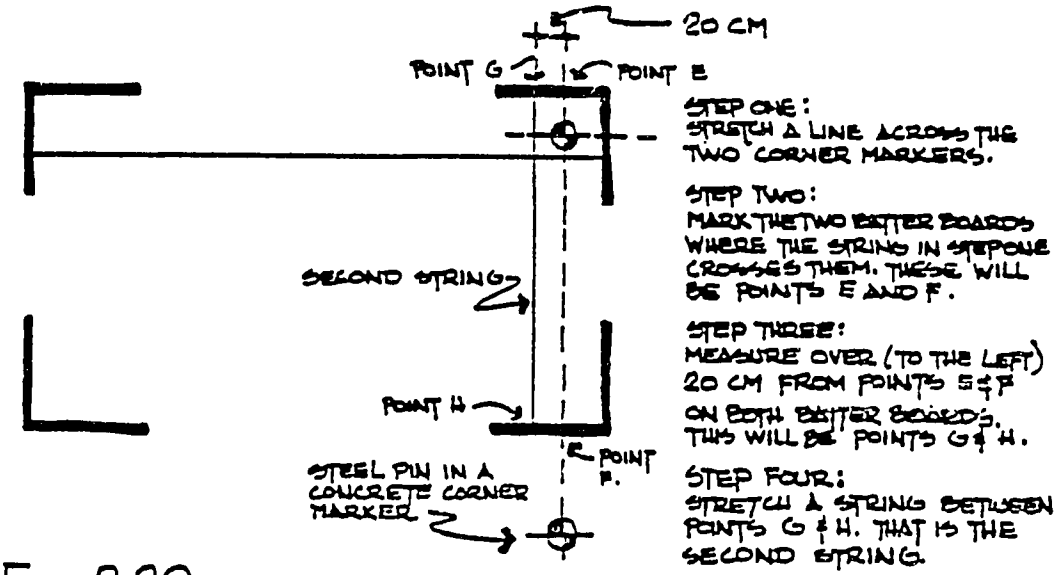


FIGURE 2.20
THE SECOND STRING

This temporary placement of String #2 is used to find the exact placement, which will be square (or perpendicular) to String #1. The exact location is determined as follows:

a. Use an ink marker to mark both strings where they cross (point K in Fig. 2.21).

b. On String #1, measure 850 cm from the point of intersection (point K) and make a mark (point L). These two points mark the location of one inside face of the foundation. See Fig. 2.21.

c. On String #2, measure 454 cm from the point of intersection (point K) and make a mark (point M). These two points mark the location of another inside face of the foundation. See Fig. 2.21.

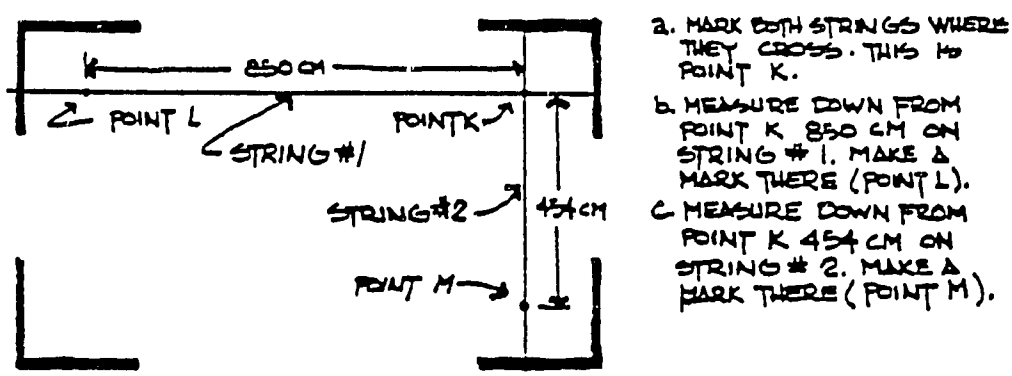


FIGURE 2.21
SQUARING THE SECOND STRING - 1

d. Before the second string can be set in its final position, the distance of the diagonal needs to be determined. For any triangle with a right angle, the length of the sides can be expressed in the proportion: $A^2 + B^2 = C^2$.

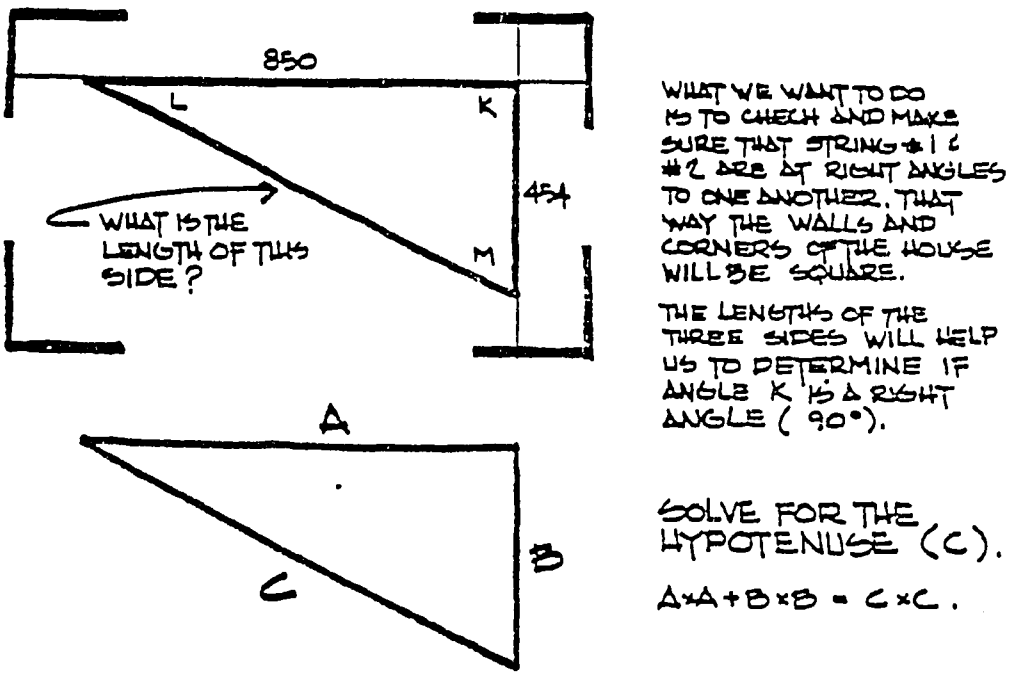


FIGURE 2.22
SQUARING THE SECOND STRING - 2

Using the lengths already established for the inside faces of the foundation, the length of the diagonal can easily be found.

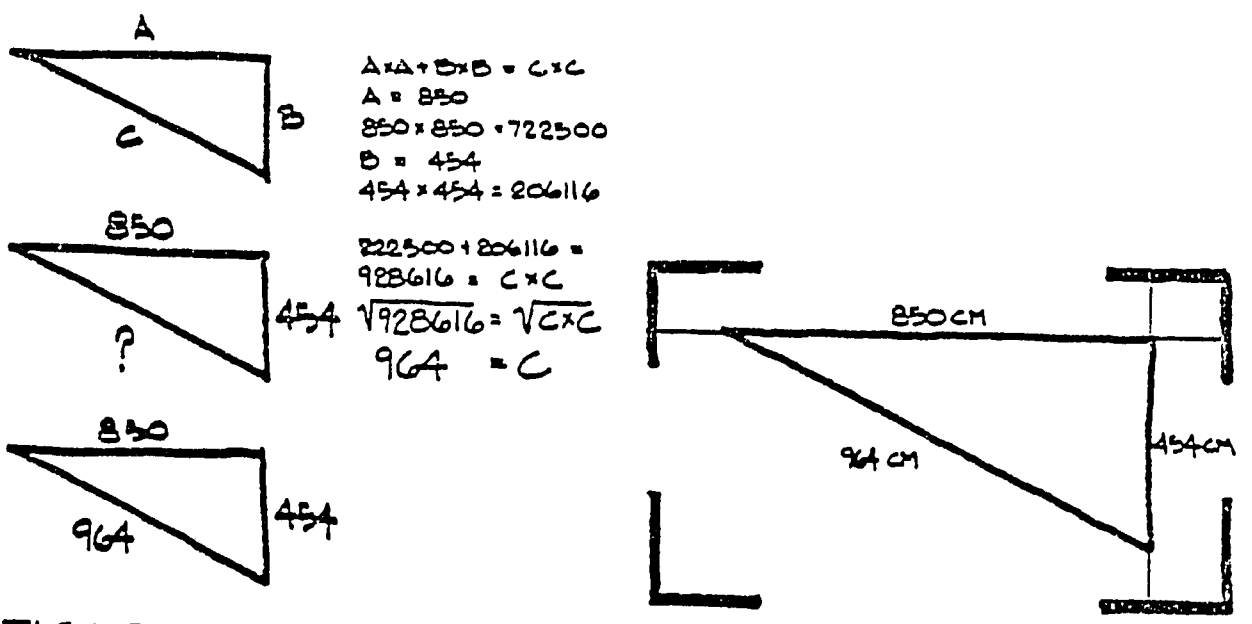


FIGURE 2.23
SQUARING THE SECOND STRING -3

e. Once the length of the diagonal has been determined, the exact location of String #2 can be set. This task requires five people and is done in the following manner:

- The first person stands at point L and holds the zero mark on the tape measure over the 850 cm mark on string #1.

- The second person stands at point M, pulls the tape measure tight, and holds the 964 cm mark (the length of the diagonal) over the 454 cm mark on String #2.

- The third person stands at point F and moves String #2 to the left or right, so that the 454 cm mark on the string is below the 964 cm mark on the tape.

- The fourth person stands at point K and keeps the two marks on Strings #1 and #2 lined up.

- The fifth person stands at point E and moves String #2 to the left or right, according to the directions of the fourth person.

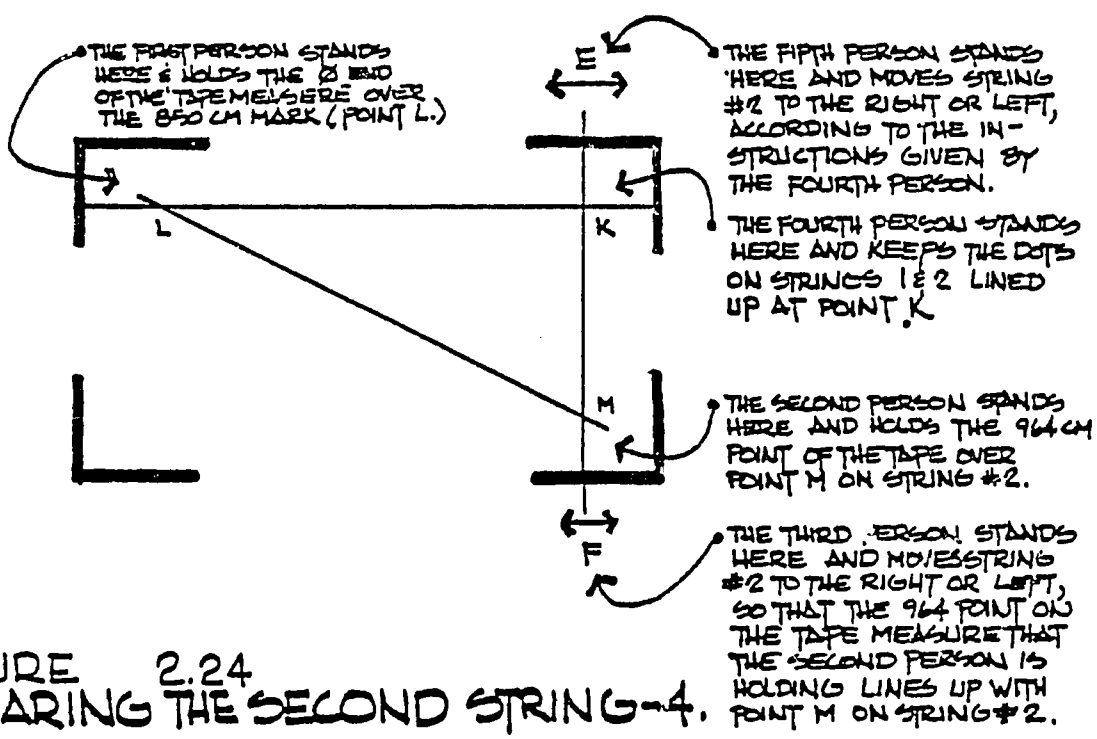


FIGURE 2.24
SQUARING THE SECOND STRING-4.

3. The Third String

The third string is set in much the same way as the second string, only at the other end of the house.

a. Set String #3 so that it crosses over point L on String #1.

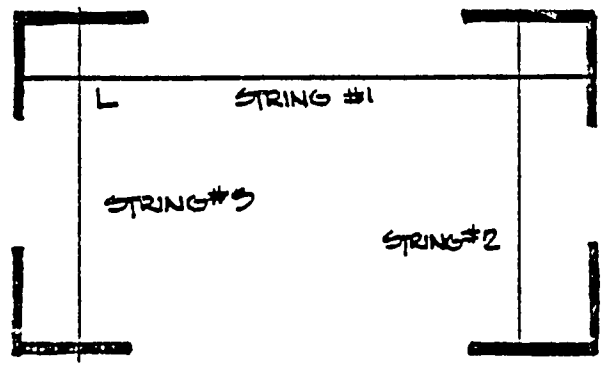


FIGURE 2.25
THE THIRD STRING - 1

Make a mark on String #3 where it crosses String #1 (point L). Then measure 454 cm from that point and make a second mark (point N) on String #3.

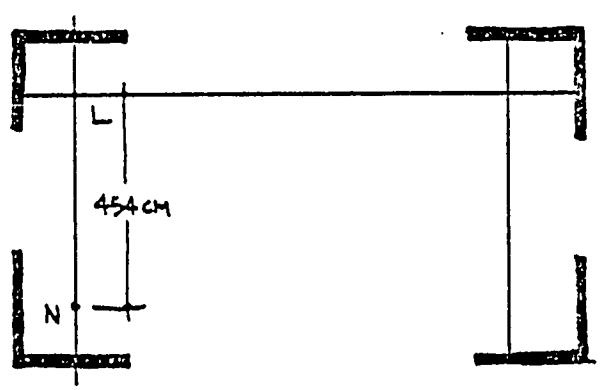


FIGURE 2.26
THE THIRD STRING - 2

The length of the diagonal between points L and M will be the same as the length of the diagonal between points N and K. The exact location of String #3 is determined by the same procedure as that described for String #2, (see section 2-e), except that the location of the people is changed. See Fig. 2.27 for an explanation of this procedure and the required changes in position of the participants.

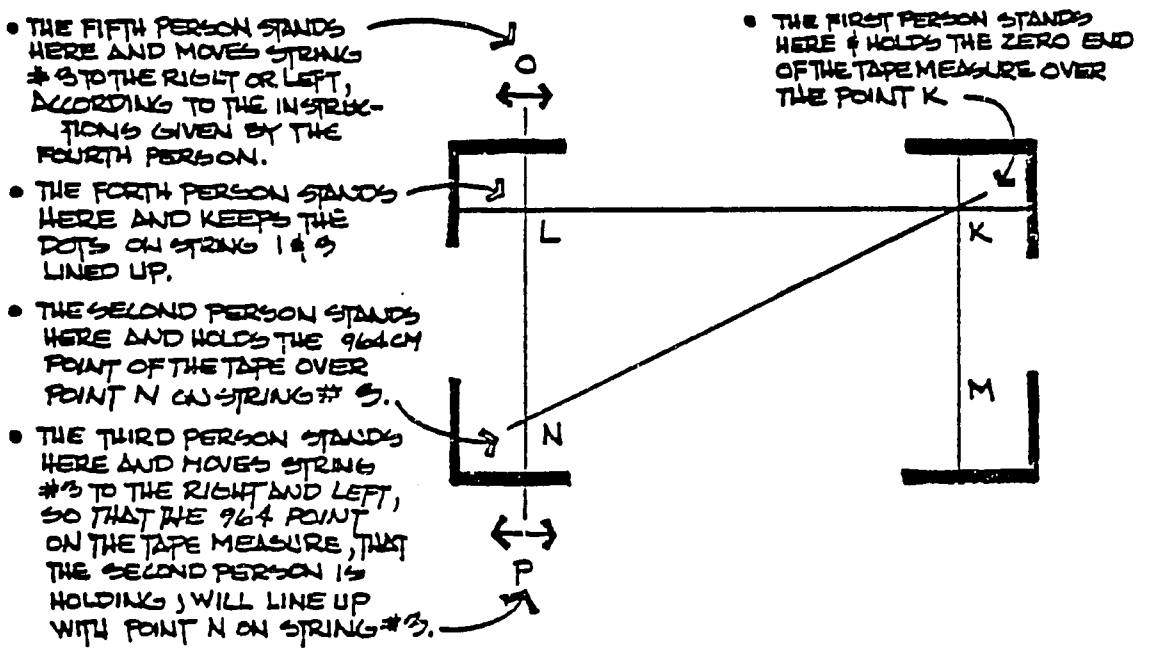


FIGURE 2.27
SQUARING THE THIRD STRING

4. The Fourth String

The fourth and last string is the easiest to set. Simply set the string over the two 454 cm marks on String #2 and String #3 (points N and M). The distance between these two marks should measure 850 cm, or the distance between the inside faces of the foundation.

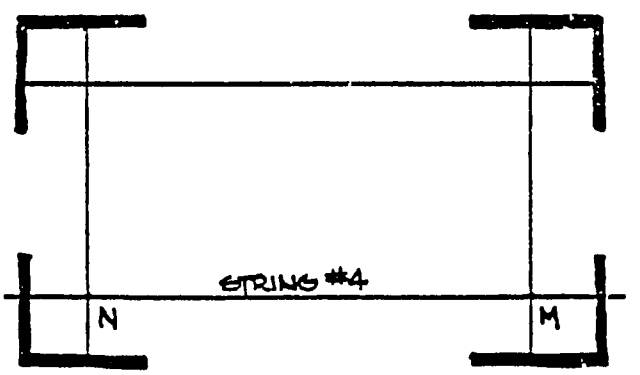


FIGURE 2.28
THE FOURTH STRING

5. Checking the Final Location of the Strings

To check the final placement of the strings, simply measure the diagonal distances between opposite corners. (Remember to hold the tape measure tight and have someone hold it in the middle if the wind is blowing.) The diagonal distances will always be equal if the strings have been set properly and the corners are square.

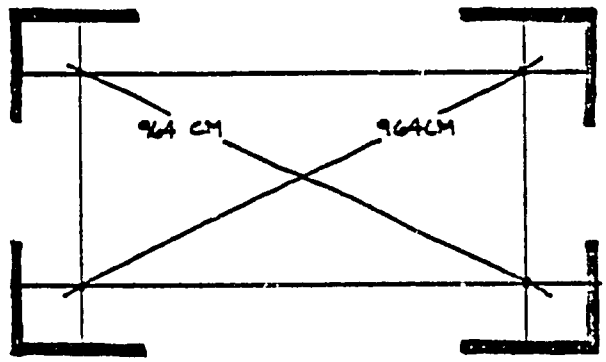


FIGURE 2.29
FINAL STRING LOCATION - CHECK

If the diagonals are not equal, it means that (a), one of the corners is not square, or (b), one of the distances measured on the strings is not accurate. First, check the distances between the corners. The two short sides should measure 454 cm and the two long sides should measure 850 cm.

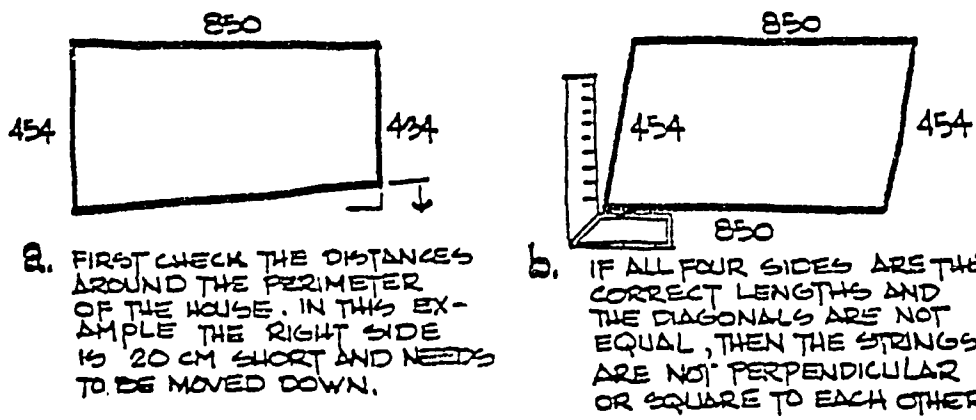


FIGURE 2.30
BUILDINGS WITH MISTAKES

If the distances of the sides are correct but the diagonals are not equal, then the corners are not square. To correct this problem, the strings must be adjusted so that the diagonals are equal.

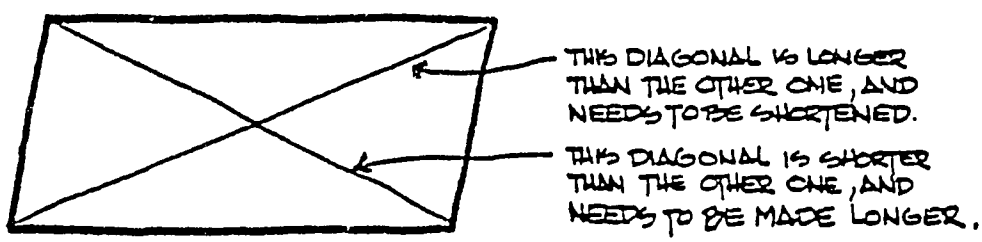


FIGURE 2.31
OUT OF SQUARE - 1

For example, assume that one diagonal (between points N and K) is 968 cm and the other diagonal (between point L and M) is 960 cm. The strings must be moved to decrease the length of the long diagonal and increase the length of the shorter diagonal.

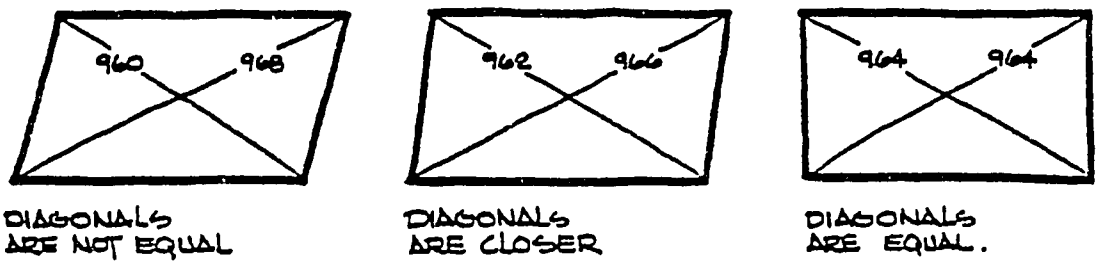


FIGURE 2.32
OUT OF SQUARE - 2

Moving any of the four strings will affect the length of the diagonals. To simplify matters, use String #1 as a reference line and adjust the location of the other three strings until the diagonals are equal. Use the following procedure:

a. Use String #1 as a reference line. After the other three strings have been adjusted, String #1 will be adjusted.

b. In order to decrease the length of the long diagonal (between points N and K), the lower ends of Strings #2 and #3 must be moved to the right. This is done by making a mark 2 or 3 cm to the right of the points where Strings #2 and #3 cross the batter boards, then relocating the strings to those points. (See Fig. 2.33.)

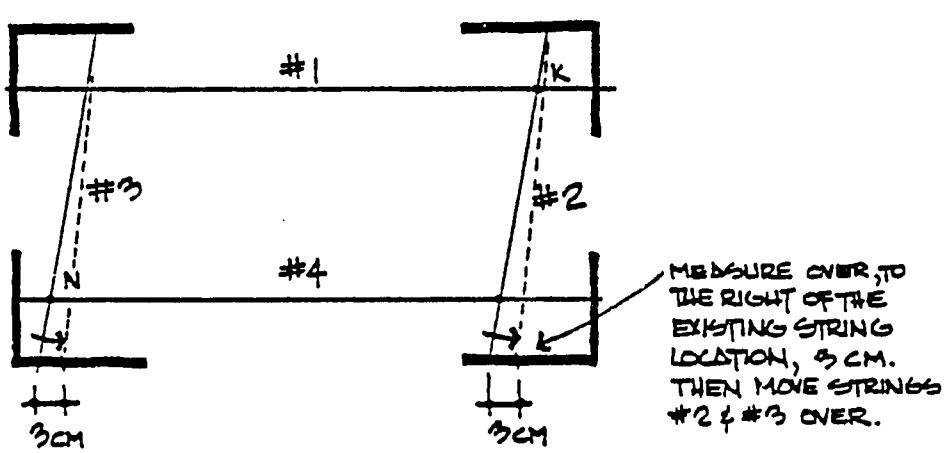
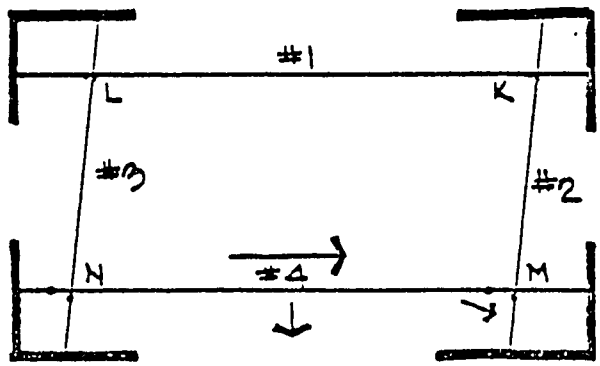


FIGURE 2.33
SQUARING THE STRINGS - 1

c. Move String #4 to the right and slightly down so that the marks on Strings #2 and #3 again line up with the marks on String #4. (See Fig. 2.34.)



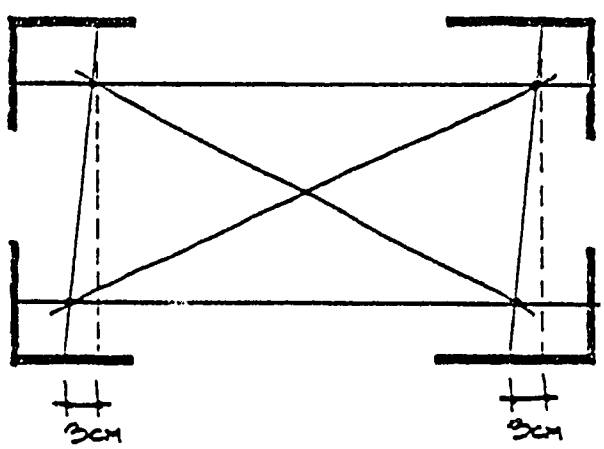
THE MARKS ON STRINGS #1, #2, #3, & #4 ARE NOT LINED UP AT POINTS N & M; L & K.

MOVE STRING #4 TO THE RIGHT AND SLIGHTLY DOWN, SO THAT THE MARKS LINE UP AGAIN AT POINTS N & M.

FIGURE 2.34
SQUARING THE STRINGS - 2

d. After Strings #2, #3, and #4 have been moved, String #1 can be adjusted in the same manner that String #4 was adjusted. Have two people stand where String #1 crosses the two batter boards and have two people stand where String #1 crosses Strings #2 and #3. Adjust String #1 until the marks on Strings #1, #2, and #3 line up.

e. Continue this process until both diagonals measure 964 cm and the marks on all the corners line up.



CHECK THE LENGTH OF BOTH DIAGONALS. THEY SHOULD BE CLOSER THAN BEFORE. MEASURE OVER 3CM AND REPEAT THE SEQUENCE UNTIL THE DIAGONALS ARE EQUAL

FIGURE 2.35
SQUARING THE STRINGS - 3

f. Recheck the marks on all four strings to see that they line up at all four corners. These marks indicate the distances between the inside faces of the foundations; they must be lined up accurately in order for the foundations to be of the proper size and shape.

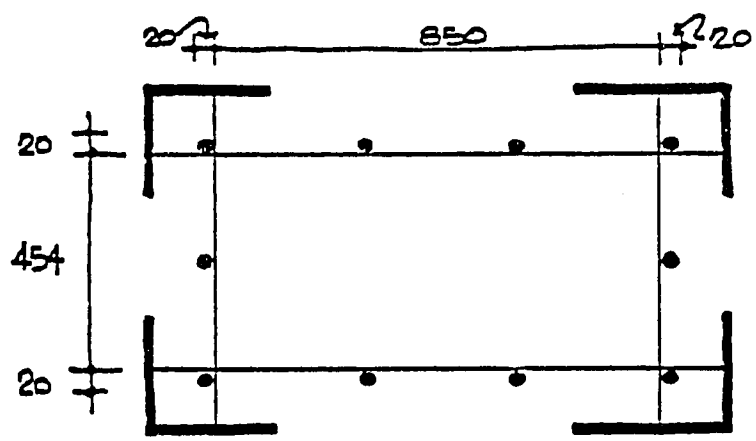
Once both diagonals are the same length and all four sides measure the correct distance, drive a nail into the top of the batter board to mark the final location of each string; then, tie the string to the nail.

IV. Piles

A. Location and Spacing

The location of the reinforced concrete piles is important because they must line up with the grade beam above. The most critical pile locations are the corner piles; these are marked well by the strings.

Look at the foundation plan to see where the piles should be located. As a rule of thumb, the piles should be located at the corners of the building and spaced not more than three meters apart between the corners. The foundations are 890 cm long and 494 cm wide, which means that there will be one pile on the short sides and two piles on the long sides, plus the four corner piles. Always check the foundation plan for the exact location of the piles.



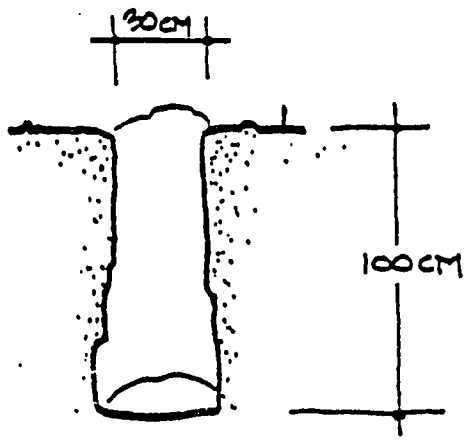
454+20+20 = 494 CM
THE SHORT SIDE OF THE FOUNDATION REQUIRES CORNER PILES AND ONE PILE BETWEEN THEM.

850+20+20 = 890 CM
THE LONG SIDE OF THE FOUNDATIONS REQUIRE CORNER PILES AND TWO PILES BETWEEN THEM, TO KEEP THE DISTANCE BETWEEN PILES 3M OR LESS.

FIGURE 2.36
PILE LOCATION & SPACING

B. Digging the Pile Holes

The pile holes are dug to the outside of the strings, which mark the inside faces of the foundation. For this project, the pile holes must be 30 cm wide and 100 cm deep.



MAKE THE BOTTOM OF THE HOLE LARGER THAN THE TOP & CLEAN ALL LOOSE DIRT FROM THE BOTTOM OF THE HOLE.

