REPUBLIC OF SOUTH SUDAN
TECHNICAL AND VOCATIONAL EDUCATION AND TRAINING
NON FORMAL TVET COMPETENCY BASED CURRICULUM

LEARNER'S BOOK

FOR
CERTIFICATE OF PROFICIENCY IN BUILDING AND CONSTRUCTION

SEPTEMBER 2019

DISCLAIMER

This training guide has been produced by the EMPOWER Project with financial support from the European Union. Its contents are the sole responsibility of the EMPOWER Consortium and do not necessarily reflect the views of the European Union.

FOREWORD

Learners are central to the success of any competence-based learning approach. This document is the Learner's Book which has been developed as part of the competence-based learning package of the South Sudan non-Formal TVET Curriculum development assignment. The purpose of this book is to provide essential competence-based learning information to the trainees of the seven priority trades. The document is presented in six sections.

Section one gives general introduction and goes further to give information on learning program, structure, organization of the training course contents, learning strategies in a competency based learning environment and how to use the learner's book. Section two provides for the theory of competence-based learning and its assessment criteria. Section three provides for the competency profile of the Certificate of Proficiency (Level 1) holder and market job opportunities available on successful completion of the training. Section Four gives information on the various learning modules for the trade. Section five gives information on the on-job training during industrial attachment and section six gives the summary notes for theoretical understanding of the various modules theories, trade tools, equipment's and knowledge. This has been provided in the form of learning information sheet.

The competence-based curriculum gives the learners an opportunity for the second chance education through the acquisition of technical and vocational skills. It is my wish to the learners of these curricula to take this life-long journey seriously and make use of the learning opportunities provided to them to be of value addition. These opportunities will enable them acquire skills for direct employment in the relevant industries as well as for self-employment in the practice of trade specific skills.

The Ministry of General Education and Instruction wishes all the users of this Learner's Book the very best in their quest for discovering knowledge through competence-based learning.

Hon. Deng Deng Hoc Yai
Minister of General Education and Instruction

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We are grateful to the collaboration between UNESCO and EMPOWER that conducted South Sudan Labour Market Assessment in 2018.This market assessment led to the identification of trades that formed the foundation upon which the seven priority trades were selected. Appreciation goes to Afri-Project Management Consultants, under the leadership of Mr. Joseph Odhiambo Ndaga who were contracted by Finn Church Aid to undertake this assignment.

We wish to appreciate the role played by the Minister of General Education and Instruction, Hon Deng Deng Yai Hoc, The Minister for Labour and Human Resource Development Hon, James Hoth Mai, the Minister of Youth, Culture and Sports Hon Nadia Arop Dudi for their commitment throughout the entire curriculum development process. Their commitment and visionary messages for strengthening TVET delivery in South Sudan kept the team on course.

We wish to recognize the great involvement and participation of the Director Generals in the MoGEI, MoLPSHRD, and Ministry of Culture, Youth and Sports and all the technical teams in the above ministries. We thank in a special way, contributions of trainers/instructors from Juba Multi-Purpose training centre (MTC), Juba Technical School, SSOPO, St Vincent and Don Bosco vocational centres all of whom played a key role in revising and making the curriculum module contents relevant to the South Sudan Context.

Appreciation is extended to development partners and private actors who participated throughout this curriculum development process. Specifically, we recognize the contributions from United Nations Development Programme (UNDP), EMPOWER Consortium members (NRC, FCA, ACROSS, Nile Hope, BBC Media Action & VOSDO), Academy for Professional Development, World Vision, Save the Children, AAH and Dorcas Aid International.

Through this guide, we look forward to a great future for the South Sudanese youths.

ACRONYMS AND ABBREVIATIONS

AAH	Action Africa Help International
ASK	Attitude Skills and knowledge
ACROSS	Association of Christian Resource Organisation Serving Sudan
APMC	Afri-Project Management Consultants
BBC MA	BBC Media Action
BEST	Based employable skill training
CBET	Competence Based Education and Training
CBT	Competency Based Training
COP	Certificate of Proficiency
DDR	Disarmament, Demobilization and Reintegration
EBTVET	Enterprise based Technical Vocational Education and Training
EST	Employable Skill training
EU	European Union
FCA	Finn Church Aid
IBTVET	Institution Based Technical and Vocational Education and Training
ILO	International Labor Organisation
JICA	Japan International Cooperation Agency
LAG	Japan International Cooperation Agency
MCCC	Module of competence completion certificate
MoA	Ministry Of Agriculture
MoCYS	Ministry of Culture, Youth and Sports
MoGEI	Ministry of General Education and Instruction
MoLPSHRD	Ministry of Labour, Public Service and Human Resource Development
MTTH	Module Theory Training Hours
MTC	Multi-Purpose Training Centre
NFTVET	Non Formal Technical and Vocational Education and Training
NFTVST	Non formal Technical and Vocational Skills Training
NFVSET	Non Formal Vocational Skills Education Training
NGO	Non-Governmental Organization
NRC	Norwegian Refugee Council
NVQF	National Vocational Qualifications Framework
OJTC	On Job Training Curriculum
OJTH	On Job Training Hours
PLAR	Prior Learning Assessment and Recognition
PLE	Prior Learning Experience
PSTH	Practical Sessions Training Hours
PTH	Practical training hours
RPLE	Recognition of Prior Learning Experience
SDG	Sustainable development Goals
SMoL	State Ministry of Labor
SSOPO	South Sudan Older People's Organization
SYB	Syllabus

JICA	Japan International Cooperation agency
TVT	Technical Vocational Training
TVST	Technical and Vocational Skill training
TTH	Theory training hours
TVET	Technical Vocational Education and Training
SMoL	State Minister of Labour
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
VOSDO	Vocational Skills Development Organization
VST	Vocational Skills Training
VSDT	Vocational skill development training

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1.0 SECTION ONE : GENERAL INTRODUCTION

1.1 INTRODUCTION

This learners' book is an information book let that provides learners of certificate of proficiency (COP) in Building and Construction occupation with the key and strategic information that they need to know as they go about their competency based learning experiences. The curriculum learning experience has been designed such that the trainees learns both at the Intuitional Based Technical and Vocational Education and training (IBTVET) and Enterprise Based Technical and Vocational Education and Training (EBTVET). The South Sudan Non-Formal Competency based TVET curriculum has been designed to facilitate learning at three places namely, Theory classes at the IBTVET, Practical classes at the IBTVET practical training workshop and practical on job training experience in the place of work within the respective trade industry.

This document provides learners with the key information about the competency based learning for the COP in Building and Construction. It gives the specific objectives for each of the competencies development learning modules as derived from the learning outcomes in the main curriculum training syllabus and the associated Trainers' Guide. The learning activities for each module are reflected in the Learners' Guide only in order to avoid unnecessary repetition and also with the understanding that each activity can only be executed effectively under the guidance of the trainer who is the facilitator of learning.

The document gives a sample revision questions and self-competency assessment questions. These are provided within the Learner's Guide to enable learners to gauge the extent to which they have digested the material associated with each module and learning outcomes as contained in the training syllabus. The learners are advised not to set the limit of his/her scope of subject knowledge and competence to the few sample questions provided in this book let. They should read wider so as to gain more knowledge and competencies. This is a lifelong learning journey experience and learners are encouraged to be motivated and learn to learn the skills that will increase their chances of getting sustainable livelihood within their communities and be motivated to continue with their lifelong learning journey so as to contribute to the attainment of SDG 4 in South Sudan.

Learning Information Sheet comprising of summarized notes for each unit of the module has been provided in this Learners' book only. The notes in the information sheet are only meant to compliment other additional references and reading materials provided by the trainer. Learners are also advised to obtain further reading materials from school/college libraries as well as from the internet and other prescribed text books.

1.2 PRESENTATION OF THE TRAINING PROGRAM

The specific trade occupation skills that once acquired will lead to the award of certificate of proficiency in Building and Construction trade. These respective modules have been organised in the form of Modules which are in themselves self-contained complete Basic Employable Skills Training (BEST) programs. These modules can be offered and certified on their successf ul completion as single modules with the exception of module I that cuts across all the trades. The module one covers the issues surrounding specific trade theory, trade tools and equipment, occupational health and safety. Fundamentals of trauma awareness and understanding of competency based learning and its assessment criteria.

The course comprises of nine modules of competencies with each module being a certifiable basic industry employable skill in the practice of occupation of Building and Construction. The course aims at formal, non-formal and informal training for persons who wish to acquire the right knowledge, attitude and skills that will enable them to either engage in salaried employment in the profession of Building and Construction business operating firms at junior level or be self-employed by managing their own business within the trade of Building and Construction course. The course training curriculum has been designed and developed to achieve the objectives of providing multi skilled worker for the occupation of Building and Construction industry in South Sudan and beyond.

1.3 ORGANIZATION AND PRESENTATION OF THE LEARNERS BOOK CONTENTS

The competency based learning course for the Certificate of Proficiency in Building and construction comprises of life skills, trade theory, modules of technical competency in Building and Construction, work-shop practical training skills and on job training industrial attachment. The course is structured into Core competencies attainment modules and Cross Cutting Skills Modules. Modules are subdivided into Units of Learning specific competencies which are further sub-divided into Learning Outcomes with assessment Criteria. Each module is a comprehensive self- contained employable skills short course training capable of being offered alone. Each modules training has been designed to last for about 80-120 hours. The course has been designed to allow for practical on the job training industrial attachment on completion of each module or with an option of industry attachment at the end of the IBTVET training on all the prescribed modules. The curriculum design provides for post IBTVET training in an EBTVET learning environment.

1.4 TRAINING AND LEARNING STRATEGIES FOR A COMPETENCY-BASED LEARNING AND TRAINING CURRICULUM

Competency-based training delivery is based on the defined competency standards, which are established by the national industry standards or trade occupation standards. The traditional role of a trainer in delivery of this kind of training program changes and shifts towards facilitation of learning. A facilitator encourages and assists trainees to learn by themselves. Trainees learn at their own pace. Individual differences are considered. Trainees present themselves for assessment only when they are ready. As trainees learn at different paces, they might well be at different stages in their learning, thus learning must be tailored to suit individual needs of the learners.

1.5 HOW TO USE THIS CERTFICATE OF PROFICIENCY IN BUILDING AND CONSTRUCTION LEARNERS BOOK

This is a learner's book and as the name suggests, it focuses on facilitating learners to learn and acquire the desired course competencies. Its aim is to guide the learners in conducting self-paced study that will enable them gain competencies and be certified with the skills for each module and with the entire modules on completion of all the qualifying modules of competency for the certificate of proficiency in Building and Construction trade. The aim of this book let is to guide learners of this important skills development program. It gives guidance on the key learning testing questions, competency assessment criteria of self-assessment, formative assessment and summative assessment. The learner's book also provides information on fundamentals of competency based learning and the differences between the traditional knowledge based approach to Education and competency based education and training approaches. It goes further to show learners on the key competencies profile for certificate of proficiency in Building and Construction trade and job profile of the COP holder for the occupation of Building and Construction.

1.6 PRESENTATION OF THE LEARNERS BOOK FOR THE COP IN BUILDING AND CONSTRUCTION TRADE

The document is presented in six sections with section one providing for the introduction to the learner's book and goes further to give information on learning program structure, organization of the training course contents, learning strategies in a competency based learning environment, how to use the learners book and presentation of the learner's book. Section two provides for the theory of competency based learning and its assessment criteria. Section three provides for the competency profile of the certificate of proficiency holder in Building and construction and market job opportunities available on successful development of the competencies upon completion of the training. Section Four gives information on the various learning modules for gaining competencies in the occupation of building and construction trade. Section five gives information on the job training during industrial attachment and section six gives the summary notes for theoretical understanding of the various modules theories, trade tools, equipment's and Occupational Health and safety. This has been provided in the form of learning information sheet which appears at the end of this document.

2.0 SECTION TWO : COMPETENCY BASED LEARING AND ASSESSMENT

2.1 WHAT IS A COMPETENCY BASED LEARNING APPROACH?

Many learners and stakeholders of TVET learning eco system have taken their education and learning experience through the use of tradition approach. As such most people are not familiar with system requirement for effective competency-based learning approaches. This section of the learner's book is meant to provide you with basic answers to some of the most frequently asked questions about competency-based education learning, training, assessment and certification. The term competency-based education is an approach to designing learning programs with a focus on learners demonstrating that they have attained module specific competencies as a result of going through their respective learning system. These competencies are related to knowledge, skills, attitudes and abilities rather than time spent in a classroom to achieve the competencies.

According to the Competency-Based Education Network (C-BEN) 2017. The term competency-based education combines an intentional and transparent approach to curricular design with an academic model in which the time it takes to demonstrate competencies varies and the expectations about learning are held constant. Learners acquire and demonstrate their knowledge and skills by engaging in learning exercises, activities and experiences that align with clearly defined programmatic outcomes. Students receive proactive guidance and support from faculty and staff. Learners earn credentials by demonstrating mastery through multiple forms of assessment, often at a personalized pace. Competency-based education therefore is an approach to teaching and learning that clearly identifies the competencies that students must master on a module for them to be declared competent and awarded with module of competency completion certificate.

The certificate is issued on a gradual process and upon completion of the entire prescribed modules the learners are awarded with certificate of proficiency for that respective trade. Each module is designed to be a basic employable skills training module. Certificate is issued on the completion of each module because this can be an exit point to some learners who feels that they gained something and would wish to go a get employment to support their livelihood and return latter to continue with the acquisition of additional skills through the long life journey experience.

The modern use of competency based approach to education and training concept has its origin in the United States of America in the late 1960s and 70s. Since then, many countries of the world are using the approach in the delivery of their education system and especially in the area of TVET programs. The individual and gradual training module certification received by the learners will later on qualify them for prior learning assessment experience when they wish to join other courses that could have similar modules that they have been trained on and certified to be competent in.

2.2 INFORMATION ON HOW TO CONDUCT COMPETENCY ASSESSMENT

Attainment of competency is undertaken through competency based assessment. There are different kinds assessment that are administered to the learners. The most popular assessments that usually administered to learners of these programs are:

Table 2.1 Information on Assessment category

SNO	ASSESSMENT	DETAILS
1	Initial assessment:	This kind of assessment is taken on the admission to the vocational training centre. Its aim is to engage the occupation of interest and level of trauma based on the learner's background. South Sudan is one of the conflict affected countries of Africa. The learners being admitted in to these programs comes from various traumatised back ground and experiences. This assessment will help the institution, trainer and the sponsor to gage the motivation for learning and identify any learning difficulty or challenge likely to be faced by the learners. This assessment will also inform on the need of giving learners numeracy and literacy skills.
2	Prior learning experience assessment:	This is carried out by the teacher who is engaged with the training of the learner. Since learners come from different background the aim of this assessment is to establish if the learner had previously acquired some competencies either through learning on the industry job working environment. In such a case the learner will apply for prior learning assessment and if they meet the requirement then such prior learning experience will be recognised and exempted. The forms for this application is provided for in the trainer's guide.
3	Self-assessment guide:	This is done by the learner on completion of each module. If the learner is convinced that he or she is now ready to be assessed then the learner will inform the trainer that he or she is ready to be assessed. Samples of these self-assessment guides for each module have been developed.

4	Formative Assessment:	This is the assessment provided by the trainer to certify that the learner has attained the competencies. The trainee's performance in the formative assessment will be recorded on the trainee's achievement record. Instructors of this curriculum needs to be trained on how to administer a competency based assessment. This is because in a competency based learning assessment, the learner is either competent or not yet competent. When assessed and proved competent then they are awarded certificate of competency in that respect module or modules. If the assessment result shows that they are not yet competent then the communication is made to the learners who will repeat the learning on those modules until when they have attained competency and are ready for the assessment. The learning progression is individualised and each learner progresses in his or her own pace.
5	5. Summative assessment:	This is done at the end of the training by an external assessor from the industry. In most cases it is done practically when the learners are practicing their acquired skills through on job training. This curriculum design has provided for 20 hours on job training industrial attachment after each and every module or with an option of taking the on Job training on completion of all the prescribed modules. South Sudan needs to put down systems and policies to govern this kind of assessment practice and there is a need to identify professionals from each trade who can be used to go and administer this important assignment. This will also require active industry participation. In the absence of these, the trainers might be allowed to use the IBTVET assessment as the countries prepares to roll out this kind of assessment. There is also a great need for this training curriculum to be supported to be supported EBTVET training guide. These will be two. One for supporting the learner and the other one for supporting the on job training instructor.
6	Competency attainment Verification	This is done both internally and externally by the verifiers to confirm that indeed the competency has been attained by the learners

3.0 SECTION THREE : COMPETENCY PROFILE FOR COP IN BUILING AND CONSTRUCTION

3.1 COMPETENCY PROFILE

The term competency profile refers to the key learning skills experience areas that trainees of the curriculum program are expected to demonstrate competence in as a proof that they have acquired learning though the occupation learning system and environment. The competence profile informs the formulation of learning out comes, contents of design of modules of competency, application of Blooms taxonomy learning experience action verbs, self-assessment guide, formative assessment, summative assessment, verification and certification. In this document the competency profile has been classified in to 3 categories namely:

1. Core, Technical /functional or hard skills
2. Soft skills or self /personal skills
3. Business skills

The table below shows the competency profiles of the certificate of proficiency holder in building and construction

Table 2.2 competency profile for certficate of proficiency in building and construction occupation.

Technical competencies	Soft skills competencies	Business skills
1. Perform bricks and concrete block making 2. Perform construction site works under supervision. 3. Perform Construction of Substructure Elements under supervision 4. Perform construction of superstructure walls under supervision 5. Perform house roofing construction under supervision 6. Perform house pipe fitting and plumbing works under supervision and instruction 7. Perform house work carpentry fittings under supervision. 8. Perform basic plastering of walls and floor in construction work under suppervision. 9. Perform house finishing works under supervision. 10. Perform basic painting works in building and construction under supervision. 11. Perform pre and post construction site clearance	1. Manage interpersonal communication 2. Self-Trauma awareness, assessment and management skills 3. Skills for Managing and dealing with e difficult and complaining customers 4. Environmental safety awareness 5. Knowledge of basic equipment's and tools for Building and construction works. 6. Knowledge of basic Occupational Health and safety for Building and construction 7. Knowledge of Sources of risks and their prevention in building and construction 8. Learning to learn and self-study skills for the occupation of Building and construction. 9. Team player in the building and construction works 10. Perform first aid and handle personal protective devises	1. Building and Construction Site Assistant store keeper 2. Perform basic Customer care services in a building and construction site. 3. Self-entrepreneur in a building and construction business operations 4. Knowledge of Building and construction sites Business information and records keeping

3.2 POTENTIAL LABOR MARKET JOB OPPORTUNITIES

The holder of Certificate of proficiency in Building and Construction trade will be able to do the following jobs in the market.

- ◊ Assistant building and construction site worker
- ◊ Bricks and concrete blocks maker
- ◊ Floor and wall plastering assistant
- ◊ Assistant fitter of house carpentry works
- ◊ Assistant roof Constructor
- ◊ House painting support Assistant
- ◊ Assistant pipefitting and plumbing

4.0 SECTION FOUR : SYLLABUS FOR TRAINING IN BUILDING AND CONSTRUCTION

4.1 MODULES OF COMPETENCY

Table 4.1: Modules of competency for cop in building and construction

CODE	MODULES	NOMINAL HOURS
4.1	TRADE THEORY, TOOLS ,EQUIPMENT'S AND SAFETY	100
4.2	BRICKS AND CONCRETE BLOCK MAKING	120
4.3	CONSTRUCTION OF SUBSTRUCTURE ELEMENTS	120
4.4	CONSTRUCTION OF SUPERSTRUCTURE WALL	120
4.5	ROOFING CONSTRUCTOR	120
4.6	PLUMBING FITTINGS INSTALLER	120
4.7	HOUSING WORK CARPENTRY FITTERS	120
4.8	BUILDING PLASTERING, PAINTING, FINISHES	120
4.9	EMPLOYABILITY AND LIFE SKILLS (OPTIONAL)	120
TOTAL		**940**

4.2 MODULE 4.1 TRADE THEORY, TOOLS, EQUIPMENT'S AND SAFETY IN BUILDING AND CONSTRUCTIONS.

The details for this is not included in this learner's guide as it is not examinable. However, the details are in trainer's guides. The trainer will show the learners the trade theory, trade tools and equipment's, safety measures, assessment criteria and motivation for the learners to like this trade of building and construction

4.3 MODULE 4.2 BUILDING BRICKS AND CONCRETE BLOCK MAKER

Table 4.2: Building bricks and concrete block making

A: MODULE CODE	4.2	TTH	PTH	OJT
		30	70	0

B: UNITS OF MODULE

Unit of Learning Unit 4.2.1: Concept of Building Bricks and Concrete Blocks making

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.2.1.1 Demonstrate an understating on Building Bricks and Concrete Blocks making
4.2.1.2 Explore the procedure for making bricks and concrete blocks
4.2.1.3 Understand Basic first aid skills relevant for Brick and concrete making.
4.2.1.4 Explore the procedure Drying and Burning bricks blocks

Unit of Learning 4.2.2: Perform Brick and Concrete curing and treatment I

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:
4.2.2.1 Demonstration of an understand of the concept of curing and treating bricks and concrete blocks
4.2.2.2 Practice sales and marketing for bricks and concrete blocks

Unit of Learning 4.2.2: Perform Brick and Concrete curing and treatment I

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:
4.2.2.1 Demonstration of an understand of the concept of curing and treating bricks and concrete blocks
4.2.2.2 Practice sales and marketing for bricks and concrete blocks

1. C: Sample Questions

2. Discuss the correct procedure of making Building Bricks and Concrete Blocks
3. What are the different types of making bricks and concrete blocks?
4. Explain the basic first aid skills relevant for use in Brick and concrete making.
5. Explain the procedure that you would apply in Drying and Burning bricks and concrete blocks?
6. What do you understand by the concept of curing and treating bricks and concrete blocks?
7. Discuss how you will carry out sales and marketing for bricks and concrete blocks that you have produced?
8. Differentiate between the use of the concept of sales and marketing
9. How would you practice Entrepreneurship and Small Business management for Bricks and concrete block making business in South Sudan?
10. What are the Identify different strategies for marketing bricks and concrete blocks.
11. Discuss the challenges facing the practice of customer care services for the bricks and concrete blocks client in South Sudan.
12. Discuss the scope of the concept total quality management in brick and concrete block
12. manufacturing Explain the concepts of depression, culling and wetty in bricks and concrete blocks making.

13. What are the challenges facing bricks and concrete block makers in South Sudan?
14. Discuss how you would perform curing and treatment of bricks and concrete making
15. Demonstrate the Correct procedure for annealing or cooling of bricks.
16. What are the qualities of good bricks and concrete blocks?
17. State and explain the grading and classification of bricks and concrete blocks
18. Discuss the different ways of making special shaped bricks
19. What do you understand by the concept of male and female blocks?
20. Demonstrate how you would the raw manufactured clay bricks and concrete blocks.
21. Explain the procedure on treatment of the produced clay bricks and concrete blocks.
22. Demonstrate how you would dry a clay Bricks and concrete blocks.
23. How are the male and female blocks used and handle in construction sites?
24. Discuss the different types of brick and concrete block designs.
25. What are modern methods of burning bricks?
26. What are different types of fuel used in burning bricks.
27. Describe the procedure on how you would ensure environmental protection and conservation during the process of handling brick making.