FIGURE 2.37
THE PILING HOLE

The procedure for digging the pile holes is outlined below.

1. Using a shovel, carefully mark the location of each pile.

2. Move the strings so that they are not in the way, and begin to dig the holes.

3. When the holes are about 40 cm deep, reset the strings and check the location of each hole. This is done because it is very easy to dig a hole that is incorrectly located by only 15 or 20 cm.

4. Correct those holes that are not properly located, remove the strings again, and continue to dig the holes until they are one meter deep (100 cm).

5. Make the bottom of the holes a little wider than the sides of the holes to give the foundation better bearing on the soil.

6. Remove all loose dirt from the bottom of the holes. If this is not done, the foundation will settle, causing cracks in the building.

7. Do not dig the holes too far in advance of the time when they will be filled with concrete or they may fill with rainwater and need to be redug.

C. Pile Reinforcing Steel

The reinforcing steel cage is made at the steel fitter's shop and is used to strengthen the concrete piles.

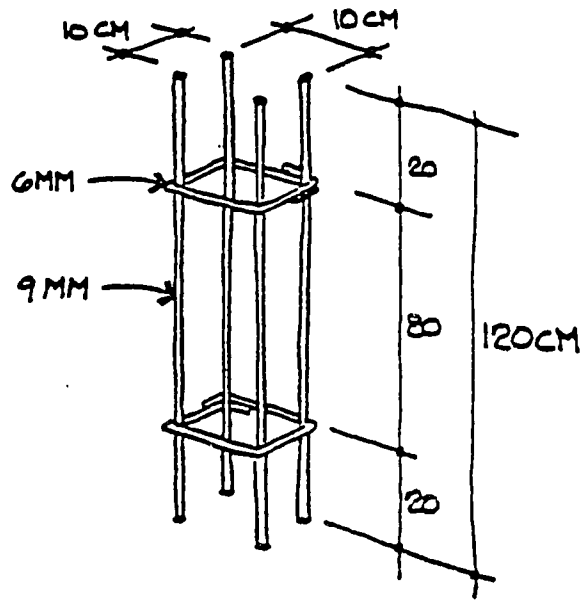


FIGURE 2.38
PILE REINFORCING

After the holes are dug and carefully cleaned, the reinforcing steel cage is set in place.

D. Placing the Concrete

After the reinforcing steel is in place, fill the pile holes with concrete, being careful not to let the wheelbarrow knock dirt into the hole. Tap the reinforcing cage so that the concrete spreads evenly around the cage. The tapping also helps to eliminate air bubbles, which will weaken the strength of the concrete. Continue to fill the hole with concrete until it is full and level with the ground. Check the final placement of the reinforcing steel, which should be about 4 cm to the outside of the string and about 10 cm below the string.

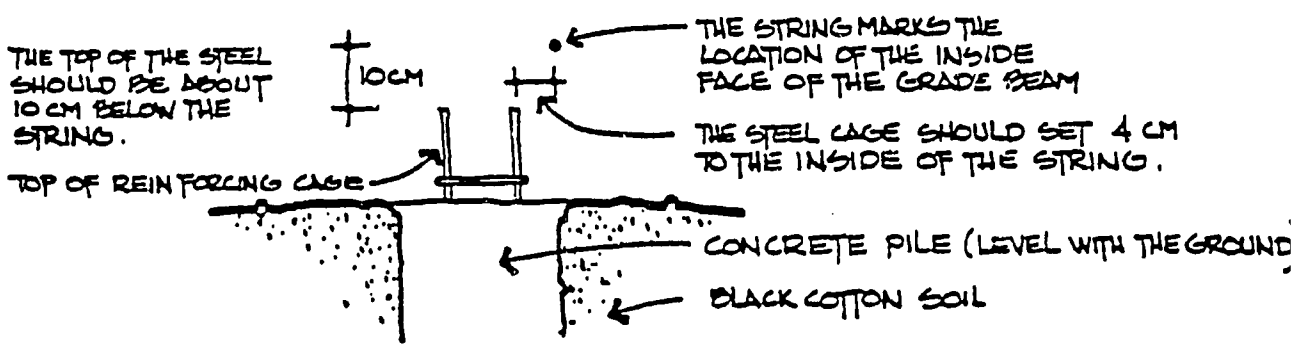


FIGURE 2.39
PLACING THE CONCRETE

V. Perimeter Beam

The perimeter beam is made of reinforced concrete, and follows the shape of the perimeter of the house. Wooden forms must be set in place and leveled up before the reinforcing steel is set in place and the concrete is placed in the form.

A. Location

The inside face of the perimeter beam is marked by the location of the strings. The elevation of the top of the beam should be 9 cm below the string. This may require that some of the foundations be dug into the ground while others will need to have gravel fill placed below them.

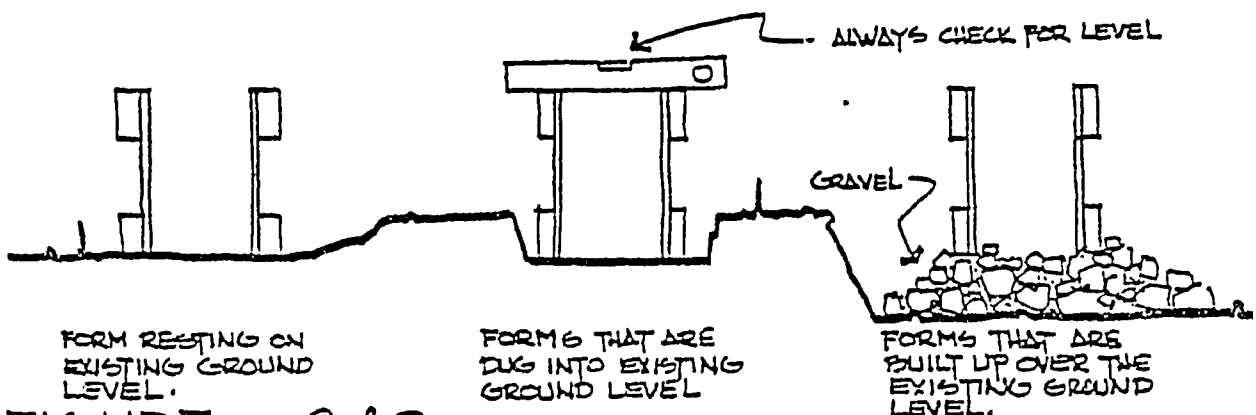


FIGURE 2.40
PERIMETER BEAM - FORMS

B. Setting up the Forms

1. Set the inside form first. The face of the form should be lined up with the string and located 9 cm below it. A small stick or piece of lumber with a mark 9 cm from the end can be used as a rule.

2. Nail the corners of the forms together, turning the smooth face of the form towards the concrete. Line up the forms with the string and dig out or fill under the form as is needed.

3. Once the inside forms are in place, drive stakes into the ground and nail the forms to the stakes. Make a final check to ensure that the top of the formwork is 9 cm below the string, and that the forms are level and square. Be careful not to move the forms while driving in the stakes, as this may bend the forms. If one of the reinforcing steel cages for the piles is in the

wrong location and this interferes with the proper placement of the forms, simply bend the steel out of the way.

4. Set the outside forms in place and nail the ends together. For this project, the long form boards always extend past the shorter form boards. This is true for both the inside and outside forms.

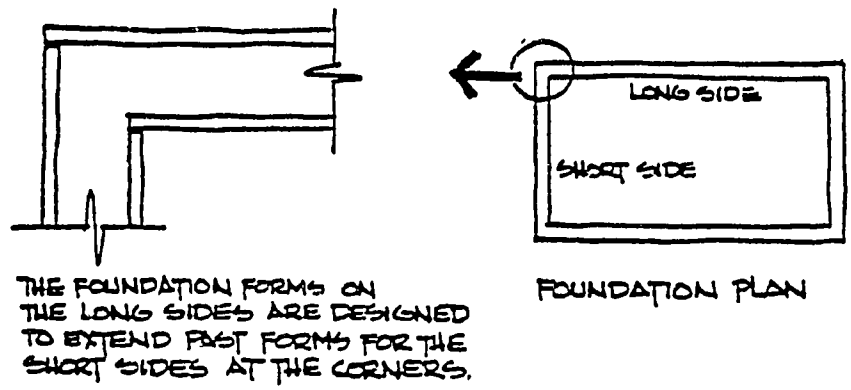


FIGURE 2.41
FOUNDATION DETAIL - 1

5. Make the top of the outside form level with the top of the inside form. This is done by placing the fluid level across the two forms and raising or lowering the outside form until it is level.

6. Set the metal form clips over the forms approximately every two meters. This automatically locates the outside forms at a uniform distance from the inside forms. Small wooden blocks should be tapped into place between the two forms to counteract the inward pressure of the metal form clips.

7. Once the outside forms are in place, drive stakes into the ground and nail the forms to the stakes.

8. After checking the forms to make sure they are level and square, remove the strings and batter boards. Store both items carefully so that they can be used again later.

9. Inspect the foundations to see whether the bottoms of the forms are touching the ground. If there are cracks between the bottom of the forms and the ground, the freshly placed concrete will leak through them. If a crack is less than 3 or 4 cm, simply use a shovel to pile up some dirt around the crack and pack it down with your foot. If a crack is greater than 4 or 5 cm, gravel fill should be used to fill the gap.

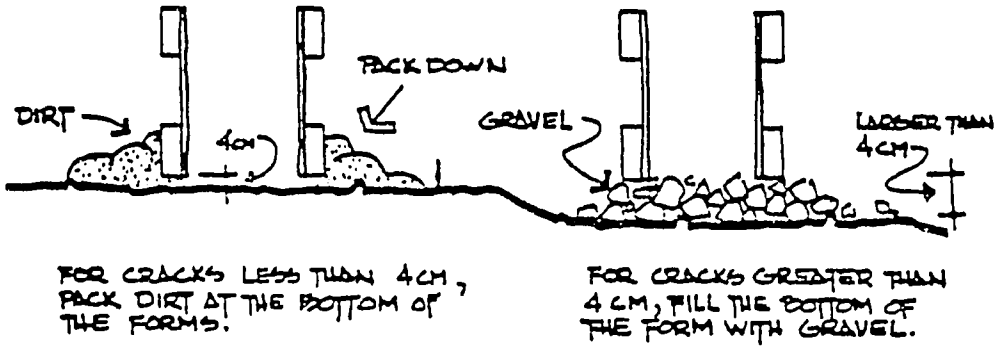


FIGURE 2.42
FOUNDATION DETAIL - 2

C. Reinforcing Steel Cage

The reinforcing steel cage is used to strengthen the concrete and increase the ability of the foundation to carry the weight of the building. The proper size and placement of the reinforcing steel is very critical to the increased strength of the foundation and should be determined by an engineer.

The reinforcing steel cages are set in place after the foundation forms have been built and the holes have been carefully cleaned. Once the cage is in the form, it must be adjusted so that it will be completely encased in the concrete. This is done by laying a small metal rod across the top of the forms and tying the steel cage to the rod with a short piece of tie wire.

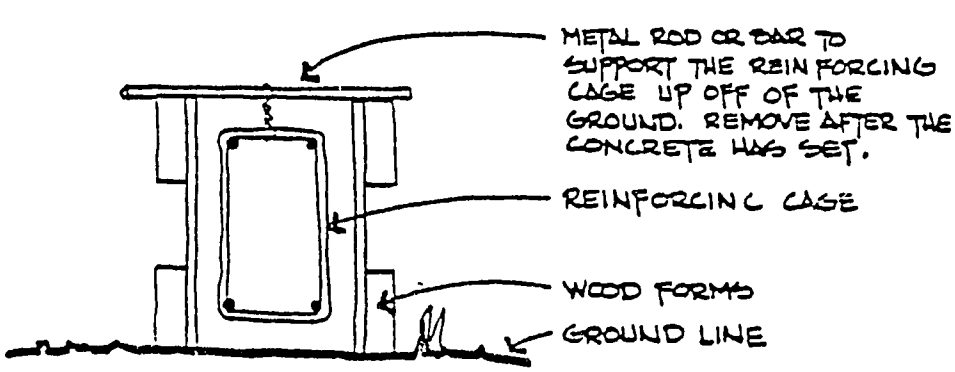


FIGURE 2.43
FOUNDATION DETAIL - 3

It is very important to remember not to set the reinforcing steel cage directly on the ground because this will cause the steel reinforcing bars at the bottom to be inadequately encased in concrete.

D. Partition Beam Connection

The interior partition walls must be supported by grade beams. These will be placed at the same time that the finished floor is placed. However, it is very important that the interior grade beams are tied into the perimeter grade beam. This connection is achieved by placing a reinforcing bar so that a portion of it sticks out of the perimeter beam. Later, after the forms have been stripped, the reinforcing bar will be bent down and covered with concrete. (See Figure 2.54.)

The reinforcing steel partition tie is "U"-shaped, with two long sides approximately 100 cm in length and one short side approximately 20 cm in length.

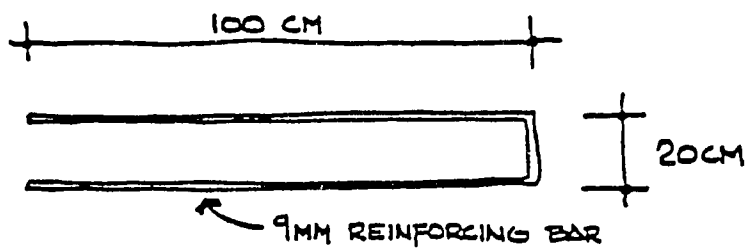


FIGURE 2.44
PARTITION TIE - 1

Locate the partition beams by looking at the foundation plan. Slip the "U"-shaped end between the top inside reinforcing bar and the inside form. Wire the 20 cm side of the partition tie to the lower outside reinforcing bar. (See Figure 2.45.)

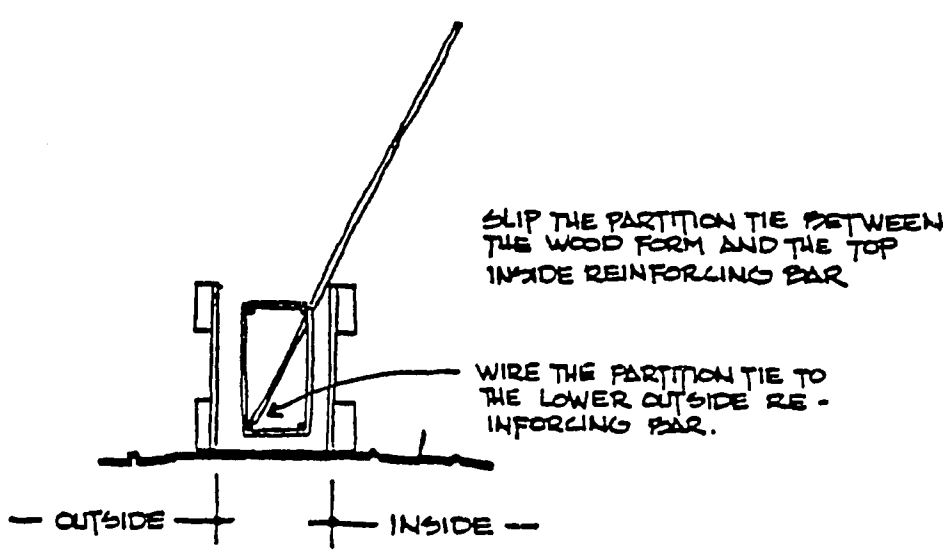


FIGURE 2.45
PARTITION TIE - 2

E. Placing the Concrete

Placing the concrete perimeter beam is primarily an organizational problem. The job requires a full crew to supply and operate the concrete mixer, a second crew to wheel the concrete over to the foundation, and a third crew to place and finish the concrete. All of this needs to be done continuously until the pour is completed. Sufficient materials and labor to finish the pour must be arranged in advance.

A preliminary check should be made before the perimeter beam is poured. Check the placement of the reinforcing steel cage, and make sure there are no holes or cracks at the bottom of the forms. Clean the tops of the concrete piles so that the fresh concrete will bond to them.

1. Mixing the Concrete

The concrete is mixed by petrol-driven mixing machines. The hopper of the machine is filled with:

1 1/2 wheelbarrows of gravel
1 wheelbarrow of course sand
3/4 sack of cement

and enough water is added to make a workable mix. After the concrete is completely mixed it is dumped into wheelbarrows.

2. Transporting the Concrete

The fresh concrete is wheeled from the mixing site to the foundation site in wheelbarrows. Be careful not to tip a wheelbarrow over by trying to carry too much concrete in it. If a wheelbarrow is turned over, shovel the concrete back into it, being careful not to pick up any dirt or trash. The trainees should be encouraged to work quickly and efficiently, but not carelessly. When wheeling the concrete up to the foundations, be careful not to bump or hit the foundation forms. Special care must be taken to avoid moving the forms after they have been set in place.

3. Placing the Concrete

It is very important that the concrete form a good bond with the reinforcing steel and that it is spread evenly in the foundation form. Any air pockets that are trapped in the wet concrete will cause a weak spot in the foundation after the concrete has cured. This can be avoided by rodding the concrete as it is placed in the form. As each wheelbarrow load is poured into the foundation, have a trainee take a metal rod and quickly move it up and down in the concrete. The movement of the rod in the concrete causes the concrete to become more liquid and to spread out. This also gives large air bubbles a chance to escape through the surface of the concrete.

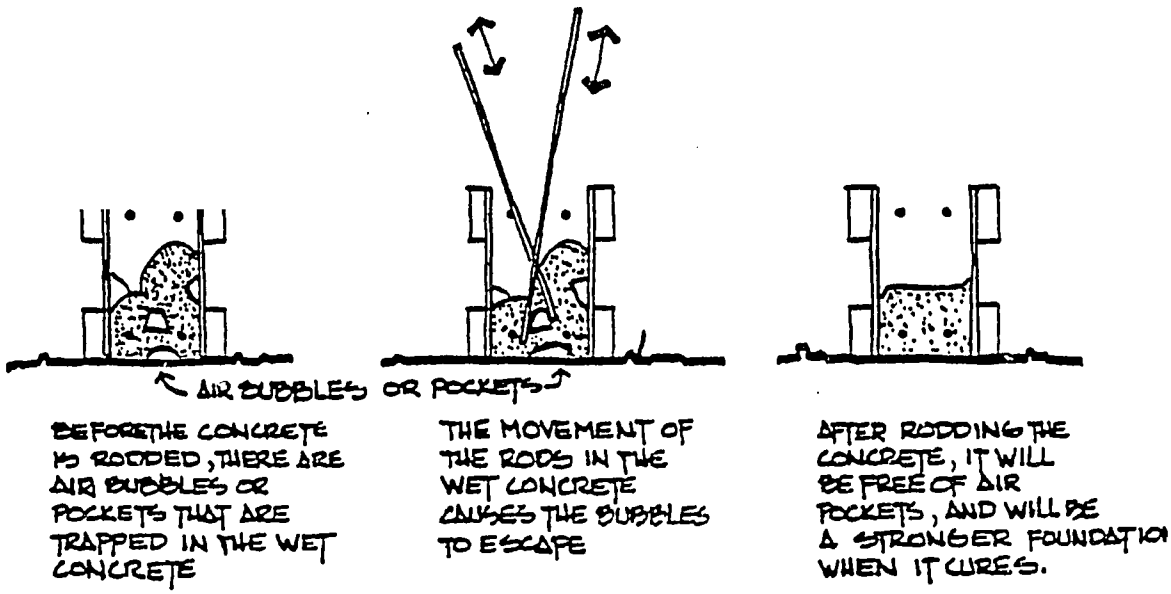


FIGURE 2.46
RODDING THE CONCRETE

When the form is filled with concrete, take a small board and screed the excess concrete off the top. After screeding the forms, rod the concrete a final time to be sure there are no air bubbles in the concrete. The rodding should cause the concrete to settle slightly, requiring that more concrete be added. Screed the excess concrete off once more.

If for some reason a foundation pour cannot be completed, a wooden spacer must be placed between the forms to stop the pour. Place a piece of wood 20 cm long between the forms, above the reinforcing steel cage.

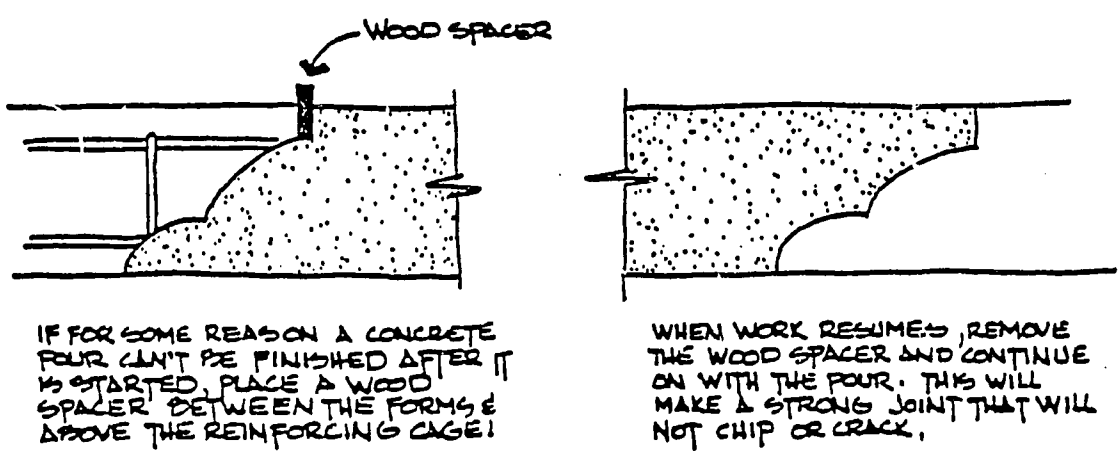


FIGURE 2.47
DISCONTINUOUS POUR

F. Stripping the Forms

After the concrete sets up and is hard to the touch, the wood forms can be removed. When removing the forms it is important to avoid breaking or chipping the concrete, which hasn't yet reached full strength.

1. Remove and store the metal form clips which were used to keep the forms the correct distance apart. Tap them slightly with a hammer to loosen them; then, pull them up.

2. Remove and store the metal rods from which the reinforcing cage was hung. Remove the excess wire that is left after the rods have been removed.

3. Carefully knock down and remove the wooden stakes which hold the forms in place. Remove any nails in the stakes and store them in a neat and orderly manner so that they can be reused on the next foundation.

4. After the stakes have been removed, use a pick and shovel to clean away any concrete spilled during the pour.

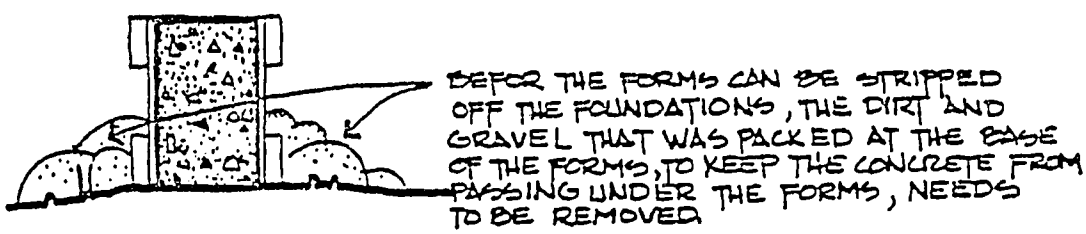
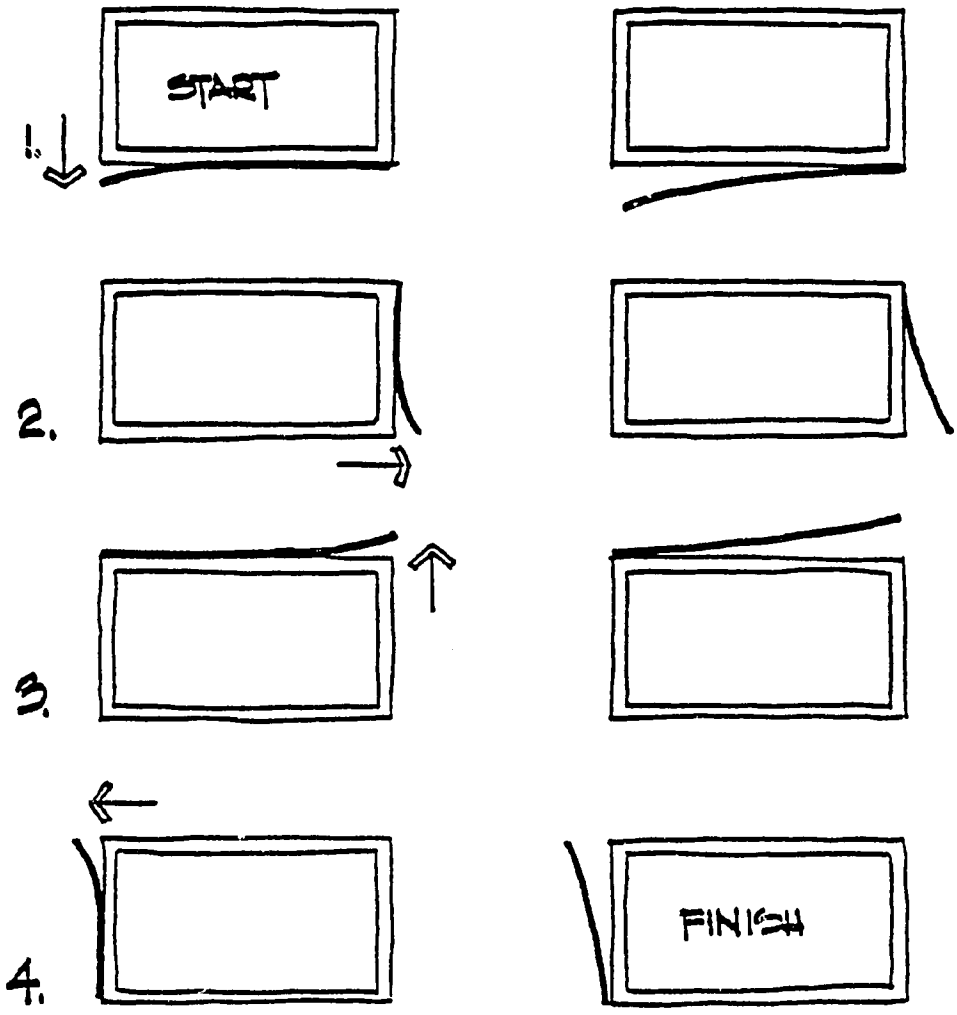


FIGURE 2.48
STRIPPING THE FORMS

5. Remove the outside forms first. Begin at one corner and open the nailed joint using a crowbar and hammer. (Avoid using too much pressure as this could break or chip the concrete, which has not yet reached full strength.) Starting at the corner, pry the form away from the concrete. Continue this process until all the outside forms have been removed. The pointed ends of the stakes can be used to help pull the forms off--these won't damage the concrete as much as will the metal pry bar.



START AT ONE CORNER OF THE FOUNDATIONS. STARTING AT THE CORNER, PRY THE FORM AWAY FROM THE CONCRETE. MOVE DOWN THE LENGTH OF THE FORM UNTILL IT IS COMPLETELY FREE

FIGURE 2.49
STRIPPING THE OUTSIDE FORMS

6. Once the outside forms have been removed, begin to remove the inside forms. The inside forms are more difficult to remove and will require special attention to avoid damaging either the forms or the concrete. Remember the way the forms were originally nailed together--the long side extended past the short side. This requires that the short sides be removed first.

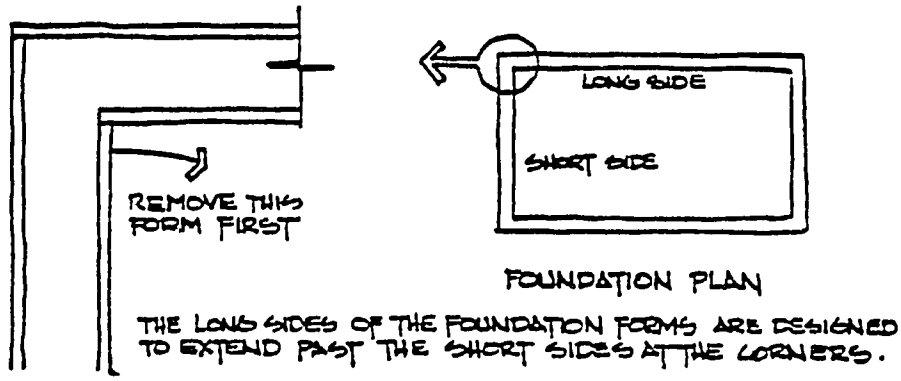


FIGURE 2.50
STRIPPING THE FORMS - DETAIL

Starting at one corner, pry the form away from the concrete. (The pointed end of a wooden stake can be used to get it started.) Move down the length of the form, prying as you go, until the form is completely free. Repeat this process at the other short end of the foundation.

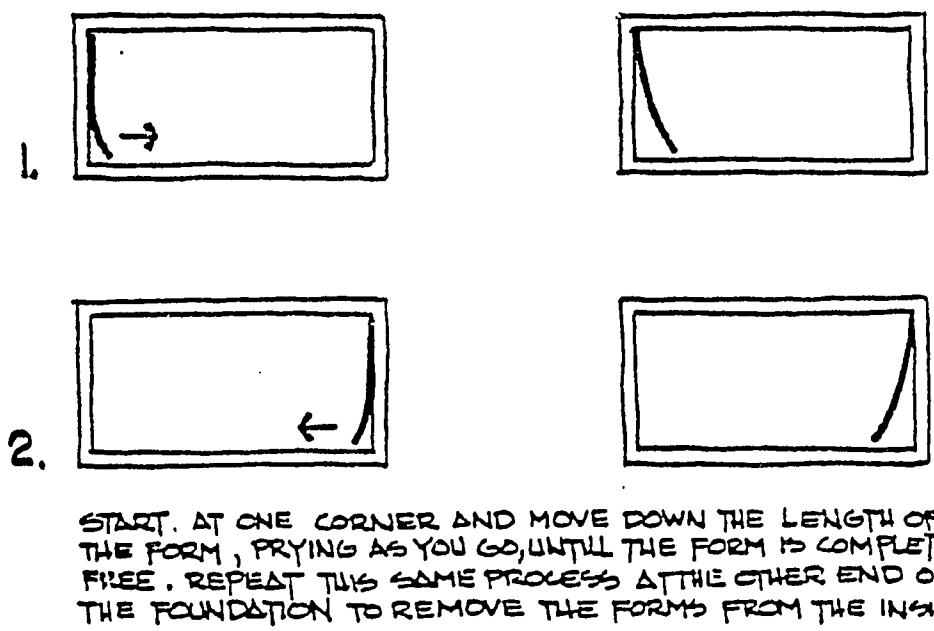


FIGURE 2.51
STRIPPING THE INSIDE FORMS -1

After the short forms have been removed, remove the long forms. The long forms on the inside of the foundation are the most difficult to remove because both ends are set in concrete. First, try to drive the wedge-shaped end of a wooden stake between the form and the concrete at one corner. If this breaks the form free, continue to move down the length of the form, prying as you go, until the form is completely free.

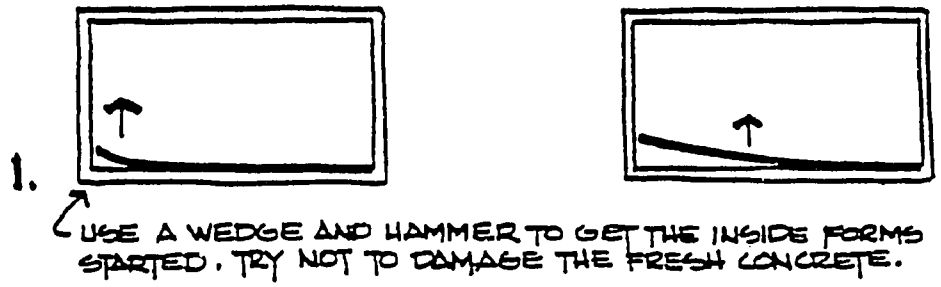


FIGURE 2.52
STRIPPING THE INSIDE FORMS - 2

If driving in the wedge at the corner doesn't loosen the form, then try starting the wedge at the middle. Once the form lets go of the foundation, move towards one corner, prying off the form as you go. After one corner is free, the rest of the form can easily be pried away.

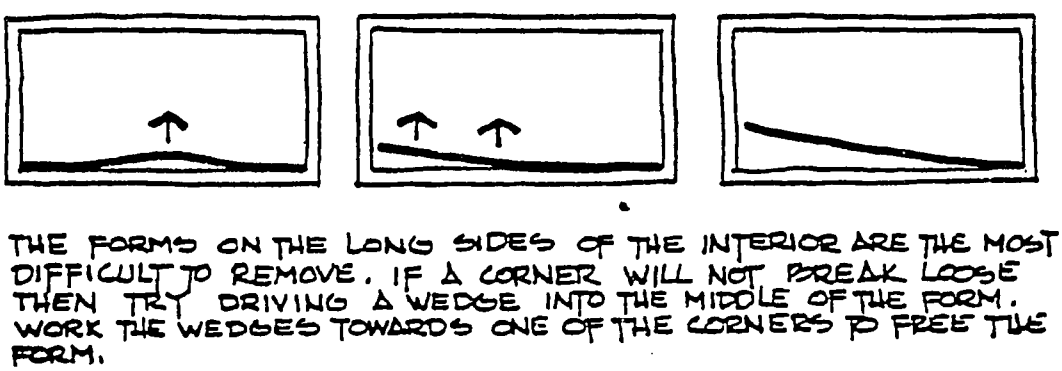


FIGURE 2.53
STRIPPING THE INSIDE FORMS - 3

7. The foundation forms are made of expensive, imported plywood, and special attention should be directed toward making them last as long as possible. After the forms have been removed, pull the nails from the ends. Carefully scrape each form with a trowel to remove any concrete left sticking to it. After the forms have been scraped, paint the inside surface with diesel fuel. This will help to prevent concrete from bonding to the forms in the future.

8. If the next foundation is ready to pour, carry the forms directly over to the site and begin setting them up. If not, store the forms in an orderly manner so that they will not get lost or damaged.

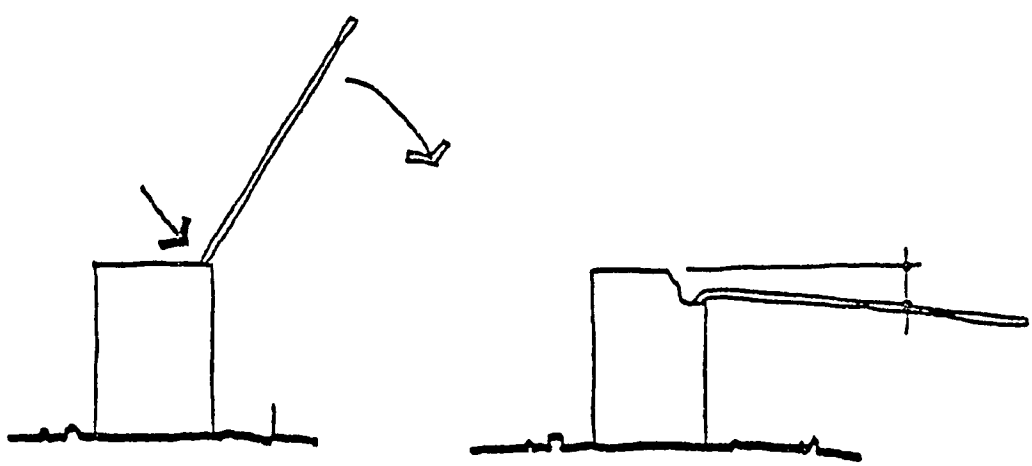
VI. Partition Grade Beam

The foundations under the interior partition walls are poured after the formwork for the perimeter beam has been stripped away and before the sub-floor fill is placed.

A. Location and Connection

Use the foundation plan to determine the exact location of the partition grade beams. This should be close to where the steel reinforcing bars are sticking out of the perimeter beam. Carefully measure and mark the foundation at the points where the ends of the forms for the partition grade beam should be placed.

To bend down the steel reinforcing bars left extending from the perimeter beam, first stand to one side of the bars and on the inside of the foundation. Use a sledge hammer to hit the top of the concrete beam next to the reinforcing bar. This action will break away some of the concrete and will allow the steel reinforcing bar to be bent down below the top of the perimeter beam.



USE A SLEDGE HAMMER TO BREAK AWAY THE CONCRETE AND TO BEND THE PARTITION TIE DOWN.

BEND THE TIE BAR DOWN BELOW THE TOP OF THE FOUNDATIONS.

FIGURE 2.54
PARTITION BEAM LOCATION

B. Setting Up the Forms

Set the forms in place and use two stakes to position each form. Use the fluid level to make sure that the top of the forms is level with the top of the perimeter beam, then nail the forms in place.

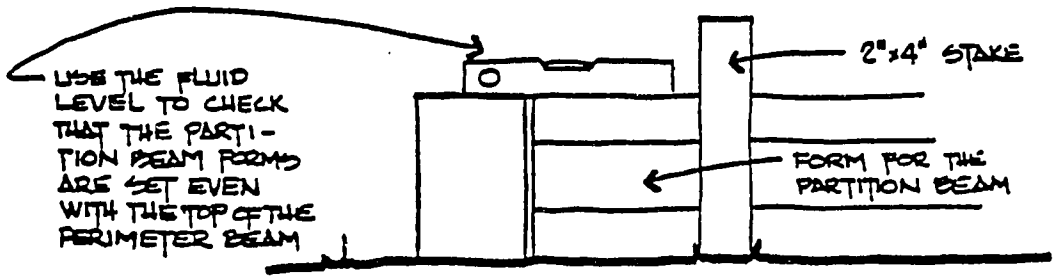


FIGURE 2.55
PARTITION BEAM FORMS

C. Steel Reinforcing

After the forms are nailed in place, lower the steel reinforcing cage into the forms. It is very important to remember not to set the steel cage directly on the ground or the bottom reinforcing bars will not be adequately encased in concrete. Place a small metal rod across the top of the forms and tie the reinforcing cage in place with a piece of tie wire. Wire both ends of the steel reinforcing cage to the steel reinforcing bars which are sticking out of the perimeter beam.

D. After a check has been made to ensure that the forms have been properly set and the reinforcing steel is properly placed within them, the partition grade beams are ready to be poured. Make sure there are no cracks or gaps between the bottom of the forms and the ground through which concrete can flow. Then, fill the forms with concrete, following the steps used for placing concrete in the perimeter beam.

VII. Sub-Floor Fill

If the site is level, the top of the foundation should be approximately 25 cm above the ground. The top of the finished floor is designed to be even with the top of the foundation. This requires about 20 cm of fill below the floor. This sub-floor fill can be made of almost anything, from broken cinva-ram blocks to gravel. Because of the size of the foundation and the volume of fill needed (7.5 cubic meters), a dump truck is used to place the sub-floor fill. Have the truck back up to the foundation as close as possible and drop a load of gravel fill. Use a shovel to spread the fill out evenly until it is about 5 cm from the top of the beam. Then have several people compact and settle the fill by tamping it with the end of 2" x 4"s as they walk over it. Packing the fill down will prevent it from settling after the floor is in place, which could cause cracks.

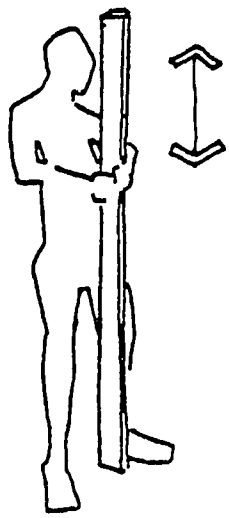


FIGURE 2.56
TAMPING THE SUB-FLOOR FILL

After the fill has been tamped down, add more fill and screed it off 4 cm below the top of the perimeter beam.

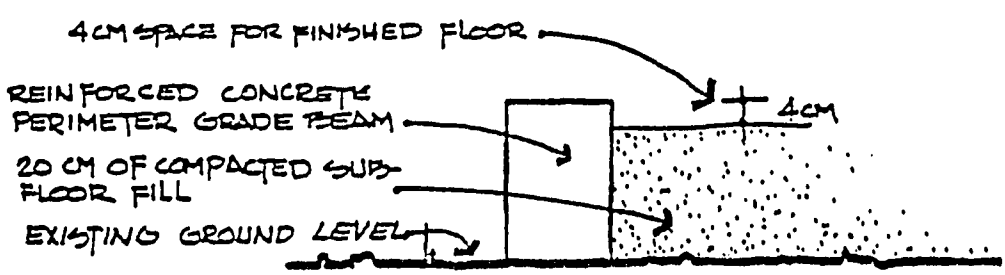


FIGURE 2.57
SUB-FLOOR FILL - DETAIL

VIII. Floor

Placing the 4 cm thick concrete floor is the last training exercise for the foundations program. Again, as with other concrete jobs, special attention must be paid to the scheduling and coordination of labor, materials, and time.

Before the concrete is placed, throughly wet the sub-floor fill with several buckets of water. This will prevent the dry fill from absorbing water from the concrete, causing cracks in the floor.

Find a long straight board that is about one meter longer than the building is wide. This board will be set on edge and used as a screed to spread the concrete evenly and smoothly across the floor. The screed board is set on top of the perimeter beam, which is used as a guide for pouring the concrete floor.

The following steps, shown graphically in Fig. 2.58, should be followed.

Step 1. Set up a ramp over the perimeter beam so that wheelbarrows full of concrete can easily be wheeled up and dumped. Lay down some wide boards or planks on which the wheelbarrows can roll so as not to disturb the sub-floor fill.

Step 2. Place several loads of concrete near the perimeter of one end of the floor.

Step 3. Use a shovel to spread the concrete evenly along the edge of the foundation. Keep the concrete higher than the top of the foundation.

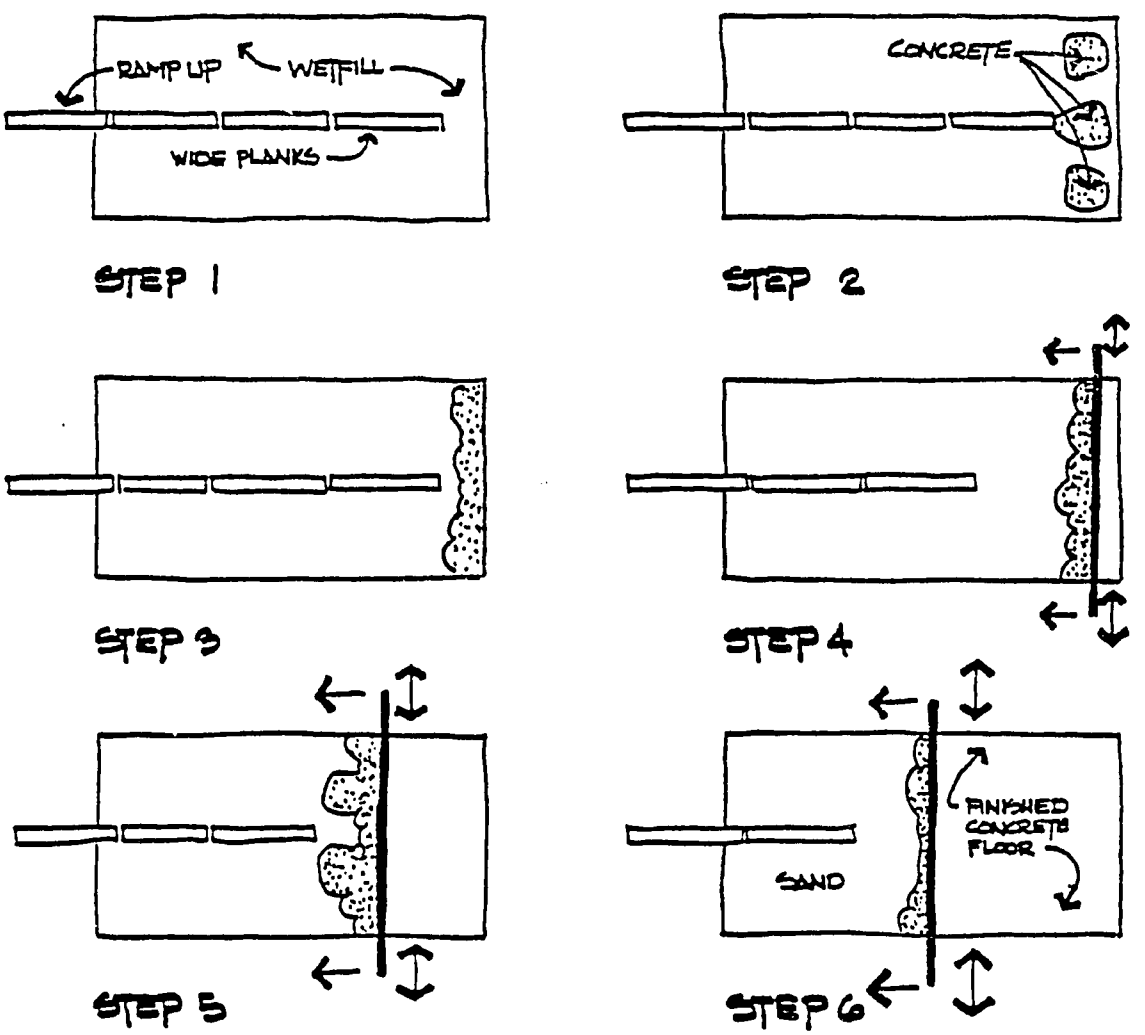


FIGURE 2.58
FINISH CONCRETE FLOOR

Step 4. Set the screed in place and begin moving it back and forth while slowly moving forward.

Step 5. Continue placing fresh concrete in front of the screed so that, as it is moved back and forth, the screed will leave a smooth, level surface.

Step 6. Continue to move forward with more concrete. Have one or two persons stand in front of the screed board with shovels to spread the concrete after the wheelbarrow has dumped it.

Do not allow the concrete to build up in front of the screed board, as this makes it more difficult to move the board forward. Keep the top of the foundations clean and free of small stones from the concrete, which could interfere with the movement of the screed board. After the floor has been screeded, let the concrete set up a little before troweling it to a final finish.

When the floor is finished, it is important that it not be allowed to dry too quickly from the sun and wind, as this will cause cracks to appear which will weaken the floor. After the concrete has been troweled, spread an even layer of sand over the concrete and then sprinkle it with water. Try to keep the floor damp for two days.

Notes and Comments

Masonry

Daily Operation

Tools

Mortar

Building Layout
- Centering the Walls on the Foundation
- Squaring the Foundation
- Leveling the First Course
- Locating the Door Openings
- Completing the First Course

Building the Corners

Exterior Walls
- Laying a Mortar Bed
- Working to a Line
- Making Vertical Mortar Joints
- Wall Reinforcing
- Tie Blocks
- Scaffolding
- Gables

Doors and Windows
- Door Openings
- Window Openings

Interior Walls

Wall Finishes

Roof Anchor Blocks

I. Daily Operation

A smooth daily operation is crucial to the success of the training program. The training of the settlers takes time, and decreasing time lost due to an inefficient daily operation increases the productivity of the program. In addition, if the settlers view the program as disorganized, there is a greater chance that tools and equipment will be stolen. It is the responsibility of the masonry instructor to organize each day's activities and to coordinate those activities with other training instructors.

The following practices will help to ensure an efficient daily operation:

Check attendance as soon as all the trainees have arrived in the morning, and again after they return from breakfast. The instructor should have the day's activities clearly planned by the time the roll is called so that the trainees can be quickly divided into groups and the day's training begun.

Make a checklist of all items or materials needed each day and check the list before leaving the compound for the site. Much lost time and needless confusion can be avoided by doing so.

Issue tools and equipment to only those trainees who will be needing them. Pick up all tools at the end of each day, and make sure that they are clean and in good working order. It is the responsibility of the instructor to check tools out and to make sure that they are returned.

Use review periods to evaluate the work done by the trainees, catch mistakes, and explain problems to the group-at-large. Review periods should be frequent at first and can also be used as rest periods. Remember, physical endurance must be developed along with construction skills, and the trainees will tire quickly at first. As the trainees continue in the program, review periods will be needed less often; but, to begin with, each course of blocks laid will need to be reviewed. The review should include discussions of how to use the tools, how to place the mortar, and how to set the blocks. There should be a final review at the end of each day in which the day's achievements are discussed and trainees are given an opportunity to express any problems they may be having.

Make sure that the necessary materials and supplies are on hand. It is the responsibility of the masonry instructor to make certain that a steady supply of blocks and mortar are made available to the masonry trainees. If no labor support is provided to haul blocks, it is the responsibility of the school superintendent to organize labor for the work. (Always have a supply of clean drinking water available.)

Communicate ways that work can be done in a safe and orderly manner. The best way to achieve this goal is to maintain a clean and orderly area around the training site. Broken blocks should be removed, scaffolding should be kept clean, and tools should be kept in their proper place. All tools should be washed with a brush and water at the end of each day.

II. Tools

Instruction in the care and use of the following tools is an essential aspect of the masonry training program:

Trowel

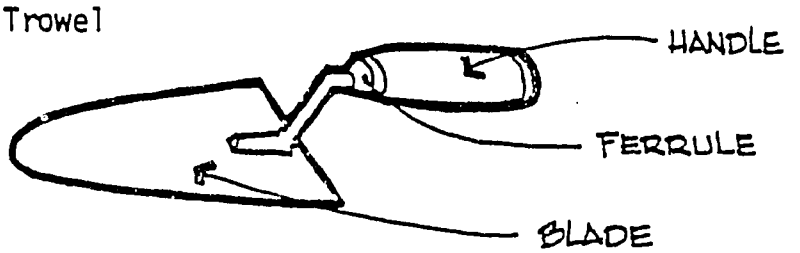
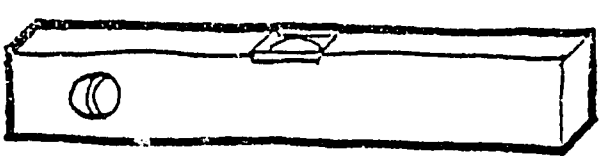


FIGURE 3.1
MASONRY TROWEL

The trowel is the mason's primary tool. The trainee must learn to feel comfortable using the trowel to place the mortar, pack the joints, pick stones out of the mortar, etc. The trowel handle is held with the right hand so that the thumb is topside and on or near the ferrule. The first finger opposite the thumb is placed on the underside of the handle and the other fingers are curled around so as to stabilize the trowel in the hand. The trowel should be gripped firmly, with the wrist relaxed enough to manipulate the trowel freely.

Level



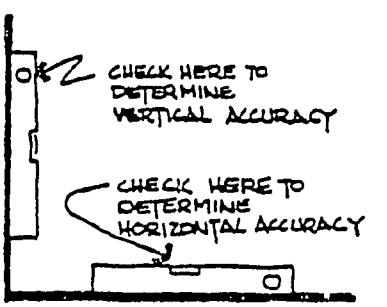


FIGURE 3.2
FLUID LEVEL

The level is a delicate tool used for determining whether a construction is plumb and level. It must be handled carefully. The level should not be used to hit or tap blocks which have been set in place. The level should not be placed under water while it is being cleaned, because water may get behind the lens and obscure the bubble.

Line Blocks

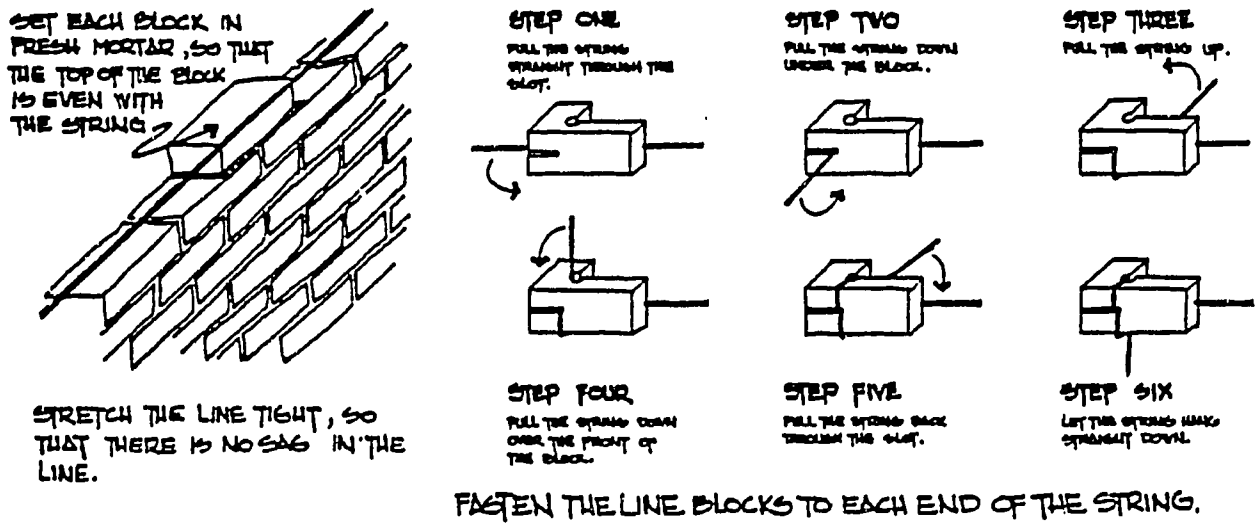


FIGURE 3.3
LINE BLOCKS

Line blocks (or corner blocks) are wooden blocks used to stretch a taut line between two corners of the building. When the string is placed in the correct position, all the blocks in that course can be quickly set to the line. The block should be placed flush with the string, which should just clear the outside face of the block.

Twig

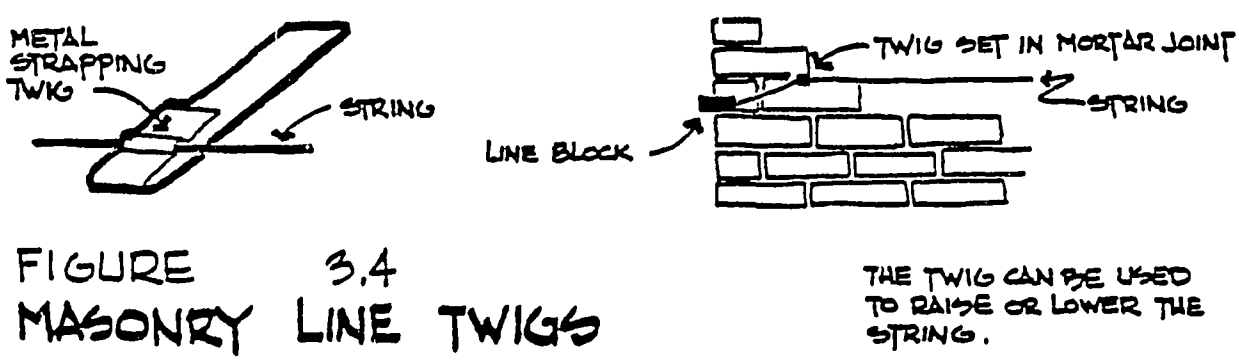


FIGURE 3.4
MASONRY LINE TWIGS

The twig is a small piece of metal strapping used to hold the string line in the correct position. It is used when chipped edges or corners on the cinva-ram blocks make it difficult to place the line blocks in the correct place.

Mortar Board

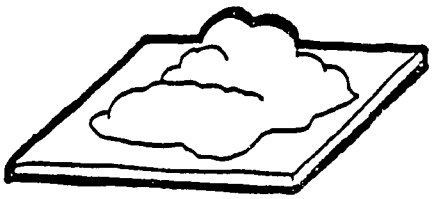


FIGURE 3.5
MORTAR BOARD

The mortar board is a piece of plywood, 24"square, used to hold the mortar. New boards should be soaked in diesil oil and then kept as clean as possible to insure a long and useful life.

Mason's Hammer

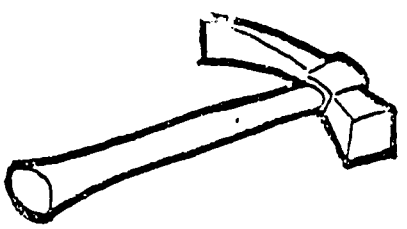
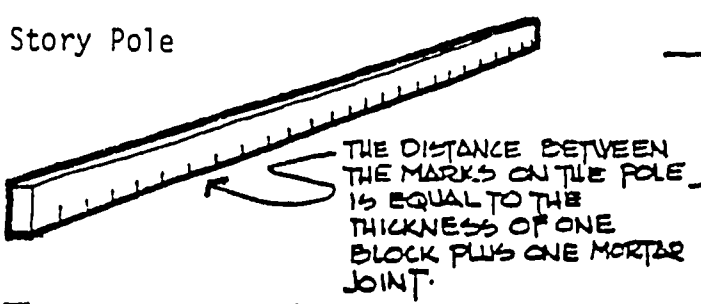


FIGURE 3.6
MASON'S HAMMER

The mason's hammer has many uses. One end is shaped like a chisel and is used to smooth, shape and cut bricks. The opposite end of the hammer is usually square and used for breaking bricks, driving nails, etc. Take good care of the hammer and always be sure that the head is fitted tightly to the handle.

Story Pole



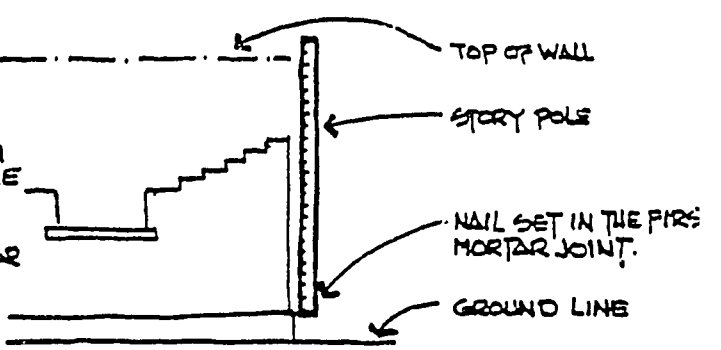


FIGURE 3.7
STORY POLE

The story pole is a straight length of 2" x 2" or 2" x 4" with markings which indicate the height of each block course. It is used by the mason to build the corners of the wall to the correct height. For this project, the cinva-ram blocks are to be made 3 1/2 inches (9 cm) thick

and should be laid with a 1/2 inch (1 cm) mortar joint. Therefore, the story pole should be marked every 4 inches (10.2 cm).

Shovel

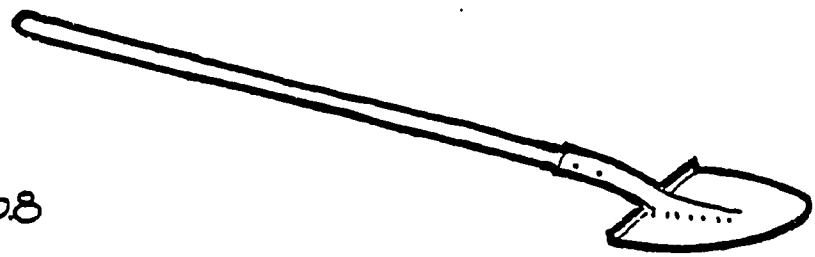


FIGURE 3.8
SHOVEL

The shovel is used frequently at a masonry construction site for moving sand and gravel, placing mortar on the boards, cleaning up mortar droppings, etc. The shovel should be kept clean of mortar buildup and should not be left on the ground where someone can step or trip over it.

All tools used by the training program should be clearly marked with blue paint for easy identification. The instructors are responsible for checking the tools in and out each day. This is an important task since it is much easier to prevent theft from starting than it is to stop it once it has begun. If a trainee is found to have stolen a tool or construction material, he/she should be dismissed from the program and a letter explaining this action should be sent to the District.

Tape Measure

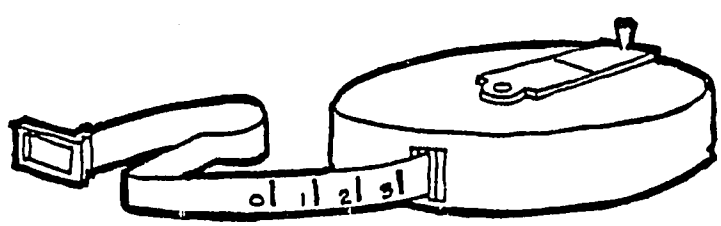


FIGURE 3.9
20-METER TAPE MEASURE

The tape measure is used to lay out the location of the first course of blocks on the foundations, measure and mark the story poles and a variety of similar jobs. The markings on the 20-meter tape do not start at the end of the tape, but begin about 20 cm from the end. This provides enough room at the end to get a firm hold on the tape. Normally, it takes at least two people to use any long tape measure in order to pull it tight between the points being measured. If it is very windy, a third person may be needed to hold the tape in the middle.

Wheelbarrow

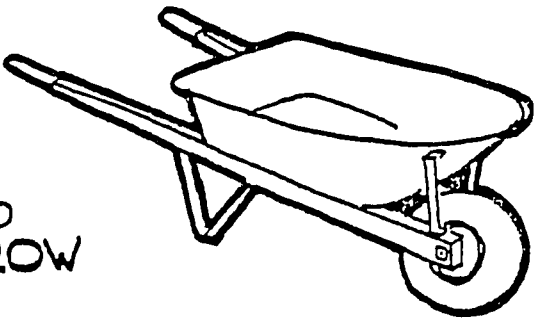


FIGURE 3.10
WHEELBARROW

The wheelbarrow is a small vehicle used to move small loads of sand, gravel, cement, blocks, water, or dirt from one place to another. The load is carried by a single wheel in front; two handles in the back are used for lifting, balancing, and guiding the load.

III. Mortar

It is important to maintain a steady supply of mortar throughout the day. This will require at least two people, working full-time. The mortar must be placed in wheelbarrows and wheeled to the bricklayers where it is placed on mortar boards. The trainees must then quickly return to the mortar line for another load of mortar.