4.4 MODULE 4.3 CONSTRUCTION OF BUILDING SUB STRUCRYE TABLE

Table 4.3 Building of sub structure

A: MODULE CODE	4.3	TTH	PTH	OJT
		30	70	120
B: UNITS OF MODULE				
Unit of Learning Unit 4.3.1: Cconstruct a Building Foundation On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements: 4.3.3.1 Demonstrate knowledge of setting out the foundation by the 3:4:5 method or mason's square 4.3.3.2 Describe the procedure of excavating foundation trench 4.3.3.3 Describe the procedure for leveling the foundation trench 4.3.3.4 Describe the procedure of casting the foundation concrete				
Unit of Learning 4.3.2: Construct a Substructure Wall On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements: 4.3.2.1 Describe the procedure for preparing cement- sand mortar and setting out the substructure masonry units 4.3.2.2 Describe the procedure for laying the ground floor slab				
C: Sample Questions 1. Explain how to set out building using 3:4:5 methods. 2. Explain how to set out building by mason square. 3. Explain how to execute the excavation operation by hand. 4. Explain how to provide levels on the foundation trench before concreting the foundation concrete 5. What is the concrete mix ratio for blinding? 6. What is the concrete mix ratio for mass concrete in foundation? 7. What concrete mix ratio for reinforced concrete in foundations? 8. Name the different masonry units used for the substructure wall. 9. Explain how mortar for bonding the substructure masonry units is mixed. 10. Name types of concrete mixers used for machine mixing of concrete.				

4.5 MODULE 4.4 BUILDING SUPERSTRUCTURE WALL CONSTRUCTOR- BRICK LAYER

Table 4.4: Building superstructure constructor module

A: MODULE CODE	4.4	TTH	PTH	OJT
		30	70	120

B: UNITS OF MODULE

Unit of Learning 4.4.1: Lay Superstructure Wall

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.3.1 Describe the procedure for setting out the substructure wall

Unit of Learning 4.4.2: Construct Ring Beam

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.4.2.1 Describe procedure for fixing of ring beam formwork
4.4.2.2 Describe procedure for placing reinforcement to ring beam
4.4.2.3 Describe the procedure of casting concrete for the ring beam

Unit of Learning 4.4.3: Construct a Super wall

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.4.3.1 Describe procedure for constructing a super wall
4.4.3.2 Identify and describe the prevalent materials and methods featured in a super wall
4.4.3.3 Describe the procedure of casting drywall-lining

Unit of Learning 4.4.4: Mmaintain Occupational Health and Safety Procedures

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.4.4.1 Maintain safety and cleanliness of the work place
4.4.4.2 Perform basic occupational first aid

C: Sample Questions

1. Name all masonry units used for construction of superstructure walling.
2. What is the mortar ratio used for superstructure walling?
3. Explain the role of DPC on the superstructure wall.
4. Explain the frequency of placing the hoop irons in the masonry courses.
5. Explain how Flemish bond differs from English bond in bricking walling.
6. Explain the process of preparing reinforcement for a ring beam.
7. Explain the process of preparing formwork for the ring bream.
8. What is the appropriate height of ring beam?
9. What is the concrete mix ratio for the ring beam concrete?
10. Explain the process of vibrating the ring beam concrete.
11. Explain the erection of scaffolding for the superstructure wall.
12. What is the duration required to strike off the form work for the various sections of the ring beam?
13. Explain the different types of hazards on a construction site and ways to minimize them.

4.6 MODULE 4.5: CONSTRUCTION OF THE ROOF

Table 4.5: Construction of the Roof Module

A: MODULE CODE	4.5	TTH	PTH	OJT
		30	70	120

B: UNITS OF MODULE

Unit of Learning 4.5.1: Assemble Timber Roof Members

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.5.1.1 Describe the procedure for fixing wall plate

4.5.1.2 Describe the procedure of fixing roof trusses

Unit of Learning 4.5.2: Install Roof Covering on the Building

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.5.2.1 Describe the procedure for fixing wall plate

4.5.2.2 Describe the procedure of fixing roof trusses

C: Sample Questions

1. What are short span roofs?
2. What are pitched roofs?
3. Highlight the three basic points to observe during roofing.
4. Define the term roofing and the main purpose of roofing.
5. Name five factors that influence the choice or selection of a roof.
6. State and explain the three types of roofs.
7. List down the 6 specifications in construction of a steel roof
8. Using clear diagrams differentiate the three types of roof trusses giving short descriptions.
9. State 3 advantages and 3 disadvantages of flat roofs.
10. Describe the following terms as used in GCI roofing.
    Angle-
    Batten-
    Creep-
11. What is galvanization?
12. State and explain the three types of galvanization.
13. State three problems with GCI sheets
14. Identify at least two preventative measures for GCI sheets
15. What is the purpose of galvanization?

4.7 MODULE 4.6 : INSTALLATION OF PLUMBING FITTINGS

Table 4.6: Installation of Plumbing Fittings Module

A: MODULE CODE	4.6	TTH	PTH	OJT
		30	70	120

B: UNITS OF MODULE

Unit of Learning 4.6.1: Fixing of Plumbing Water Closets (W/C)

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.6.1.1 Describe the procedure of placing water closet points

4.6.1.2 Describe the procedure of fixing the water closet fixtures complete with flushing cisterns

Unit of Learning 4.6.2 : Fixing of Taps, Shower Rose and Wash Hand Basins

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.6.2.1 Describe the procedure of fixing of taps

4.6.2.2 Describe the procedure of fixing of wash hand basins

Unit of Learning 4.6.3 : Disposal of Waste Water

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.6.3.1 Describe the procedure of fitting of pipes to dispose waste

C: Sample Questions

1. What are the components or plumbing fixtures? 2. What are lavatories?
2. How many plumbing fixtures are required in a two-story office building with 75 men and 57 women employees if an approximately equal number of employees are on each floor?
3. Highlight sub soil conditions that may cause the water supply to leak or rapture
4. Using a clear diagram show a location of plumbing mains and sewer in a trench remember to label the various sections
5. Describe one common kind of supply piping i.e. Copper.
6. State the 3 kinds of primary pipping.7.State 3 advantages of PVC pipes over steel pipes
7. Name 2 advantages and dis advantages of steel pipes.
8. Estimate the pipe pressure drop due to cold water flow friction.
9. Compute the pipe pressure drop due to cold water flow friction.
10. What is the equivalent length of a 60 ft long 2 in. diameter pipe that has 24 elbows in it?
11. What is thermo expansion?

4.8 MODULE 4.7: BUILDING CARPENTRY AND JOINERY FITTER

Table 4.7: Carpentry and Joinery Module

A: MODULE CODE	4.7	TTH	PTH	OJT
		30	70	120
B: UNITS OF MODULE				
Unit of Learning 4.7.1: Install Door and Window Fittings On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements: 4.7.1.1 Describe the procedure of fixing of door and window frames 4.7.1.2 Describe the procedure of fixing of doors and windows				
C: Sample Questions 1. Differentiate between a flush door and the French door. 2. What is the purpose of a window schedule? 3. Discuss the 4 types of swinging windows. 4. List at least five uses of windows. 5. Identify the two categories of doors 6. Describe the procedure of creating a door and window frame. 7. Differentiate between a storm and screen door. 8. What are the uses of interior doors in a building? 9. 9Describe the door parameters for an office. 10. What are door hinges? 11. State at least three advantages of steel doors over wooden doors. 12. Identify at least 3 specifications used in door frame construction 13. Identify the two types of sliding doors. 14. Differentiate between skylight and clerestory windows 15. Identify the two types of garage doors.				

4.9 MODULE 4.8 : APPLICATION OF MISCELLANEOUS BUILDING FINISHES

Table 4.8 : Application of Miscellaneous Building Finishes Module

A: MODULE CODE	4.8	TTH	PTH	OJT
		30	70	120

B: UNITS OF MODULE

Unit of Learning 4.8.1: Apply Finish to Wall Openings

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.8.1.1 Fixing of windows

Unit of Learning 4.8.2: Apply Finish to Walls

On completion of this learning unit, the trainee will be able to demonstrate the following competencies according to industry standards and/or requirements:

4.8.2.1 Describe the procedure for rendering of wall
4.8.2.2 Describe the procedure for floor screeding
4.8.2.3 Describe the procedure for plastering of walls
4.8.2.4 Describe the procedure for painting
4.8.2.5 Describe the procedure for pointing and jointing

C: Sample Questions

1. Identify the three functions of paint.
2. State the three components of painting systems.
3. Highlight the three classes of paint giving examples in each category.
4. Mention the four properties of paint that makes it suitable for covering.
5. What is the main function of plasters?
6. State the five advantages of gypsum plasters in construction industry.
7. Name 5 factors affecting the choice of plasters to use.
8. Identify 5 common defects in plastering
9. Identify five tools used for plastering.
10. Identify the steps in plastering.
11. Differentiate between pointing and jointing.
12. Identify 2 types of jointing and 2 types of pointing.
13. State the for functions of rendering.
14. Describe the choice of mortar for rendering.
15. Identify three types of surface coating.

5.0 SECTION FIVE : ON JOB TRAINING GUIDE

Table 5.1 : Industrial attachment

	All modules	
Module Level:	**1**	
Total Hours:	**160**	
Prerequisite	**Modules of Level 1**	
Learning Outcomes	**Performance Indicators**	**Assessment Criteria**
4.8.3 Substructure Elements	4.8.3.1 Foundation building 4.8.3.2 Sub-structure wall construction	• Direct observation • Practical demonstration
4.8.4 Superstructure Wall construction	4.8.4.1 Superstructure wall laying 4.8.4.2 Ring beam construction 4.8.4.3 Super wall construction 4.8.4.4 Occupational health and safety procedures observation	• Direct observation • Practical demonstration
4.8.5 Roof construction	4.8.5.1 Timber roof members assembling 4.8.5.2 Roof covering installation	• Direct observation • Practical demonstration
4.8.6 Plumbing installation and fitting	4.8.6.1 Plumbing water closets fixing 4.8.6.2 Taps, shower Rose and wash Hand Basin fixing 4.8.6.3 Waste Water disposal 4.8.6.4 Professional development needs identification	• Direct observation • Practical demonstration
4.8.7 Carpentry fitting	4.8.7.1 Door fittings installation	• Direct observation • Practical demonstration • Oral Questioning, • Presentations by trainees,
Sessional assessment will be adopted and the following guidelines should be followed regarding Industrial attachment marks: 1. Participation 25% 2. Attendance 10% 3. Time Management 10% 4. Log book: 15% 5. Safety 5% 6. Communication skills 5% 7. Creativity 5% 8. Customer care 5% 9. Cleanliness and hygiene 5% 10. Readiness to be corrected 5% 11. Team work 5% 12. General conduct 5%		
Internal evaluation & marks: Total internal marks are700. Marks shall be awarded at the end of every module of the a ttachment		

6.0 SECTION SIX : LEARNING INFORMATION SHEET

6.1 CONSTRUCTION OF SUBSTRUCTURE ELEMENTS

Setting out

The operations carried out once the site is handed over

- Clearing the site
- Setting out the building
- Establishing a datum level

What is setting out?

Picture taken at a construction by Chinese in Jubek state, Juba.

It is the process of developing the physical positions of corners and walls of a building, and it's done by transferring dimensions from the layout plan (also called as setting out plan, demarcation plan) to the ground. The setting out clearly defines the outline of the excavations and the centre line of the walls, so that the construction can be carried out according to the plan.

When is setting out done?

- when building a new house
- when renovating an already existing one, especially an extension.

The process of Setting out is done by a contractor, and overseen by the lead project consultant engineer, architect or any other qualified member of the project team.

Function of setting out

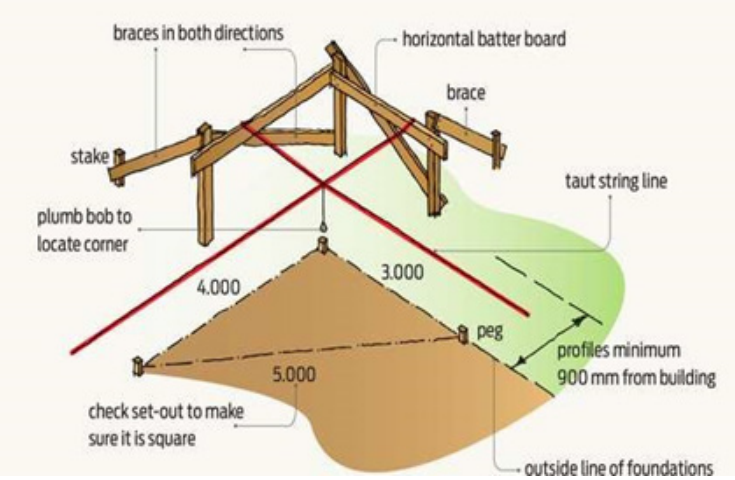
To establish the position of the trench and wall of the house as well as the position of corners and rooms.

METHODS OF SETTING OUT

1. Peg or rope method (commonly used).

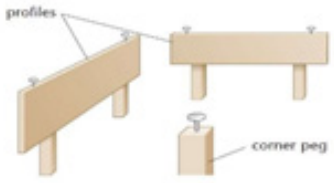
Dumpy Level (Best for big construction projects)

Trainees undergoing training in Juba



ITEMS RE-

QUIRED IN SETTING OUT.



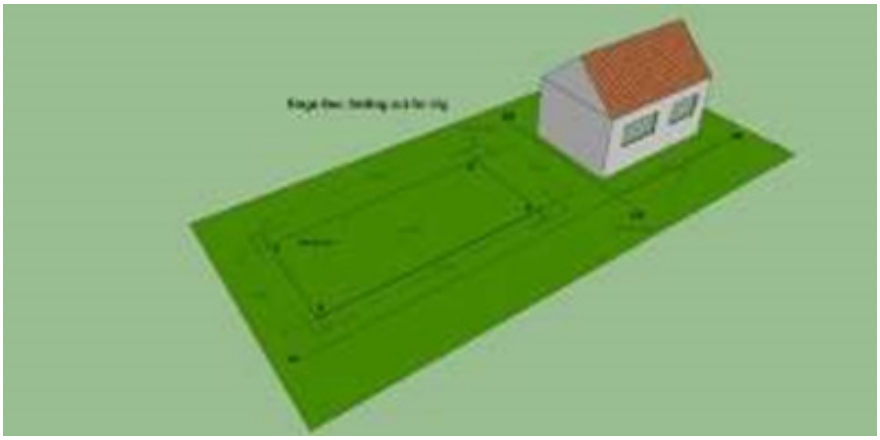
- Timber, 75mm by 50mm or any appropriate size.
- Round poles/ timber to act as pegs or steel for hard ground.
- Nylon threads (Manila rope).
- Ordinary nails inch and 2 inch.
- White chalk or lime.
- Clear hose pipe for determining horizontal levels.
- Sledge hammer.
- Measuring tape
- Builder's square

DATUM LEVEL

A point which serves as a reference or base for the measurement of other quantities. Where there are no benchmarks on or near the site, a suitable datum must be established. A site datum or temporary benchmark could be a post set in concrete or a concrete plinth set up on site

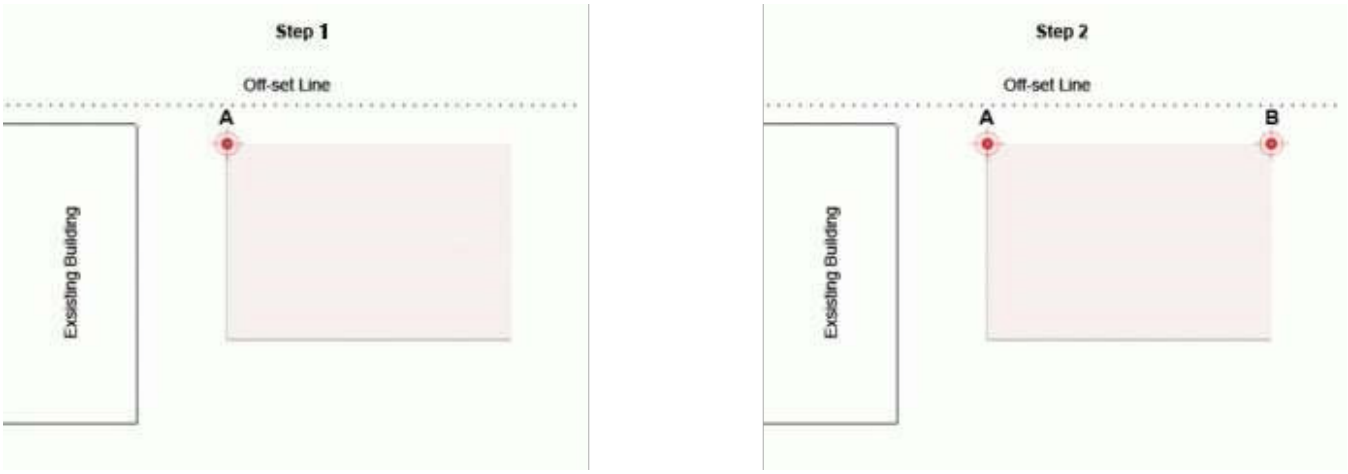
PROCESS OF SETTING OUT

Setting out is done on the principle of whole to part. According to this principle the largest possible rectangle of the building is found and set out. The rectangle is further partitioned into small parts (internal rooms). The first thing we need to establish is a parallel/ reference/ base line, to which all other lines can be related. This can be taken along an existing building close to the proposed new structure/ boundary wall if existing/ kerb line etc.

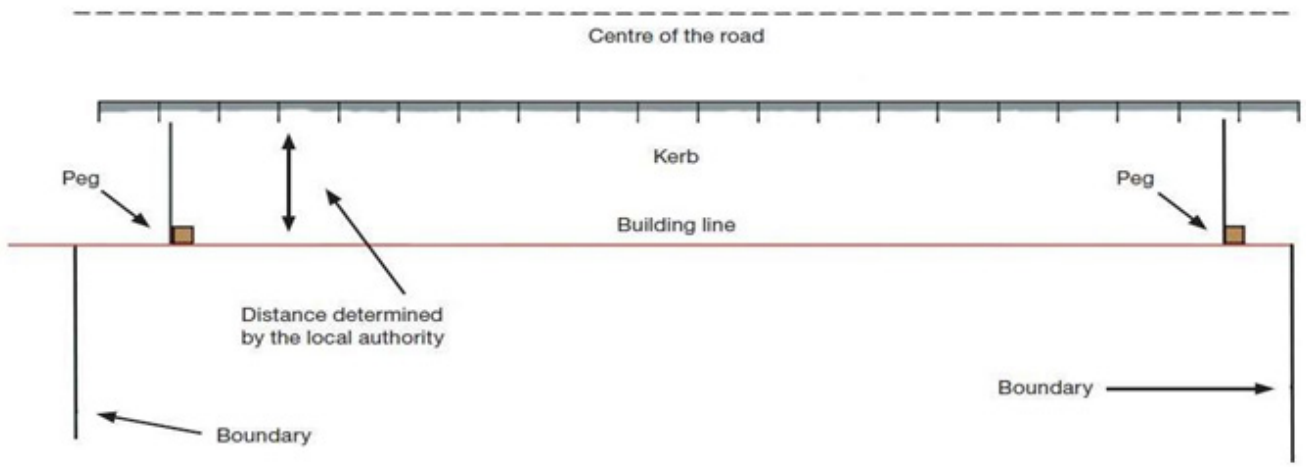


PROCESS OF SETTING OUT

STEP 1: SETTING OUT THE BUILDING LINE



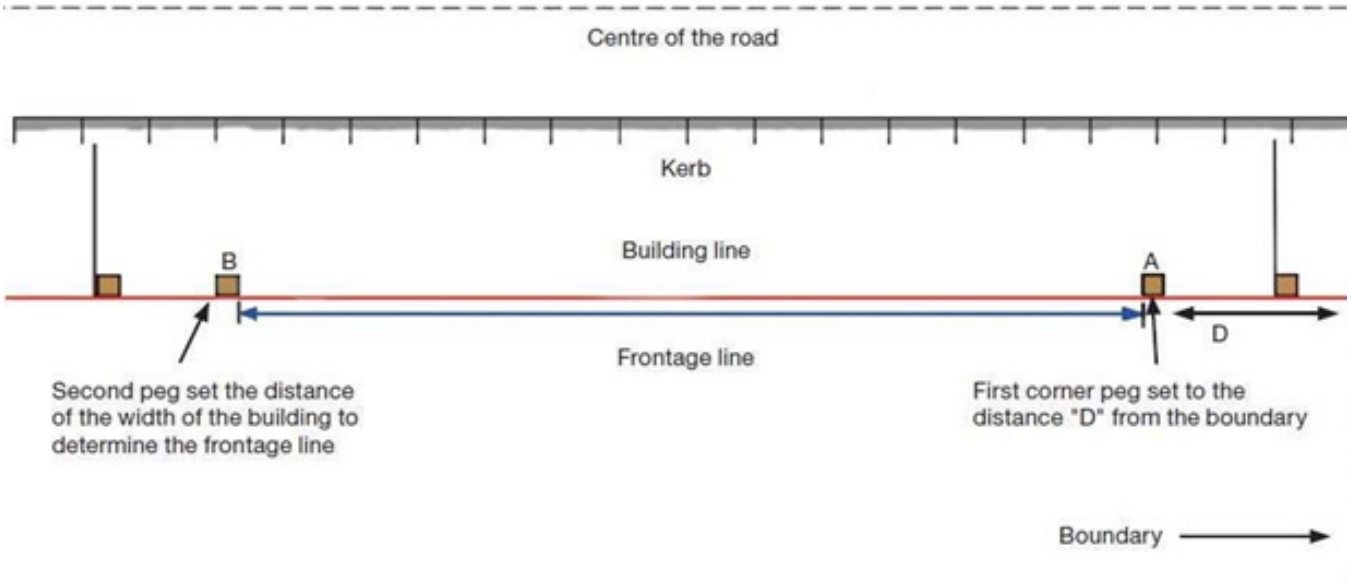
Two square offset lines are set from the kerb to the position of the building line. The length of the line is greater than the width of the proposed building. Pegs are positioned at these points and a ranging line is fixed to these, giving a position of the building line.