The proper mix ratio for the mortar is 1 cement: 2 lime: 6 fine sand: 4 water. This is mixed as follows:

- Pour 2 buckets of water into the mixer. (This will rinse the mixer of the remains of the last batch and thus help to keep it clean.)
- Add the lime and cement, allowing them to mix for a few minutes.
- Add the sand last, with as much water as is needed to obtain the proper consistency. Avoid adding too much water. If the mixture becomes too runny, it may be necessary to add more sand and lime to the mix.

The mortar may be retempered with water if it becomes hard due to drying, but not if it has set up chemically.

Always keep the mortar boards, wheelbarrows and shovels as clean as possible to prevent mortar buildup.

IV. Building Layout

After the foundations have been poured and the floors have been finished, the masonry walls can be laid out. The correct layout of the first course of blocks is essential to the ultimate stability of the walls; this task should be performed carefully and accurately.

A. Centering the Walls on the Foundation

For this project, the masonry walls are designed such that, when the blocks are laid on the foundation, a small amount of space is left over at each end. This enables slight adjustments to the block layout should any corrections for squareness be required.

To center the walls on the foundation with an equal amount of space left over at each end, the following procedure should be followed:

1. Measure the ends of the foundation from outside face to outside face. This distance should be equally divided into some number of feet (30.5 cm) plus some number of centimeters left over (usually about 6 cm).

2. Divide the excess number of centimeters by two (for example, 6 ÷ 2 = 3). This is the amount of space that must be left at each end in order for the wall to be centered on the foundation.

3. Measure in from the corner the required distance and make a mark. (In this example, the mark will be made 3 cm from the corner.)

4. Starting at this point, mark the foundation every 12 inches (30.5 cm). The last mark should be the same distance from the corner as the first mark.

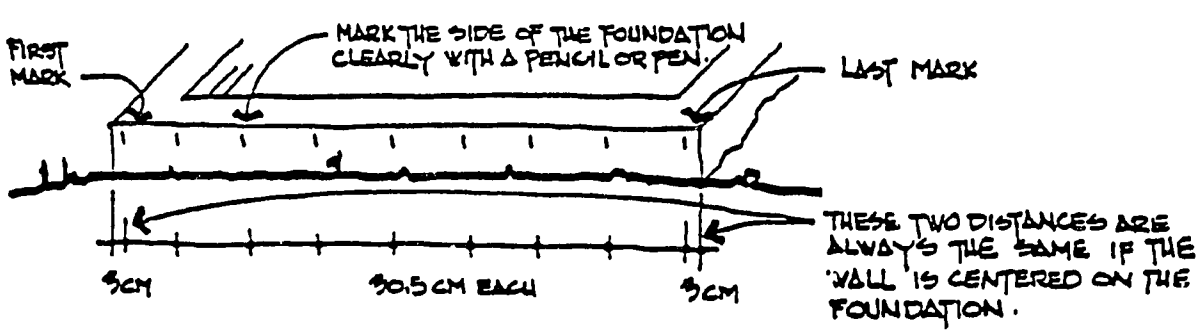


FIGURE 3.11
MASONRY LAYOUT - 1

5. Repeat this process at the other end of the foundation.

A similar process is followed for laying out the blocks on the sides of the foundation, except that an allowance must be made for turning the corner with the blocks.

6. Repeat Steps 1 through 3 above.

7. Starting at the mark made close to the outside corner, measure in 6 inches (15.2 cm) and make a second mark.

8. From this point, mark the foundation every 12 inches (30.5 cm). The last mark should be approximately 7 inches (18 cm) from the corner of the foundation.

9. Measure 6 inches from the last mark and make a final mark. This mark should be 3 cm from the corner, or the same distance as the first mark.

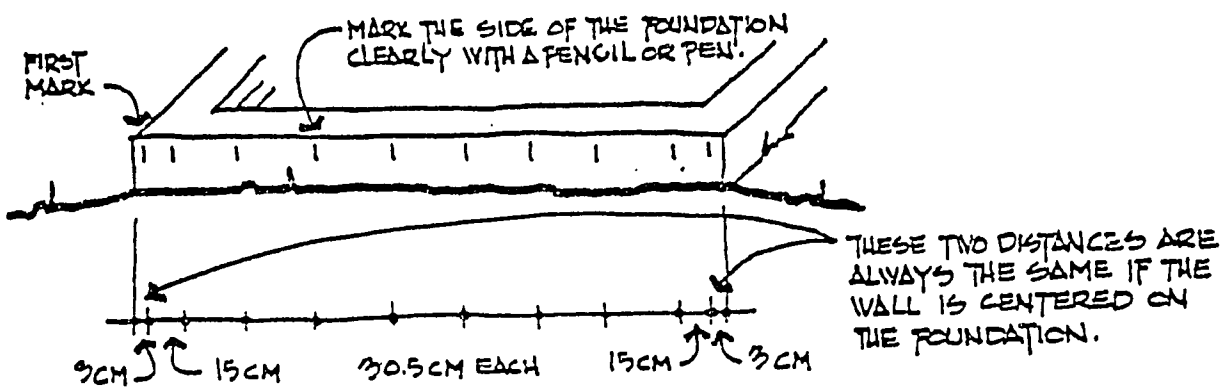


FIGURE 3.12
MASONRY LAYOUT - 2

As previously stated, this process allows the mason to turn the corner with the blocks.

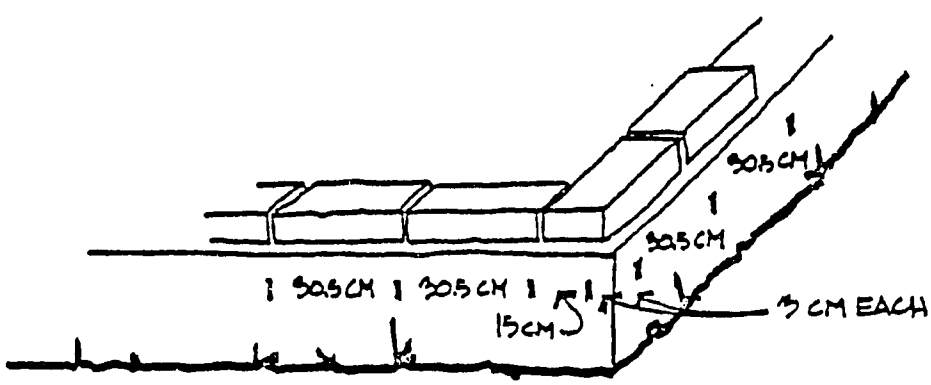


FIGURE 3.13
CORNER LAYOUT - DETAIL

B. Squaring the Foundation

If the foundation is visibly out of square, the small amount of space left free at the corners may be used to correct the problem. Shift the block layout until the corners are square and walls opposite each other are equal in length. This may require that the blocks slightly overhang the foundation in some places.

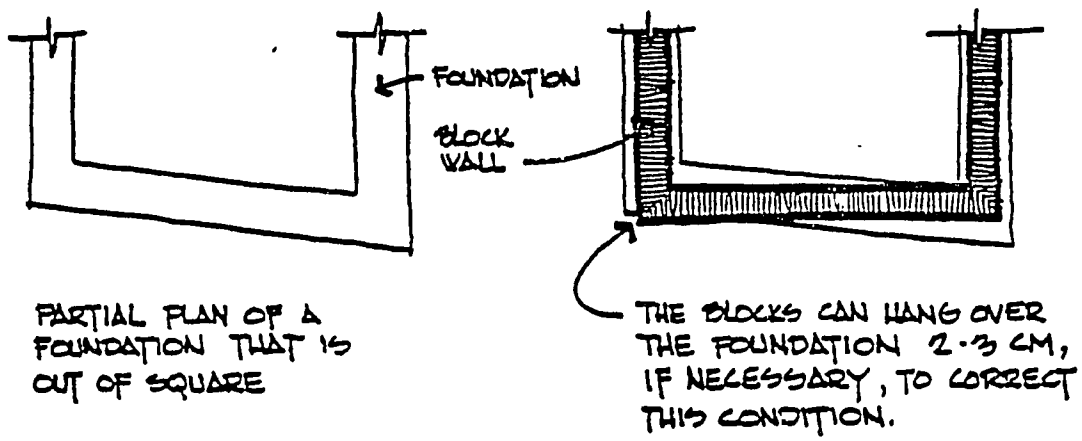


FIGURE 3.14
SQUARING UP THE FOUNDATION

C. Leveling the First Course

Once the layout for the blocks has been established, efforts must be made to make the first course of blocks level. Use the following procedure:

1. As shown in Figure 3.15, use a straight board and a level to determine the highest point on the foundation. This is the height at which all blocks must be laid in order for the first course to be level.

2. Starting at the highest corner, lay a thin layer of mortar on the foundation and set the two corner blocks on top. Using the fluid level, adjust the blocks until they are level.

3. Set a block in place (without mortar) approximately 10 to 12 feet (305 to 366 cm) from the corner blocks, using the marks on the foundation as a guide.

4. Use the board and level to determine how much mortar is needed to make this block level with the corner blocks.

5. Set the block in place using the correct amount of mortar. Recheck the height, using the board and level, to make sure that the block is properly placed.

6. Move to the next corner and repeat this process, making sure that the blocks are level with both the block in the middle of the wall and the blocks at the other corner.

7. Using this procedure, continue around the building until all corners are in place and level. Recheck to be sure that all corner blocks line up with the marks on the foundation which indicate their correct position.

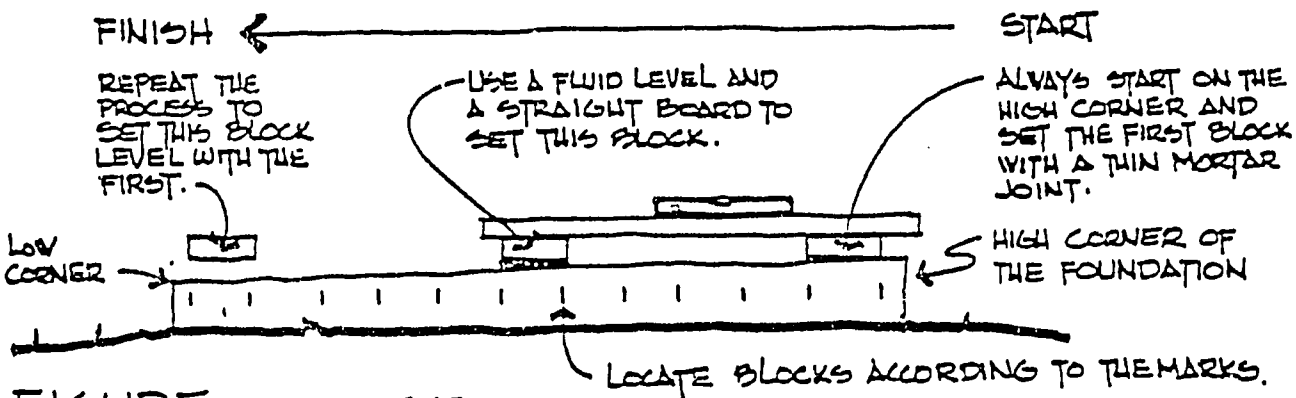


FIGURE 3.15
LEVELING THE FIRST COURSE

D. Locating the Door Openings

Door openings are normally 2 feet (61 cm) wide or 2 1/2 feet (76.2 cm) wide. This is equal to the length of 2 blocks or 2 1/2 blocks, respectively.

Use the building plan to locate the door openings and mark the foundation accordingly. (See Section VII-A of this chapter for further details on framing door openings.)

E. Completing the First Course

Once the corner blocks are level and properly placed and door openings have been located, set up the line blocks and string. Set the rest of the blocks for that course, keeping the faces even with the string.

V. Building the Corners

Once the first course of blocks is in place, the corners of the building must be built. Properly constructed corners are essential to the overall integrity and stability of the building, and the procedures outlined in this section must be followed with great care.

Each block must be set carefully, using the level, so that it is level and plumb.

The corner is begun by setting 5 blocks onto the first course, as in Figure 3.16.

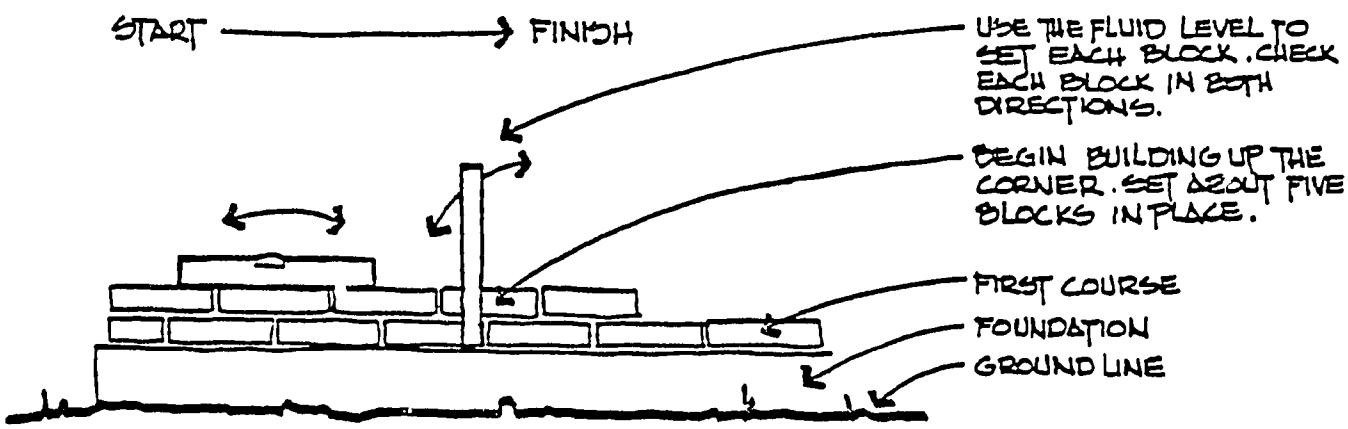


FIGURE 3.16
BUILDING THE CORNER - 1

Start the third course by staggering the corner block. Then set four more blocks on top of the second course, as shown in Figure 3.17.

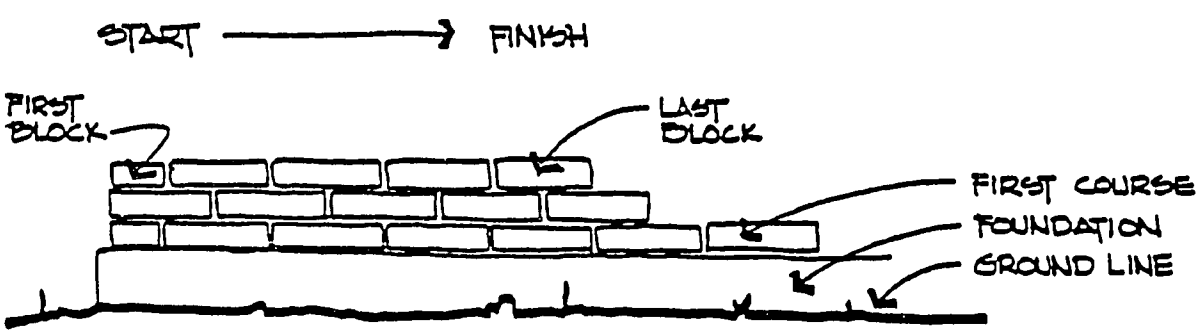


FIGURE 3.17
BUILDING THE CORNER - 2

As you continue to build the corner, each course will be 1/2 block shorter in length.

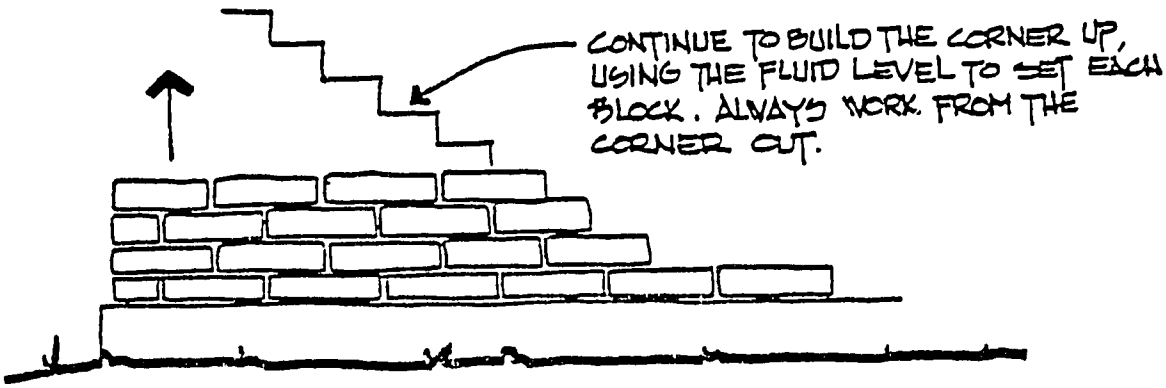


FIGURE 3.18
BUILDING THE CORNER - 3

Eventually the corners will be used as guides to establish the correct height and alignment of the blocks that are set between them.

For this reason, the corners must be constantly checked to make sure that they are level and plumb. This is done using the level, as shown in Figures 3.19 and 3.20. Always be sure that the bottom of the level is touching the wall.

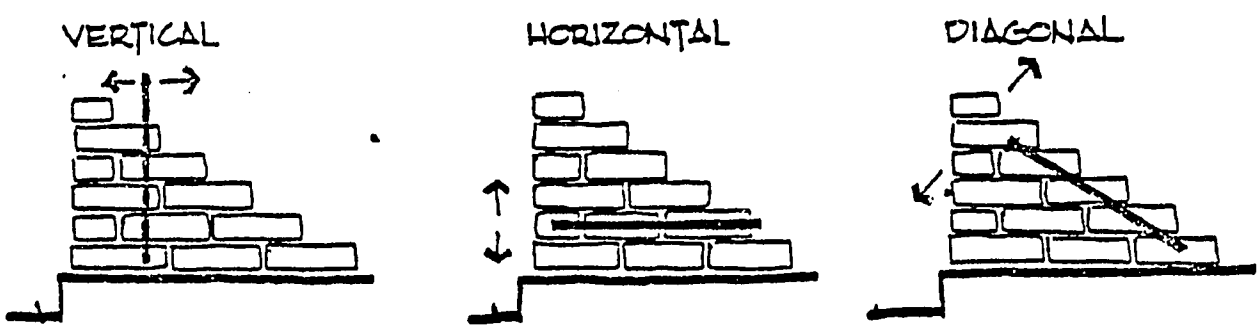


FIGURE 3.19
CHECKING THE CORNERS

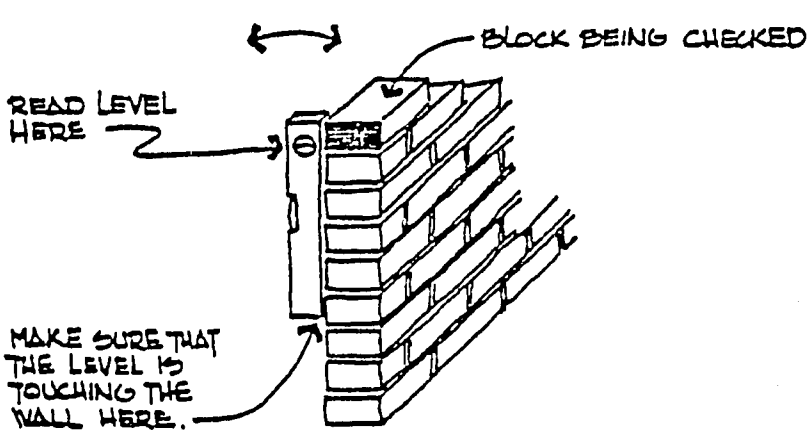


FIGURE 3.20
USING THE LEVEL

If the corner is laid out of plumb and the error goes unnoticed until after the mortar has set, it will be necessary to cut the blocks back until the level indicates that the wall is plumb. Remember, constant review of the trainees' work is required to avoid and/or correct mistakes as they occur.

Each course must be checked with the story pole to make sure that it is the correct height. This is made easy by setting nails into the mortar joint between the first and second courses at each corner. Since special efforts were directed toward making the first course level, the nails, if carefully placed, should also be level with respect to each other. The story pole is set on the nails after each course of block is laid. The top of each block should be even with a mark on the story pole.

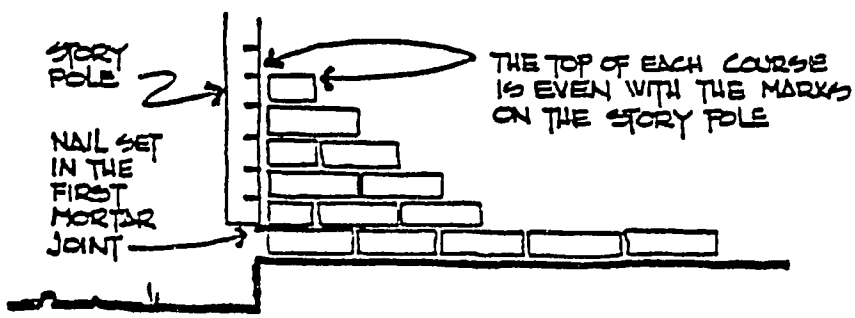


FIGURE 3.21
USING THE STORY POLE

Wall reinforcing is required between the tenth and eleventh courses. The instructor should make certain that this essential step is not forgotten.

VI. Exterior Walls

After the corners have been built, the rest of the wall can be built by setting each course to the line.

A. Laying a Mortar Bed

Until the trainee learns to work quickly, he should set out a mortar bed large enough for only one block. This will prevent the mortar from drying before the blocks are placed. As the trainee's skill and speed increase, he may begin to extend the mortar bed to two or three block lengths.

"Throwing" a three-block mortar bed is diagrammed in Figure 3.22. A trowel laden with mortar is held, palm-up, at the start of the

stroke. The trowel is gradually turned until, at the end of the stroke, the trowel is upside-down.

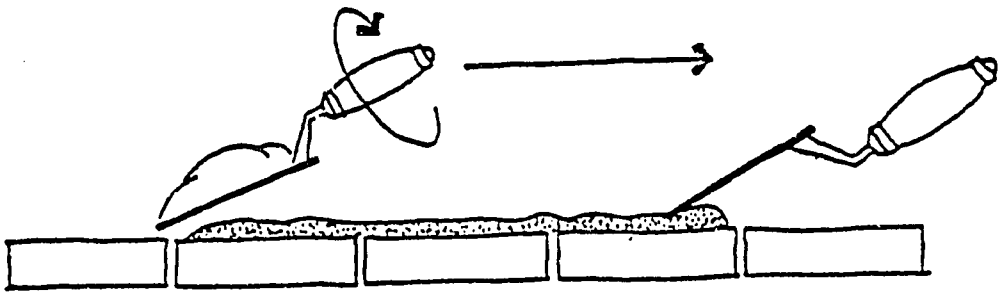


FIGURE 3.22
USING THE TROWEL

The trainee should be encouraged to practice throwing a mortar bed of this type after he has mastered the general techniques of masonry construction. Teach him to pick up a quantity of mortar and, in a smooth action, try to cover more than one or two bricks. This throwing action involves turning the trowel as it is moved longitudinally. It should deposit enough mortar on each brick so that the furrowing procedure that follows will produce a fairly uniform mortar bed that covers all surfaces.

After each throw, excess mortar should be cut away and placed on the next mortar bed, or returned to the mortar board.

B. Working to a Line

All blocks except for the corners must be set to a line.

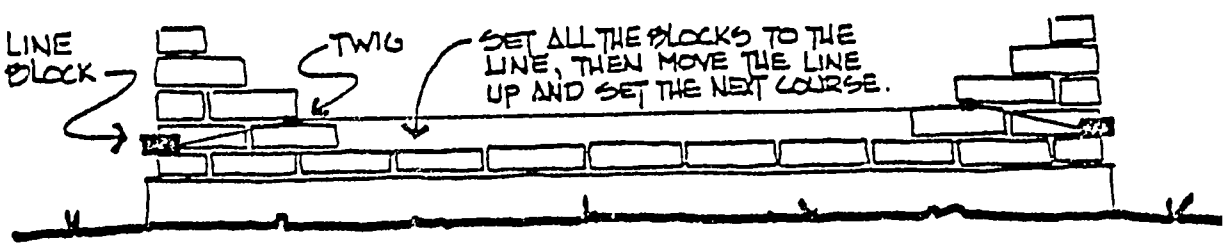


FIGURE 3.23
USING THE LINE BLOCKS AND LINE

When working to a line, it is very important that no one touch the line while setting a block, as this could cause other people who

are working to the same line to set blocks in the wrong place.

It is also very important that the block not touch the line. If the block touches the line, it has actually moved the line a small distance. If the next block touches the line, then the line has been moved again. This action, repeated often, will cause the wall to bow out and will weaken the strength of the wall.

Always set the top of the block flush with the line. It is better for the block to be slightly too low than for it to be slightly too high. If the block is set too high, it will be difficult to set the course above it to the correct height. See Figure 3.24.

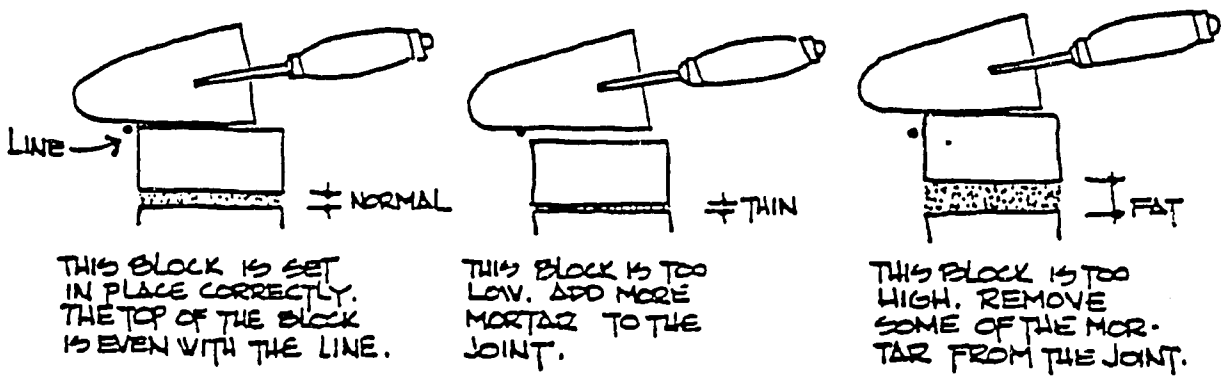


FIGURE 3.24
WORKING TO THE LINE

Except when building the corners, never set blocks without a string line.

C. Making Vertical Mortar Joints

If both corners have been built vertically and, therefore, the length of the wall is constant, then the number of blocks and number of vertical mortar joints should be the same for every other course. See Figure 3.25.

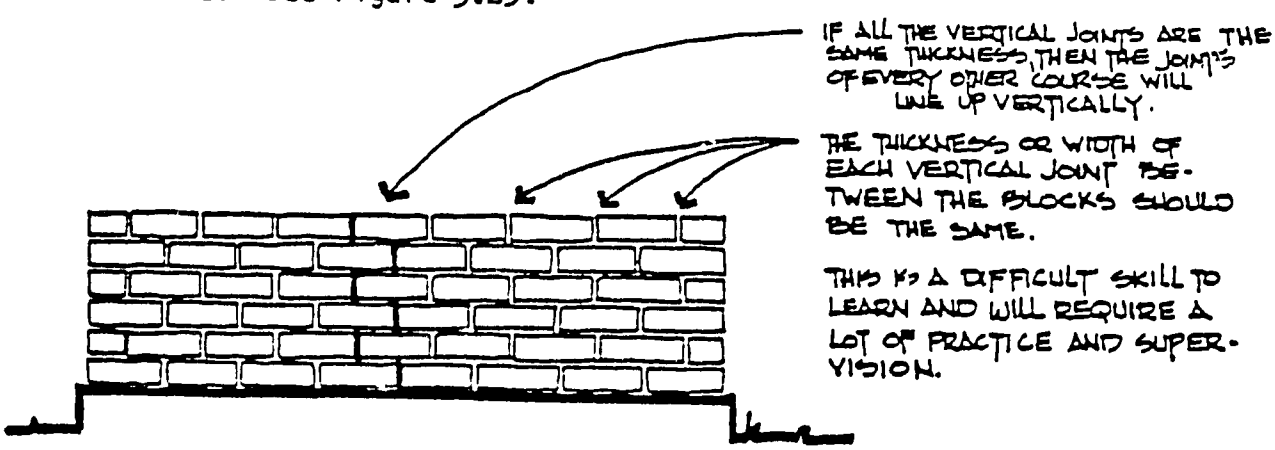


FIGURE 3.25
CORRECT VERTICAL JOINTS

This means that the vertical mortar joints in every other course must line up. The trainees must be instructed to make vertical mortar joints that are the correct thickness. Otherwise, the individual mistakes will accumulate and the sum of those mistakes will affect the setting of the final mortar joint for that course. It may be necessary to increase the thickness of the final mortar joints or to trim the final block in order to correct such a problem. See Figure 3.26.

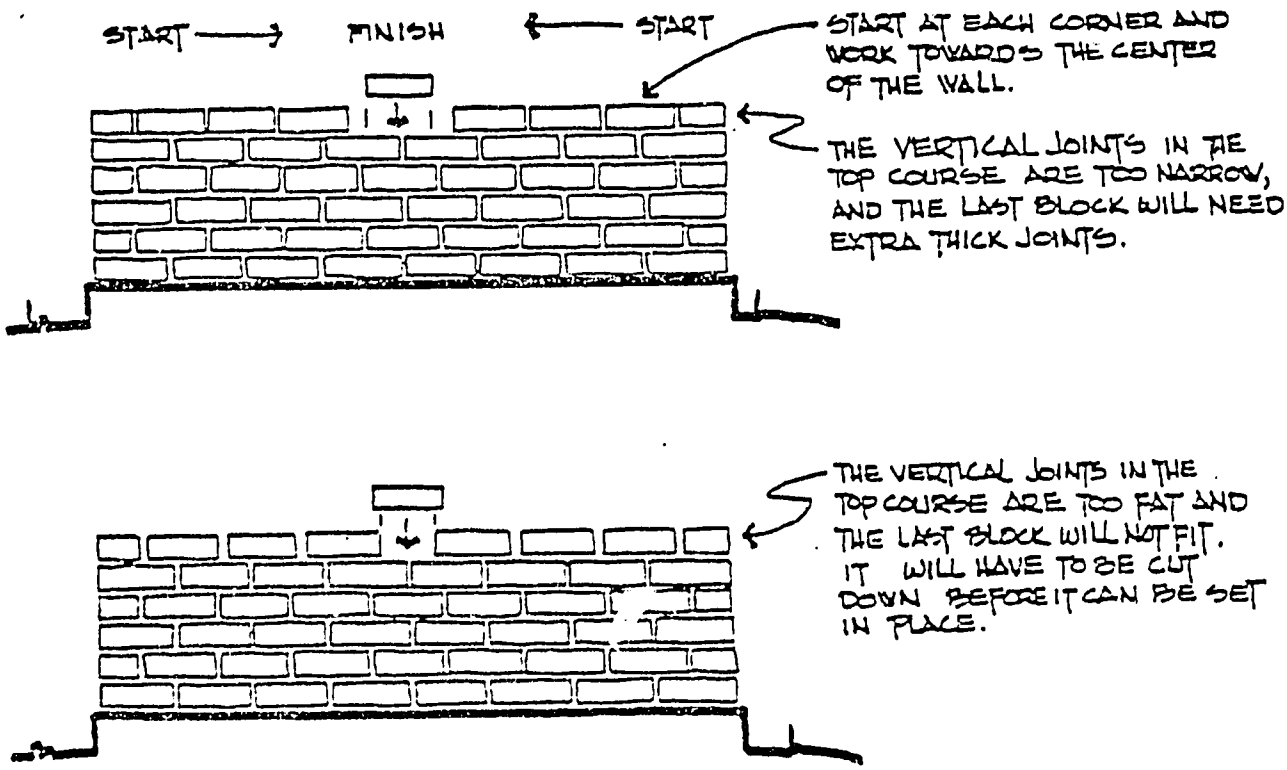


FIGURE 3.26
INCORRECT VERTICAL JOINTS

If the vertical coursing is so far out of alignment that blocks must be trimmed, it is best to stop the work and mark off the correct location of the joints, as was done for the first course. (See Section IV-A of this chapter). If the corners are level and plumb, simply use a tape measure to mark off the joints.