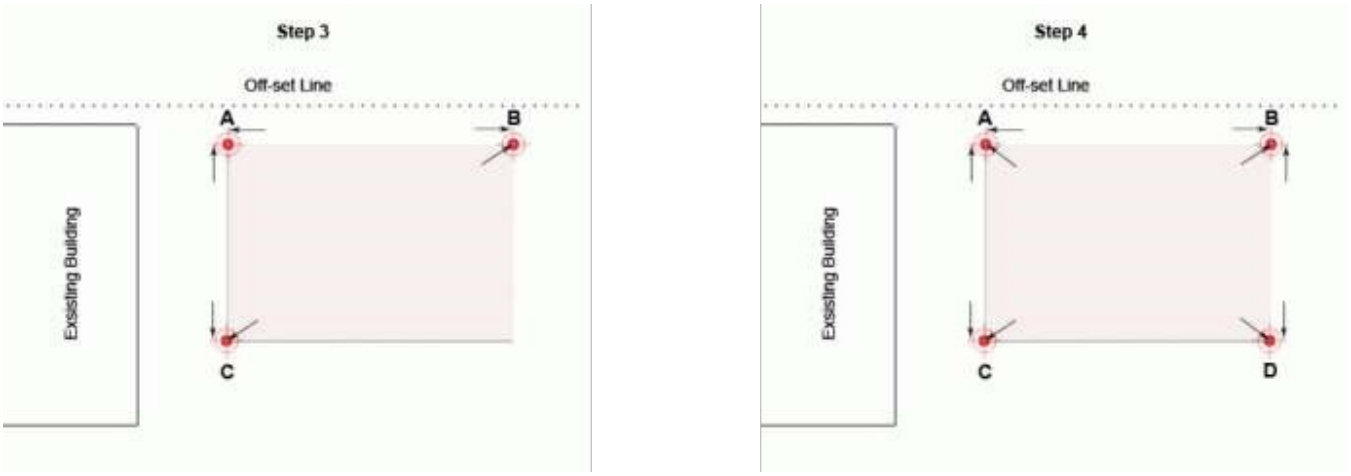
Setting out the building line

STEP 2: SETTING OUT FRONTAGE LINE/ BASE LINE

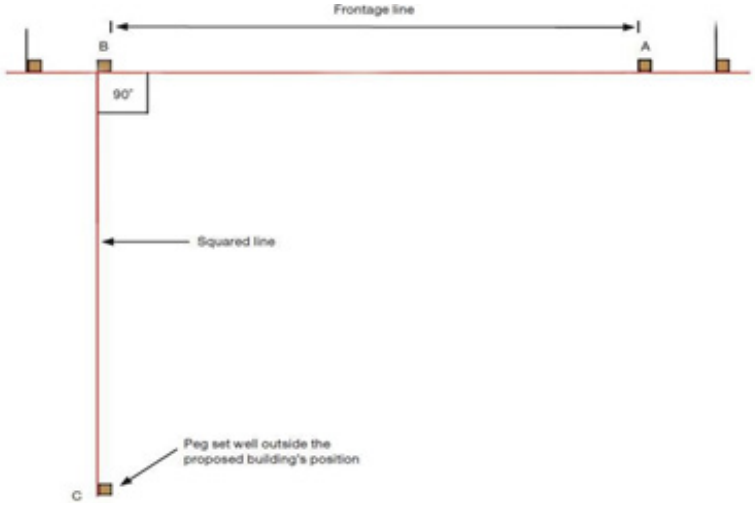
After taking the dimensions from the drawing, the frontage line is set out. This can be either on building line or behind it. The first corner peg (A) will be positioned from dimensions given on the drawing, which relates to site features such as distance from kerb, gatepost, boundary wall etc. E.g.: the point A is positioned a distance of (D) from the boundary. Following the position of first peg, the second peg (B) is positioned after carefully measuring the width along the frontage line. The nail is knocked into each peg to determine the exact position of the corner.



STEP 3: SETTING OUT OF FIRST RIGHTANGLE TO THE FRONTAGE LINE

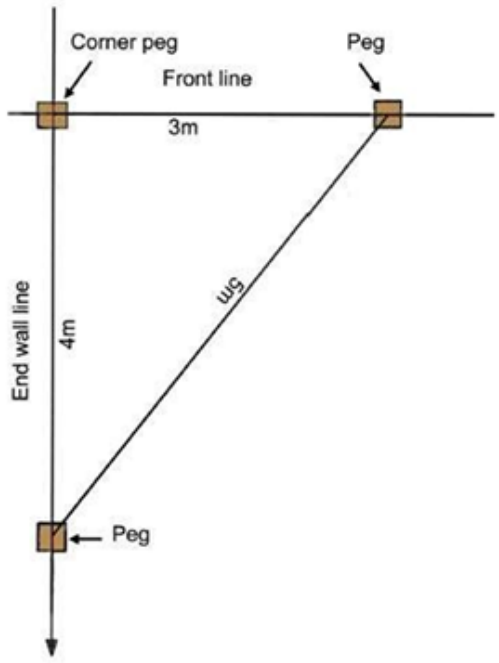


Attach the taut line to the nail on the corner peg, which will be extended well beyond the length of the wall to be set out. Adjust the line carefully to cross the frontage line at 90 degree by using a builder's square or the 3:4:5 method. When the line is correct, knock the peg with nail at the distance greater than the length of the wall.



RIGHT ANGLE TRINAGLE USED IN SETTING OUT

One of the most important procedure used in setting out is the process of ensuring that all right-angle corners are properly aligned. One of the simplest ways is to use the method known as 3:4:5-triangle method.

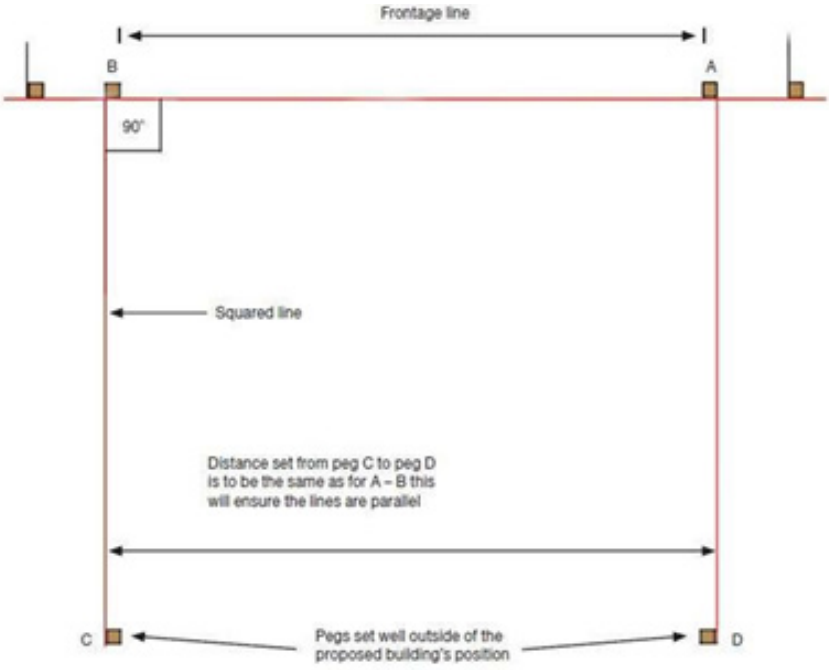


Setting out a right angle using the 3:4:5 method

PROCEDURE:

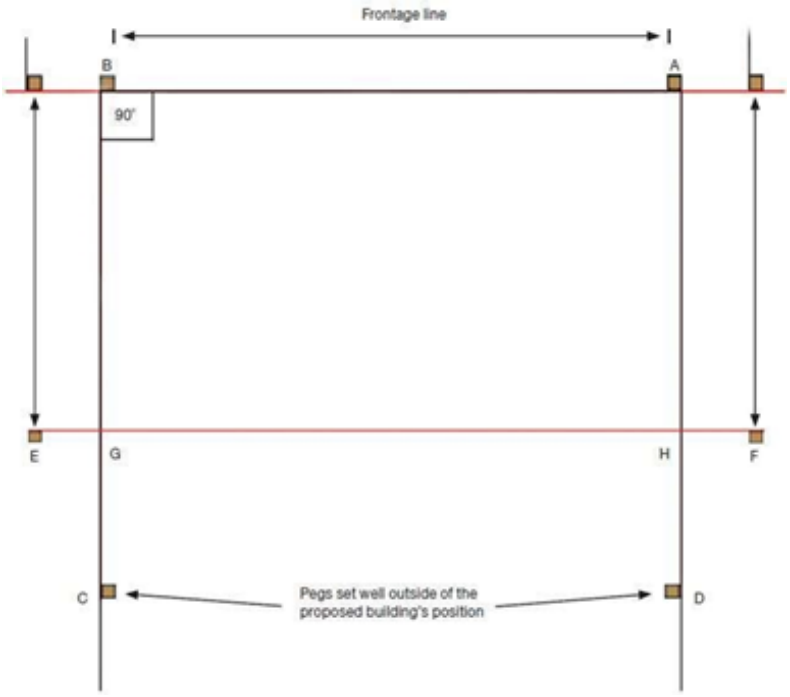
1. A peg with a nail is fixed exactly at 3m from the corner peg on the fixed line.
2. A measuring tape is the hooked to the nail on the corner peg and another tape is hooked to the nail of the peg on the front line.
3. Both the tapes are pulled towards the end wall and with distance of 4m showing on one tape and 5m on the other tape. Where they cross third peg will be fixed.
4. This will establish a line at 90 degrees to the front line.

STEP 4: SETTING OUT OF SECOND RIGHT ANGLE TO FRONTAGE LINE



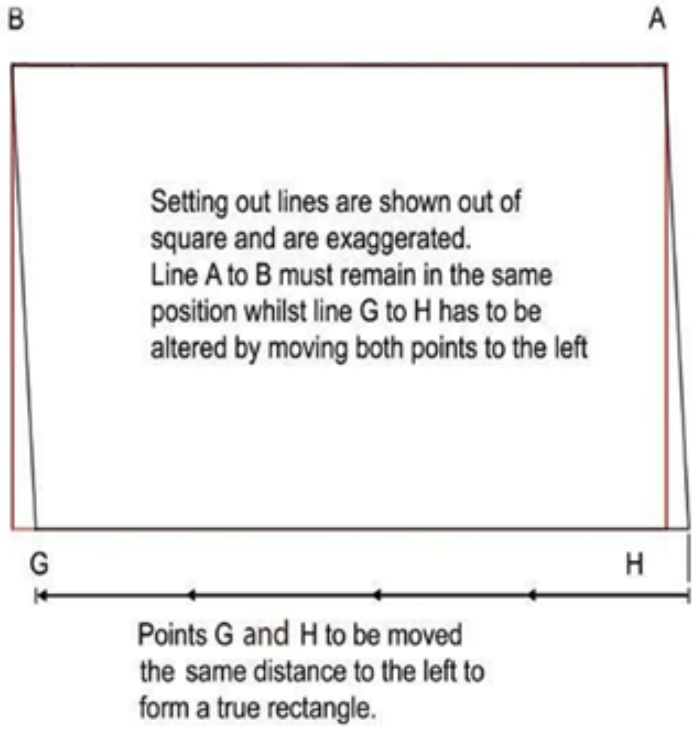
Measure the same length from the frontage line and set point D. Check the ranging lines before proceeding.

STEP 5: SETTING OUT OF FINAL BACK LINE



Measure the dimensions of the building sidewall from the outer peg of the frontage line and set pegs parallel to the wall lines. Attach ranging lines to the pegs to establish the back-wall line. Pegs can be positioned at G and H, but this is not essential.

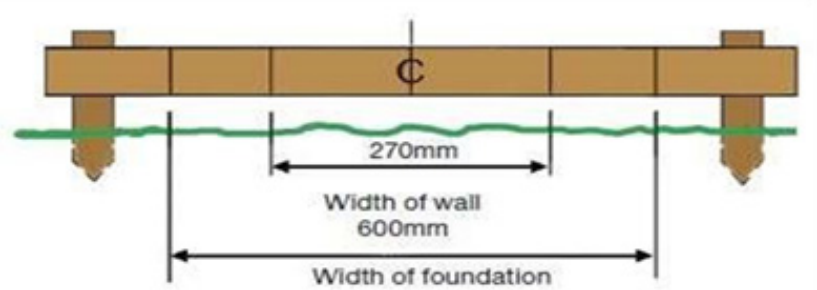
STEP 6: CHECKING THE BUILDING SETTING OUT



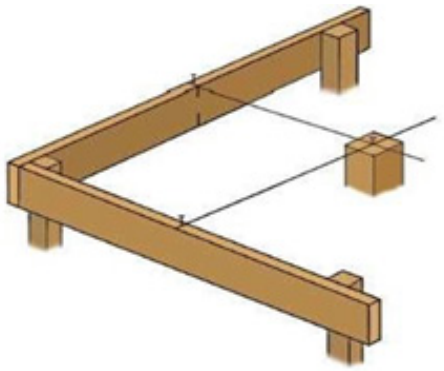
The setting out will be confirmed if all measurements are correct and the diagonals measure exactly the same. Measure the dimensions from A to G and B to H. these should be same if the building has been set perfectly. If there is some difference in the measurement, adjust the back pegs as per dimensions. The frontage line should not be altered.

STEP 7: SET UP PROFILES AND ATTACH RANGING LINES

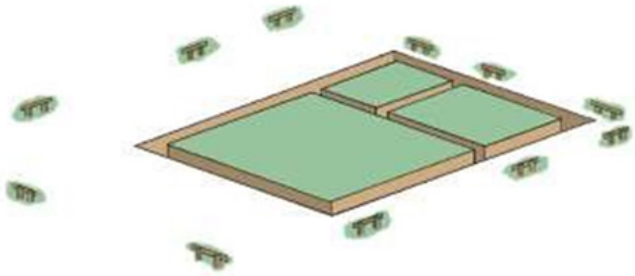
When the building has been set out and proved by checking the diagonals, profiles can be erected to enable the corner points to be easily located after the trenches have been excavated. The ranging lines attached to the pegs are extended by holding the line to pass over the peg to the profile. The wall position is then clearly marked on the profile.



Single profile with dimensions marked on it



Corner profile with ranging lines



Profiles are positioned at every wall junction

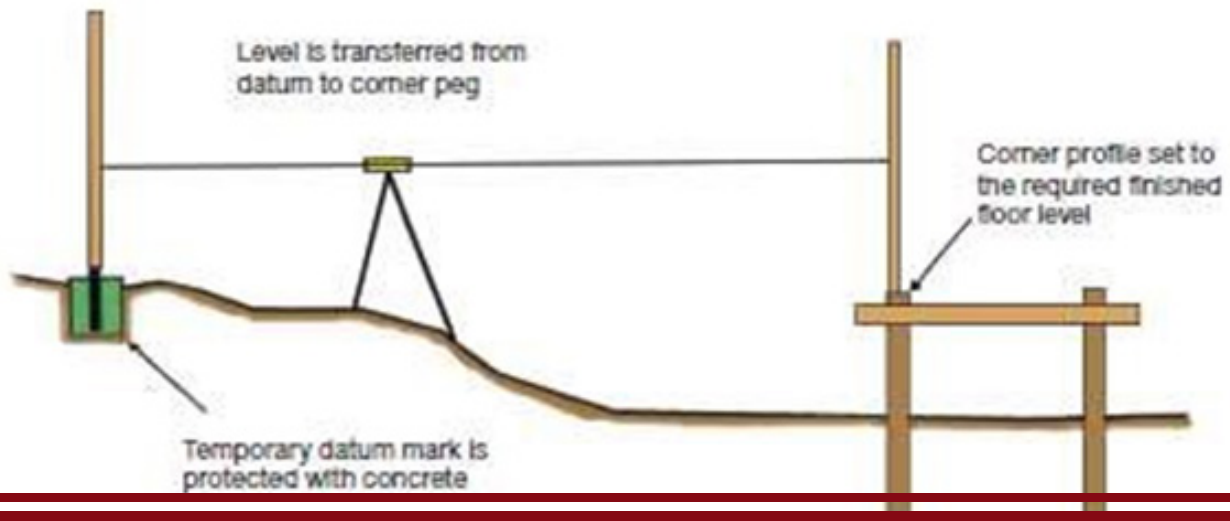
POSITIONING OF PROFILE

The profiles are positioned well away from the proposed excavations to allow an adequate working space. This is even more important when the excavations is to be carried out by a mechanical means.

SETTING PROFILE LEVELS

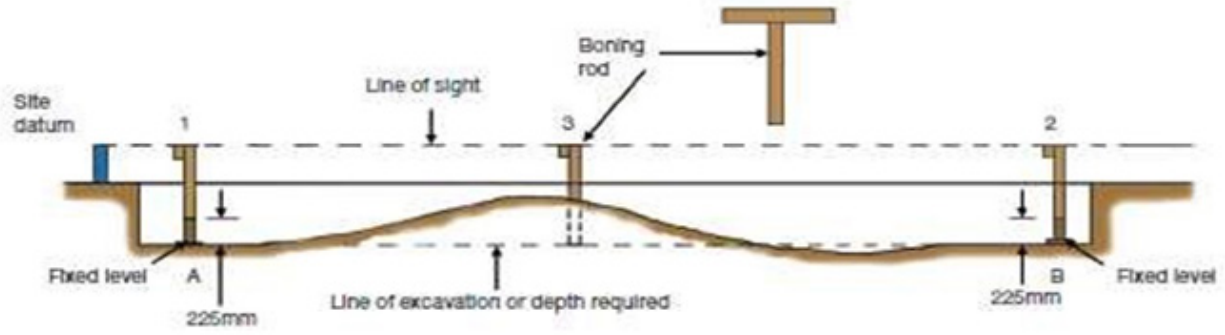
While setting up profiles, it is essential that they are as level as possible. This avoids inaccuracies when re measuring the walls and diagonals before commencing work.

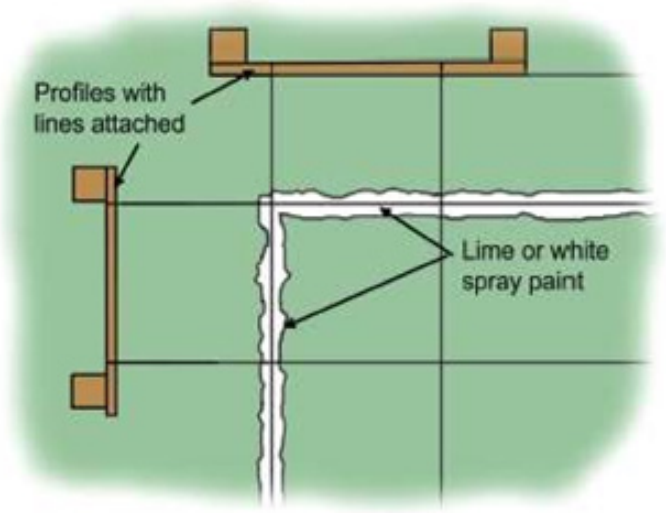
The profile is most conveniently levelled to the DPC level of the proposed building.



BONING RODS

A boning rod is a simple device used to quickly position leveling pegs. It consist of two pieces of timber nailed together at right angles. Boing rod can be used to transfer levels between the two known points.

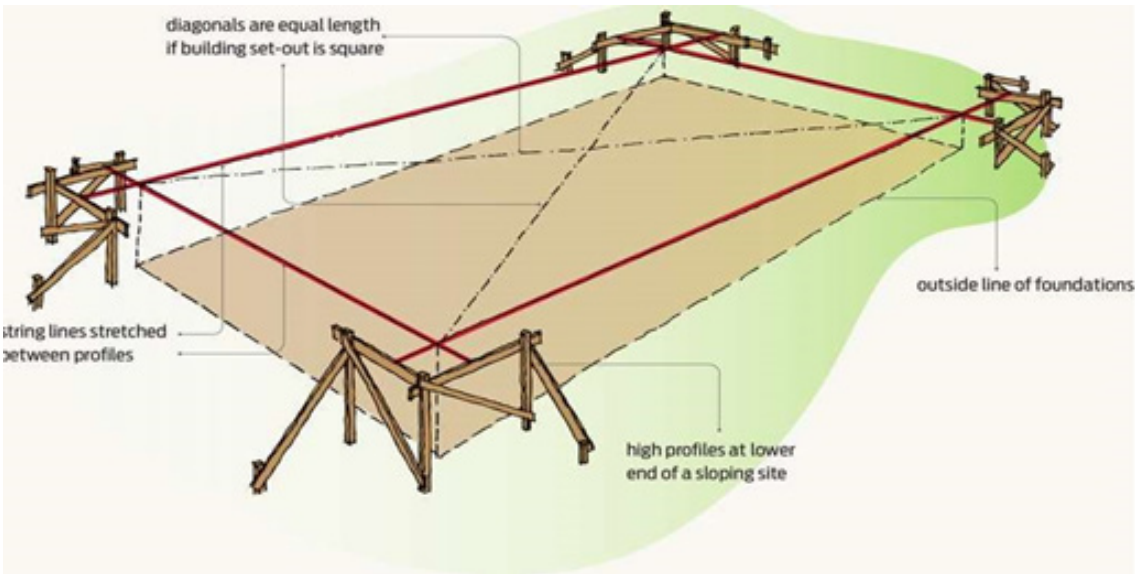




Outline of trench marked

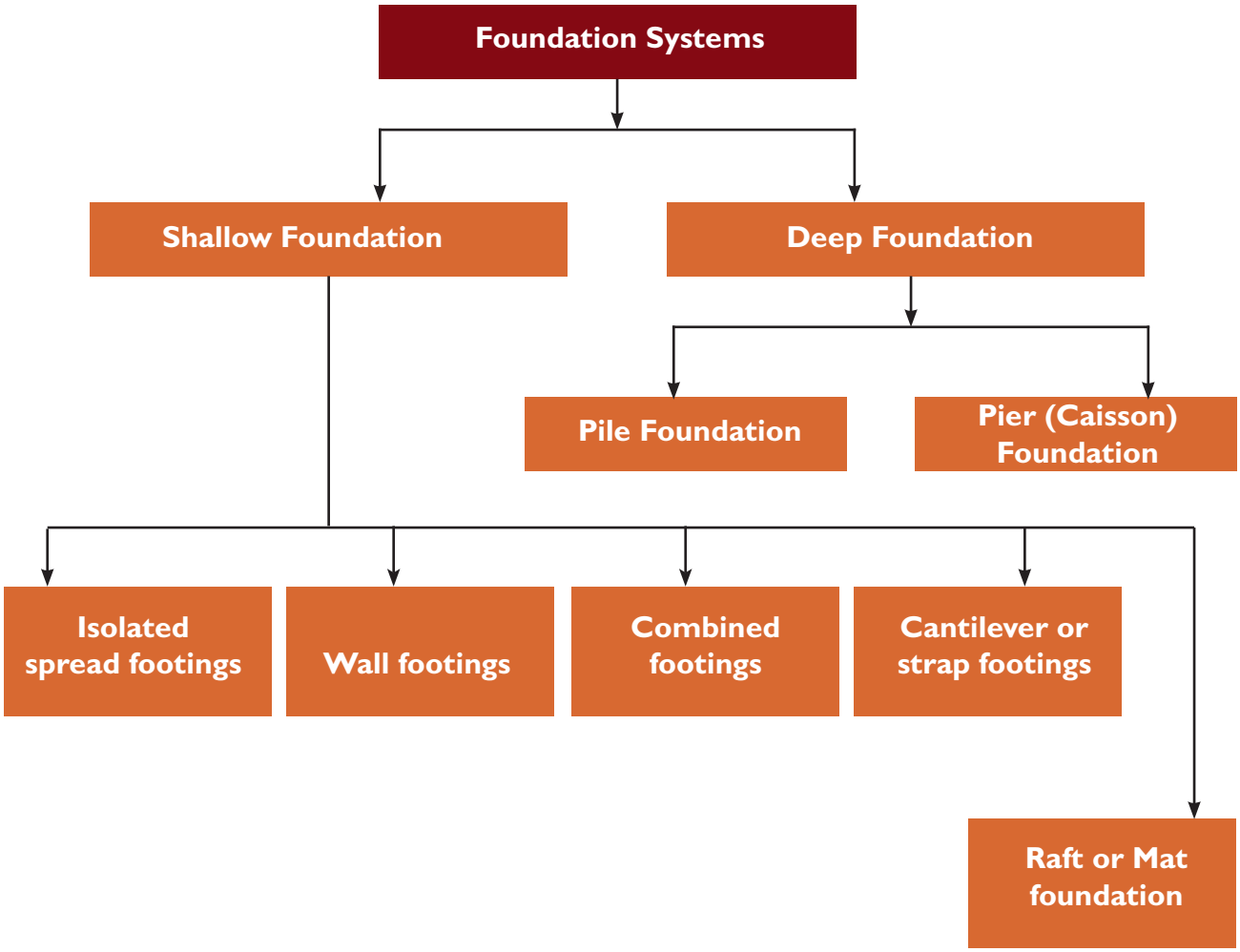
MARKING THE POSITION OF FOUNDATION TRENCH

Before excavation begins, the position of the foundation trench is marked on the ground. The original corner pegs can be then removed. The foundation line is then marked using lime or a spray paint.