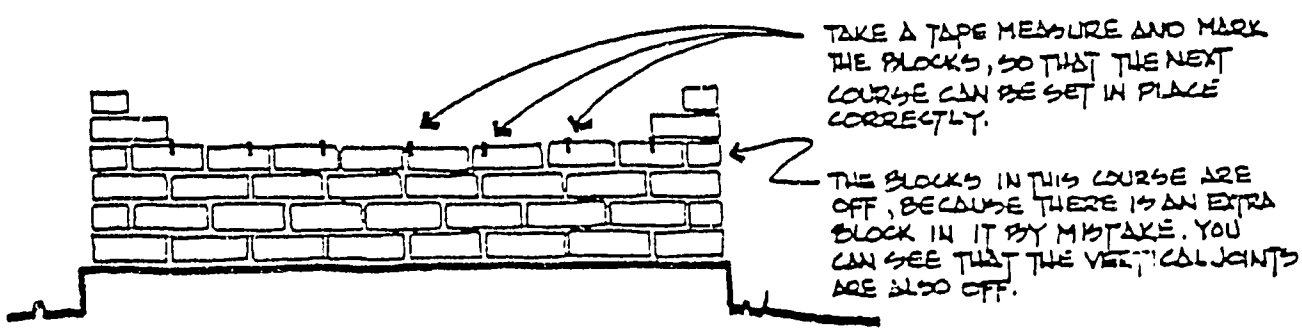


FIGURE 3.27
CORRECTING THE PROBLEM

D. Wall Reinforcing

Wall reinforcing helps to strengthen the building and reduces cracking in the walls. The first horizontal wall reinforcing is placed between the 9th and 10th courses, or just below the window sills. The second horizontal wall reinforcing is placed above the door and window lintels.

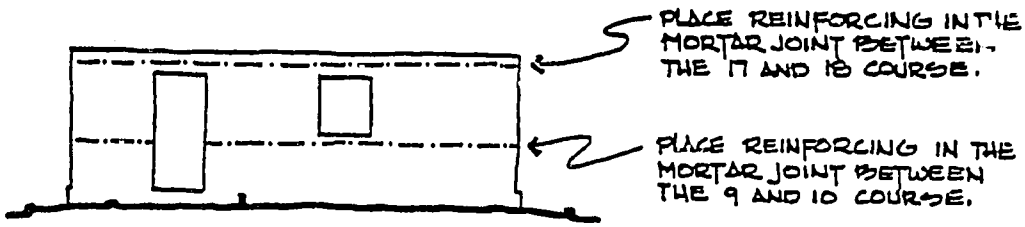


FIGURE 3.28
WALL REINFORCING

E. Tie Blocks

Special tie blocks must be set into the exterior walls so as to form a connection with the interior walls. Five tie blocks, set vertically every four courses, are used to tie each end of the partition wall to the exterior wall.

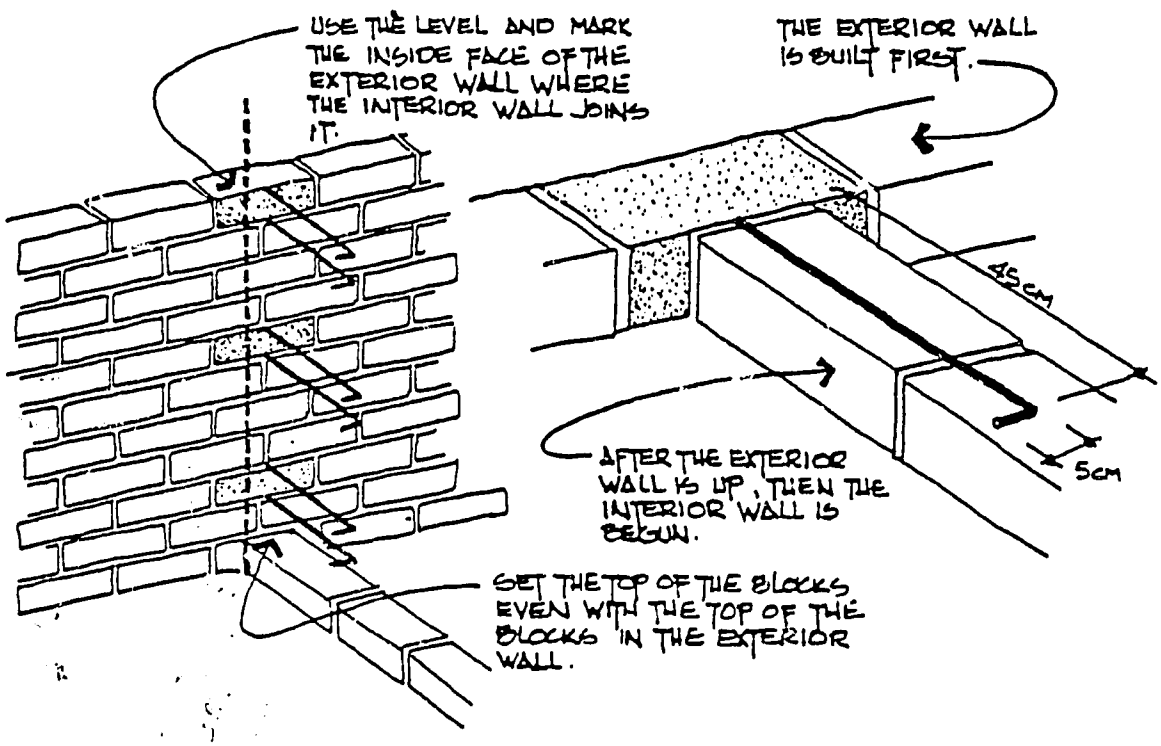


FIGURE 3.29
WALL TIE BLOCKS

F. Scaffolding

The scaffolding is set up when the wall reaches the height of the window sills. Set up the sawhorses so that they are level. This should be done by digging the legs into the ground. Never build up the ground beneath the sawhorses in order to level them. Space the sawhorses evenly around the building, being careful not to space them too far apart. Always use enough planks to provide a safe work surface for the trainees.

Due to the increased working height, the stability of the gable scaffolding is very important. Special attention should be directed toward making it level, and it should be nailed and braced so that it won't shake. The work surface should be five planks wide, with a space no greater than 3 - 4 cm between each plank. Stack the blocks along the outside edge of the scaffold, so as not to crowd the trainees, and place the mortar board in the middle so that it can be shared.

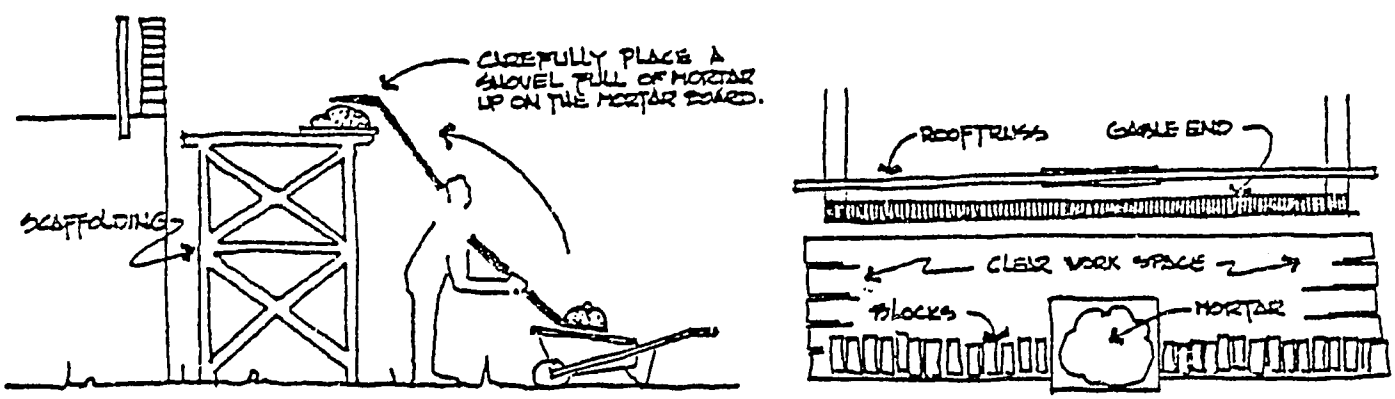


FIGURE 3.30
SCAFFOLDING DETAILS

A masons' helper should keep the trainees who are working on the scaffolding supplied with bricks, mortar, water and tools so that the gable can be built quickly and efficiently.

G. Gables

The gables are built after the roof trusses are in place, using the following procedure:

1. Carefully mark the roof truss at the point where the top of the block will be. This is done on both sides of the truss. Make notches in the truss at these points. Tie a block to each end of a string and hang the string over the roof truss, slipping the string into the notches. (See Figure 3.31.) The blocks are set to the top of the string.

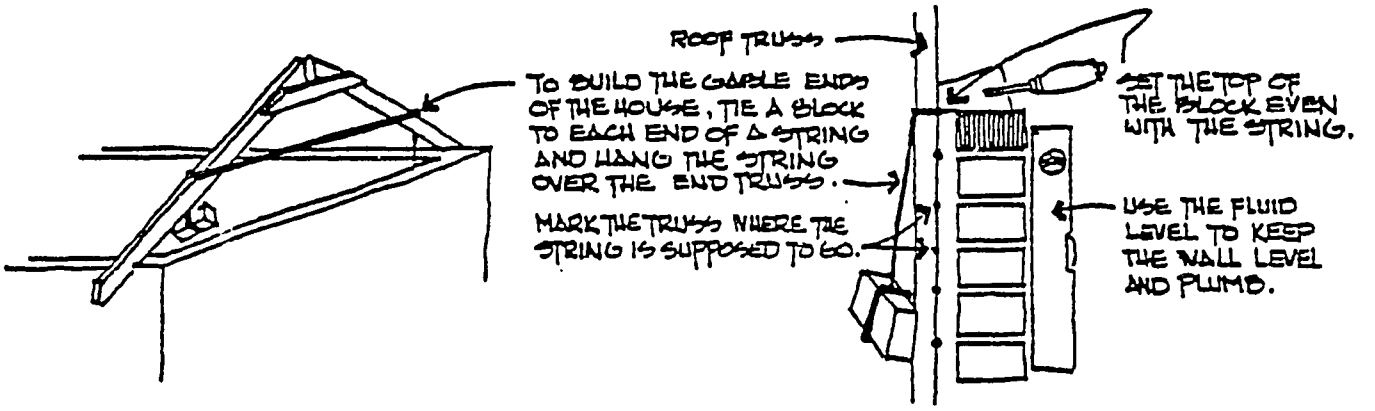


FIGURE 3.31
BUILDING THE GABLE ENDS

2. Use the level to set the gable blocks plumb with the wall. Begin by setting the blocks at the center, then work toward the ends. The last block on each end should be cut to fit the slope of the roof. Tie the top of the gable to the roof truss with steel ties which are set into the mortar joint.

   A vent should be built into each gable to release heat from the house. (See Figure 3.32.)

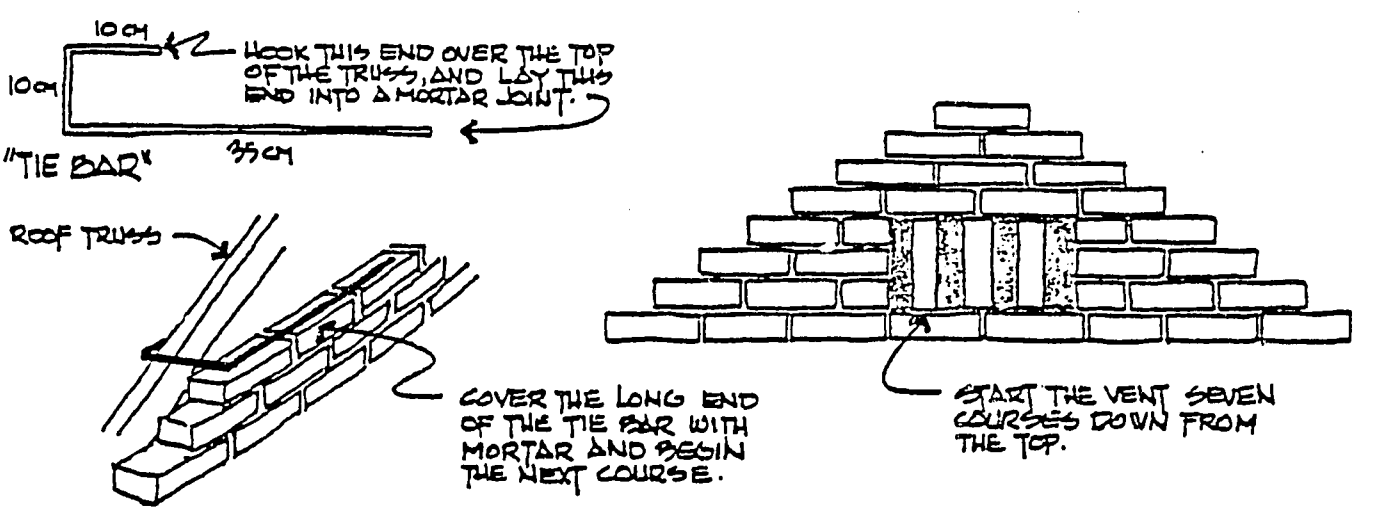


FIGURE 3.32
GABLE END DETAILS

After the scaffolding has been taken down, all nails should be removed and it should be stored in a neat and orderly manner.

Remember to groom the inside of the gable wall by filling and striking all mortar joints.

VII. Doors and Windows

The location of the doors and windows should be known before construction begins. If the door and window placement isn't fully understood, remember that the roof trusses are 4 feet (122 cm) on center, starting from the corner of the building. Doors and windows should be located between the roof trusses, not directly below them, as shown in Fig. 3.33.

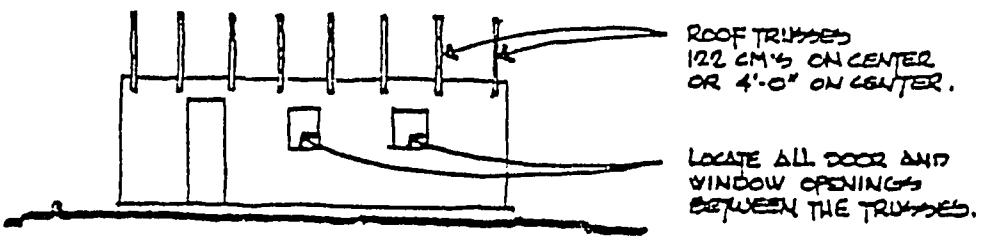


FIGURE 3.33
DOOR & WINDOW LOCATION

A. Door Openings

Door openings should be located and marked on the foundation when the first course of blocks is laid out. The door opening is normally 2'-0" or 2'-6" wide which is equal to 2 blocks or 2 1/2 blocks wide, respectively. The door height is normally 6'-0" or 6'-4", which corresponds with 18 and 19 courses of blocks, respectively.

Door openings should be framed as follows:

1. Set a temporary wood frame in the door opening. This should be set back from the outside face of the wall and braced to the inside so that the brace doesn't interfere with the string line.

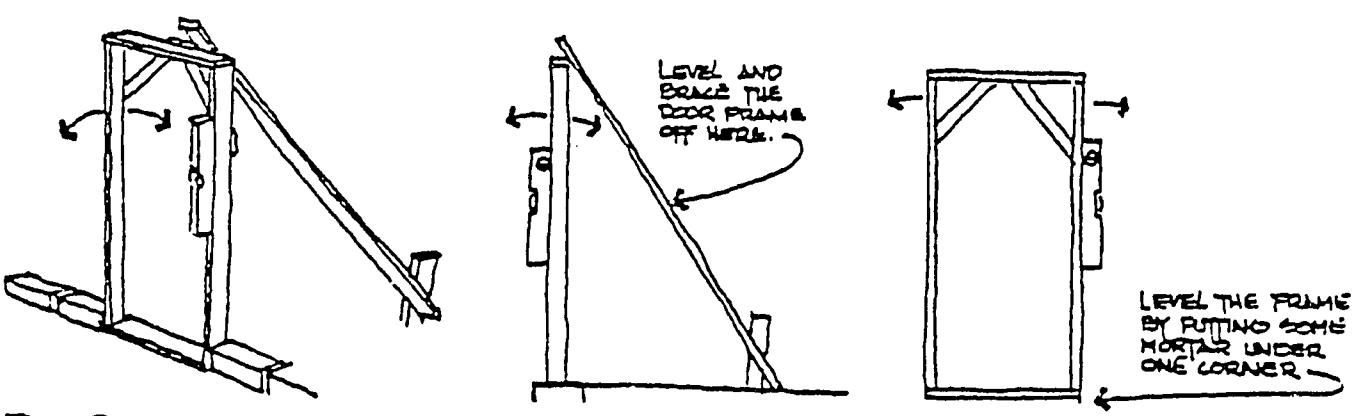


FIGURE 3.34
DOOR FRAMING DETAILS

2. Set each course to the edge of the temporary wood frame until the height of the lintel is reached. Special "hinge blocks" should be set three courses from both the top and the bottom of the door opening, placed so that the metal pin is on the inside face of the wall. These will be used to mount the door to the blocks.

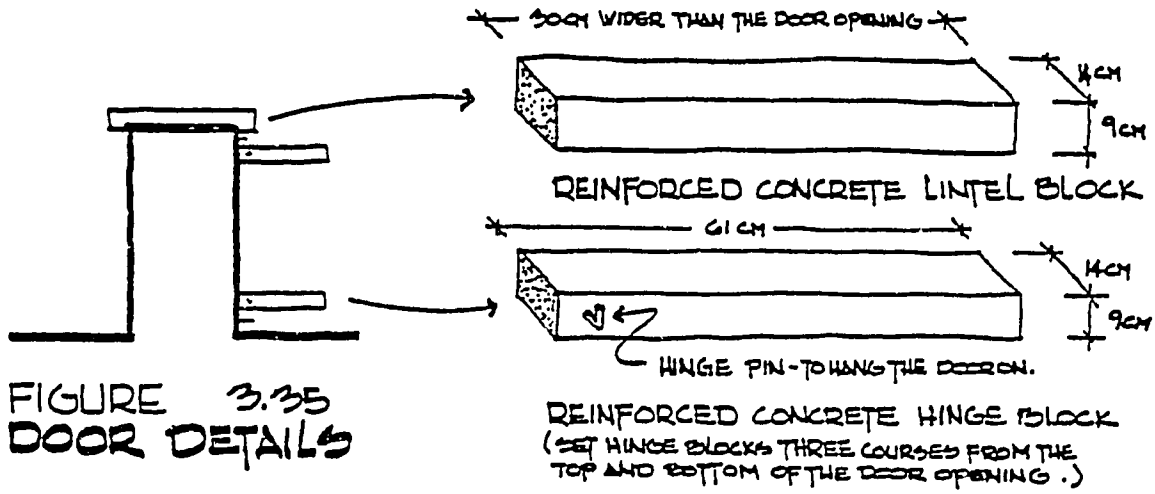


FIGURE 3.35
DOOR DETAILS

3. Carefully remove the temporary wood frame and store it for future use.

4. Set the door lintel using the string line as a guide.

B. Window Openings

The window sills are to be placed on top of the tenth course. These should be 12 inches (30.5 cm) wider than the finished window opening, thus allowing for a 6 inch (15.2 cm) bond on each side.

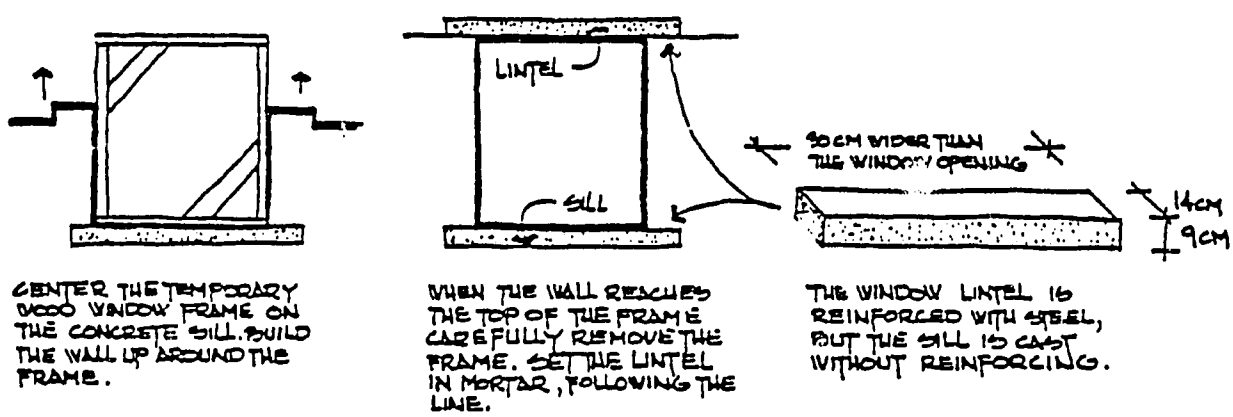


FIGURE 3.36
WINDOW DETAILS

The window openings should be framed as follows:

1. Place the wall reinforcing on top of the tenth course.

2. Set up the block and line to determine the thickness of mortar joint required to bring the sill up to the proper height.

3. Lay a mortar bed and set the sill in place.

4. Set the temporary wood frame in place, slightly back from the outside face of the building so that it does not interfere with the string line. Level the wood frame in both directions.

5. Set each course to the edge of the temporary wood frame until the height of the lintel is reached.

6. Remove the temporary wood frame and set the lintel, working carefully to the line.

VIII. Interior Walls

The interior walls must be connected to the exterior walls, which are constructed first. Tie blocks are set in the exterior walls, and have a short length of reinforcing steel sticking out of them. The reinforcing steel will line up with the mortar joints of the interior partition walls and forms a strong connection.

The interior walls are constructed in the following manner:

A. Use a straight board and level to mark the location of the partition wall on the inside of the exterior walls.

B. Mark the proper placement of the blocks on the floor.

C. Mark the location of door openings. (See section IV-D of this chapter.)

D. Build up each end of the interior wall as if it were a corner. After 4 or 5 courses, stretch a string and fill in the rest of the wall.

E. Remember to use horizontal reinforcing between the 9th and 10th courses and again over the door lintels.

F. When the interior wall is finished, strike all joints and brush the wall.

IX. Wall Finishes

The joints between each block must be completely filled with mortar. This is best done by placing the mortar properly on the blocks, setting the block properly and then filling the joint with extra mortar.

After setting two or three courses of block, the mason should "strike" the horizontal and vertical joints with a stick to ensure that the joint is uniformly full of mortar. This is done by carefully making straight, even lines with the stick. The skill level of a mason can be quickly determined by the neatness of the mortar joint. Do not let the trainees plaster the face of the blocks with mortar.

A cement wash is used for the first wall finish. This is prepared by mixing one part cement with three parts screened lime in water. Before brushing the wash onto the building, look for small holes in the mortar joints and fill them.

Lime wash is used for the final wall finish. Mix screened lime and water and brush the mixture onto the building. It will be most convenient to put both the cement and the lime wash on the gable ends while the scaffolding is up.

Roof Anchor Blocks

Special anchor blocks must be set into the top of the exterior walls to connect or anchor the roof trusses to the masonry walls. These special blocks are made out of concrete, just like the window sills and door and window lintels. The anchor blocks are set into the fifth course down from the top of the wall. The weight of the wall above the anchor blocks resists the force of the wind which will blow the roof of the house off if it is not anchored down. The anchor blocks are set directly under where the trusses will go. In the top course, a concrete bearing block is set under the trusses to carry and distribute the weight of the roof.

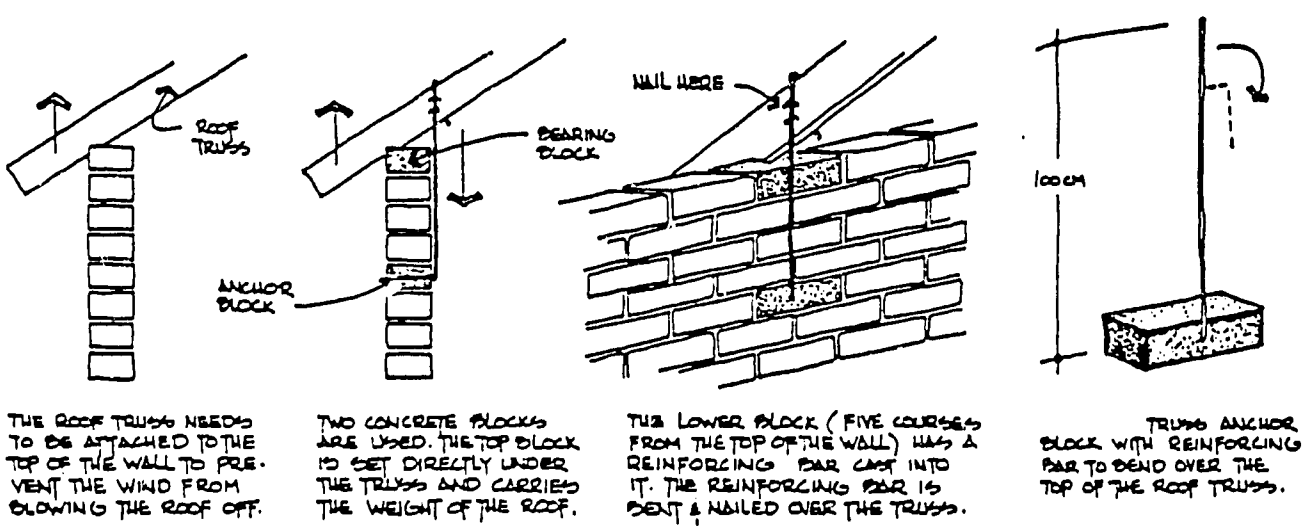


FIGURE 3.37
ROOF ANCHOR BLOCKS

Carpentry

Daily Operation

Tools

Typical Roof Design

Truss Fabrication
- Sizing the Truss Members
- Truss Fabrication
  - Top Chords
  - Bottom Chord
  - Ridge Plates
  - Assembly
  - Heel Cuts

Truss Erection
- Setting the Trusses in Place
- Diagonal Bracing
- Ridge Beam

Roofing
- Palm Stalk Roof Battens
- Roofing Felt
- Palm Thatch

Temporary Door and Window Frames

Wooden Doors and Windows

I. Daily Operation

A smooth daily operation is crucial to the success of the training program. The training of the settlers takes time, and decreasing time lost due to an inefficient daily operation increases the productivity of the program. In addition, if the settlers view the program as disorganized, there is a greater chance that tools and equipment will be stolen. It is the responsibility of the carpentry instructor to organize each day's activities and to coordinate those activities with other training instructors.

The following practices will help to ensure an efficient daily operation:

Check attendance as soon as all the trainees have arrived in the morning, and again after they return from breakfast. The instructor should have the day's activities clearly planned by the time the roll is called so that the trainees can be quickly divided into groups and the day's training begun.

Make a checklist of all items or materials needed each day and check the list before leaving the compound for the site. Much lost time and needless confusion can be avoided by doing so.

Issue tools and equipment to only those trainees who will be needing them. Pick up all tools at the end of each day, and make sure that they are clean and in good working order. It is the responsibility of the instructor to check tools out and to make sure that they are returned.

Use review periods to evaluate the work done by the trainees, catch mistakes, and explain problems to the group-at-large. Review periods should be frequent at first and can also be used as rest periods. Remember, physical endurance must be developed along with construction skills, and the trainees will tire quickly at first. As the trainees continue in the program, review periods will be needed less often; but, to begin with, each board that is sawed or nail that is driven will need to be reviewed. The review should include discussions of how to use the tools, how to stand while working, how to correct mistakes, etc. There should be a final review at the end of each day in which the day's achievements are discussed and trainees are given an opportunity to express any problems they may be having.

Make sure that the necessary materials and supplies are on hand. It is the responsibility of the carpentry instructor to make certain that a supply of lumber and nails are taken to the site each day; valuable time can be wasted when special trips must be made to the storehouse at the compound for additional materials. This problem can be eliminated by building a warehouse on the site, thus allowing materials to be stored close to the training area.

Always have a supply of clean drinking water available.

Communicate ways that work can be done in a safe and orderly manner. The best way to achieve this goal is to maintain a clean and orderly

area around the training site. Lumber should be stacked neatly, work areas should be kept clean, and tools should be kept in their proper place.

II. Tools

Hammer

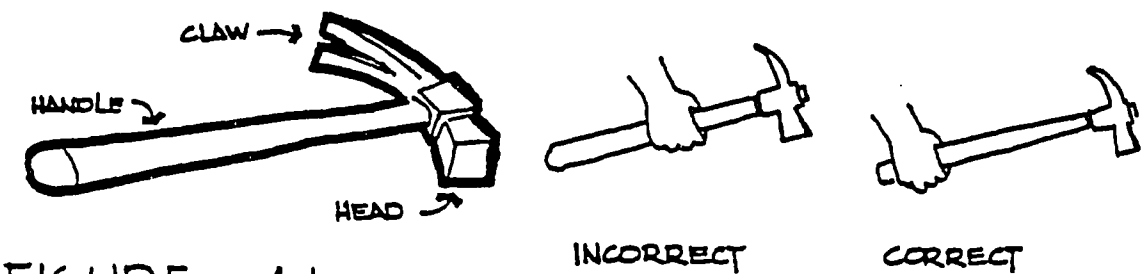
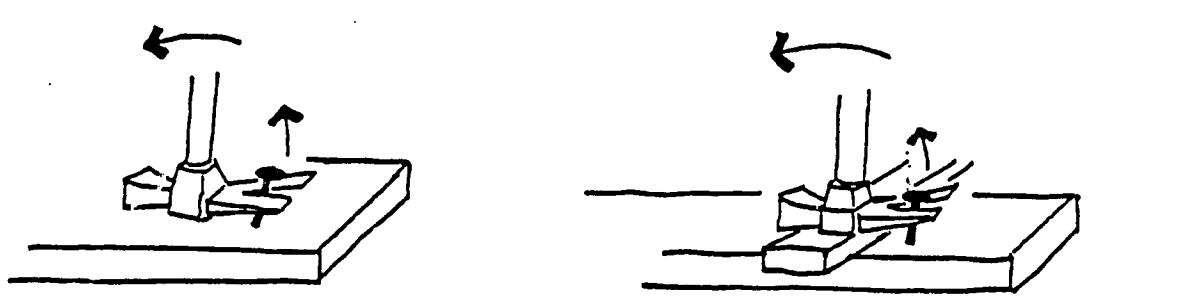


FIGURE 4.1
CARPENTERS HAMMER

The hammer is the primary tool of the carpenter and the trainee must learn to use it in the correct manner, so that the hammer does the work, not the carpenter. The hammer has a square end which is used for driving nails into wood, and a clawed end which is used for removing nails.