6.2 FOUNDATION

TYPES OF FOUNDATIONS

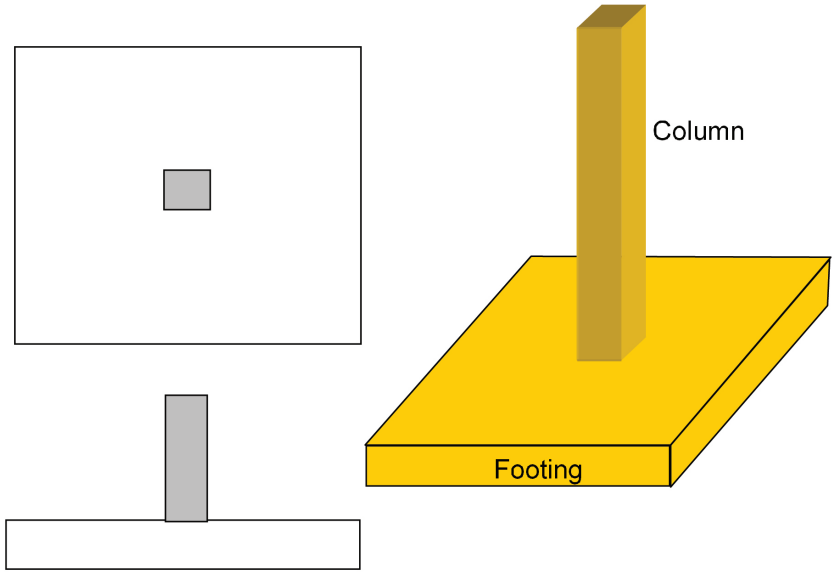


Shallow Foundations– are usually located no more than 6 ft below the lowest finished floor. A shallow foundation system generally used when (1) the soil closes the ground surface has sufficient bearing capacity, and (2) underlying weaker strata do not result in undue settlement. The shallow foundations are commonly used most economical foundation systems.

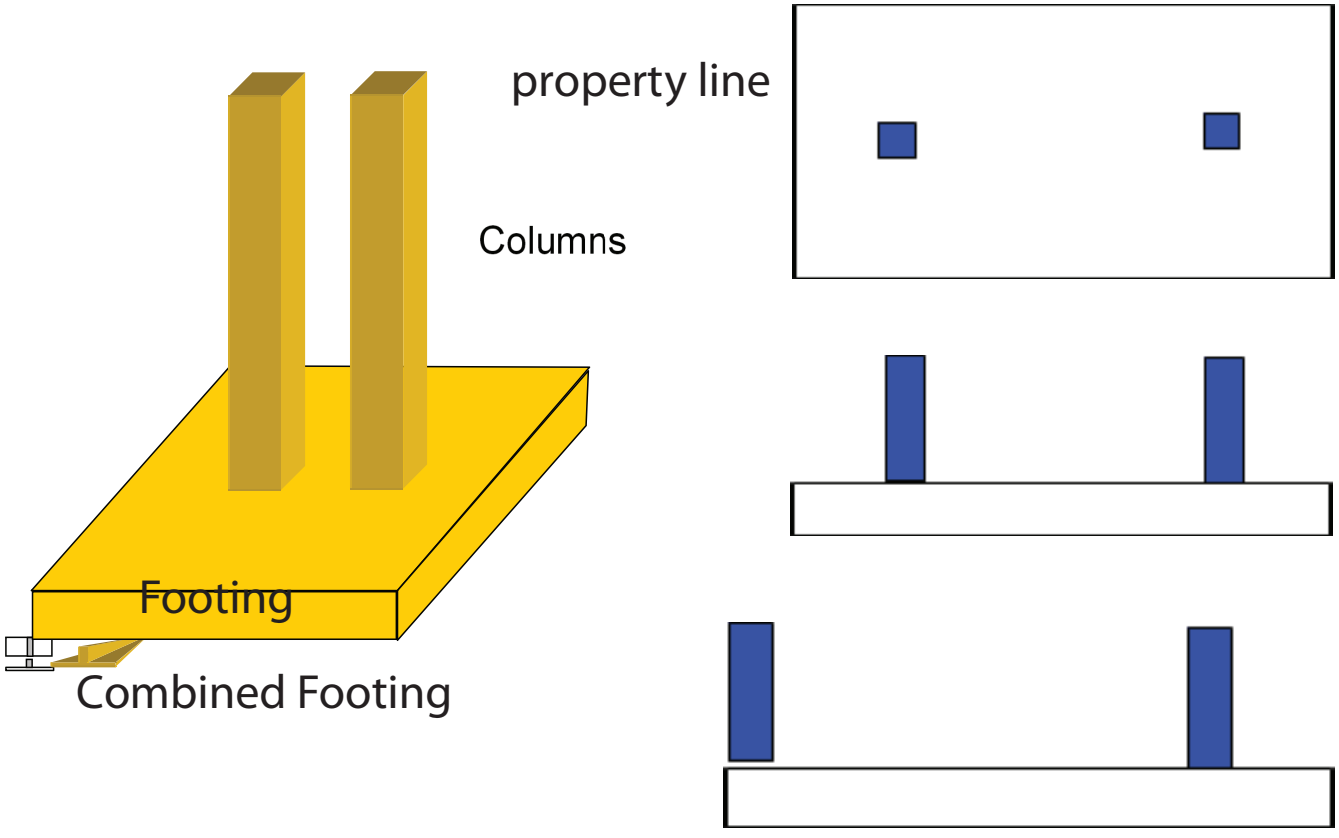
Footings are structural elements, which transfer loads to the soil from columns, walls or lateral loads from earth retaining structures. In order to transfer these loads properly to the soil, footings must be design to

- Prevent excessive settlement
- Minimize differential settlement, and
- Provide adequate safety against overturning and sliding.

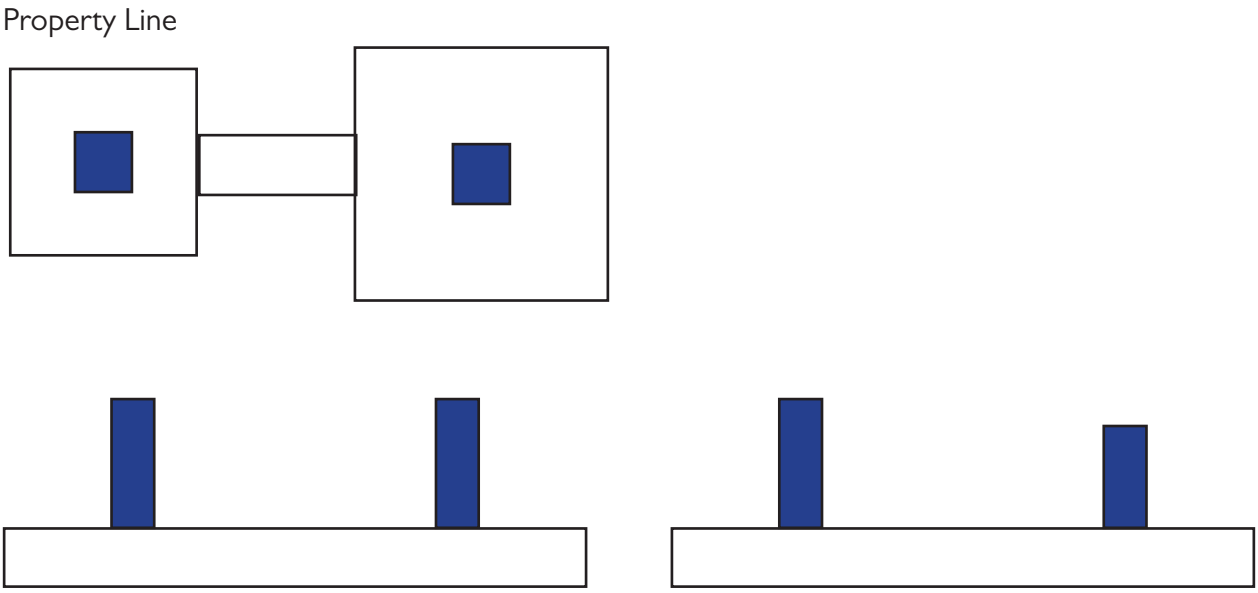
Types of Footings



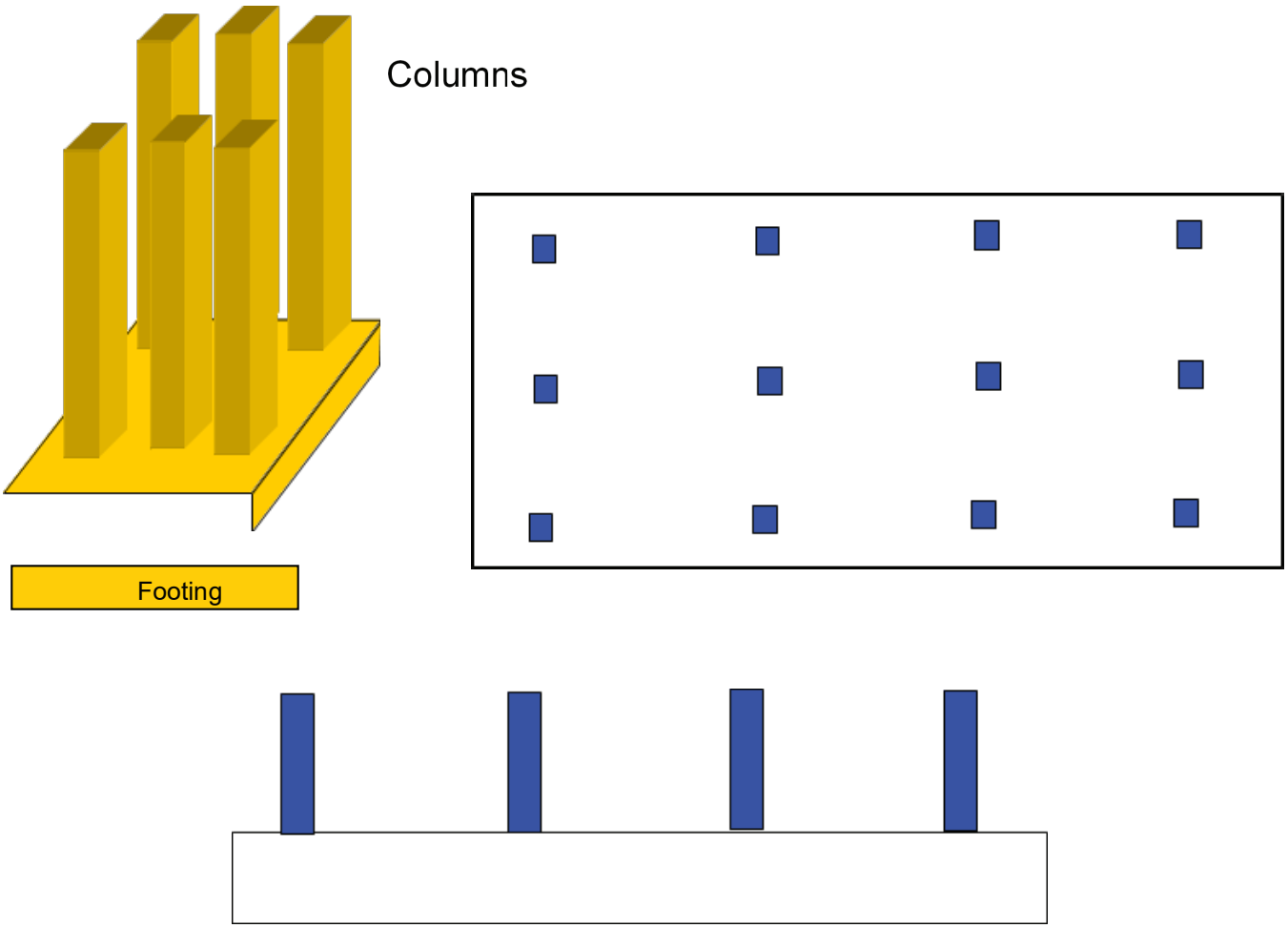
Isolated spread footings under individual columns. These can be square, rectangular, or circular.



Combined footings support two or more columns. These can be rectangular or trapezoidal plan.



Cantilever or strap footings: These are similar to combined footings, except that the footings under columns are built independently, and are joined by strap beam.



Raft or Mat foundation: This is a large continuous footing supporting all the columns of the structure. This is used when soil conditions are poor but piles are not used.

Deep Foundations – The shallow foundations may not be economical or even possible when the soil bearing capacity near the surface is too low. In those cases, deep foundations are used to transfer loads to a stronger layer, which may be located at a significant depth below the ground surface. The load is transferred through skin friction and end bearing (Figure below).

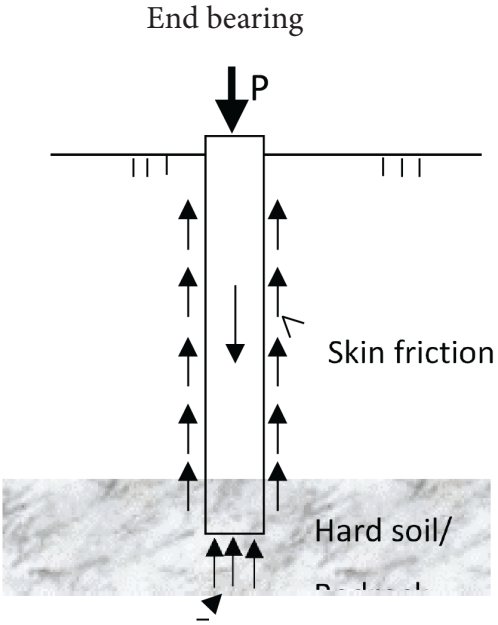
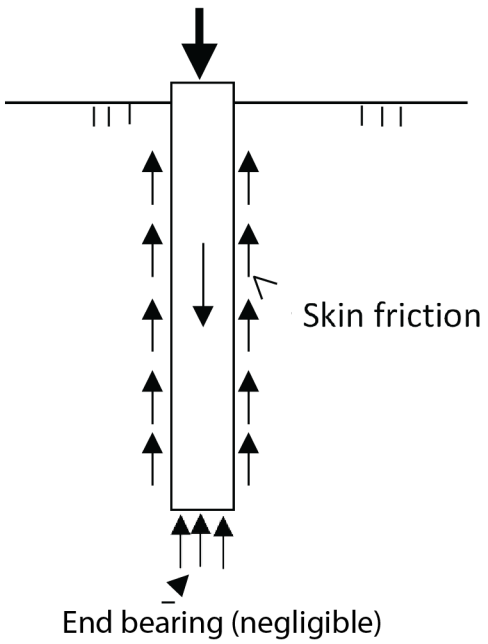


Fig. 1(a) Axial Compressive Load transfer in deep foundations



End bearing (negligible)

Fig. 1(b) Axial Compressive Load transfer in deep foundations

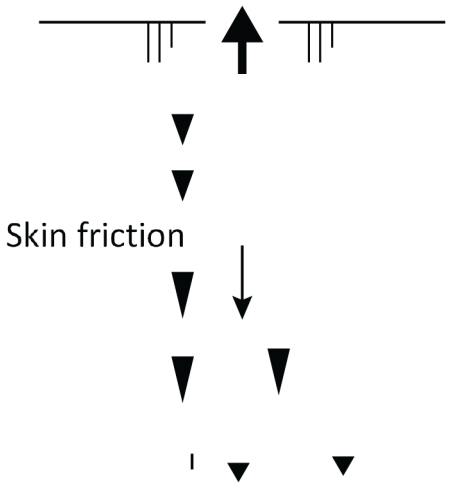
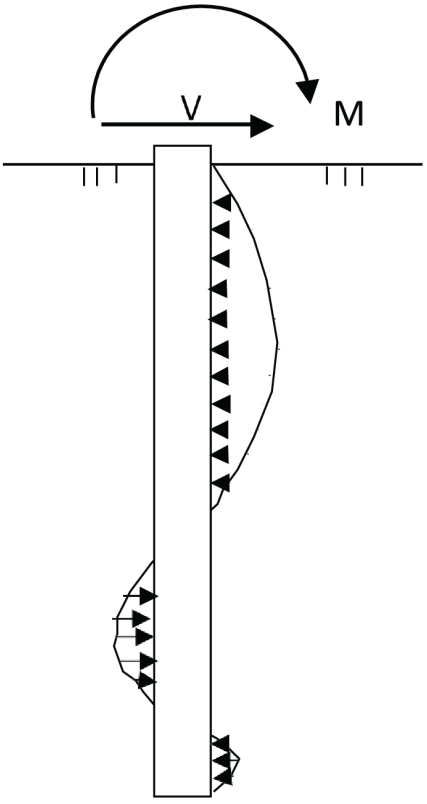


Fig. 2 Axial Tension Load transfer in deep foundations



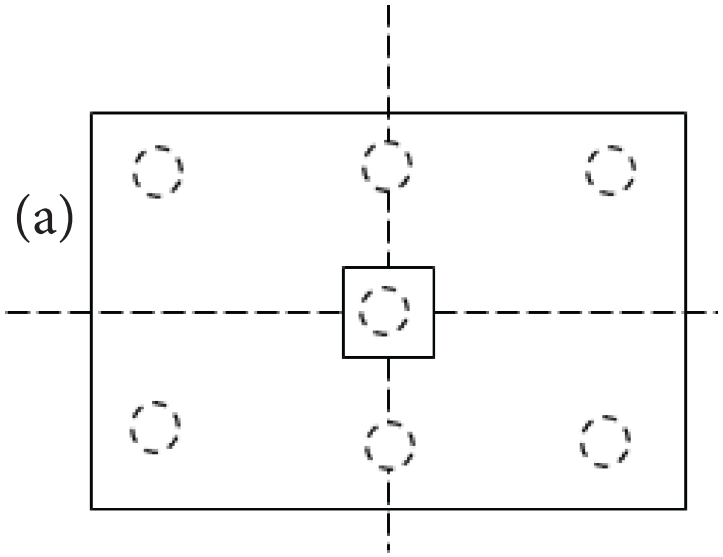


Fig. Pile Foundation- (a) Vertical Piles; (b) Battered Piles

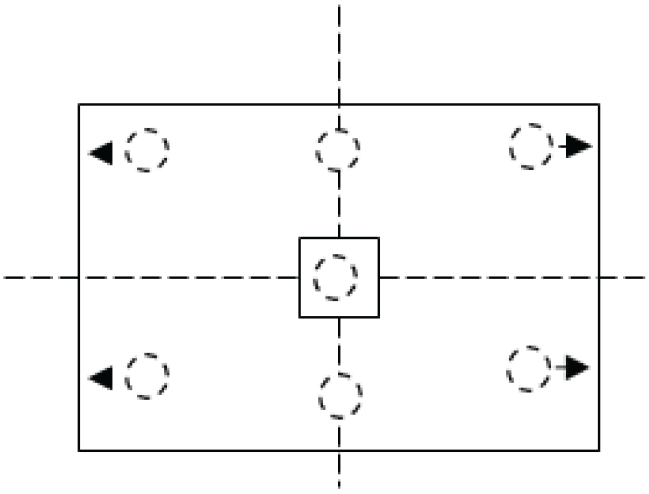
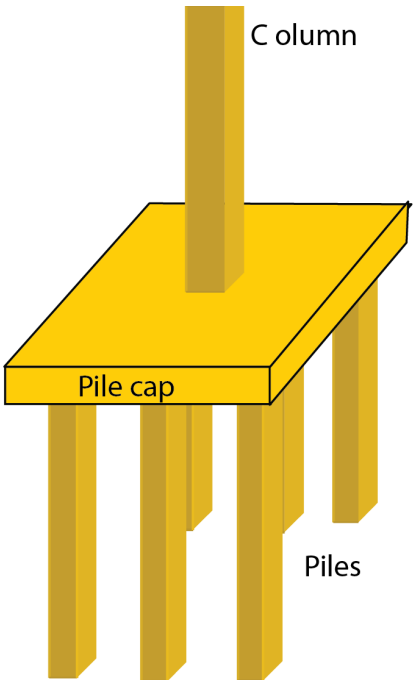
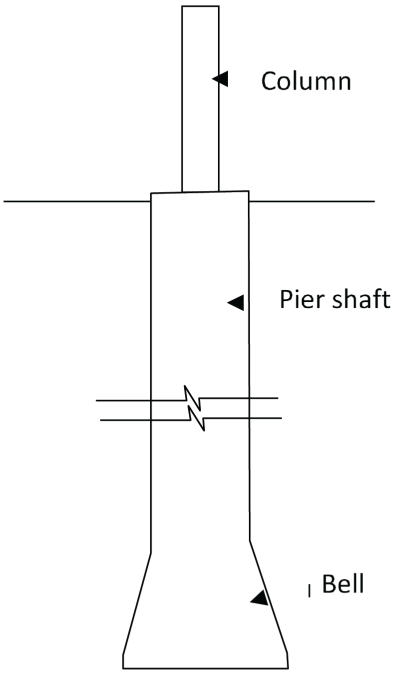


Fig. 3 Lateral Load transfer in deep foundations



Pile Foundation



Pier Foundation (Caisson)

Soil properties and parameters, and Foundation Systems

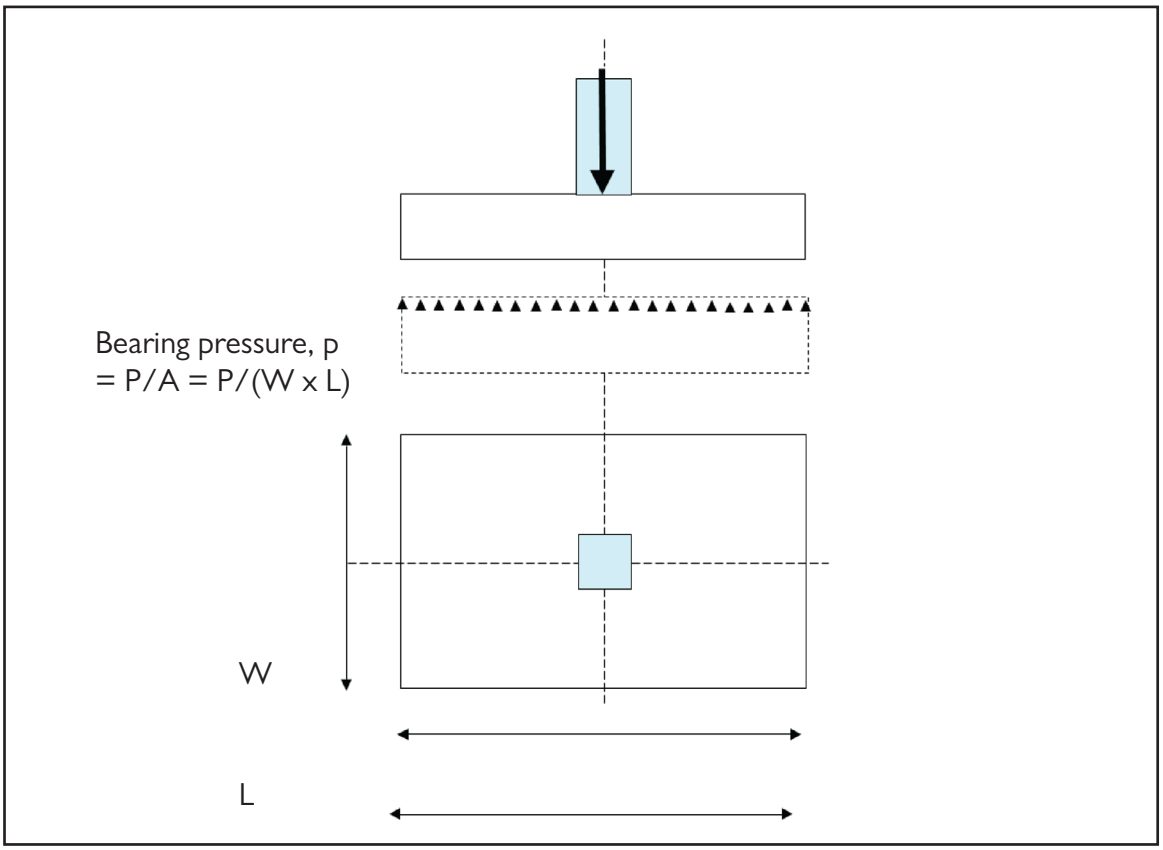
Capillary action (capillarity, capillary motion, or wicking) is the ability of a liquid to flow in narrow spaces without the assistance of, and in opposition to, external forces like gravity.

If the diameter of the tube is sufficiently small, then the combination of surface tension caused by cohesion within the liquid and adhesive forces between the liquid and the tube act to lift the liquid (Figure).

The capillary action is due to the pressure of cohesion and adhesion, which cause the liquid to work against gravity

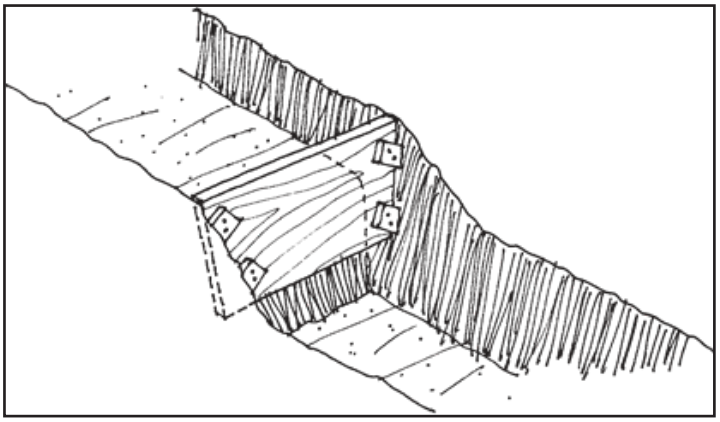
Soil Bearing Pressure at base of Footings

A. Concentrically Loaded Footing



3.2 SUBSTRUCTURE WALL

Basements are quite common in many parts of the country and almost unheard of in others. Where the frost line is relatively shallow and the footings are therefore close to the finish grade, only a short foundation wall (or stem wall as they are sometimes called) is needed to bring the construction above ground to provide support for the building frame. In cold climates where footings are required to be set deep in the ground to avoid frost heave, foundation walls may have to be several feet tall to reach above grade. With a little additional excavation, the footings can be set deeper and the foundation wall height extended sufficiently to accommodate construction of a habitable basement that is fully or partially below grade. The taller the foundation wall required by footing depth, the less additional work required to enclose a basement space.



Stepped footing without forms.

(Source: Council of American Building Officials)

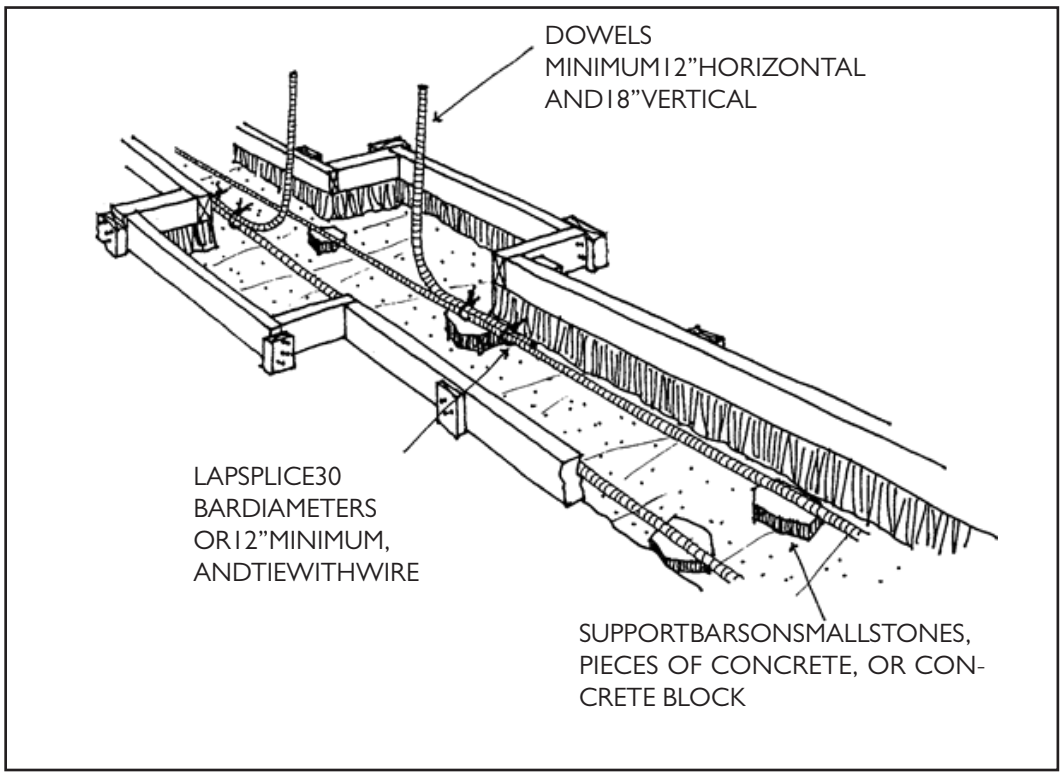


FIGURE 6-12

Footing dowels (Source: Council of American Building Officials)

Foundation Walls

Excavations for foundation walls may be done in one of two ways. If the foundation wall will be only a foot or two in height, the footing and the wall may be built in a trench that outlines the perimeter of the building and then backfilled from both sides. If the footing must be deeper because of the frost depth, it is often expedient to excavate the entire "footprint" of the building using heavy equipment. The wall is then backfilled from the outside only, leaving a crawl space on the inside of the wall. Walls that are backfilled on both sides are very stable because the soil pressures are balanced and help the wall to resist buckling from vertical loads. Tall walls that are backfilled on only one side must resist significant lateral loads from the unbalanced backfill. Trench excavations for short walls and crawl space excavations for taller walls can be roughly marked on the ground with a sack of mason's lime so the backhoe operator can see where to dig. The excavations should be wide enough to allow plenty of room for erecting the forms, with the sides sloped generously to prevent cave-ins.

Foundation walls are typically built of concrete or masonry. Masonry foundation walls can be constructed of brick or concrete block, but are usually built of block for its economy and because its utilitarian appearance is not typically exposed to view. Foundation walls must be strong enough to support the weight of the building superstructure and resist the lateral loads of the adjacent soil. They must also be durable enough to withstand years of exposure to moisture in the soil. Foundation walls may be unreinforced or plain as they are referred to in some codes or they may be reinforced with steel bars for greater strength and load resistance.

Building codes typically specify maximum height and backfill limits for unreinforced foundation walls and minimum reinforcing requirements for walls which exceed the limits for unreinforced walls.

The Code provides minimum design requirements based on the type of soil in which the foundation

is built. Figure 6-13 lists soil properties according to the United States Soil Classification System, which is referenced in the Code.

The minimum requirements of the CABO One- and Two-Family Dwelling Code for foundation walls include the following:

- Walls must extend a minimum of 4 in. above the adjacent finished grade where masonry veneer is used and a minimum of 6 in. elsewhere.
- The thickness of foundation may not be less than the thickness of the walls they support except that foundation walls of at least 8-in. nominal thickness are permitted under brick veneered frame walls and under 10-in. double-Wythe masonry cavity walls as long as the total height of the wall being supported (including gables) is not more than 20 ft.
- Except for walls with less than 4 ft. of unbalanced backfill, backfilling may not begin until the foundation wall has cured to gain sufficient strength and has been anchored to the floor or sufficiently braced to prevent overturning or other damage by the backfill.
- Concrete and masonry foundation walls must be constructed as set forth in Figure 6-14 or Figure 6-15 for unreinforced and reinforced walls, respectively.

Figure 6-16 shows four basic types of concrete and concrete masonry foundation walls. In areas with significant risk of earthquake, building codes typically require more stringent design standards for all types of construction, including foundations. The map in Figure 617 shows the seismic risk areas for the United States, with zero being the lowest risk and 4 being the highest risk. Foundation walls in Seismic Zones 3 and 4 which support more than 4 ft. of unbalanced backfill are required by Code to have a minimum nominal thickness of 8 in. and minimum reinforcement consisting of #4 vertical bars spaced a maximum of 48 in. on center, and two #4 horizontal bars located in the upper 12 in. of the wall (Figure 6-18). In concrete walls, horizontal reinforcing bars are simply tied to the vertical bars to hold them at the correct height. In masonry walls, horizontal reinforcing bars are placed in a course of bond beam units which form a continuous channel and are then grouted to bond the steel and masonry together (Figure 6-19).

The sill plate to which the floor framing will be attached must be anchored to the foundation with 12-in.-diameter bolts spaced 6 ft. on center and not more than 12 in. from corners. The bolts must extend at least 7 in. into the concrete or masonry and have a 90° bend at the bottom. For concrete walls, the bolts can be placed into the concrete as it begins to set and develop enough stiffness to hold them in place. For concrete block walls, the cores in which anchor bolts will be located must be grouted to hold the bolts in place. To isolate the grout so that it will not flow beyond the core in which the anchor will be placed, the webs of that core should be mortared in addition to the face shells, and a piece of screen wire placed in the bed joint just below the top course (Figure 6-20). As the grout begins to stiffen, the bolt is inserted in the same way as for concrete. Make sure the bolt spacing is accurate so that it does not interfere with stud spacing, and leave the threaded end exposed sufficiently to penetrate the full thickness of the plate with allowance for a nut and washer. If the wall will have stucco or siding applied, the bolt should be located so that the plate is toward the outside of the foundation wall. If the wall will have a brick or stone veneer, the bolt should be located so that the plate is toward the inside of the foundation wall (Figure 6-21). This will allow room for support of the veneer on the top of the foundation wall.

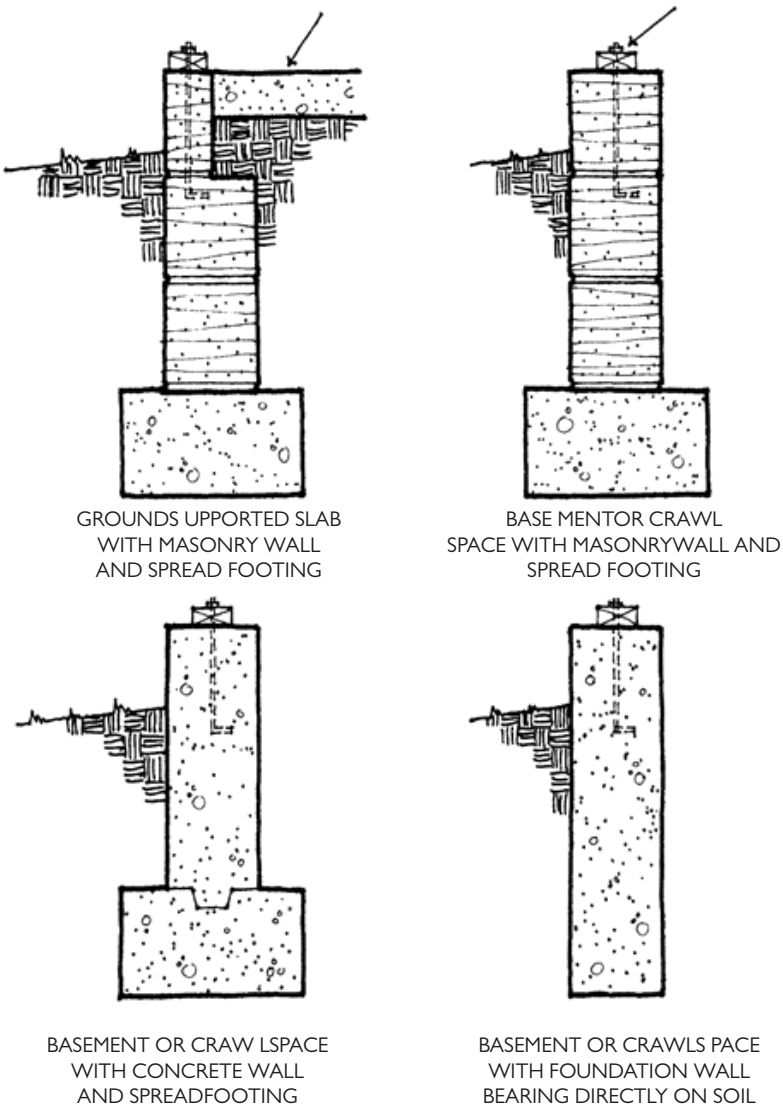


FIGURE 6-12

(Source: Council of American Building Officials)

Figure 6-14 or 6-15 may be used to design concrete and masonry foundation walls except when any of the following conditions exist:

- The building official has determined that suitable backfill material is not available.
- Walls are subject to hydrostatic pressure from groundwater.
- Walls support more than 48 in. of unbalanced backfill and do not have permanent lateral support at the top and bottom.

When any of these conditions exist, walls must be designed in accordance with accepted engineering practice and in accordance with the requirements of an approved standard such as
ACI 530/ASCE 5/TMS 402 *Building Code Requirements for Masonry Structures, or ACI 318 Building Code Requirements for Reinforced Concrete. Basement Walls*

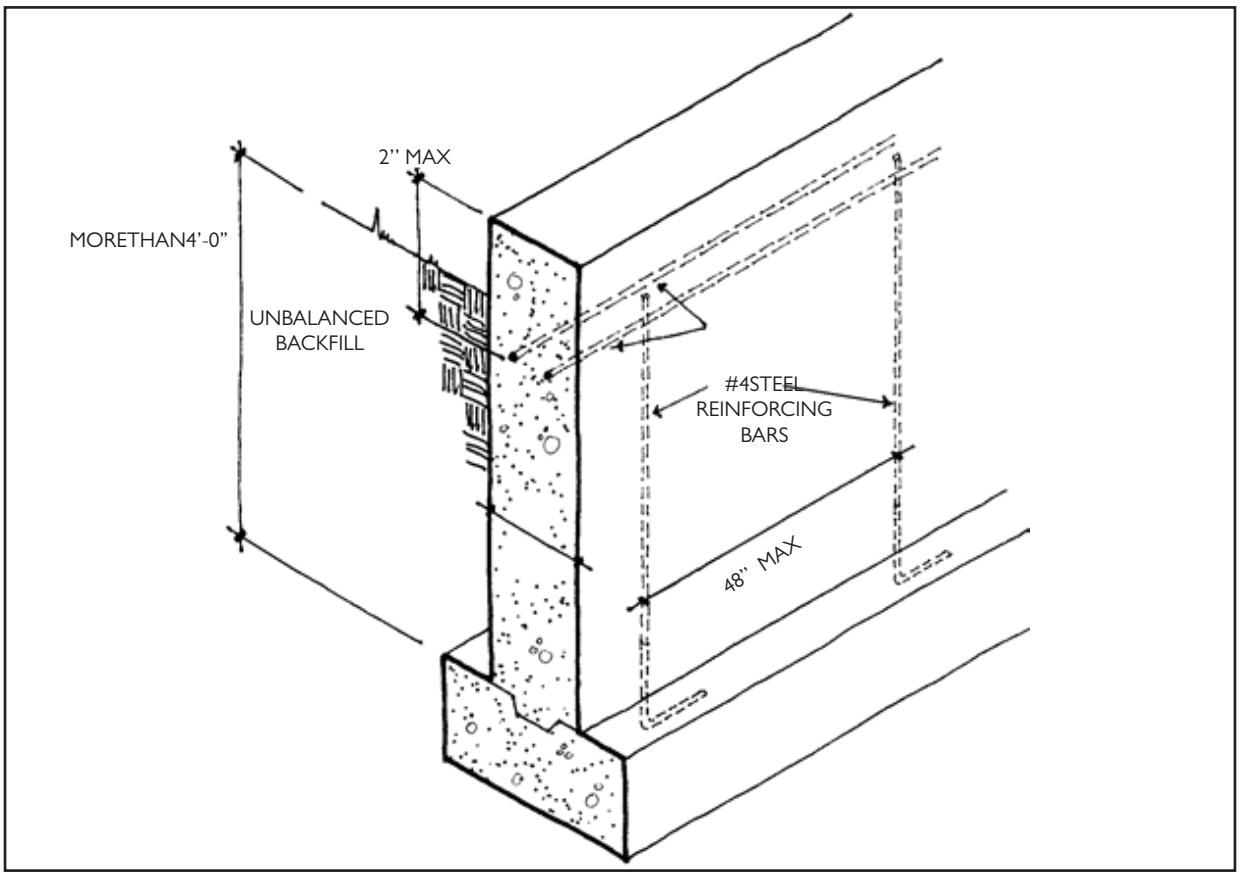


FIGURE 6-18
(Source: Council of American Building Officials)

FIGURE 6-19
Grouted and reinforced bond beam (Source: Council of American Building Officials

Basement walls

are essentially just tall foundation walls which will enclose habitable space instead of a crawl space. Their construction is essentially the same, and the minimum requirements discussed above for foundation walls apply equally to basement walls. The taller the wall, though, the greater the lateral load it must resist as the backfill soil pushes against it. Lateral support at the top of the wall is provided by the first-floor framing, and at the bottom by the footing and basement floor slab. Since the first floor helps resist soil pressures,

backfilling should be delayed until the floor construction is in place. If earlier backfill is unavoidable, temporary bracing must be provided to prevent possible collapse of the wall. Walls should be allowed to cure for at least three weeks so that sufficient strength is gained before any backfilling may begin. The gravel and soil backfill should be placed in depths of 12 to 24 in. at a time to avoid large impact loads against the wall.

6.3 SUPERSTRUCUTRE WALL

Stone Masonry

Construction

Stone masonry is similar in many ways to unit masonry, but there are also some differences. Stone is a natural material, so its size and shape are not uniform, and it's also a very heavy material. Stone is dimensionally stable and does not expand and contract with changes in temperature or moisture content, so stone masonry construction does not require expansion or control joints.

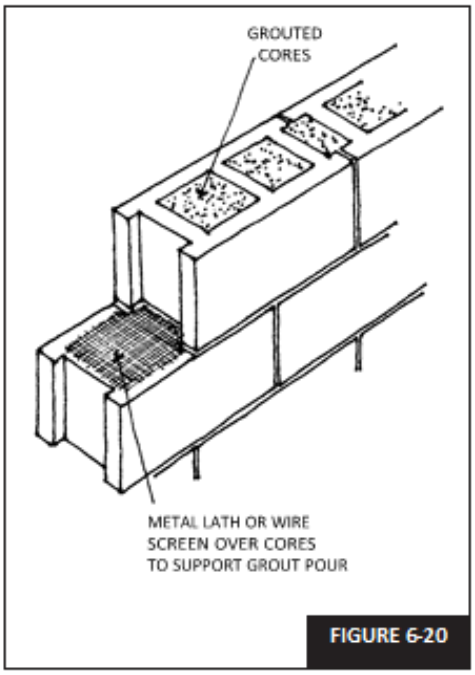


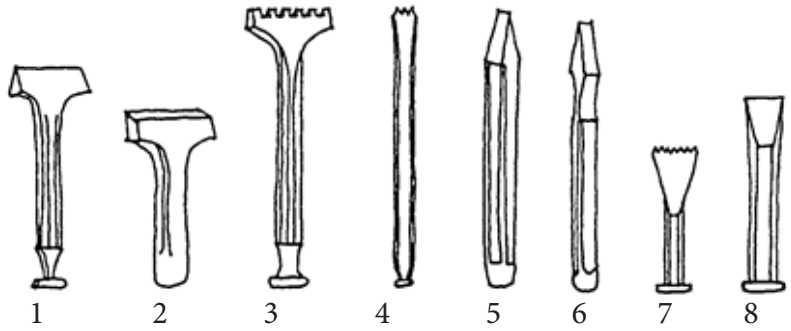
FIGURE 6-20

(Source: Council of American Building Officials)

Cutting and Shaping Stone

When rubble stone is laid in mortar, irregular shapes are taken up to some degree in the mortar joints themselves. When stone is dry stacked without mortar, the fit of the stones must be more precise. For both types of stonework, though, it will often be necessary to cut and shape individual stones to make them fit better.

To work with stone requires very few tools besides those required for working with mortar. Cutting and shaping rubble stone will require a brick or stone mason's hammer, a small club hammer, and a couple of chisels called a pointing chisel and a large pitching chisel or small mason's chisel (Figure 5-31).



1. 2 – 3" WIDE DROVE CHISEL
2. 31/2 – 41/2" WIDE BOASTER OR BOLSTER TOOL
3. 19TH CENTURY TOOTH CHISEL
4. 16TH CENTURY ITALIAN TOOTH CHISEL
5. 19TH CENTURY NARROW CHISEL
6. SPLITTING CHISEL
7. 13/4", 7 – TOOTH CHISEL
8. 11/2" CHISEL

Stone working tools. (*from Harley J. McKee,* Introduction to Early American Masonry— Stone, Brick, Mortar and Plaster. *The Preservation Press*).

Granite is the most difficult stone to cut, but limestone, sandstone, and slate are relatively easy to work with. To cut rubble, it is first laid on solid ground for firm, even support. Cutting should not be done on concrete surfaces because the hard concrete and uneven support may cause the stone to break in the wrong place. The cut is marked with chalk, crayon, or pencil, and scored with a chisel. Often, the stone will break along the line before it is scored all the way around. Small lumps or protrusions are removed with the pointing chisel. Flagstones can be cut by laying them over a small pipe and striking with the chisel. Small pieces can also be trimmed off of flagstone with a mason's hammer.