The hammer should not be held too close to the head, but more towards the end of the handle. This allows a more powerful swing with less physical effort. If a nail is bent over while being driven into the wood, the claw of the hammer can be used to straighten the nail so that it can be driven again, or it can be used to remove the nail.



TO REMOVE A NAIL, SLIP THE NAIL BETWEEN THE CLAWS OF THE HAMMER AND PULL THE NAIL OUT.

FOR MORE DIFFICULT NAILS, SLIP A PIECE OF WOOD UNDER THE HAMMER, WHICH GIVES THE CARPENTER BETTER LEVERAGE TO PULL THE NAIL OUT.

FIGURE 4.2
REMOVING NAILS

Crowbar

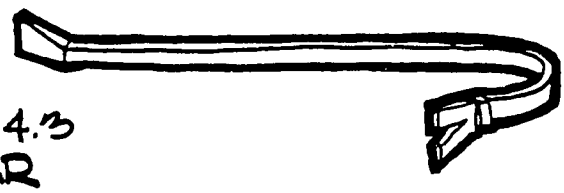


FIGURE 4.3
CROWBAR

The crowbar is a heavy metal bar with one curved and one wedge-shaped end. It is used to pry objects apart, and pull nails out.

Tape Measure

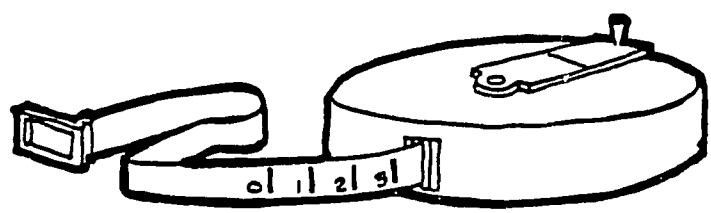
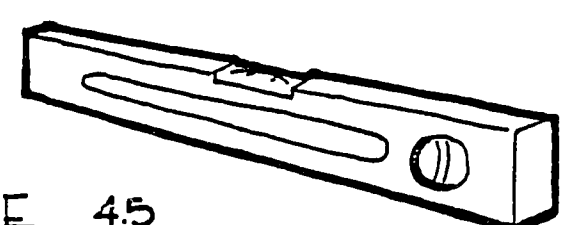


FIGURE 4.4
TAPE MEASURE

The tape measure is used to measure boards which need to be cut, and to check their location or placement before nailing them in place.

Fluid Level



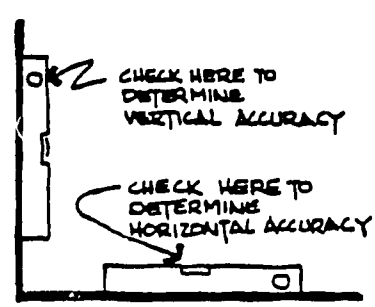


FIGURE 4.5
FLUID LEVEL

The fluid level is a tool used to determine points which are parallel with or perpendicular to the horizon. The carpentry training program has several uses for the fluid level, but its principal use is to ensure that the roof trusses are placed correctly, not leaning or tipping in either direction.

Hand Saw

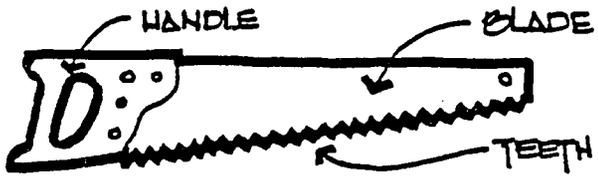


FIGURE 4.6
HAND SAW

The hand saw is used by the carpenter to cut wood. The trainees must be shown how to make saw cuts that are straight and square, so that, when cut boards are nailed together, a good, tight joint results.

Carpenter's Square

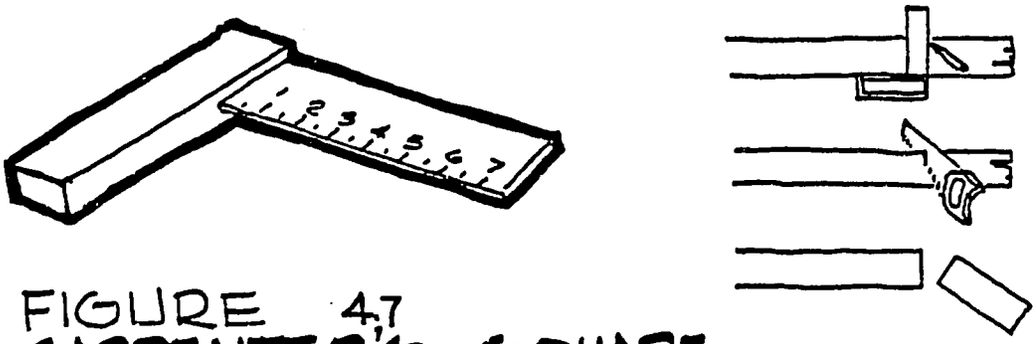


FIGURE 4.7
CARPENTER'S SQUARE

The carpenter's square is used by the carpenter to draw a straight line across a board, perpendicular to the length of the board. The board can then be cut squarely with a hand saw.

III. Typical Roof Design

The roofs of the houses built for this project are made of mackuti (palm thatching), asphalt-impregnated roofing felt, and wood trusses. The carpentry instructor should have a thorough understanding of the roof design before training is begun.

A. Roof Slope

The slope (or pitch) of a thatched roof is very important. The greater the slope, the less chance that rain will penetrate the roof and enter the house. For this project, a roof slope of eight to twelve (8/12) is used. This ratio describes the vertical and horizontal components of the roof slope. This means

that for every 8 cm of rise (vertical distance), there are 12 cm of run (horizontal distance).

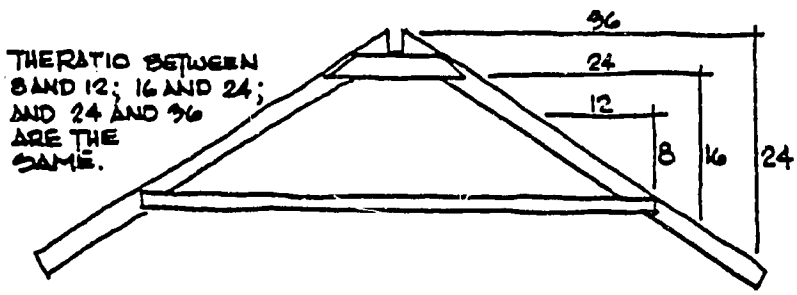


FIGURE 4.8
ROOF SLOPES

B. Truss Spacing

The roof trusses are typically spaced 122 cm (4 feet) on center, or the equivalent of four blocks set end to end. This requires that the length of the building be some multiple of 122 cm.

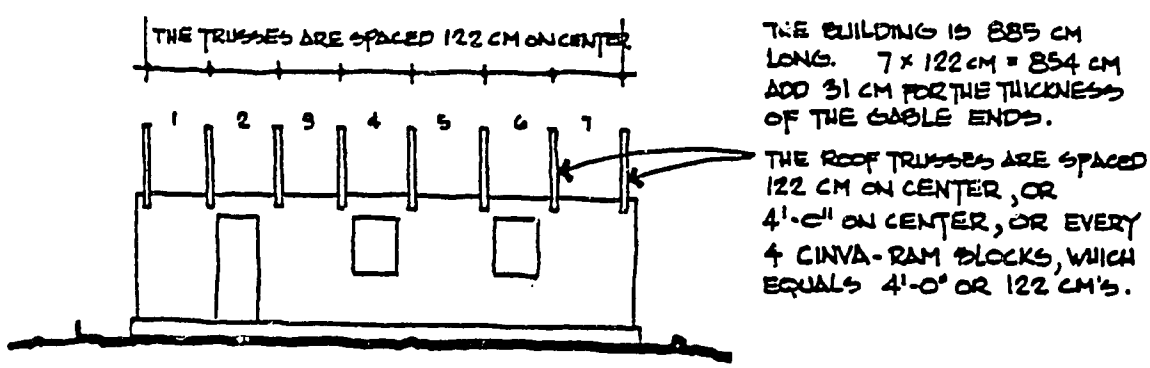


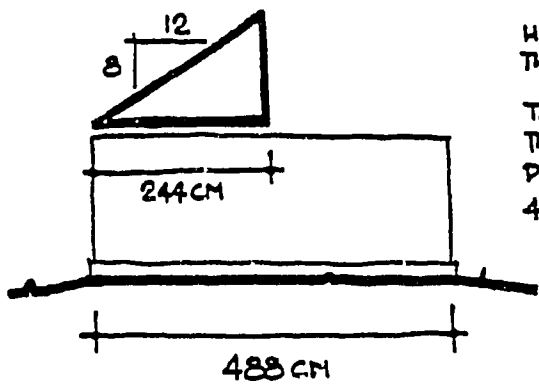
FIGURE 4.9
TRUSS SPACING

IV. Truss Fabrication

A. Sizing the Truss Members

The roof truss always spans the smaller dimension of the house. Therefore, if the house if five meters wide and ten meters long, the roof truss will span the five meter distance. The houses being built in this project are 488 cm wide. As mentioned previously, the roof slope is eight to twelve.

Before the trusses can be built, it is necessary to determine how long the boards that go into it must be. The easiest way to do this is to look at only half of the roof; this forms a right triangle.



HOW LONG WILL THE BOARDS THAT MAKE UP THE TRUSS BE?

TAKE THE WIDTH OF THE BUILDING THAT THE TRUSS WILL SPAN, AND DIVIDE THAT DISTANCE IN HALF.

488 CM ÷ 2 = 244 CM.

FIGURE 4.10
TRUSS DESIGN - 1

For any triangle with a right angle, the length of the sides can be expressed in the proportion: $A^2 + B^2 = C^2$, where A and B are the two sides that form the right angle, and C is the side that stretches between them (the hypotenuse). This fact can be used to determine the length of the boards.

First, divide the span, 488 cm, by 2. The result is 244 cm. This number will be used to calculate the length of the other two sides. The roof pitch is 8 to 12 (8/12). This means that the height of the triangle (side B) is related to the bottom of the triangle (side A) in the proportion 8:12, or:

$$\frac{8}{12} = \frac{\text{Height of Triangle}}{244 \text{ cm}}$$

To find the height of the triangle (side B), multiply 244 by 8, then divide that number by 12.

$$244 \times 8 = 1952$$

$$1952 \div 12 = 163$$

The height of the triangle is 163 cm.

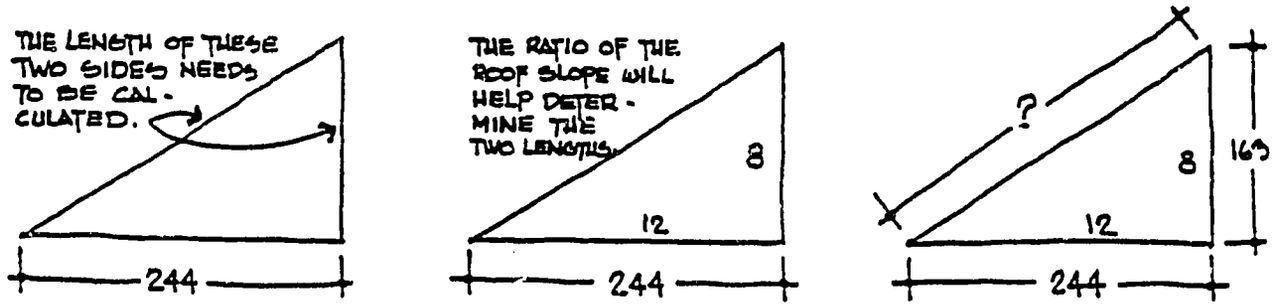


FIGURE 4.11
TRUSS DESIGN - 2

Next, find the length of the longest side of the triangle (the hypotenuse). As previously stated, for any triangle with a right angle, the length of the sides can be expressed in the proportion A2 + B2 = C2.

Since $A = 244$ cm,

and $B = 163$ cm,

then $C^2 = (244)2 + (163)^2$

$C^2 = (244 \times 244) + (163 \times 163)$

$C^2 = 59{,}536 + 26{,}569$

$C^2 = 86{,}105$

$C = 293$

The length of the hypotenuse is 293 cm.

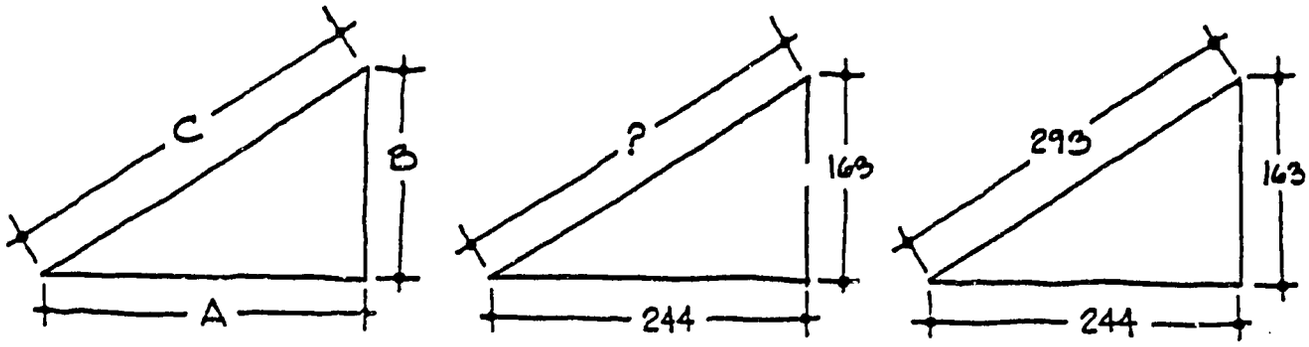
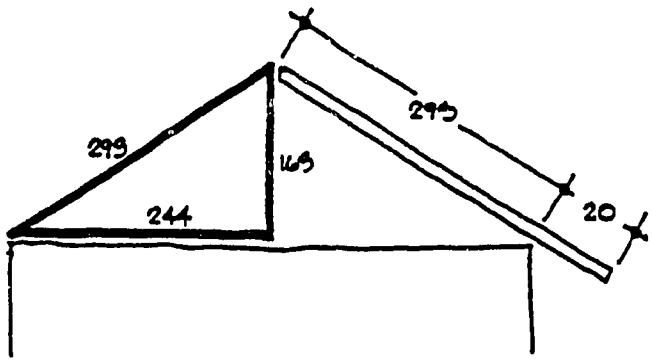


FIGURE 4.12
TRUSS DESIGN - 3

The overhang around the perimeter of the building is important to keep water out of the building, off of the walls, and away from the foundation. To allow for the roof overhang at the edge of the building, add 20 cm to the length of the hypotenuse.



THE TOP CHORD OF THE ROOF TRUSS NEEDS TO BE APPROXIMATELY 313 CM LONG.
293 + 20 = 313

FIGURE 4.13
TRUSS DESIGN - 4

The top chord should be approximately 313 cm long. For this project, 2" x 4" timbers are supplied in lengths of 305 cm, 427 cm, and 488 cm. The 305 cm timbers are closest to the desired length, and will be used for the top chord, since using the 427 cm length would cause too much wood to be wasted. If the overhang is reduced from 20 cm to 12 cm, the full length of the 305 cm timber can be used, and no waste will occur. Thus, the bottom chord will be an uncut board which can be nailed directly in place.

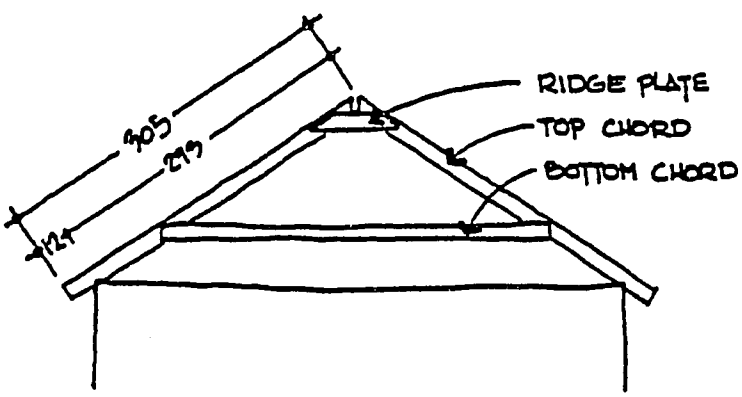


FIGURE 4.14
TRUSS DESIGN - 5

B. Truss Fabrication

Each truss is made of five pieces: two top chords (which are the same length), one bottom chord, and two ridge plates.

1. Top Chord

To determine the number of top chords for the roof trusses,

count the number of trusses needed for the house (8) and multiply by 2 (two top chords per truss). Thus, sixteen pieces of 2" x 4" timber, 305 cm long, will be required for the top chords.

One end of the boards must be trimmed at an angle. How do you find that angle? Remember that the roof slope is 8 to 12. The timber is 9 cm deep. The ratio of 6 to 9 (6/9) is the same as the ratio 8 to 12 (8/12). Therefore, measure 6 cm from the end of the board, draw a line with a straight edge and cut the timber at that angle, as shown in Fig. 4.15.

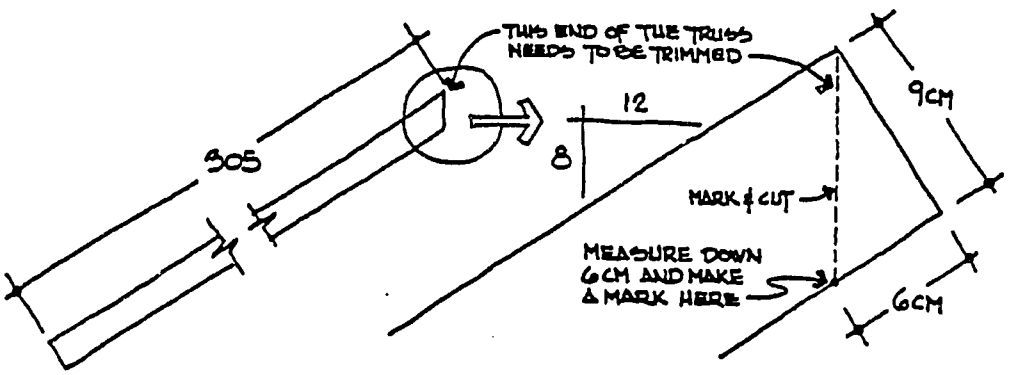


FIGURE 4.15
TRUSS FABRICATION - 1

The above exercise should be repeated several times for training purposes; for production work, a simple template should be made, allowing the carpenter to mark the timber and make the cut quickly.

2. Bottom Chord

Next, the points at which the bottom chord is nailed to the top chords must be determined.

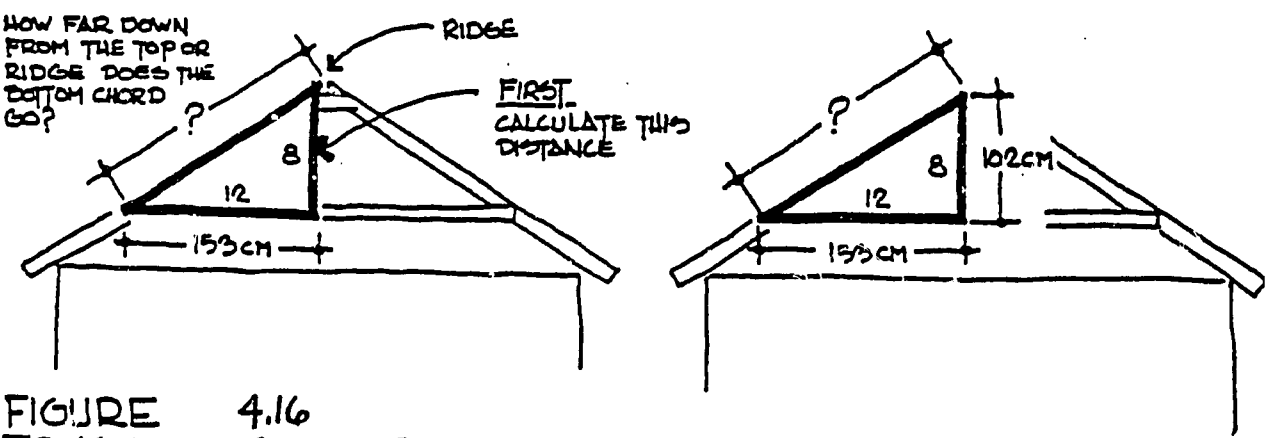


FIGURE 4.16
TRUSS FABRICATION - 2

a. To determine the distance from the bottom chord connection to the ridge of the truss, first determine the height of the triangle:

- Divide the length of the bottom chord by two,

  305 ÷ 2 = 153 cm

- Multiply the length of the bottom of the triangle by eight,

  153 x 8 = 1224 cm

- Divide the above number by twelve,

  1224 ÷ 12 = 102 cm

The height of the triangle is 102 cm. (See Figure 4.17.)

b. Next, determine the length of the hypotenuse, which will be equal to the distance from the ridge of the truss to the points at which the bottom chord connects to the top chord. This procedure is outlined in Section IV-A (Figures 4.11 and 4.12) and demonstrated in Figure 4.17 below.

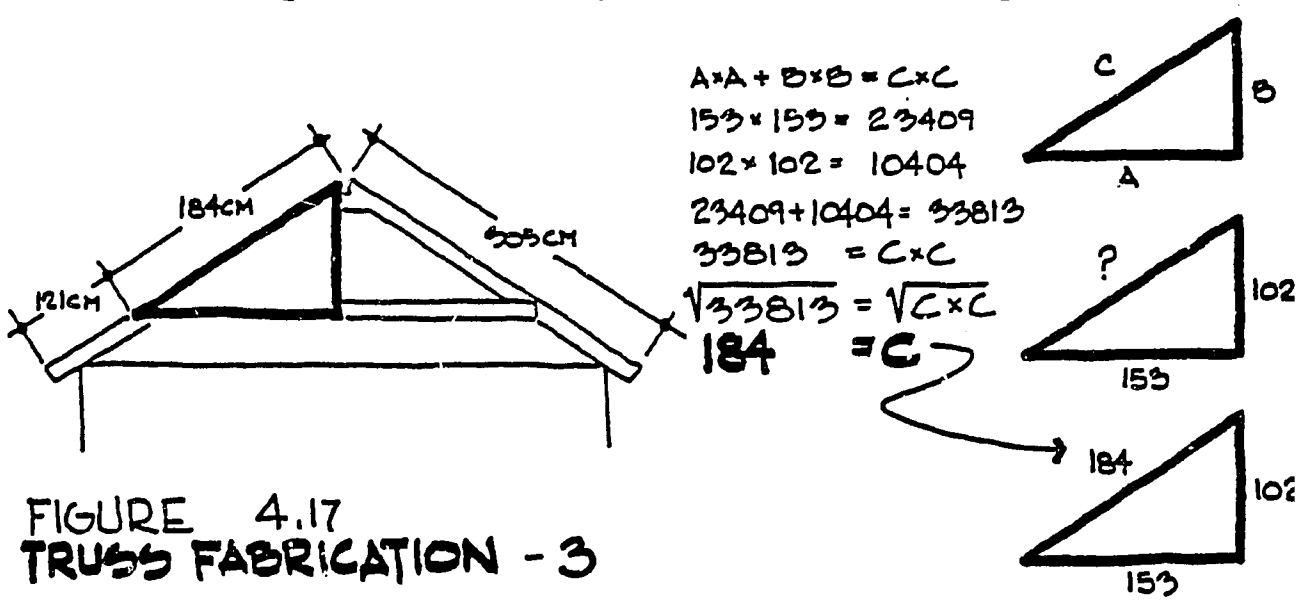


FIGURE 4.17
TRUSS FABRICATION - 3

Mark the top chord at a point 184 cm from the end. This is the point at which the bottom chord will connect to the top chord.

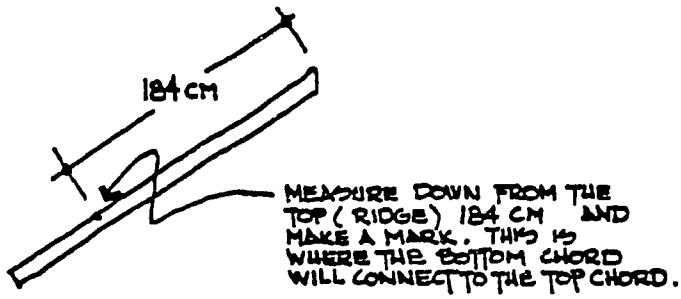


FIGURE 4.18
TRUSS FABRICATION - 4

3. Ridge Plates

The ridge plates serve two functions: they help to hold the top of the truss (the ridge) firmly together, and they act as a seat on which the ridge beam can rest. The production process is speeded up by making one ridge plate out of a 1" x 6" board, as shown in Figure 4.16, and using it as a template with which to cut the other ridge plates. By placing the template on a 1" x 6" board, the remaining ridge plates can easily be drawn and then cut into the correct shape. The template should be appropriately labeled so that it is not confused with the completed ridge plates.

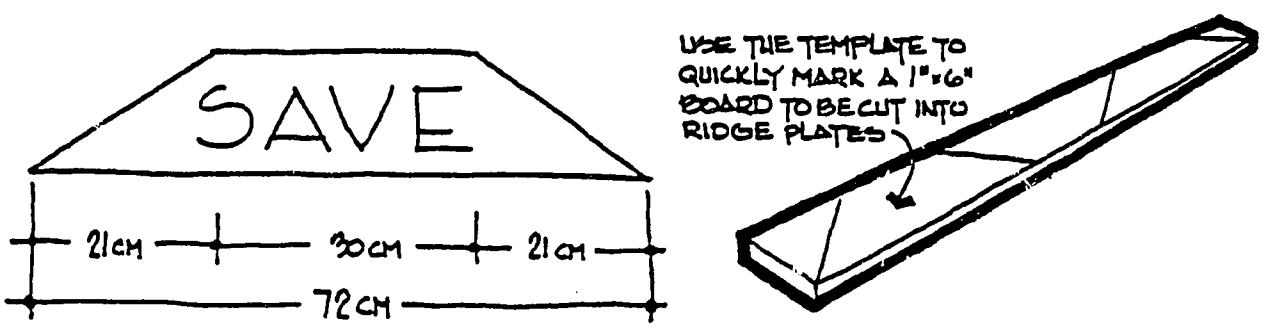


FIGURE 4.19
RIDGE PLATE TEMPLATE

4. Assembly

Once the correct number of pieces has been cut, the trusses must be assembled. Lay out the timbers on a level and clear piece of ground. For rapid assembly, have four trainees work on each truss--one person at the ridge and the other two at the points where the bottom chord connects with the

top chords. Have one person nail while the other two hold the boards in place.

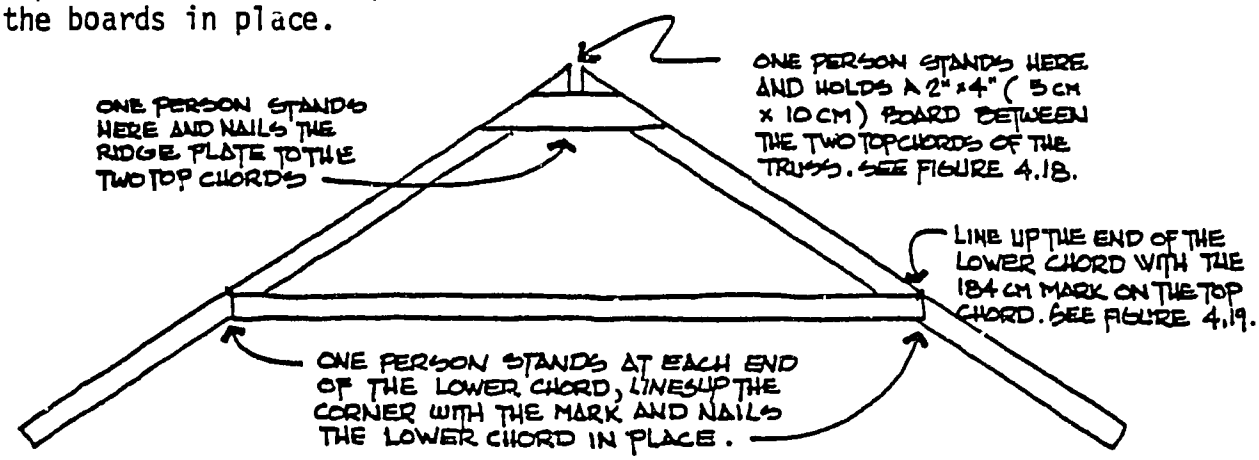


FIGURE 4.20
TRUSS CONSTRUCTION

Bracing the ridge of the truss is very important. Nail one ridge plate to each side of the two top chords, as shown in Figure 4.21. Then, nail the bott m chord to the top chords as shown in Figure 4.22, joining the boards at the locations marked.