Mortar for Stone Masonry

The same types of mortar used for laying masonry unit is determined by the strength of masonry unit. Sometimes the proportion of lime is reduced, and one popular mix uses 1-part lime, 2-parts Portland cement, and 9 parts sand or 1-part masonry cement to 3-parts sand. Because stone is so heavy, the mortar should be mixed to a slightly stiffer consistency than that used with unit masonry, even though a stiffer mix is a little more difficult to work with. For light-colored stone, a light-colored mortar can be made using white Portland cement instead of ordinary gray cement, or pigments can be added to create other colors.

Setting Stone

Ashlar stone that is laid in straight horizontal courses can be installed using string lines and line blocks just like unit masonry. For rubble stone that is less precise, pattern bonds are more like putting together a puzzle in which no two pieces are the same size or shape. There is an art to creating uniformity in pattern so that the front of the house looks the same as the sides and back. Colors must be blended and some regularity of coursing and placement is required. The necessary skills can be acquired only with hands-on

experience and a good eye for the esthetics.

Flashing and Weep Holes

Even though stone is not as absorptive as brick or block, stone masonry walls still require flashing and weeps to drain moisture from the wall. Water entry in stone walls, like in brick and block walls, is most often through the mortar joints, and when the joints are irregular and difficult to tool, water penetration can be significant.

Accessories

Residential stone masonry usually is limited to veneer applications, garden walls, and retaining walls. Steel reinforcement is seldom necessary for these applications, so the accessories necessary for stone masonry construction are usually limited to wall ties and anchors. These need flexibilities to accommodate the irregularities of the stone, and either wire or corrugated metal are most frequently used.

RING BEAM

Lintel is a horizontal flexural member that spans over the openings in the walls for doors, windows, ventilators, cupboards etc. The load of masonry above the opening is transferred to the wall by flexural action of the lintel so that frames of doors, windows etc. are not unduly loaded. The end bearings for the lintel should be at least 200 mm. The width of lintels is same as that of wall.

Lintels of various materials are used. They are:

a. Wood
b. Stone
c. Brick
d. R.C.C. and
e. Steel

a. Wood Lintel: It may be a single piece or may be assembled by joining 2 to 3 pieces. Sometimes the wooden lintels are strengthened by steel plates at top and bottom. Such lintels are called as fletched beams.

b. Stone Lintels: Wherever stones are available stone beams are used as lintels. As stone is weak in tension they can be used only for small spans. Their depth is kept about 1 /10th span. Stones are cut to the width of wall and dressed before using as lintels.

c. Brick Lintels: Well burnt, good quality lintels are laid on ends or edges to form lintels as shown in Fig. 8.34. It needs temporary form work at the time of construction. The lintel is to be cured for 7–14 days before form work is removed. Such lintels are useful to span small openings.

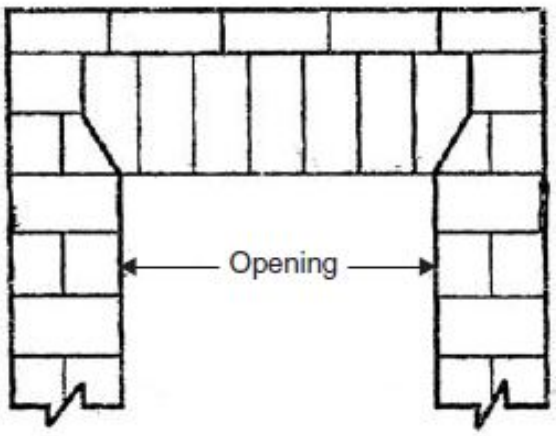


Fig. 8.34. Brick lintel

d. R.C.C. Lintels: It is possible to provide R.C.C. lintels of any span required in the building.They can be isolated or continuous over the openings. They are provided with suitable reinforcement—main reinforcements beings on lower side in the opening. Nowadays these lintels are used very commonly in buildings.

e. Steel Lintels: Steel angles or rolled steel I-sections are used as lintels. Tube separators may be provided to maintain the spacing between the sections. If the sections are opened to atmospheric action, regular painting is necessary. Many times, they are encased in concrete to avoid maintenance problem. These lintels can be used for large openings.

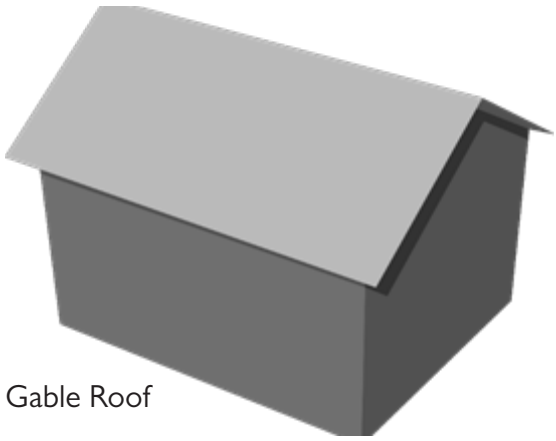
6.4 CONSTRUCTION OF THE ROOF

TIMBER ROOF MEMEBERS

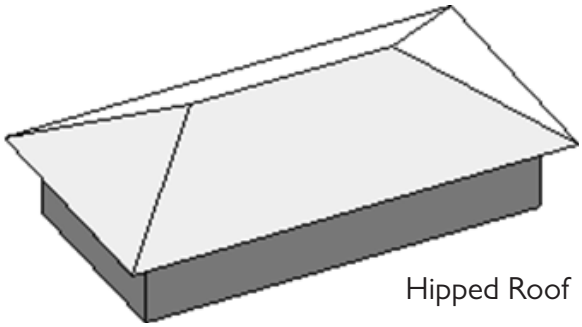
The most important function of roofs is to provide protection from the weather. The main functional requirements of all roofs include the following:

- Weather resistance.
- Strength and stability. The roof must be able to support both dead and live loads. The effect of wind pressure requires special consideration. Wind speeds vary depending on the location of the site, its altitude, and the season of the year. Secure fixing is necessary because uplift in high wind pressure areas may exceed the dead weight of the roof.
- Durability. The quality of the original work and the quality of materials used are important factors in durability. Other factors that affect durability include industrial, natural pollutants and organisms that may attack the roofing materials.
- Thermal insulation. The provision of thermal insulation in roofs is essential to reduce heat loss from the interior of the building and to prevent excessive heat gain from the exterior in hot weather.
- Ventilation. The roof space must be adequately ventilated to prevent condensation.
- Fire resistance. This is necessary to give protection against the spread of fire to and from adjacent buildings, to prevent early roof collapse, and to protect means of escapewhere they occur through the roof.
- Sound insulation. When considering sound insulation, the roof is as important as the
- walls. Most roofs offer adequate levels of sound insulation.

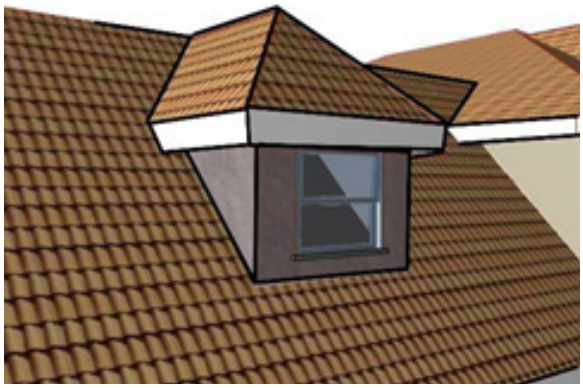
Roof Types



Gable Roof



Hipped Roof



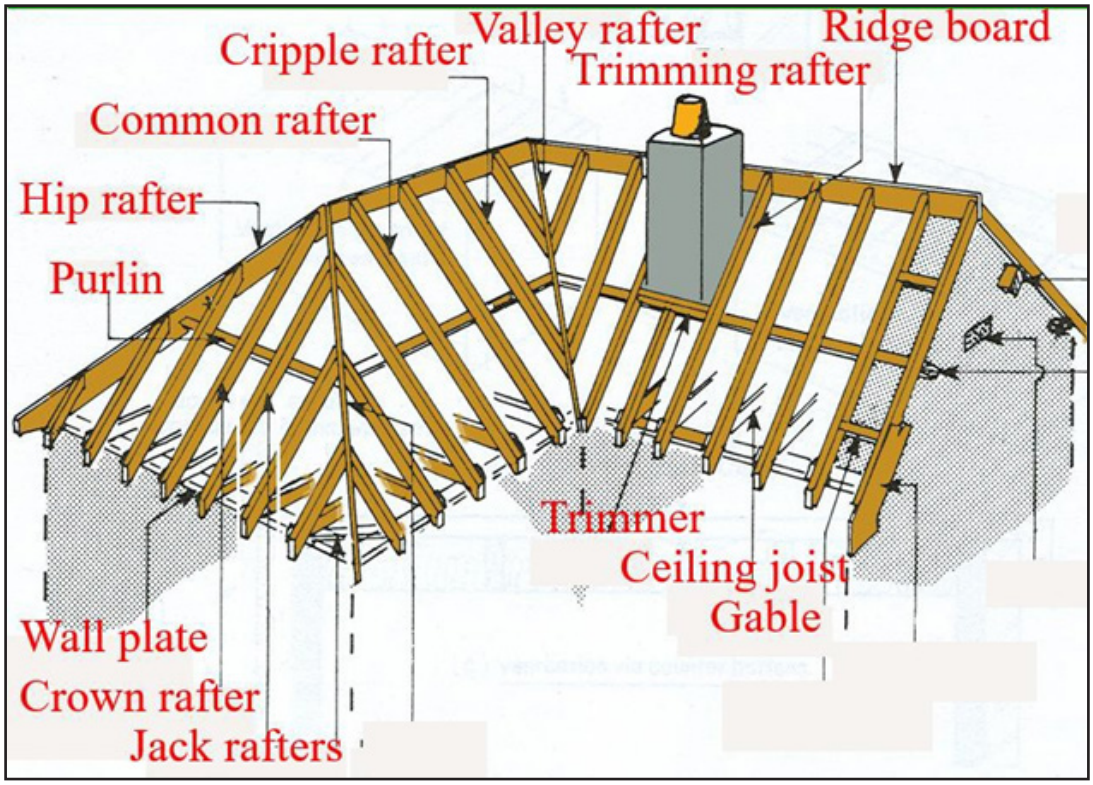
Lean to- Roo

Hipped Gable Roof

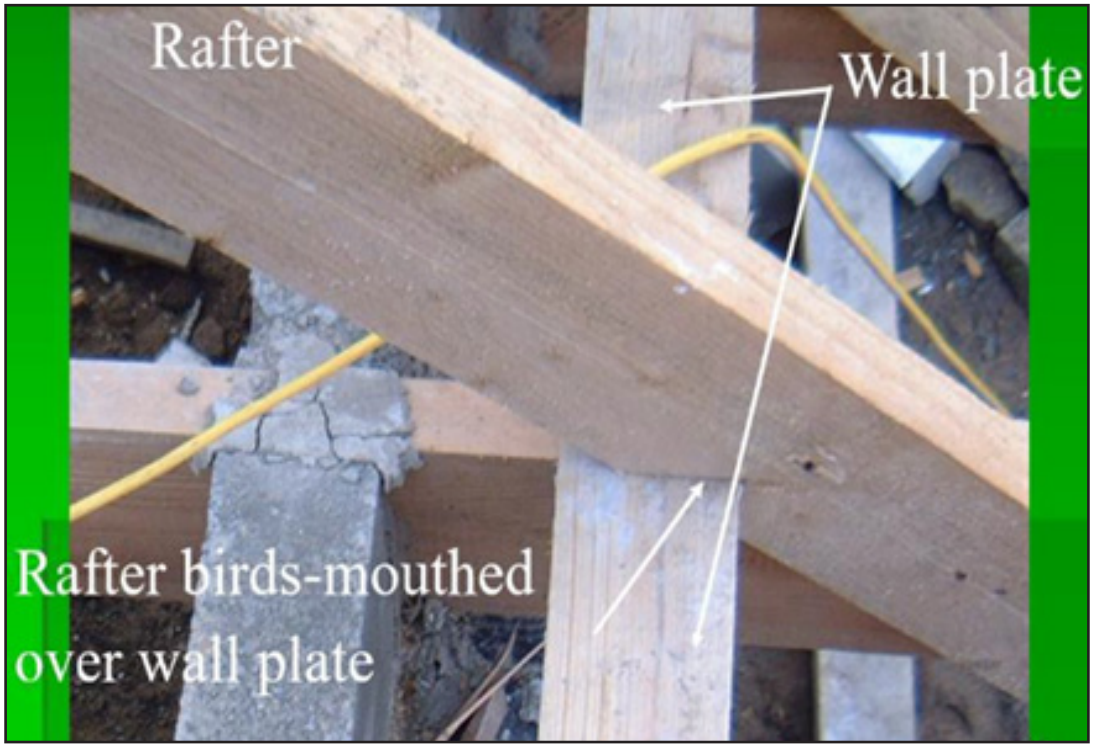
Flat Roof

Dorm Roof

Mansard Roof

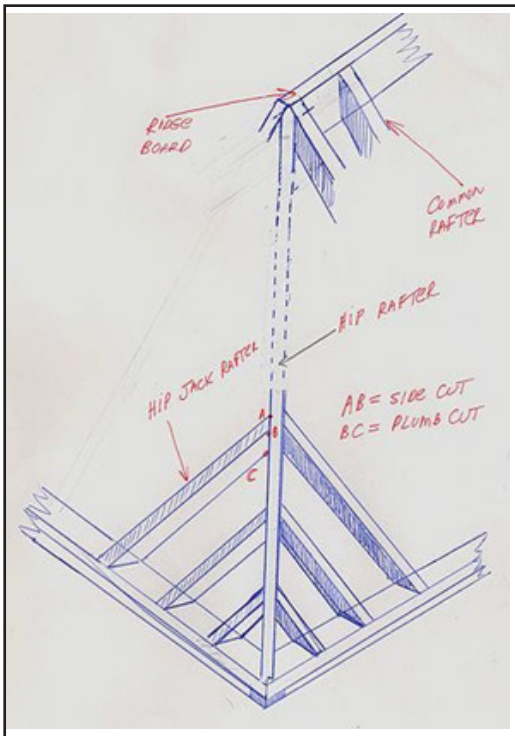


Pitched Roof:



A pitched roof may be defined as any roof surface that makes an angle of between **10° and 70°** to the horizontal. Surfaces below 10° are categorized as flat roofs and surfaces greater than 70° are regarded as walls.

Common rafters. These are the main load-bearing elements of the roof. They span between the wall plate and the ridge. They are notched and nailed to a wall plate, which is in turn secured to a load bearing wall, usually the external cavity walls. The notch is referred to as the bird's mouth, and its depth should not exceed one-third the depth of the rafter.



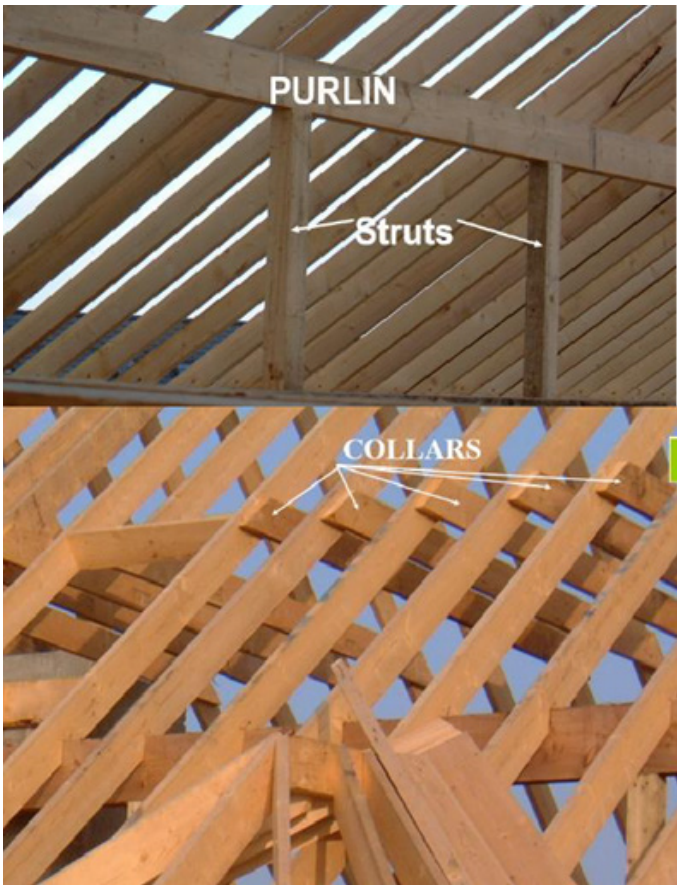
RIDGE. Every pair of common rafters is nailed to a ridge board at the apex of the roof.

HIP RAFTERS. These are longer and heavier than common rafters and are located at the intersection of external angles.

JACK RAFTERS. These are used to fill in the area from ridge to valley rafter or from the hip rafter to the wall plate. Consecutive jack rafters decrease in length by a set amount. The longest jack rafter will be shorter than the common rafter.

VALLEY RAFTERS. Similar to hip rafters except that they are located at the intersection of internal angles.

WALL PLATES. These are fixed to load-bearing walls using galvanized steel straps. The roof members are fixed to the wall plate. Wall plates distribute the loads evenly over the load- bearing walls



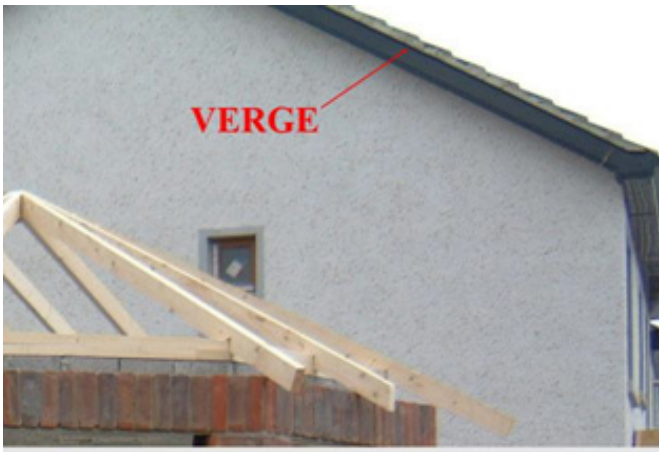
PURLINS. These act as beams and provide support to the rafters. They are usually built-in to the wall in a gable roof.

Purlins are supported by struts which bear onto a load-bearing wall. In a hipped roof they are joined at the corners and supported by struts.

STRUTS. These transfer the loads from the purlin to roof members below. Struts are always in compression.

COLLARS. Usually referred to as collar ties, these connect the common rafters and prevent them from spreading outwards. They are usually positioned from one-third to one-half the height of the rise. Collar ties are in tension

CEILING JOISTS. These tie the roof at the base, on top of the wall plate. They are connected to the rafters and to the wall plate. The spacing of the ceiling joists is important because the plaster boards, which form the ceiling, are fixed to the bottom of the ceiling joists.



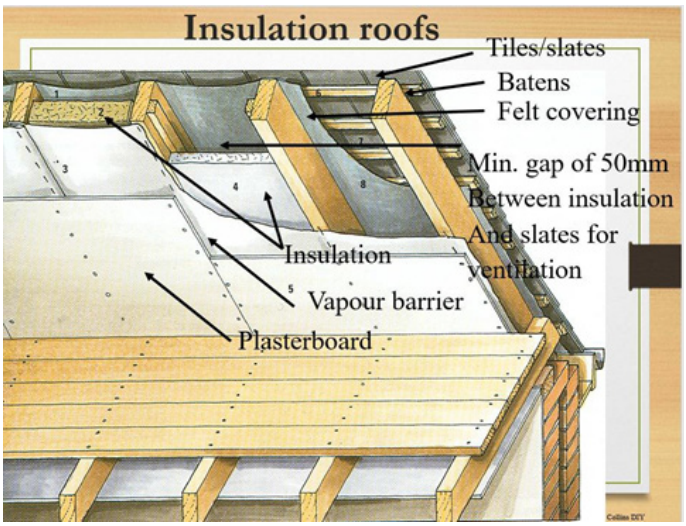
EAVES. The part of the roof that overhangs the walls.

VERGE. The part of the roof covering that overhangs the gable wall

Roofing Ventilation for roofs serves the same purpose as for all other ventilations, i.e. to remove water vapour and prevent condensation. Ventilation has become more important as a result of increased standards of insulation.

Openings should be provided on opposite side of the roof at least equal to a continuous ventilation strip running the full length of the eaves. The width of the strip depends on the roof type.

Vapour barriers reduce the amount of moisture reaching the roof, but are not an alternative to ventilation. Vapour barriers are fixed on the warm side of the insulation. Use 500-gauge polythene with sealed laps



ROOF COVERING

One of the great strengths of our market economy is the number of product choices we are provided with. So, when it comes time to replace the roof on your home there are several roofing products manufactured from a variety of natural and human-made materials from which you can choose. However, the number of choices can be confusing. This information sheet is meant to provide consumers with basic information about common roofing materials used on residential structures.

The five most common groups of residential roofing materials are:

- Asphalt
- Wood
- Metal
- Tile
- Slate

Table 1 gives cost and life expectancy estimates for each material group. A brief description of these five roofing materials and information about product types available within each group is also included in this information sheet.

Table 1: Roofing Material Comparisons

Material	Asphalt	Wood	Metal	Tile	Slate
material cost*	$20-$140	$95-$170	$155-$310	$140-$850	$320-$1200
weight* (Lb.)	195-430	300-400	50-270	900	900
Estimated life expectancy	15-30 years	15-30	20-50	50	50-100+

*Cost and weight figures are per 100 square feet of roof area covered Source: Consumer Reports: August, 1997

ASPHALT ROOFING SHINGLES

Asphalt shingles are the most commonly used material on residential roofs in the United States. And for good reason. This type roofing material is durable, easy to install, and is moderately priced.

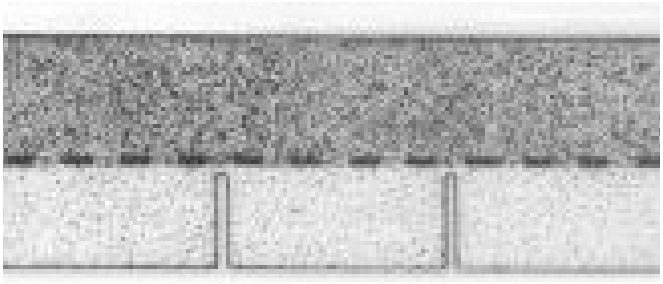
Asphalt roof shingles are composed of a mat core that is coated with multiple layers of asphalt (Figure

1). Pulverized minerals are embedded into the final layer of asphalt on the topside of the shingle. The granules protect the asphalt and mat from the suns damaging ultraviolet rays.

Asphalt shingles are manufactured with either a fiberglass mat-core or an organic mat-core.

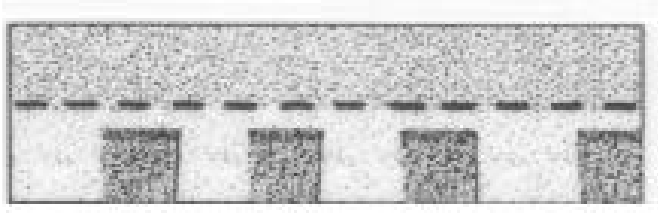
1. Fiberglass Mat-Core Asphalt Shingles: The central core is made from lightweight fiber-glass. The durability and quality of fiberglass shingles has been an issue in the roofing industry in the past. Although these problems have reportedly been addressed by fiberglass shingle manufacturers, The National Roofing Contractors Association recommends using only fiberglass shingles that meet ASTM1standard D6432. This standard is a measure of the tear resistance of fiberglass shingles, which is considered to be an indication of durability for fiberglass shingles. However, Consumer Reports (vol., n. 8 p.26-29) recently tested fourteen types of fiberglass shingles, although the manufacturers of each of these type shingles claimed they met ASTM D6432, only 50% of the fiberglass shingles tested by Consumer Reports actually passed the test.
2. Organic Mat-Core Asphalt Shingles:The central core is made from cellulose fibers. Organic shingles are recommended for extremely cold or windy areas. Most asphalt shingles used in residential work are known as three-tab shingles (Figure 2). Three-tab shingles weigh about 240 pounds per 100 square feet of area and they are typically available with a 15 or 20-year warranty. Heavier, more durable asphalt shingles are also available. But if you want to purchase an asphalt shingle product with a 30- or 40-year warranty you will have to buy laminated shingles, also called architectural shingles (Figure 3). These type shingles are solid across their entire length and width. They consist of multiple mats laminated together within each shingle. They are installed so that three to four

ASTM is an acronym for the American Society for Testing & Materials. It is an international organization made up of engineers, scientists, educators, manufacturers, government agencies, etc. The society determines methodologies for materials testing and sets standards that materials should meet in areas such as strength and durability. ASTM standard D6432 was developed by groups of engineers and scientists who are members of this organization. So, when you see "Meets ASTM Standard D6432" stamped on a bundle of shingles, it is your assurance that this product has met durability criteria as determined by a group of neutral scientists and engineers. Layers of shingles overlap, providing multiple layers of protection from the weather. Architectural shingles are significantly more expensive than 3-tab shingles.



3-TabShingle

Figure2



Laminated Shingle

Figure 3

It is important to note that weight it is not a reliable indicator of the quality and durability of asphalt shingles. Jefferson Kolle (1995) quotes a report written by W. Kent Blanchard for the National Roofing Contractors Association. According to this report..." shingle testing and observation from field performance have frequently shown that weight alone is not a sufficient indicator of shingle quality". Better predictors of a shingle products quality are..." the quality of the individual components of the composite structure, the asphalt, the mat-core and the manufacturing controls". Unfortunately, there is no way a consumer can determine this. Talk to building suppliers and roofing contractors as a method to determine which asphalt shingle products to purchase. They may know which manufacturers reliably produce good quality shingles

and which do not.

WOOD:

Wood roofing products are available in two basic forms:

1. Wood shakes and
2. Wood shingles.

Shingles are produced by sawing wood into long tapered shapes, Shakes are produced by splitting wood into long tapered shapes. Sawing produces, a more uniformly shaped and relatively smooth surface. Splitting produces a rough, highly textured appearance.

Wood shingles and shakes tend to be expensive to purchase and install. In addition, wood is ignited relatively easily, so wood roofing products must be treated with fire retardant chemicals. Even then, wood roofs usually do not qualify for a Class A fire rating, the most fire resistant. This is the reason that building codes in some communities will not permit wood roofs. So, check with your local building department before buying and installing wood shingles or shakes.

The aesthetic beauty of a wood roof is perhaps its greatest advantage. Wood roofs typically provide an interesting and attractive texture and the wood weathers to a beautiful silver-gray color.

METAL:

Metallic coated steel, copper, aluminum, and stainless steel are some metals commonly used for roofing. Galvanized (zinc coated) steel is the most common metallic coating used on steel roofing. Metal roofs are relatively lightweight and vary greatly in price depending upon which type metal is used.

Metal roofing comes in two different forms:

1. agricultural panels and
2. standing seam panels. What follows is a description of each form and advantages and disadvantages of each.

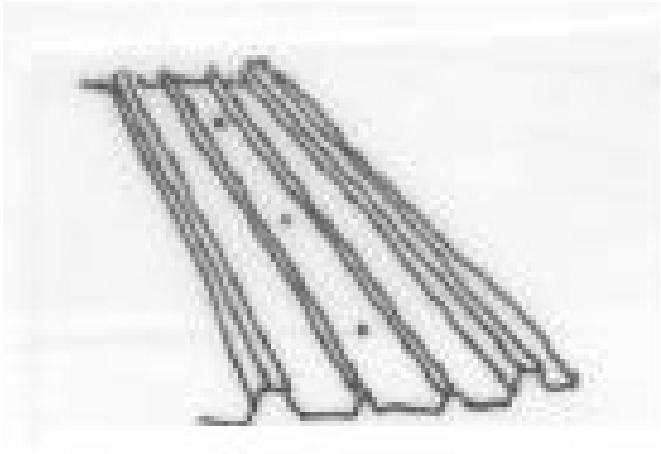
Agricultural Panels:

Agricultural panels have ribbed shapes pressed into them (Figure 4). Exposed fasteners with rubber gaskets are used to attach the panels to the roof deck. Applying this form of metal panel directly to a plywood roof deck usually results in early failure of the roof. The expansion and contraction factor of metal roof panels is so great that the fasteners can become loosened causing panels to blow off. Expansion and contraction can also cause the holes around fasteners to become enlarged, causing leakage. This is the reason that manufacturers of agricultural panels usually do not recommend their use on residential structures.

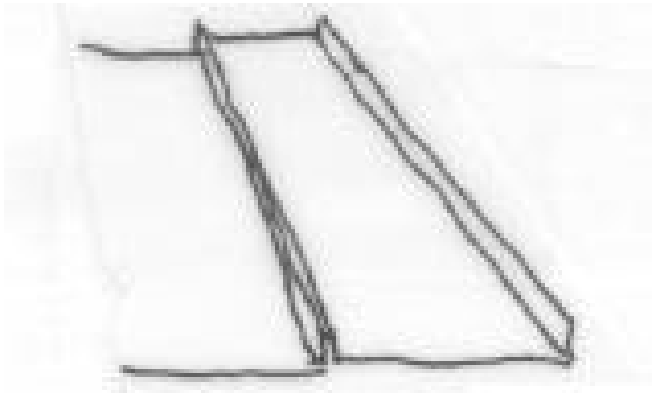
Standing Seam Metal Roofing:

Standing seam metal roofing has folded seams and all fasteners are covered by the seam folds (Figure 5). Copper, easily shaped and highly durable is often used for standing seam roofs.

When highly durable metal is used, coupled with proper installation, standing seam roofs are extremely long lived. Installation of this type roof is labor intensive and requires skilled installers. Therefore, it is best to



leave installation to professionals



Agricultural Panel

Figure 4:

Standing Seam Panel

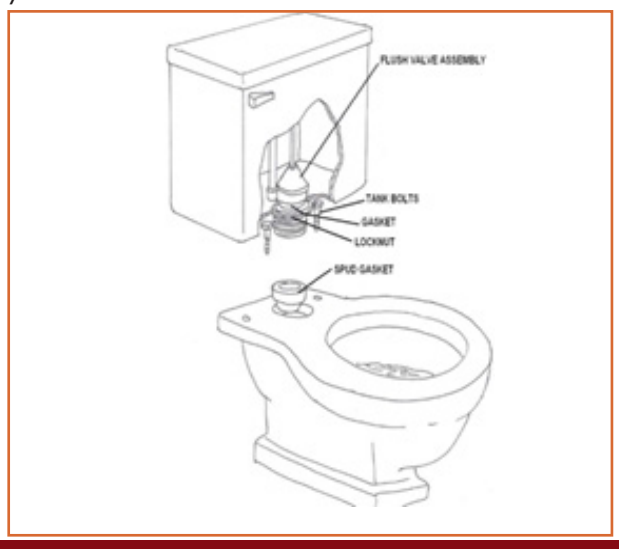
Figure 5:

TILE:

Clay, concrete, and fiber cement are the three most common materials used for roof tiles. Of the three, clay tiles are the most expensive. Tile roofs have a class A fire rating and create a pleasing textured look on a roof. Tile roofs are difficult and time consuming to install.

SLATE:

Slate is probably the most durable roofing material. In fact, the slate will last forever. It is the fasteners that hold the slates to the roof and the flashing's which limit the life of a slate roof? But, if proper fasteners and flashing are used, along with careful installation, a slate roof has a life span of at least 100 years.



6.5 INSTALLATION OF PLUMBING FITTINGS

Water Closets (Toilets)

Closet tanks and bowls are made of vitreous china and are impervious to ordinary household acids. If something more than hot water and soap is needed to clean them, apply a non- abrasive powder or cleaner recommended by your plumber. Many good bowl cleaners are on the market today. Most plumbers however, have found that the "blue water" continuous bowl cleaners tend to accelerate the deterioration of the rubber and neoprene parts in the tank, due to the chemicals they contain. Seat bumpers should be replaced if worn. Defective bumpers may cause breakage of the seat or hinges.

Stains

Stains or moisture at the base of the closet bowl indicate that the joint or seal between the closet and its outlet have failed and should be reset immediately to prevent rotting of the floor, damage to the plaster of the ceiling below, and possible leakage of sewer gas into the home.

Types of Toilets

Water Closet Tanks

If water continues to run into the closet bowl after the toilet is flushed, it is obvious that some part of the mechanism is out of order. When the tank has refilled, if water continues to seep into the bowl or if there is a low humming noise, this indicates leakage from the tank. This leakage can occur from either the supply valve or the improper seating of the rubber tank ball or (flapper) on the discharge opening.

A small amount of food coloring added to the tank water will help you determine whether the tank ball in the bottom of the tank is leaking. Add it to the water after the tank is filled. Watch for the coloring to seep into the toilet bowl, and if it does, the ball or

flapper over the discharge opening is not watertight If the rubber tank ball does not fit tightly over the discharge opening, a defective ball, irregular seat or bent lift wires may be responsible. If the ball is worn out, has lost its elasticity and fails to drop tightly into the hollowed seat, it should be replaced with a new one. Sometimes the ball is covered with a slimy coating which can easily be wiped off.

To replace the ball, shut off the water supply (a stop is installed underneath the tank where the water may be conveniently shut off at this point) and empty the tank or place a stick under the ball float lever-arm to hold it up, thereby shutting off the intake cock and preventing the tank from refilling. Then unscrew the ball from the lower lift wire and attach a new ball of the same diameter as the old one. (Note: some old tank balls swell from age and absorption of water.) If the collar or seat of the discharge opening is corroded or grit-covered, it should be scraped and sand-papered until it is smooth and forms a uniform bearing for the stopper.

Straighten or replace bent lift wires so that the ball drops squarely into the hollowed seat. A leaky, waterlogged float ball holds the supply valve open and does not completely shut off the water. If the rod which connects the tank float to the supply valve has become bent, it may prevent the float from reaching its full height, thus leaving the valve open and allowing leakage. This rod should be straightened and a little oil applied to the lever joints to insure smooth action.

Sometimes the tank will not fill sufficiently or will fill to overflowing. These difficulties may be corrected without disturbing the supply valve by bending the rod attached to the tank float upward or downward. If the rod is bent upward, the water will rise higher in the tank, and if downward, the water level will be lowered. An overflow tube or pipe is provided in the closet tank to take care of the water in case it should rise above its accustomed level which should be at least 3/4 of an inch below the top of the overflow. While there is not much danger of its becoming stopped up, it might be well to examine it occasionally to see that it is in working order. If water rises to the top of the overflow pipe an adjustment or new fill-valve assembly is necessary.

Testing 1.6-gallon toilets against each other

Toilet retrofit programs have save thousands of gallons of water

How a Toilet Works

The toilet is essentially a "trap" just like the one under the kitchen sink but only larger (for obvious reasons).

And like a trap, the fact that water is always present in the bottom (the bowl) it "traps" or prevents sewer gases from backing up into the house

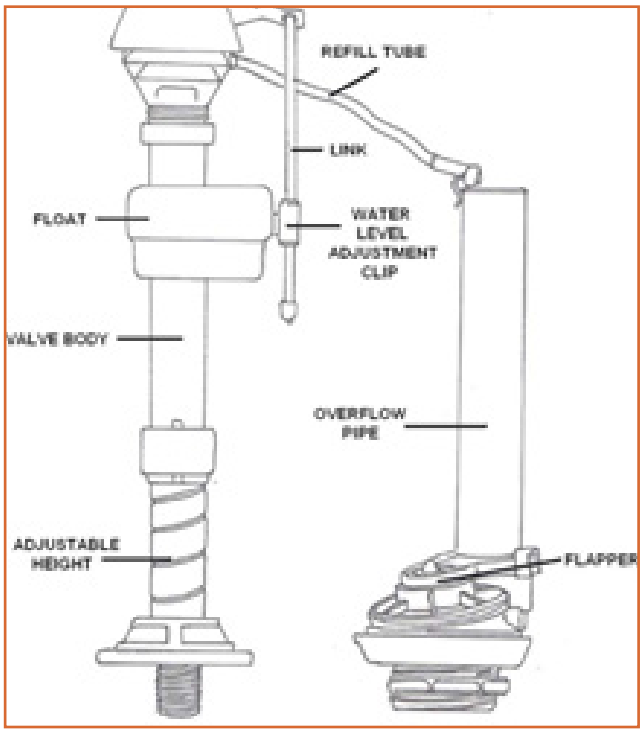
Below are a couple of the principles involved in how a toilet works:

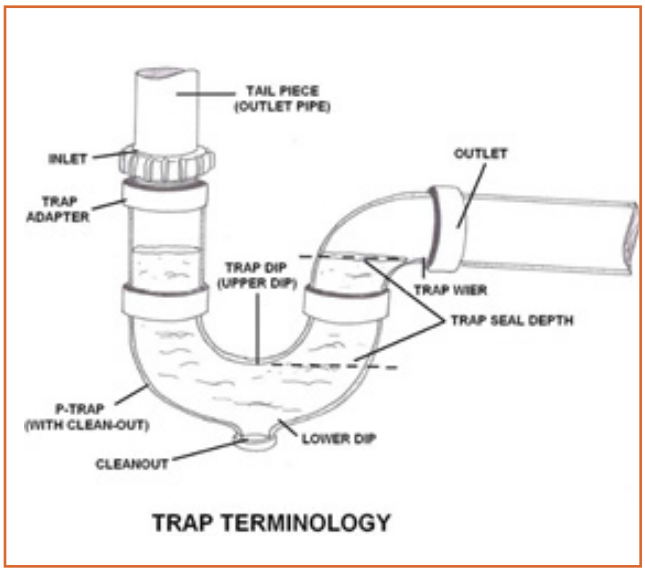
- Water seeks its own level.
- A simple siphon

- Flush or Flood

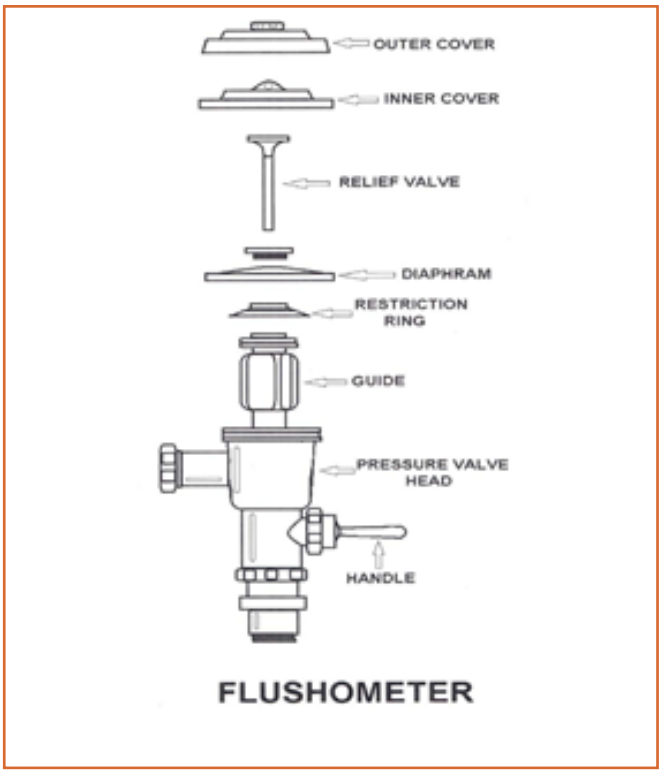
- Momentum

imply speaking, we "flood" a toilet to make it work. When we press the handle on the tank (not shown here), the flapper valve is opened and the water stored in the tank is released into the bowl at a very fast rate causing the water level in the bowl to rise and overflow rapidly. The rising water seeks its own level and overflows down the trap creating a siphon that literally sucks the water out of the bowl. The siphoning continues until the water level in the bowl falls below the lip at the bottom of the bowl. When this happens, air enters the drain path and **"breaks"** the siphon and the flush stops. But since the siphon created such momentum in the moving water the new level in the bowl is considerably lower than before the flush. This is where the standpipe comes in. With the flapper valve closed, the tank starts to fill again and a separate tube directs water down into the standpipe directly into the bowl through a bypass under the flapper valve. This filling of the bowl will stop automatically when the tank is filled. If for some reason the tank float valve (not shown here) fails to shut off the water filling the tank, the water will continue to rise until it reaches the top of the standpipe which will drain the overflow from the tank into the bowl of the toilet. Under these circumstances though, the

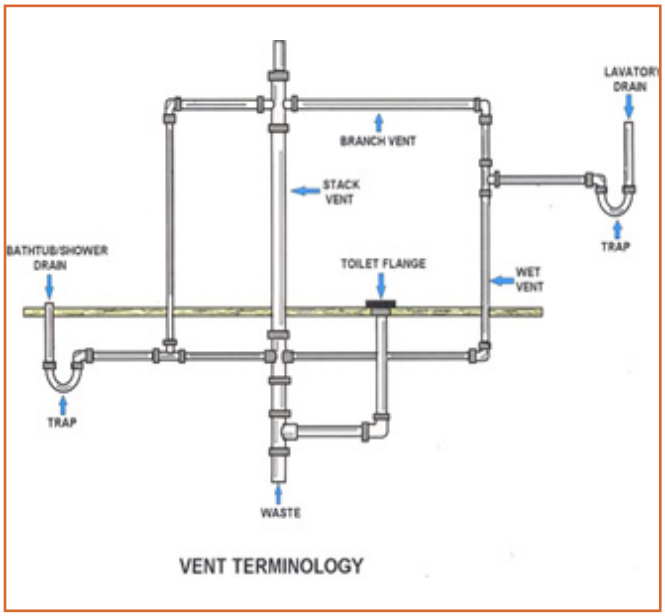




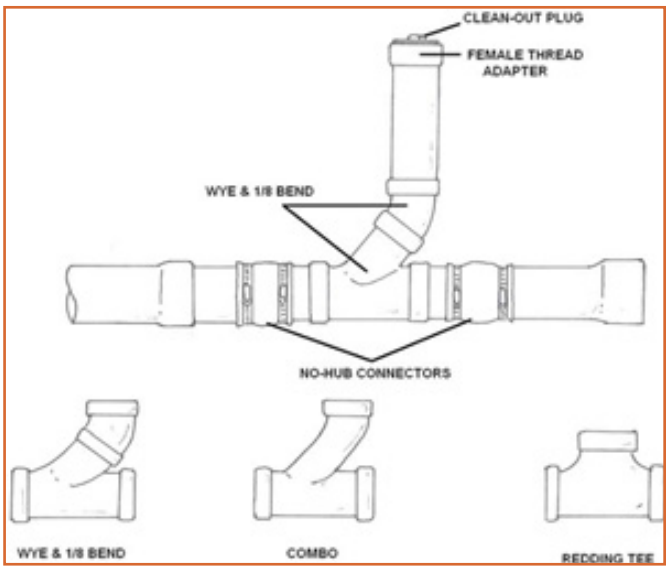
TRAP TERMINOLOGY

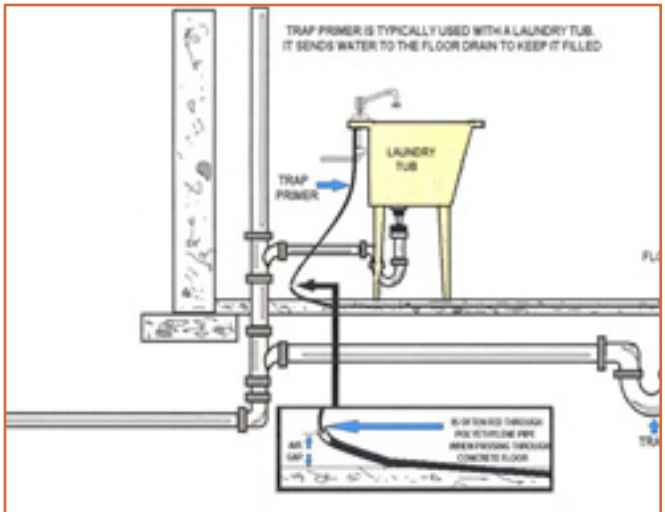


FLUSHOMETER



VENT TERMINOLOGY





TRAP PRIMER

6.6 TAPS, SHOWER ROSE & WASH HAND BASINS

WATER DISPOSAL

Drains & Vents

Odors in the Plumbing System

The well-designed and correctly installed plumbing system is odorless. Odors are most likely to arise from leaks in the waste or vent piping or from traps which have lost their water seal. In an incorrectly installed system, there are, of course, many opportunities for odors to result from defects in the system, particularly if it is not properly vented. Unusual odors should never be ignored. Such odors are often an indication that sewer gas is present. Sewer gas, while not always deadly, is noxious and capable of causing headaches and other minor illnesses. Sewer gas is foul smelling air and should be prevented from entering the house.

If it is suspected that sewer gas is entering through a leak in the piping, a plumber will subject the system to a test either by means of smoke, water or oil. The test will indicate the location of the leak. In order to explain how the sewer gas may enter a house through a plumbing fixture, it is necessary to clarify the function of traps and vents. Every plumbing fixture is the terminus of the city water supply system and the beginning of the city sewerage system. The faucets control the water supply. The traps and vents control the sewer air. They do so by a very simple method. Sewer air will not penetrate a water barrier. Therefore, a device is employed which keeps several inches of water between the house air and the sewer air. This is the trap, which is plainly visible under such plumbing fixtures as sinks and lavatories. It is built into water closets. In the case of bathtubs and shower cabinets, it is usually concealed in the floor or basement.

A trap, however, would lose its water seal by siphonicaction every time a fixture is used unless the air on the sewer side is balanced with the air on the house side. This is the function of the vents. Occasionally, due to changes in atmospheric conditions, a compactly vented trap will lose its seal. Usually, however, when a trap loses its seal it is due either to incorrect design of the vents, absence of vents or to evaporation of the water in the trap. Traps under fixtures that are used infrequently should be filled with water from time to time to insure an adequate trap seal.