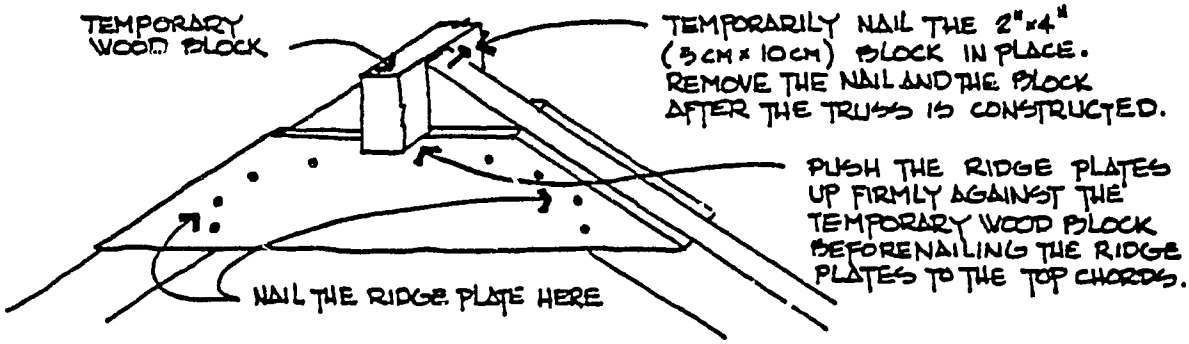


FIGURE 4.21
RIDGE PLATE DETAIL

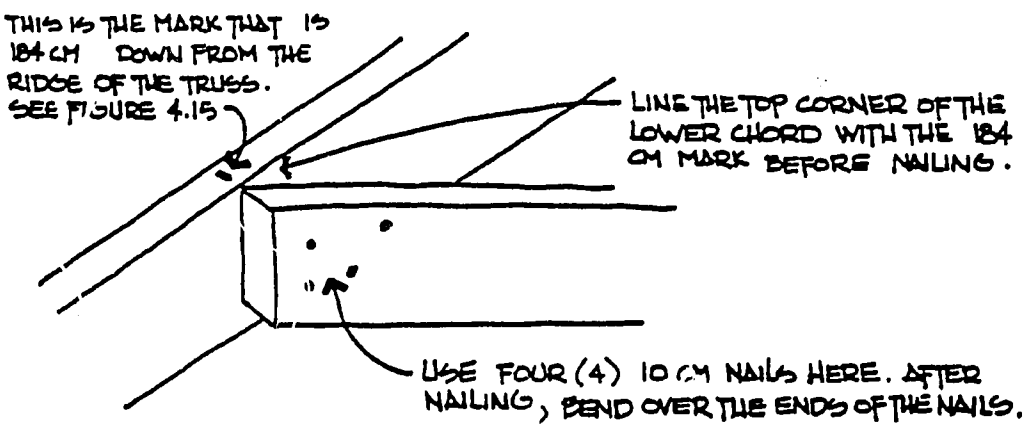


FIGURE 4.22
BOTTOM CHORD DETAIL

After the truss is nailed together, turn it over and use a hammer to bend over the nails that are sticking through the wood.

5. Heel Cuts

After the trusses have been fabricated, special notches, called heel cuts, must be cut into the bottom edge of both top chords, so that the truss will rest firmly on top of the masonry wall. The accurate location of the notch (or heel cut) on the truss is important since, if the heel cut is made in the wrong place, the truss will not line up with the other trusses.

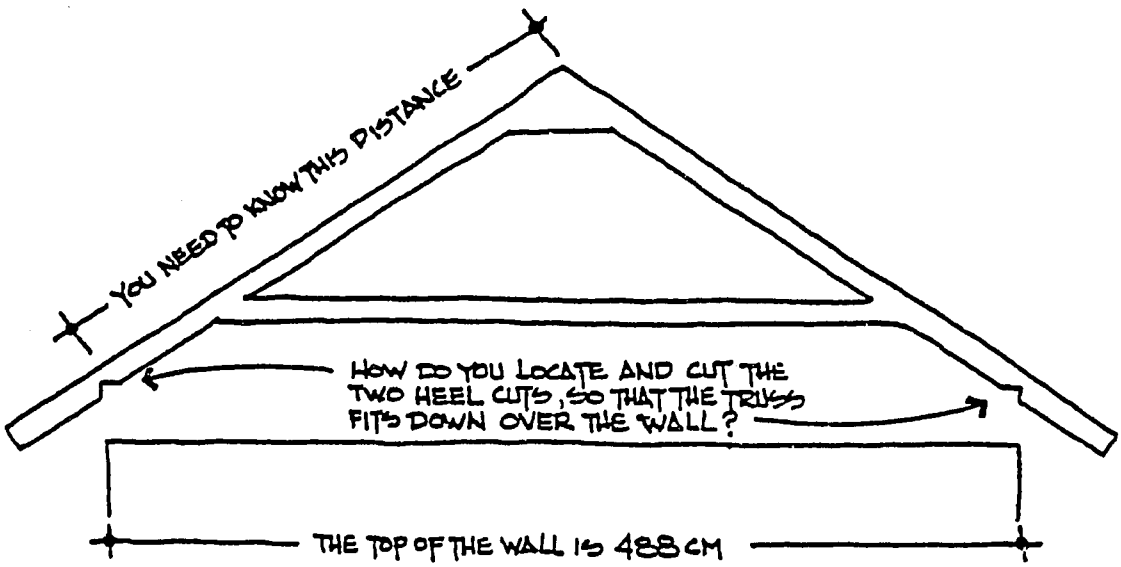


FIGURE 4.23
HEEL CUTS

a. Use a tape measure to check the width of the building at the point where the truss will be located. Pull the tape tight and measure accurately from outside face to outside face of the building. The distance should be very close to 488 cm. This dimension will be used to determine the distance from the ridge to the point on the top chord where the heel cuts should be located.

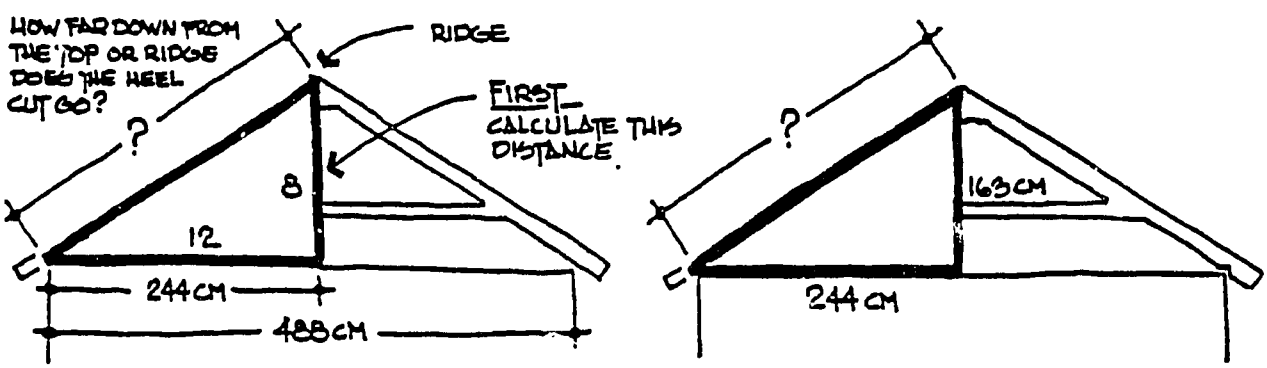


FIGURE 4.24
HEEL CUT LOCATION - 1

b. Use a right triangle and the 8/12 roof slope to calculate the length of the vertical side of the triangle:

(1) First, solve for the height of the triangle:

$$\frac{8}{12} = \frac{\text{Height of Triangle}}{244 \text{ cm}}$$

Height of Triangle = 163 cm

(2) Next, solve for the hypotenuse of the triangle:

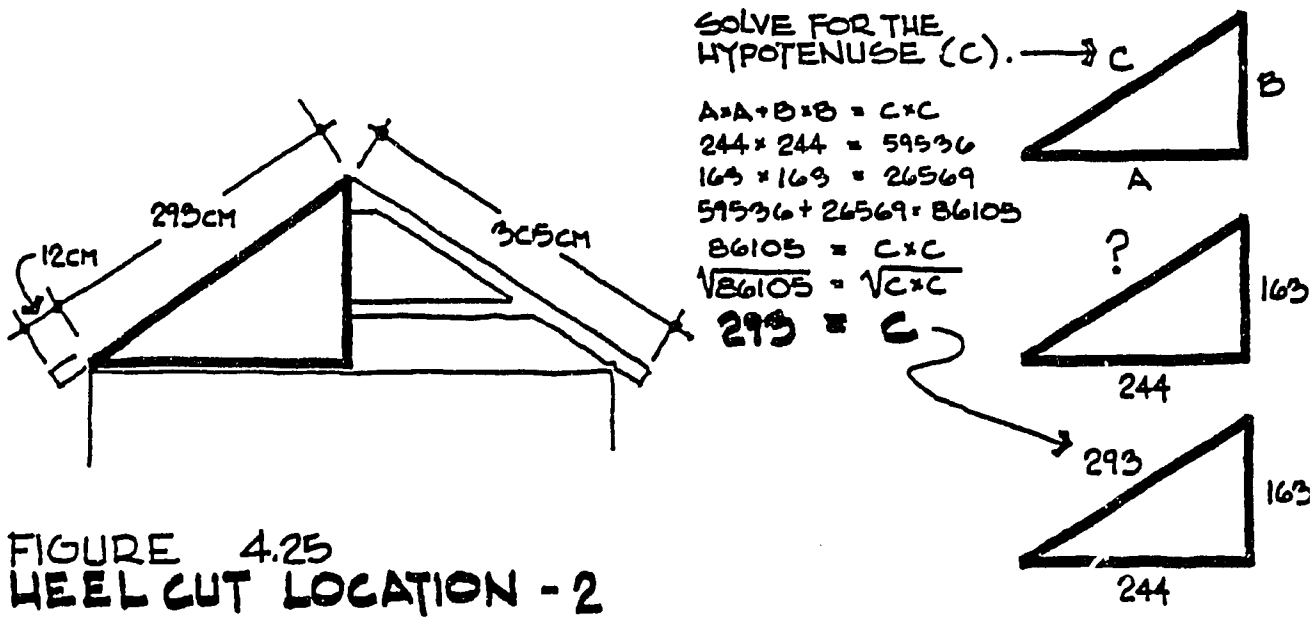


FIGURE 4.25
HEEL CUT LOCATION - 2

c. Use the distance found for the hypotenuse (293 cm) to locate the heel cut on the top chord, as shown in Fig. 4.26.

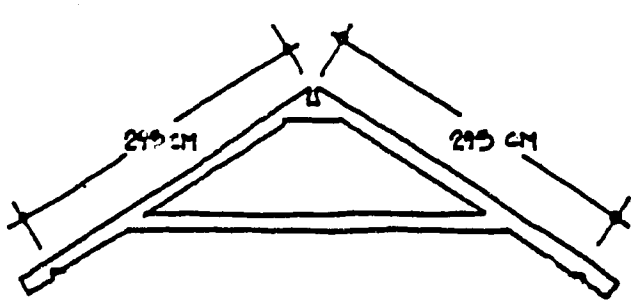


FIGURE 4.26
HEEL CUT LOCATION - 3

d. Mark the heel cuts, using the following procedure (See Figure 4.28 on the following page.)

(1) Make a mark on the top chord, 293 cm from the center of the ridge slot.

(2) Use a carpenter's square to draw a line across the timber. This line will be 9 cm long.

(3) Make a second mark on the opposite side of the timber, 6 cm from the line just drawn.

(4) Connect the first mark with the second mark. This line will be vertical when the truss is in place.

(5) On the vertical line just drawn, make a third mark 6 cm from the second mark.

(6) Draw a line from the third mark straight across to the point where the first line meets the edge of the timber. This line should be perpendicular to the vertical line; check it with the carpenter's square.

(7) The line just drawn in Step #6 and the 6 cm distance marked in Step #5 are the lines which must be cut in order to make the heel cut.

(8) Before cutting, repeat the preceding steps on the other side of the truss.

e. When both heel cuts have been drawn, check the distance between the vertical lines -- it should be slightly larger (by about 1 cm) than the distance between the outside faces of the walls (approximately 488 cm).

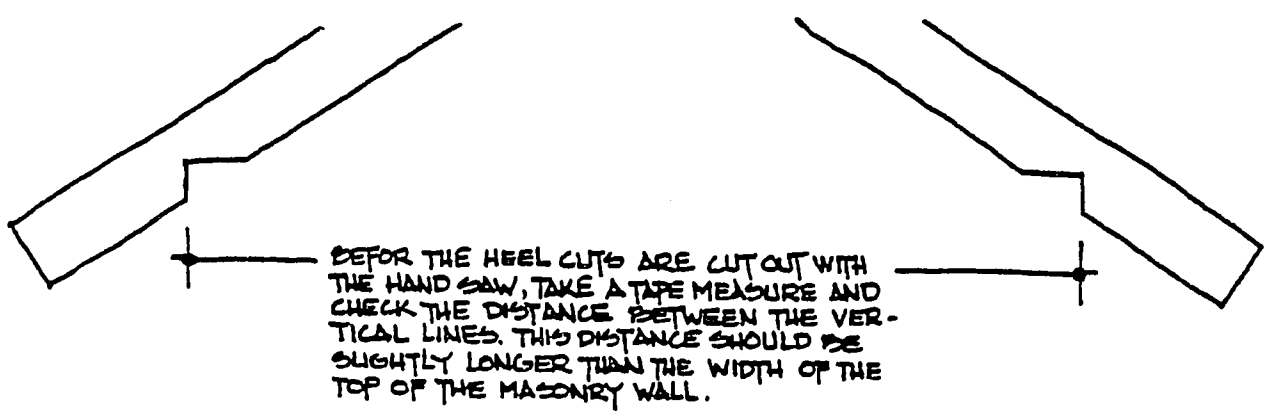


FIGURE 4.27
LOCATION CHECK

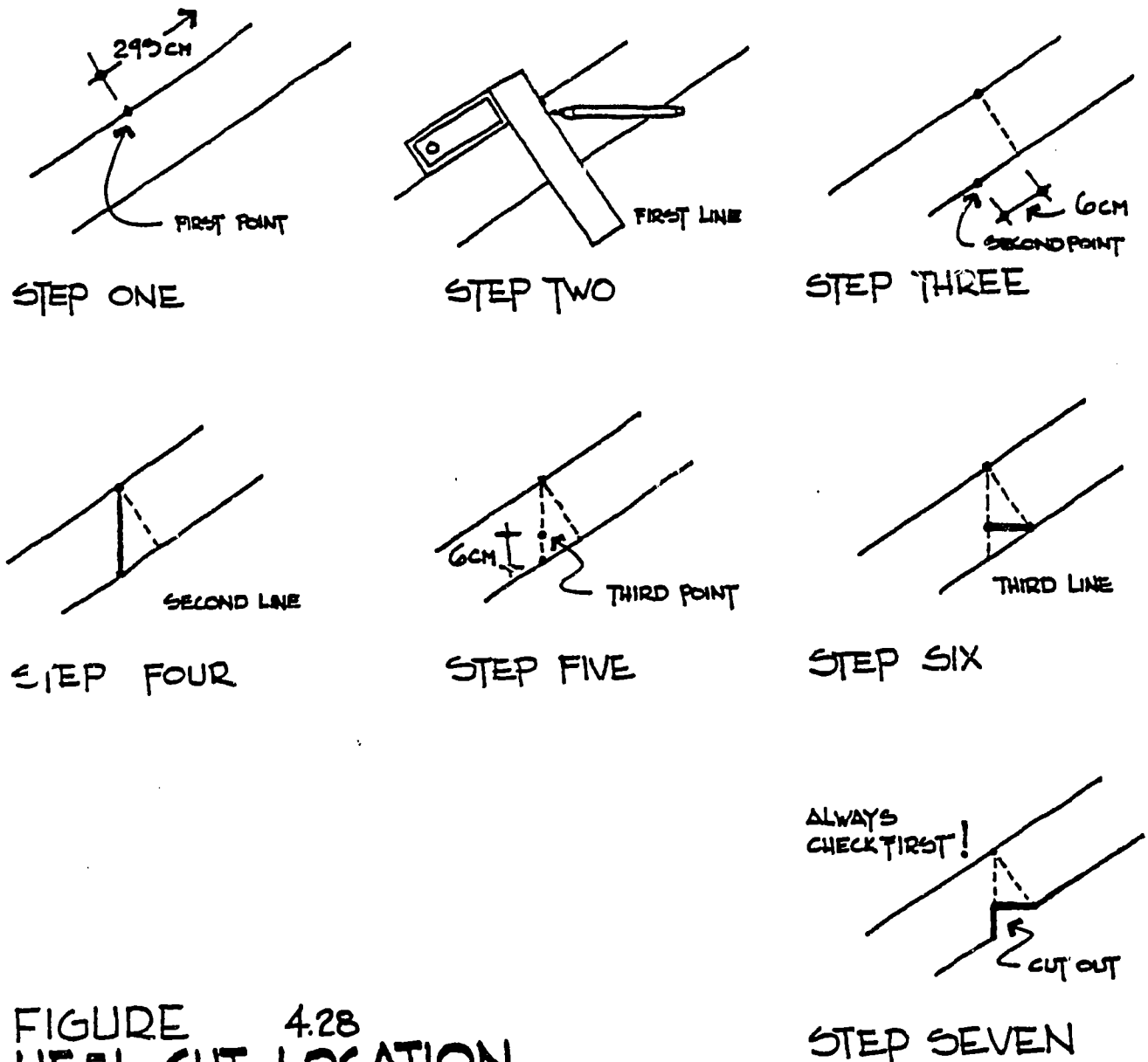


FIGURE 4.28
HEEL CUT LOCATION

If the distance between the heel cuts is less than the distance between the outside faces of the walls, split the difference between the two sides. For example, if the heel cuts as drawn are 489 cm apart but the distance between the outside faces of the wall measures 492 cm, there is a 3 cm difference. Move each heel cut out 1.5 cm, so that the total distance apart is increased by 3 cm. (See Figure 4.29.)

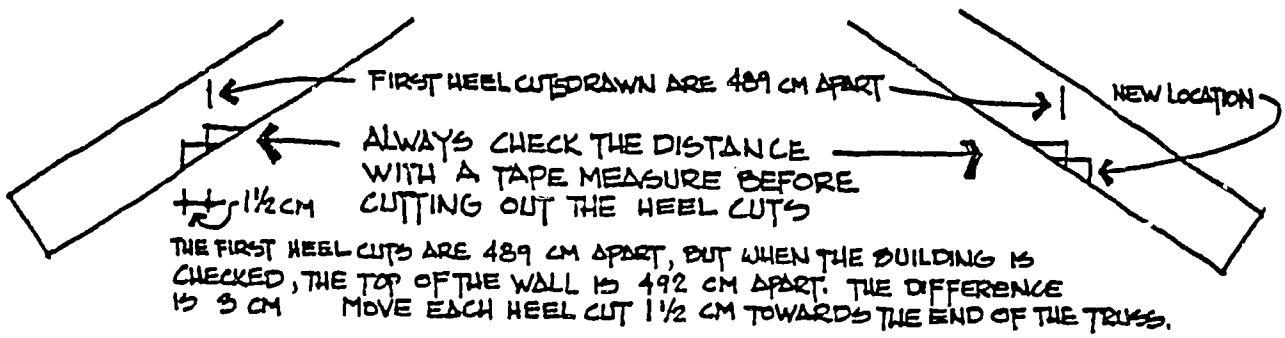


FIGURE 4.29
HEEL CUT ADJUSTMENT

f. After the marked heel cuts have been checked, and corrected if necessary, they can be cut. Make sure the cuts are straight and square.

6. The final step before the truss is ready for erection is to mark the top edges of the truss for the placement of the palm stalks. Starting at the bottom, make a mark every 20 cm on both top chords. These marks will be used later when the palm stalks are nailed to the truss.

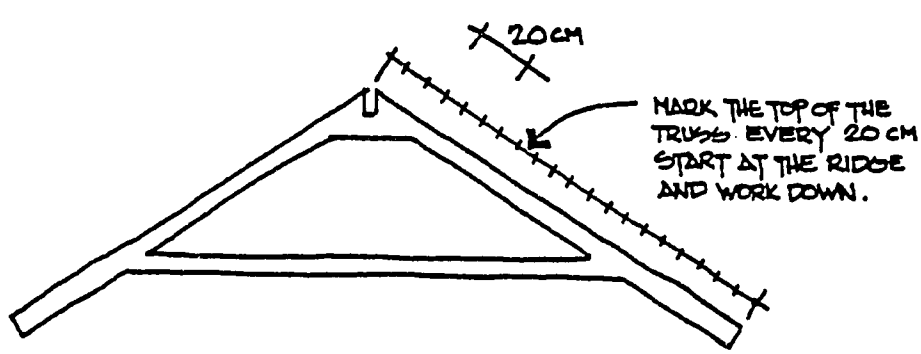


FIGURE 4.30
MARKING THE TRUSS

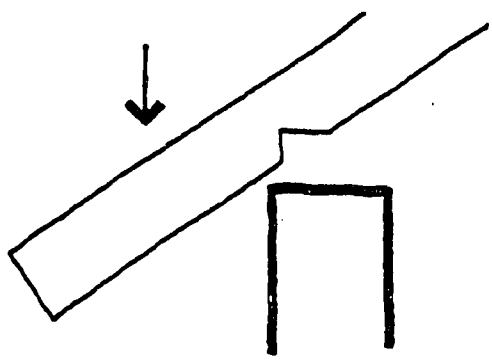
V. Truss Erection

After the trusses have been fabricated, they must be set in place and braced.

A. Setting the Trusses in Place

Check the width of the building at the point where each truss will be placed and compare it with the distance between the heel cuts. If the building is wider than the distance between the heel cuts, re-mark the truss and cut half the difference from each heel cut.

When setting the trusses in place, do not try to force them down over the masonry wall, as the cinva-ram blocks will pop loose if too much pressure is placed on them from the side.



SOMETIMES, EVEN AFTER YOU HAVE CHECKED, THE TRUSS WILL NOT FIT DOWN OVER THE TOP OF THE WALL.

DO NOT FORCE THE TRUSS DOWN!

MEASURE HOW MUCH NEEDS TO BE TRIMMED. TAKE THE TRUSS DOWN AND TRIM HALF THE NEEDED DISTANCE FROM BOTH SIDES. SEE FIGURE 4.29 ON PAGE 105.

FIGURE 4.31
TRUSS ERECTION

Start at one end of the house and place the first truss 18 cm from the outside face of the masonry wall. (This is done so as not to interfere with the construction of the gable wall.) Bend the truss tie-down rod over the top of the truss and nail it in place.

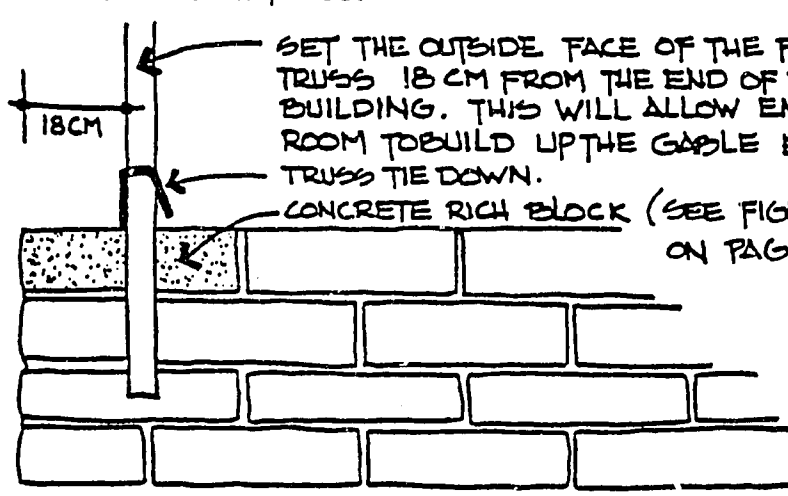


FIGURE 4.32
THE FIRST TRUSS

Brace the first truss with temporary bracing to the outside of the house. Use a straight board and a level to make sure that the truss is braced in a vertical position.

Set the second truss 122 cm from the first truss. This should be in the center of the fifth full block from the corner. Bend the tie-down steel over the top of the truss and nail it in place.

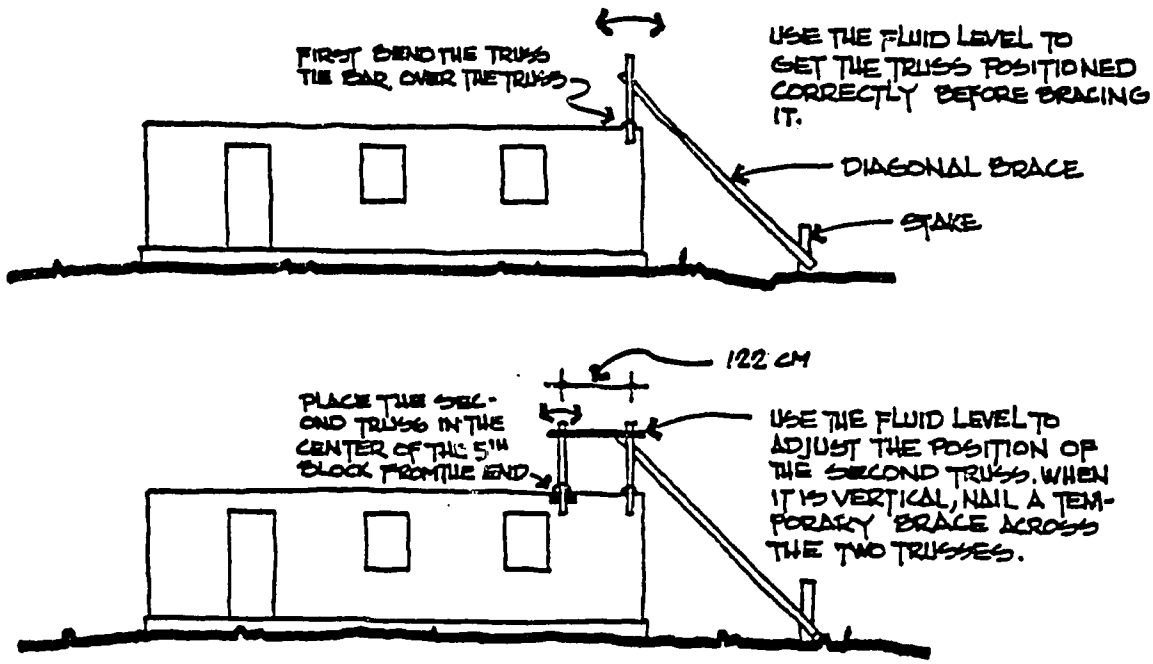


FIGURE 4.33
TEMPORARY BRACING

Place the remaining trusses every 122 cm on center, or every four blocks. Bend the tie-down steel over each truss and nail it in place. Level each truss before placing the temporary bracing in place.

B. Diagonal Bracing

Once all the trusses are in place, and have been visually checked to see that they are plumb, they are ready to be nailed in place with permanent diagonal bracing. The diagonal bracing is placed at an angle to resist all forces acting along the weak axis of the truss.

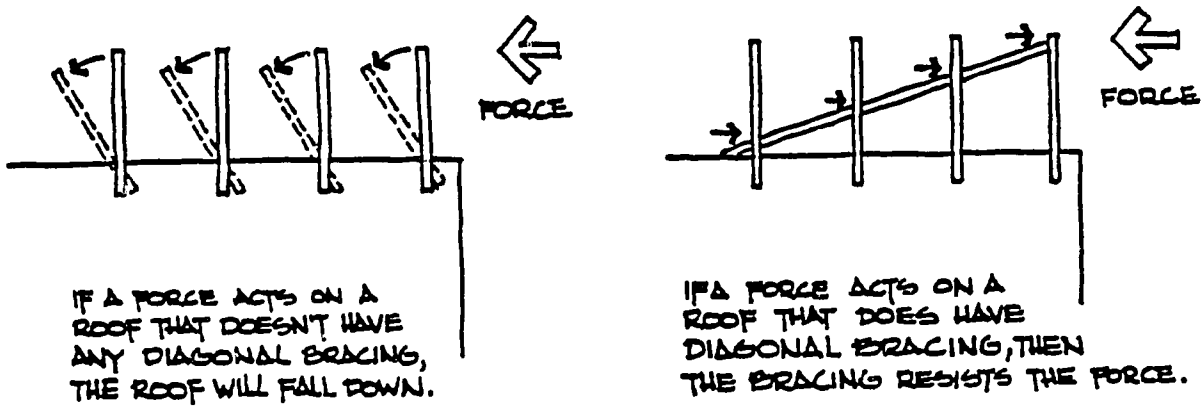


FIGURE 4.34
DIAGONAL BRACING

C. Ridge Beam

Once all the diagonal bracing is in place, the ridge beam can be installed. The ridge beam is made up of two boards, one 488 cm long and the other 427 cm long.

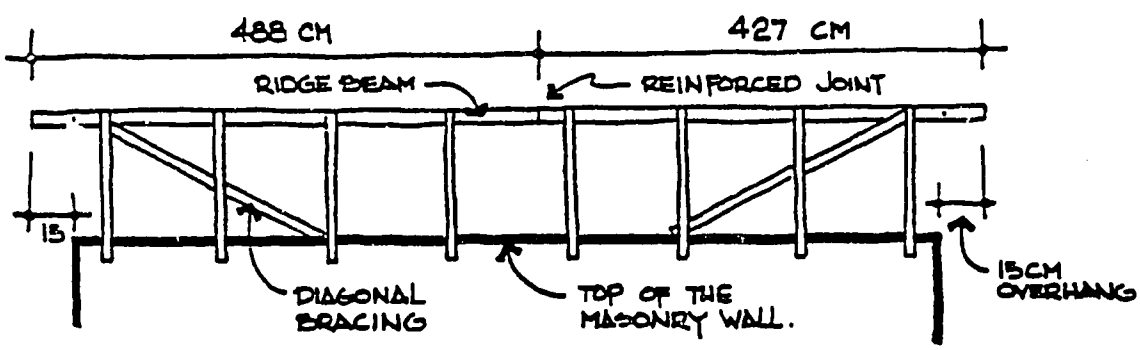


FIGURE 4.35
RIDGE BEAM

Use a straight stick and a level to set the first ridge beam in place. It should overhang 15 cm beyond the outside face of the house, as shown in Fig. 4.36.

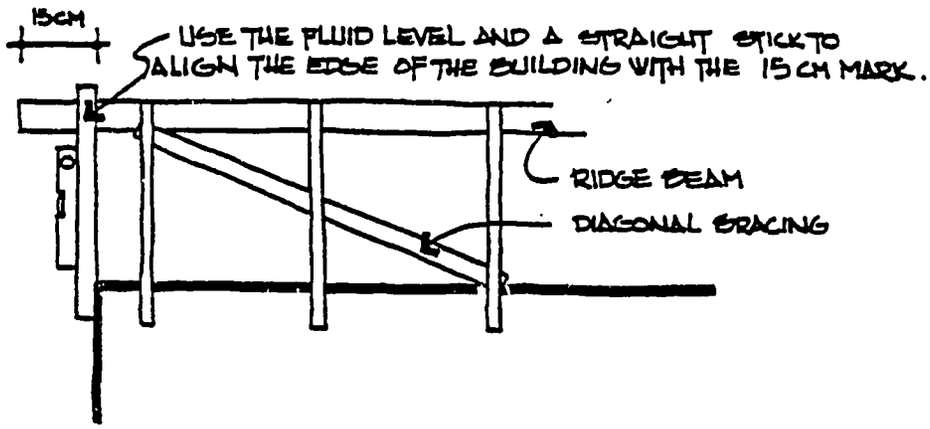


FIGURE 4.36
RIDGE BEAM - DETAIL 1

Once the two ridge beams are in place, and have been checked for the correct overhang at each end, nail them in place.

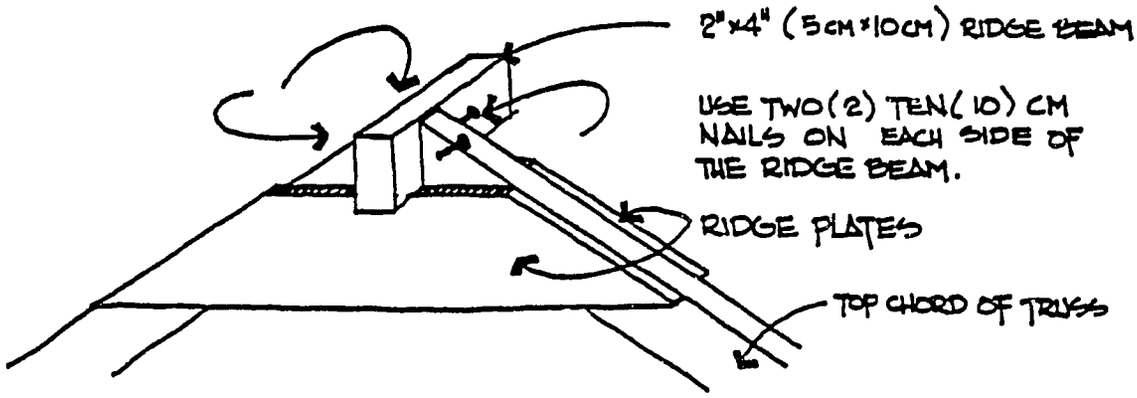


FIGURE 4.37
RIDGE BEAM - DETAIL 2

The last step in the installation of the ridge beam is to scab a short (50 cm) piece of 2" x 4" lumber over the joint between the 488 cm timber and the 427 cm timber, as shown in Fig. 4.38.

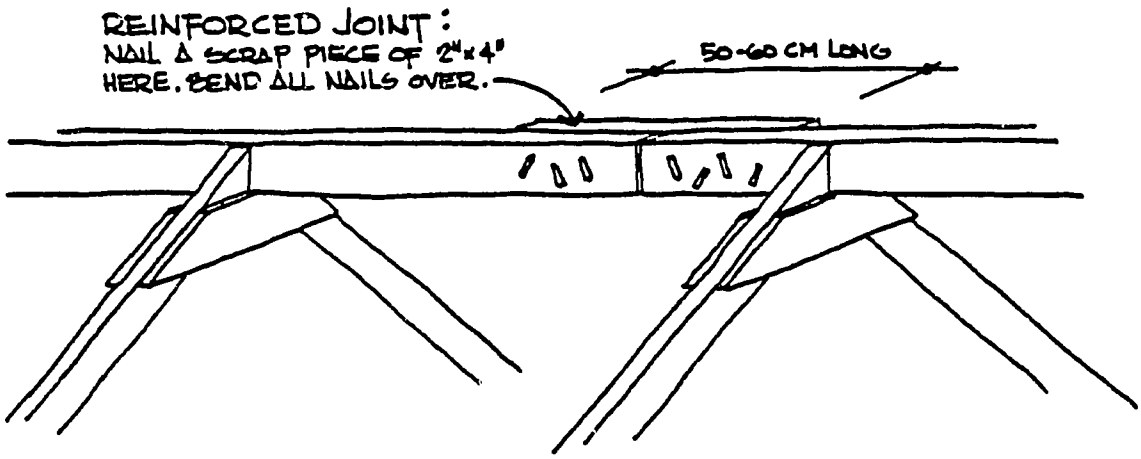


FIGURE 4.38
RIDGE BEAM - DETAIL 3

After the diagonal bracing is in place and the ridge beams have been installed, the temporary bracing between the trusses can be removed and stored. At this point, the roofing materials may be applied to the trusses.

VI. Roofing

The roof consists of alternating layers of asphalt-impregnated roofing felt and palm thatch laid over palm-stalk battens.

A. Palm Stalk Roof Battens

Palm stalks are used to span the 122 cm distance between the roof trusses; the palm thatch will be tied to them. It is very important to nail down the stalks in a straight line so as to provide for even and uniform coverage by the roofing felt and thatch roof.

Starting at the lower edge of one end of the roof, nail down a palm stalk on each of the marks, spaced 20 cm apart, which were made earlier. Allow the thick end of the stalk to extend 15 cm beyond the outside face of the wall. Tie a string to the thick end of the first stalk and to the outside end of the ridge beam to be used as a guide for placing the remaining stalks.

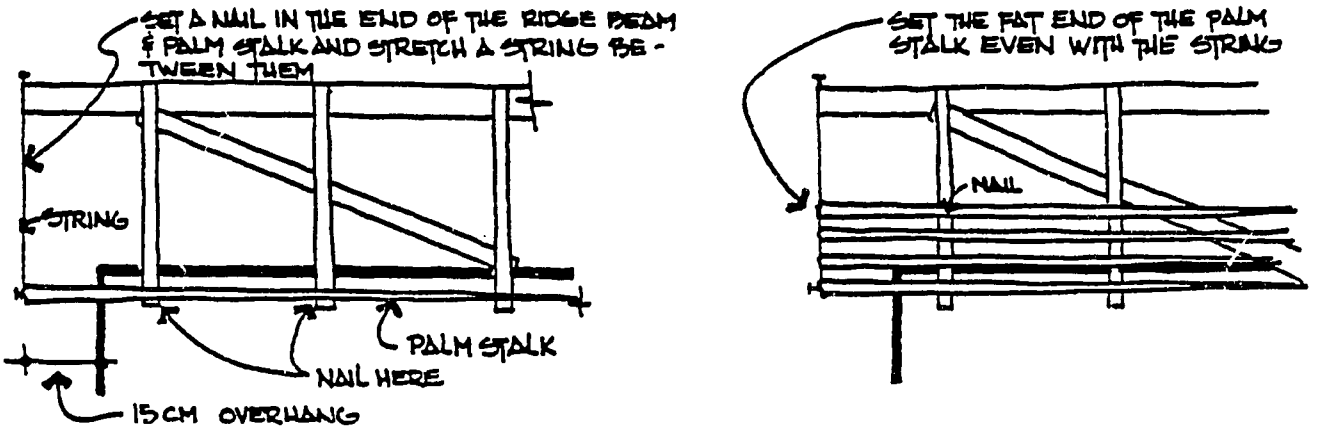


FIGURE 4.39
NAILING THE PALM STALKS ON

B. Roofing Felt

The asphalt-impregnated roofing felt is used to improve the water-repelling quality of the roof, which is composed of alternating layers of roofing felt and palm thatch.

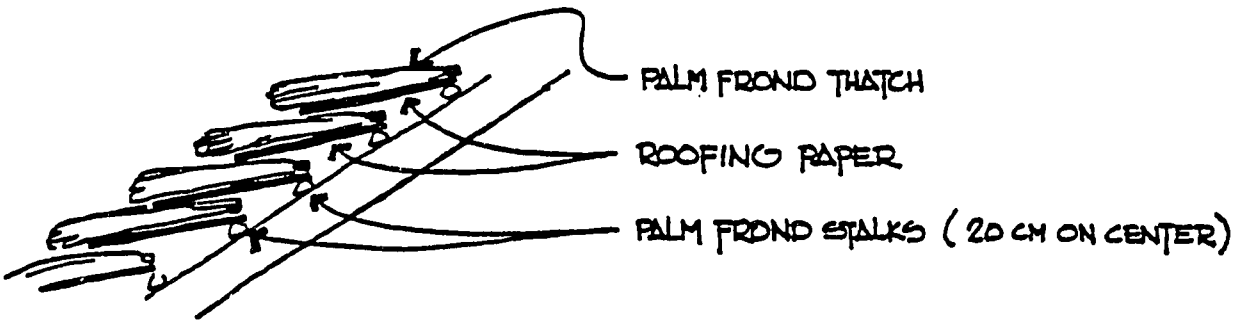


FIGURE 4.40
THATCH ROOFING

Always start to attach the roofing paper and thatch at the bottom of the roof. The roofing paper that forms the first layer of the roof must be reinforced to keep it from tearing. This is done as follows:

1. Roll the roofing paper out on the ground and cut it slightly longer than the length of the roof.

2. Fold back the edge along the length of the roofing paper. The folds should be approximately 30 cm from the edge.

3. After the roofing paper has been folded, turn it over and carefully roll it up. This will make it easier to set the paper in place.

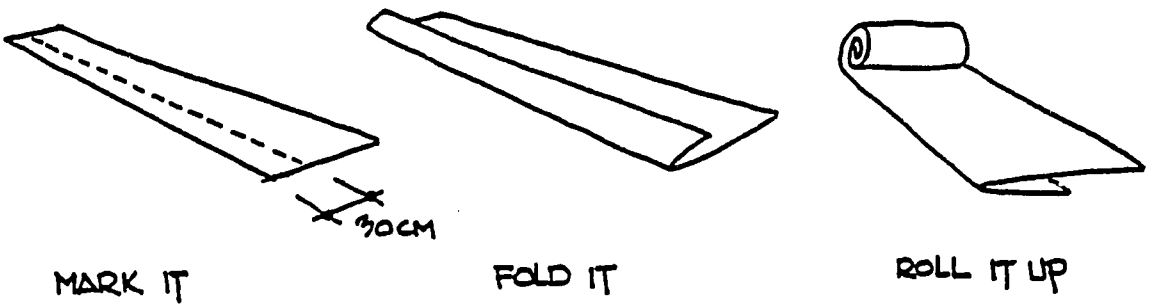


FIGURE 4.41
ROOFING PAPER

4. Set the first piece of roofing paper into place with the folded edge even with the bottom of the roof trusses.

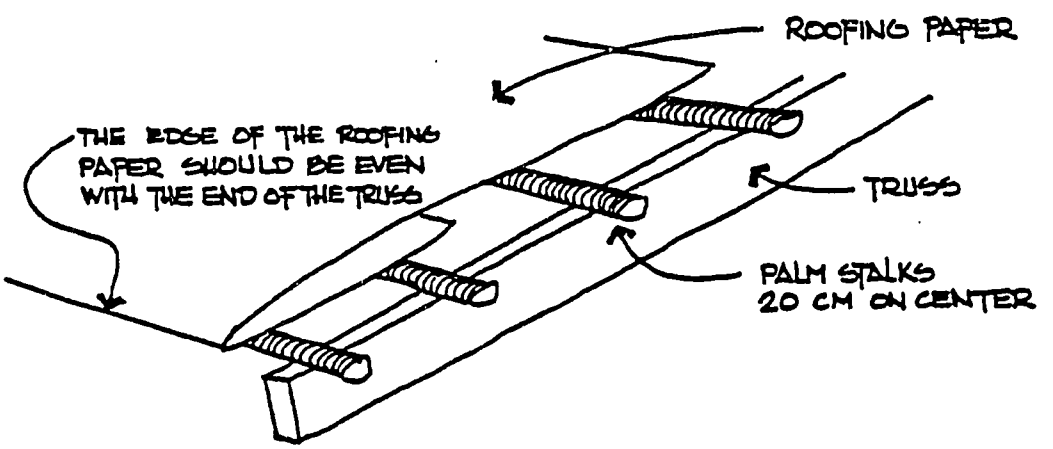


FIGURE 4.42
ROOFING PAPER - DETAIL 1

C. Palm Thatch

Once the roofing paper is in place, the thatch can be applied. The thatching is actually a bundle of three individual pieces of palm thatch, held together with a piece of tie-wire. The tie-wire will also be used to fasten the thatch to the palm-stalk battens.

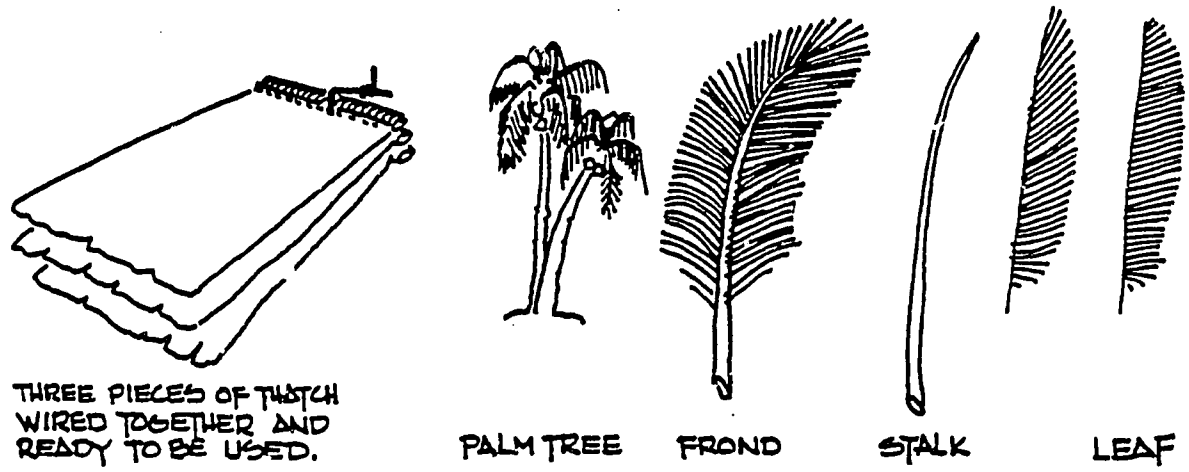


FIGURE 4.43
PALM FROND THATCHING

Tie the first row of thatch to the fourth row of palm stalks. Push the wire through the roofing paper and twist it around the palm stalk.

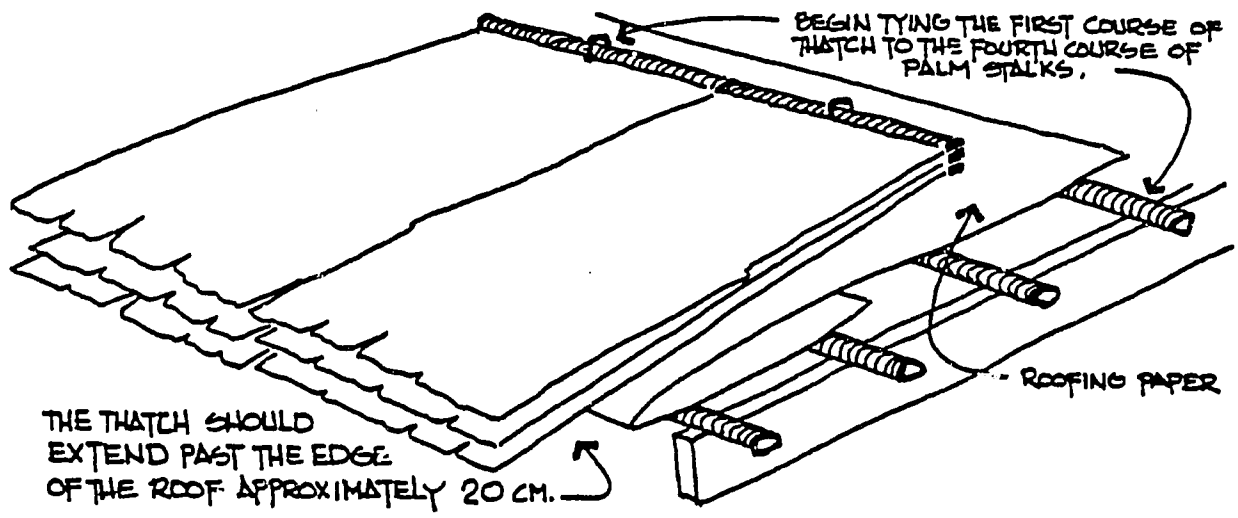


FIGURE 4.44
THATCH DETAIL

After the first row of thatch is in place, apply the next row of roofing paper. Again, roll out the roofing paper on the ground and cut it slightly longer than the length of the roof. Use a knife to cut the roofing felt down the center, making two pieces approximately 46 cm wide. Roll the strips up tightly and pass one roll to the trainees on the roof. This piece of roofing paper is placed on top of the first

row of palm thatch and set even with the fifth row of palm stalks. When the roofing paper is in place, the second row of thatch is tied to the fifth row of palm stalks.

Apply each succeeding row of roofing paper and thatch in the same manner--first the roofing paper, and then the thatch. Each row should be placed above the previous row.

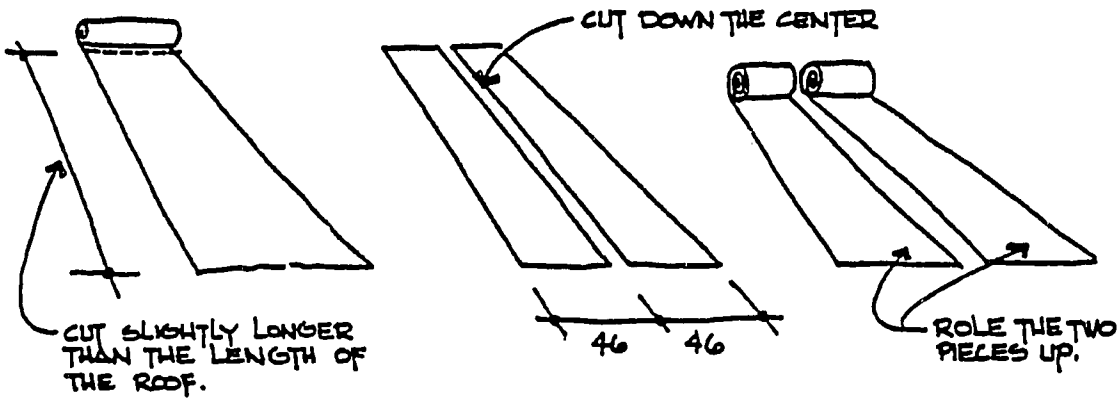
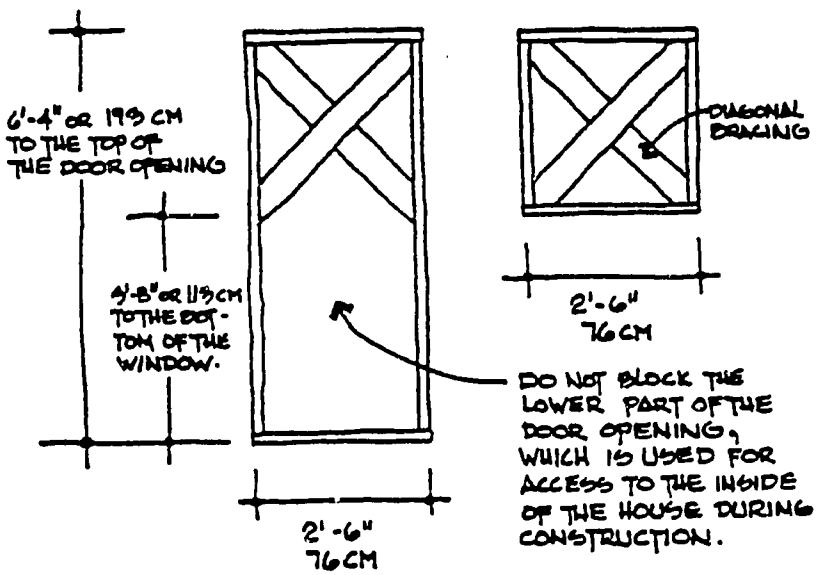


FIGURE 4.45
ROOFING PAPER - DETAIL 2

VII. Temporary Door and Window Frames

Temporary door and window frames must be made for the masons, who use them to set blocks against so as to evenly frame door and window openings.



THE DIMENSIONS SHOWN HERE CAN BE ADJUSTED IN ORDER TO SAVE MONEY, INCREASE SECURITY, OR TO AFFECT CONVENIENCE.

DOOR & WINDOW WIDTH

THE WIDTHS OF THE DOORS AND WINDOWS IS BASED ON THE LENGTH OF THE CINVA-RAM BLOCKS. HERE ARE SOME COMMON WIDTHS.

2'-0" OR 61 CM OR 2 BLOCKS
2'-6" OR 76 CM OR 2½ BLOCKS
3'-0" OR 91 CM OR 3 BLOCKS

DOOR & WINDOW HEIGHTS

THE HEIGHT OF THE OPENINGS IS BASED ON THE THICKNESS OF THE CINVA-RAM BLOCK (PLUS ONE MORTAR JOINT) OR 4" (10 CM). COMMON DOOR HEIGHTS ARE:

6'-0" OR 183 CM OR 18 COURSES
6'-4" OR 193 CM OR 19 COURSES
6'-8" OR 203 CM OR 20 COURSES

FIGURE 4.46
DOOR AND WINDOW FRAMES

They will be removed and reused many times over the duration of the project and must be constructed with adequate bracing. Always store door and window frames that are not being used in a neat and orderly manner.

VIII. Wooden Doors and Windows

Wooden doors and windows should be made to provide security for the houses. Check with the carpentry superintendent for final construction details before training begins.

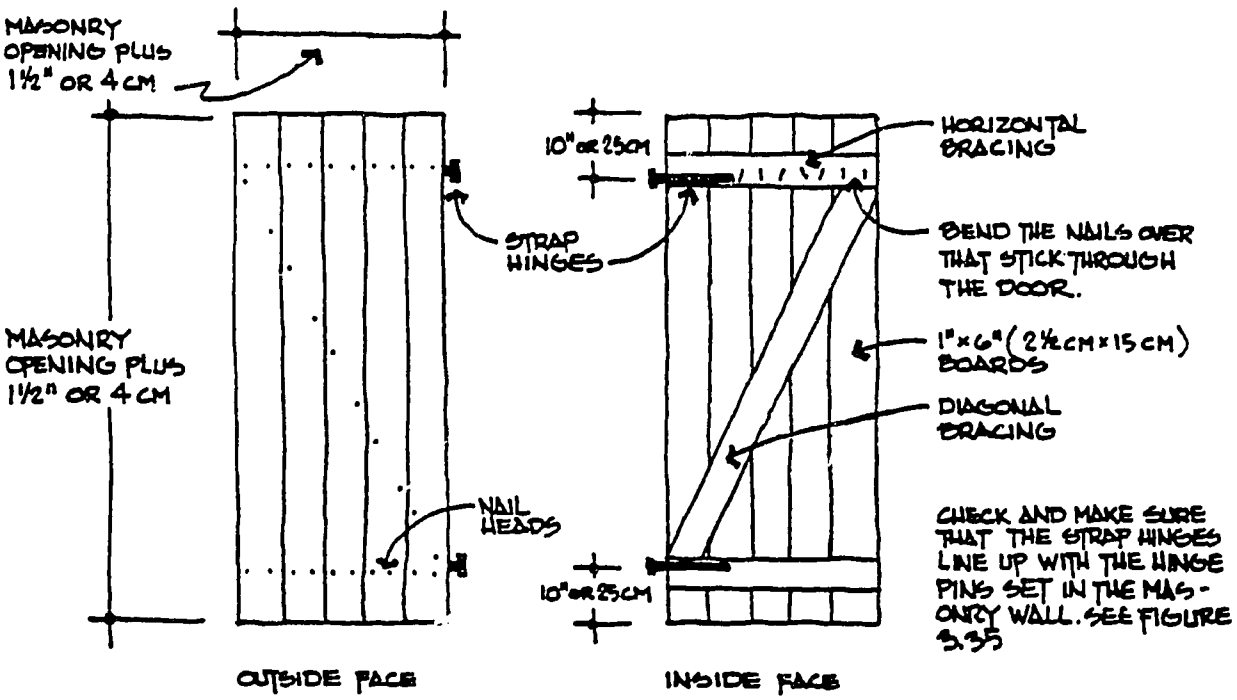


FIGURE 4.47
WOOD DOORS

To make wooden doors and windows, measure and cut the vertical boards at the appropriate length, clamp them together, and nail them in place, as shown in Fig. 4.48. As a final step, measure and cut the diagonal brace, then nail it into place.

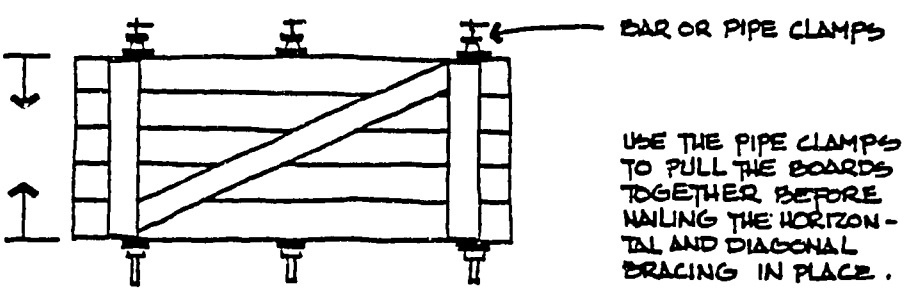


FIGURE 4.48
CONSTRUCTING THE DOOR

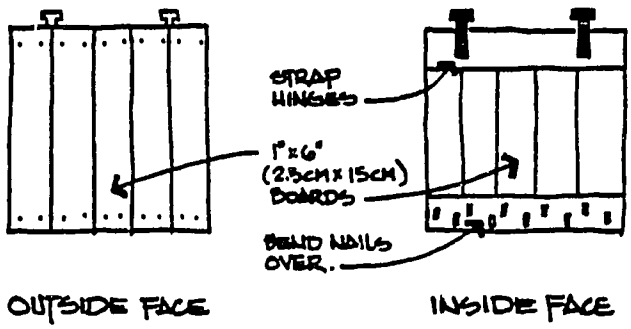


FIGURE 4.49
WOOD WINDOWS

Notes and Comments

List of Illustrations

ADMINISTRATION

FOUNDATIONS

MASONRY

CARPENTRY

ILLUSTRATIONS

NUMBER	TITLE	PAGE
ADMINISTRATION		
1.1	Traineee Evaluation Card	14
1.2	Training School Site	16
1.3	Proposed Site Plan	17
1.4	House Plan	18
FOUNDATIONS		
2.1	Digging Bar	24
2.2	Shovel	24
2.3	Pick	25
2.4	Sledge Hammer	25
2.5	20-meter Tape Measure	25
2.6	Carpenters Hammer	26
2.7	Fluid Level	26
2.8	Transit	26
2.9	Transit Detail	27
2.10	Metal Form Clips	27
2.11	Wheelbarrow	28
2.12	Crowbar	28
2.13	Batter Boards	29
2.14	Batter Boards - Detail	29
2.15	Batter Boards - Detail	30
2.16	Setting the Foundation Elevation	30
2.17	Using the Transit	31
2.18	Batter Boards - Detail	31
2.19	The First String	32
2.20	The Second String	33
2.21	Squaring the Second String - 1	33
2.22	Squaring the Second String - 2	34
2.23	Squaring the Second String - 3	34
2.24	Squaring the Second String - 4	35
2.25	The Third String - 1	36
2.26	The Third String - 2	36
2.27	Squaring the Third String	37
2.28	The Fourth String	37
2.29	Final String Location - Check	38
2.30	Buildings with Mistakes	38
2.31	Out of Square - 1	38
2.32	Out of Square - 2	39
2.33	Squaring the Strings - 1	39
2.34	Squaring the Strings - 2	40
2.35	Squaring the Strings - 3	40
2.36	Pile Location and Spacing	41
2.37	The Piling Hole	42
2.38	Pile Reinforcing	43

2.39 Placing the Concrete 43
2.40 Perimeter Beam - Forms 44
2.41 Foundation Detail - 1. 45
2.42 Foundation Detail - 2. 46
2.43 Foundation Detail - 3. 46
2.44 Partition Tie - 1. 47
2.45 Partition Tie - 2. 47
2.46 Rodding the Concrete 49
2.47 Discontinuous Pour 49
2.48 Stripping the Forms. 50
2.49 Stripping the Outside Forms. 51
2.50 Stripping the Forms - Detail 52
2.51 Stripping the Inside Forms - 1 52
2.52 Stripping the Inside Forms - 2 53
2.53 Stripping the Inside Forms - 3 53
2.54 Partition Beam Location 54
2.55 Partition Beam Forms 55
2.56 Tamping the Sub-floor Fill 56
2.57 Sub-floor Fill - Detail. 56
2.58 Finish Concrete Floor. 57

MASONRY

3.1 Masonry Trowel 64
3.2 Fluid Level. 64
3.3 Line Blocks. 65
3.4 Masonry Line Twigs 65
3.5 Mortar Board 66
3.6 Mason's Hammer 66
3.7 Story Pole 66
3.8 Shovel 67
3.9 20-meter Tape Measure. 67
3.10 Wheelbarrow 68
3.11 Masonry Layout - 1 69
3.12 Masonry Layout - 2 70
3.13 Corner Layout - Detail 70
3.14 Squaring up the Foundation 71
3.15 Leveling the First Course. 72
3.16 Building the Corner - 1. 73
3.17 Building the Corner - 2. 73
3.18 Building the Corner - 3. 74
3.19 Checking the Corners 74
3.20 Using the Level. 74
3.21 Using the Story Pole 75
3.22 Using the Trowel 76
3.23 Using the Line Blocks and Line 76
3.24 Working to the Line. 77
3.25 Correct Vertical Joints. 77
3.26 Incorrect Vertical Joints. 78
3.27 Correcting the Problem 78
3.28 Wall Reinforcing 79
3.29 Wall Tie Blocks. 79
3.30 Scaffolding Details. 80

3.31 Building the Gable Ends 81
3.32 Gable End Details 81
3.33 Door and Window Location 82
3.34 Door Framing Details 82
3.35 Door Details 83
3.36 Window Details 83
3.37 Roof Anchor Blocks 85

CARPENTRY

4.1 Carpenter's Hammer 90
4.2 Removing Nails 90
4.3 Crowbar 91
4.4 Tape Measure 91
4.5 Fluid Level 91
4.6 Hand Saw 92
4.7 Carpenter's Square 92
4.8 Roof Slopes 93
4.9 Truss Spacing 93
4.10 Truss Design - 1 94
4.11 Truss Design - 2 95
4.12 Truss Design - 3 95
4.13 Truss Design - 4 96
4.14 Truss Design - 5 96
4.15 Truss Fabrication - 1 97
4.16 Truss Fabrication - 2 97
4.17 Truss Fabrication - 3 98
4.18 Truss Fabrication - 4 99
4.19 Ridge Plate Template 99
4.20 Truss Construction 100
4.21 Ridge Plate Detail 100
4.22 Bottom Chord Detail 100
4.23 Heel Cuts 101
4.24 Heel Cut Location 101
4.25 Heel Cut Location 102
4.26 Heel Cut Location 102
4.27 Location Check 103
4.28 Heel Cut Location 104
4.29 Heel Cut Adjustment 105
4.30 Marking the Truss 105
4.31 Truss Erection 106
4.32 The First Truss 106
4.33 Temporary Bracing 107
4.34 Diagonal Bracing 108
4.35 Ridge Beam 108
4.36 Ridge Beam - Detail 1 109
4.37 Ridge Beam - Detail 2 109
4.38 Ridge Beam - Detail 3 110
4.39 Nailing the Palm Stalks On 111
4.40 Thatch Roofing 111
4.41 Roofing Paper 112
4.42 Roofing Paper - Detail 1 112

4.43 Palm Frond Thatching. 113
4.44 Thatch Detail 113
4.45 Roofing Paper - Detail 2. 114
4.46 Door and Window Frames. 114
4.47 Wood Doors. 115
4.48 Constructing the Doors 116
4.49 Wood Windows. 116