Drains

Plumbers get more calls to open clogged drains than for any other service. Many such calls could be prevented by greater care in the use of drains. The most-used drain is the one in the kitchen sink and that is the drain most often clogged. Preventing this situation can be done by carefully watching what is emptied into the sink drain and by the regular use of a safe biodegradable waste digester. Your plumber can give you more information on these products.

Sink Stoppages

Sink stoppages are usually caused by liquid fats, emulsified by warm dishwater and carried through the pipes. The water cools as it proceeds to the main sewer and leaves the fatty deposits along the way. A film of grease forms on the pipe wall, then another and another. Coffee grounds and bits of food add to this accumulation layer until the pipe becomes impassible.

Pour excess grease into a tin can and throw it out with the garbage, not down the sink drain. When using a food disposer, always let sufficient cold water run to carry the particles down and into the main line to prevent buildup in the smaller waste lines.

In the event of a stoppage, you should have a “plumber’s friend,” or plunger - a large rubber suction cup with a wooden handle. Cup it tightly over the drain and plunge it vigorously several times. If it is a double drain sink, make sure you seal the other drain, so

water will not splash out into the other bowl or on you. Drain piping can also be cleaned by removing the J-bend on the trap below the fixture. First place adhesive tape around the packing nut or wrap the wrench jaws with cloth to prevent scratching the metal surface. If plastic piping is in place, do not grip the nuts too tightly with the wrench, as they can crack easily.

Place a bucket directly under the pipe to catch any dripping from the open pipe. Pull out the clogging material with a piece of wire or small hand-turned cable. If you take the trap off, have some new gaskets ready to slip into the joints.

Using A Sewer Snake

Another handy tool is a sewer "snake "or auger. It's basically a flexible metal rod with a spiral hook or ball on the end.

There are two basic snakes: 1) a closet auger with bent tip made to fit in a toilet's built in trap,
a drain auger which is a coiled rod or flattened metal strip. With both augers, when the rod meets an obstruction in the line, tighten the handle and ram the snake into the clog - sometimes that's all it takes to clear the line. Otherwise, crank the rod clockwise so the hook (or ball) snags the clog. Back the snake off slightly, then steadily pushes inward again while turning the handle clockwise until the debris is solidly hooked. Firmly push the snake back and forth until the obstruction is freed. The clog may have moved a bit further down the line just to get stuck again.

So, repeat the procedure while running water and feeding out more line -- all the way to the septic tank or city sewer line connection if possible. Once the clog is gone, reconnect the sink's trap and flush the line with water. Check the connections for leaks. Run more water down the drain and monitor it a few minutes to ensure the clog is gone. If the blockage still remains (like tree roots), you may need to rent a commercial "power" auger with a rotor or blade bit that chops up whatever is in the line.

Toilets

A clogged trap way in a water closet is a ticklish problem, so be careful with whatever method you use for cleaning the drain. Most water closets are made of vitreous china which might crack if exposed to extremely hot water. A plunger will normally handle simple toilet clogs. Another method of cleaning a water closet trap or toilet is the use of an auger with an adjustable, crank-type handle. Known to plumbers as a "snake," the spring-steel coil is easily worked past the trap and down the pipe. A three-foot auger is inexpensive and will quickly drill through most clogs. Use the auger carefully. Careless handling may crack the toilet

Tubs

When trying to clear a plugged bathtub drain, place a heavy cloth in the bottom of the bath tub so your shoe soles won't scratch the bath's enameled surface. Hold your hand or rag over the waste and overflow plate, cup the plunger over the drain and plunge it vigorously several times. If it doesn't open easily, the drain may require cabling to open it. Heavy steel spring coils should not be used to clean traps under lavatories, sinks, or bathtubs. A more flexible type of wire or spring should be used -- one which is easy to work through the bend of the trap.

Floor Drains

To clean out a floor drain, remove the strainer or grating which covers the drain box. The dirt and grease can then be dug out with a spoon or a stick. After that, a hooked wire or coil spring- steel auger will clean out the bend or trap. Check to find out whether a removable clean-out plug has been provided to make this job easier.

Sewer Gases

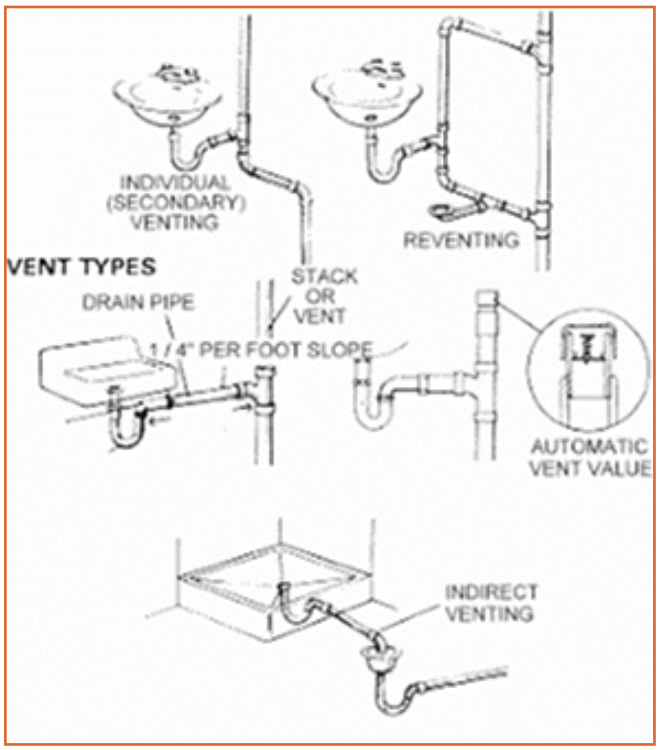
Unclogging Sinks

Hair can often clog a bathroom sink and potato peels and other food waste will plug up kitchen sinks. Regardless of the obstruction, unclogging both sinks are done the same way. Place a plunger over the clogged drain. Add enough water to cover the plunger lip and form a seal. Plunge straight up and down several times and "pop "the plunger away. Repeat this method a few times to free the clog. If the clog remains, position a bucket underneath the sink's trap. Unscrew each end of the trap and drain the water into the bucket. Clean out any debris in the trap and if a kitchen sink has a disposer, disconnect and drain its waste line and clean out any debris. If no significant debris is found in the sink lines, the clog is located in the sink's drain line or main waste line. A clog in the main line will also plug other drains above it, and that needs to be cleared with a sewer snake.

Unclogging A Toilet

Use a "fluted" or funnel plunger designed to seal inside a toilet bowl. Extend the fluted flap of the plunger; fit it tightly inside bowl drain to form a good seal. Plunge up and down several times; to quickly break the seal. Repeat this a few times to work the clog back and forth and eventually free it. If the clog remains, insert a closet auger into the bowl. Position the bent end of the auger into the bowl's trap and fish the rod through until it hits the clog. Crank the auger's handle clockwise and push it into the clog a bit more. Once the clog is "hooked" with the spiral tip (or ball) pull the auger back and forth. Repeat these steps until the clog is freed. Avoid flushing the toilet. It may still be clogged and backup. Instead, fill the bowl with a bucket. If the water level doesn't go down, the clog is still in the line.

Drain-Waste-Vent (DWV) System



The drain-waste-vent system transports all the used water and waste from the house to the septic/sewer system. It's a network of drain pipes that runs to all the sinks, toilets, baths, showers, and washer. Most new waste systems use rigid plastic PVC (polyvinyl chloride) or ABS (acrylonitrile butadiene styrene) pipe that are sealed with glue. Older homes generally have had cast iron pipe sealed with lead solder. However, today's homes may utilize cast iron pipe sealed with neoprene in some places as a way to avoid the noise plastic creates when water is draining through it. The soil stack is the main component of the waste drain. It's a vertical "stack" of pipes that starts in the basement/crawlspace floor or wall where it's connected to the outbound sewer/septic line. The top end of the stack acts as a vent. It extends vertically out through the roof, allowing gases to escape outside and also helps promote drain flow by drawing air inward.

A plugged vent can trap dangerous gases and inhibits drainage; similar to plugging a drinking straw with your thumb to hold liquid. Make sure the vent doesn't terminate in the attic. Trapped sewer gases can be dangerous, stink and cause serious structural problems. And a system without a vent may actually suck water out of a sink's trap, or do the reverse and fill the sink with water when another fixture drains. A trap blocks sewer/septic gas. Without one, sewer gases can flow up the stack, drainpipes and come out wherever there's a drain. A trap looks like a "U" and is installed below the drain. When water drains, the trap's shape causes a small amount of water to remain in the bend. That water blocks any gases from moving up the pipe and entering the room.

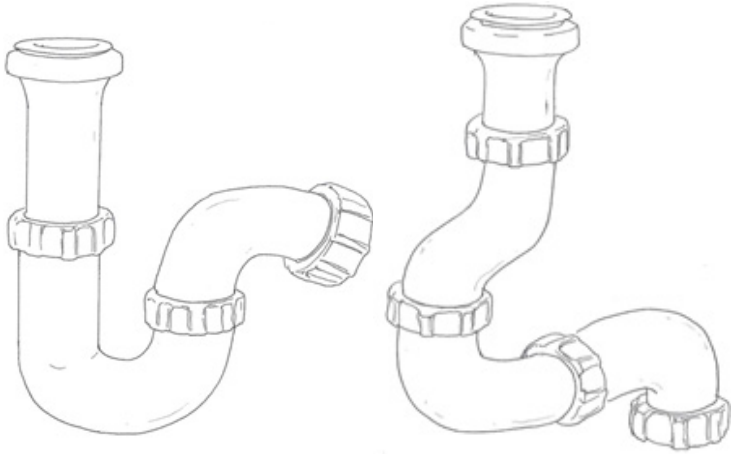
NOTE: Traps are needed on all drains. That is, sinks, tubs, showers, washers, and floor drains all need to have a trap in their drain lines. In most cases, a toilet has a built-in trap and doesn't require a trap in the drain line.

(Source: Council of American Building Officials)

No Hub compression type fitting used on drain, waste and vent lines.

Drain Waste Vent System Installation Most Common Mistakes

1. Violating or ignoring code restrictions,
2. Not installing D/W/V with at least a 1/4" slope per one-foot pipe,
3. Not properly venting or trapping all fixtures,
4. Attaching too many fixtures to a drain or vent pipe,
5. Using pipes that are too small,
6. Not providing enough cleanouts or not providing cleanouts at the prescribed places,
7. Venting the fixture too far from the fixture's trap,
8. Not properly aligning tubing into fittings or stop valves. (Forcing the nut onto the compression ring at an angle when the tubing is at an angle will cause a leak.)
9. Using a fitting in a wrong position,
10. Installing rough plumbing in the wrong location,
11. Reducing pipe size as the pipes run downstream,
12. Cutting pipe too long and not allowing for the ridge in the fittings, and
13. Forcing the trap and waste arm fittings out of alignment and putting too much stress on the nuts and washers in the tubing.
14. Make certain the compression tubing is put in the fittings so that it is evenly tightened.



3/4 S-TRAP

BAG TRAP

Prohibited Joints and Connections in Drainage Systems

Drainage System. Any fitting or connection, which has an enlargement, chamber, or recess with a ledge, shoulder, or reduction of pipe area that offers an obstruction to flow through the drain, is prohibited. No fitting or connection that obstructs flow shall be used. In existing buildings only, a flow control valve or device may be connected to the fixture drain and shall not be considered as an obstruction. The enlargement of a three (3) inch closet bend or stub to four (4) inches shall not be considered an obstruction.

Increasers and Reducers

Different Sizes. Where different sizes of pipes or pipes and fittings are to be connected, the approved proper size increasers, reducers or reducing fittings shall be used between the two sizes.

General Requirements - Material and Design

a. Quality of Fixtures: Plumbing fixtures shall comply with approved designs, be constructed from approved materials, have smooth, impervious surfaces and be free of defects and concealed fouling surfaces.
b. Used plumbing material, equipment and fixtures for plumbing installations shall comply with this Part.
c. Any plumbing equipment condemned by the Department because of wear, damage, defects or sanitary hazards shall not be used in a plumbing system.

Overflows

a. Design. When any fixture is provided with an overflow, the waste piping shall be so designed that the standing water in the fixtures cannot rise in the overflow when the stopper is closed or remain in the overflow when the fixture is emptied.
b. Connection. The overflow pipe from a fixture shall be connected on the house or inlet side of the fixture trap, except that overflows of flush tanks may discharge into the water closets or urinals served by them. No overflow shall be connected to any other part of the drainage system.

Installation

a. Cleaning. Plumbing fixtures shall be installed in a manner to afford easy access for cleaning.
b. Securing Fixtures. Floor outlet or wall hung fixtures shall be secured by screws or bolts of copper, brass, or other equally durable corrosion resistant materials.
c. Wall-Hung Fixtures. Wall-hung fixtures shall be rigidly supported by a concealed metal supporting member so that no strain is transmitted to the fixture connection.
d. Setting. Plumbing fixtures and traps shall be set level and in a true alignment.
e. Water Supply Connection. Hot and cold, tempered and cold, or tempered water only shall be supplied to all plumbing fixtures that are designed for hot and cold, tempered and cold, or tempered water. All mixing faucets and single lever faucets shall have both hot or tempered and cold water connected to them with the hot or tempered water supply on the left side of the faucet. The cross piping of hot or tempered and cold water to a mixing faucet by internal modification of the faucet shall not be allowed. Each lavatory and sink faucet shall have supply pipes which are accessible.
f. Improper Location. Piping, fixtures, or equipment shall not be located or installed in such a manner as to interfere with the normal operation of windows, doors, or other exit openings. Plumbing fixtures shall be installed in an area where there is sufficient room for the fixture to be used for its intended purpose.
g. Where plumbing is installed it shall meet the requirements of the plumbing authority.
h. Surrounding Materials. Where water closets or urinals are installed for public use, the flooring

under the fixture base extending to at least 18 inches from the front and bothsides of the water closet or urinal, and extending from the back of the water closet or urinal to the wall, shall be of non-absorbent material.

i. A hot water heater thermostat shall not be an acceptable alternative water temperature control device.

Prohibited Fixtures

a. Drinking fountains shall not be installed in public toilet rooms.

b. Fixed wooden, concrete, cement or tile wash trays or sinks used for food preparation, utensil washing or hand washing shall not be installed in any food service establishment or commercial food establishment.

Bathtub liners/inserts are prohibited unless all of the following conditions are met:

1. Bathtub liners/inserts must be manufactured to an exact fit over existing bathtubs or be custom fabricated according to the dimensions of an existing bathtub;
2. The floor (bottom surface) of the liner/insert must have a slip resistant surface; and
3. The bathtub liner/insert must be manufactured/ fabricated from high-impact plexi glass/ ABS or acrylic/plastic material.

Indirect Waste Piping

a. Food and Beverage Handling. Commercial dish washing machines, dish washing sinks, pot washing sinks, pre-rinse sinks, silverware sinks, bar sinks, soda fountain sinks, vegetable sinks, potato peelers, ice machines, steam tables, steam cookers and other similar fixtures shall have their drain lines indirectly discharged to a proper receptor. The only exception shall be when such fixtures are located adjacent to a floor drain. The waste may be directly connected on the sewer side of the floor drain trap provided the fixture waste is trapped and vented as required by this Part, and the floor drain is located within 4 feet horizontally of the fixtures and in the same room. In the case of direct connection, no other fixture waste shall be connected between the floor drain trap and the fixture protected. All indirect waste shall discharge to a vented trap located as close as possible to the fixture and in the same room.

b. Connection. Indirect waste connections shall be provided for drains, overflows, and relief valves from the water supply system. A clear water waste shall discharge through an indirect waste into a sanitary or storm drain system located on the same floor.

c. Sterile Materials. Stills, sterilizers and other appliances, fixtures, devices and water and waste connections used for preparation of sterile material shall be indirectly discharged to the drainage system.

d. Swimming Pools. When backwash or other waste water from a swimming pool filter discharges to the sanitary waste system it shall be indirectly wasted. When deck drains around a pool discharge to the sanitary waste system they shall be indirectly wasted.

e. Clear Water Wastes. Water lifts, expansion tanks, cooling jackets, sprinkler systems, drip or overflow pans, or similar devices which discharge clear water only shall discharge indirectly into a building storm drain, building drain or building sewer, located on the same floor.

f. Fire Sprinkler Systems. The relief valve (port) of a backflow device located on afire sprinkler system which contains an additive shall drain indirectly to the building drain.

g. Cleaning. Indirect waste piping shall be so installed as to permit access for flushing and cleaning.

Material and Size

Indirect waste pipe sizes shall be the same as the fixture outlets, but at least three-fourths (3/4) inch.

Length and Grade

a. Maximum Length. The maximum developed length of the indirect waste of any sanitary waste line shall not exceed 5feet.
b. Grade. Indirect waste pipes shall be installed at a uniform grade.

Air Gaps

The air gap between an indirect waste and the drainage system shall be at least two (2) times the diameter of the fixture drains or drainage pipe served, but shall never be less than one (1) inch.

Stack Vents, Vent Stacks, Main Vents

a. aDesign. A properly designed and installed venting system, in conjunction with the soil or waste system is essential to protect trap seals and prevent siphonage, aspiration, or back pressure. The venting system shall be designed and installed to permit the admission or emission of air so that under normal and intended use the seal of any fixture trap shall never be subjected to a pneumatic pressure differential of more than a one (1) inch water column. If a trap seal is subject to loss by evaporation, means shall be provided to prevent loss of the trap seal.
b. Installation. A stack vent, vent stack or a main vent shall be installed with a soil or waste stack whenever back vents, relief vents, or other branch vents are required.
c. Terminal. Vents shall terminate independently above the roof to the outside atmosphere, or shall be connected to another vent at least six (6) inches above the flood- level rim of the highest fixture.
d. Main Stack. Each building in which plumbing is installed shall have at least one main vent stack no smaller than three (3) inches for each building drain installed.

Vent Terminals

a. Roof Extensions. Extensions of vent pipes through a roof shall be terminated at least12 inches above such roof unless a roof is to be used for any purpose other than weather protection. If a roof is to be used for any purpose other than weather protection, the vent shall be extended at least seven (7) feet above the roof.
b. Flashings. Each vent terminal shall be made water-tight with the roof by proper flashing.
c. Location of Vent Terminal. No vent terminal from a drainage system shall be directly beneath a door, window, overhang or other ventilating intake opening of the building, nor shall any such vent terminals be within 12 feet horizontally of such an opening unless it is at least two (2) feet above the top of such opening.
d. Extensions Outside Building. No soil, waste or vent pipe extension (except for vent terminals as provided in (a) and (c) above) shall be located on the outside of a wall of any building, but shall be installed inside the building. Vents located within an exterior wall or in a wall adjacent to an unheated space shall be protected from freezing.
e. Flag poles. Vent terminals shall not be used for the purpose of supporting flagpoles, television aerials, or similar purposes.

Sewer Appurtenances

The structures, which are constructed at suitable intervals along the sewerage system to help its efficient operation and maintenance, are called as sewer appurtenances. These include:

1. Manholes,
2. Drop manholes,
3. Lamp holes,
4. Clean-outs,
5. Street inlets called Gullies ,
6. Catch basins,
7. Flushing Tanks,
8. Grease & Oil traps,
9. Inverted Siphons, and
10. Storm Regulators.

Manholes

The manhole is masonry or R.C.C. chamber constructed at suitable intervals along the sewer lines, for providing access into them. Thus, the manhole helps in inspection, cleaning and maintenance of sewer. These are provided at every bend, junction, change of gradient or change of diameter of the sewer. The sewer line between the two manholes is laid straight with even gradient. For straight sewer line manholes are provided at regular interval depending upon the diameter of the sewer. The spacing of manhole is recommended in IS 1742-1960. For sewer up to 0.3 m diameter or sewers which cannot be entered for cleaning or inspection the maximum spacing between the manholes recommended is 30m, and 300m spacing for pipe greater than 2.0 m diameter (Table 8.1). A spacing allowance of 100 m per 1 m diameter of sewer is a general rule in case of very large sewers (CPHEEO, 1993). The internal dimensions required for the manholes are provided in Table 8.2 (CPHEEO, 1993). The minimum width of the manhole should not be less than internal diameter of the sewer pipes plus 150 mm benching on both the sides.

Table 8.1 Spacing of Manholes

Pipe Diameter	Spacing
Small sewers	45 m
0.9 to 1.5 m	90 to 150 m
1.5 to 2.0 m	150 to 200 m
Greater than 2.0 m	300 m

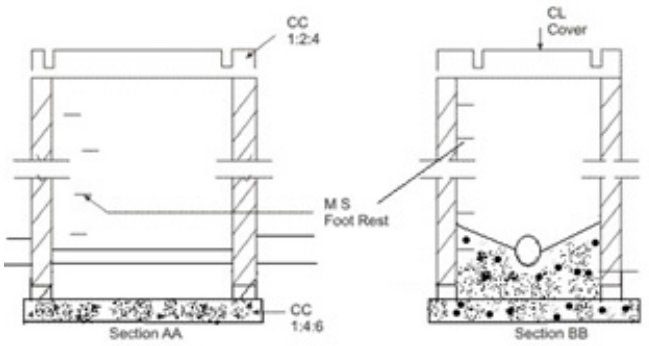
Table 8.2 The minimum internal dimensions for manhole chambers

Depth of sewer	Internal dimensions
0.9 m or less depth	0.90 m x 0.80 m
For depth between 0.9 m and 2.5 m	1.20 m x 0.90 m, 1.2 m dia. for circular
For depth above 2.5 m and up to 9.0 m	For circular chamber 1.5 m dia.
For depth above 9.0 m and up to 14.0 m	For circular chamber 1.8 m dia.

Classification of Manholes

Depending upon the depth the manholes can be classified as:(a) Shallow Manholes, (b) Normal Manholes, and (c) Deep Manholes

Shallow Manholes: These are 0.7 to 0.9m depth, constructed at the start of the branch sewer or at a place not subjected to heavy traffic conditions (Figure 8.1). These are provided with light cover at top and



called inspection chamber

Figure 8.1 Shallow manhole

Normal Manholes: These manholes are 1.5m deep with dimensions 1.0mx1.0m square or rectangular with 1.2 m x 0.9 m (Figure 8.2). These are provided with heavy cover at its top to support the anticipated traffic load.

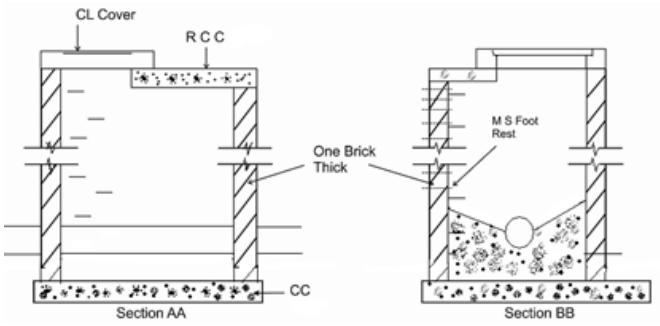


Figure 8.2 Rectangular manhole for depth 0.9 m to 2.5 m

Deep Manholes: The depth of these manholes is more than 1.5 m. The section of such manhole is not uniform throughout (Figure 8.3). The size in upper portion is reduced by providing an offset. Steps are

provided in such manholes for descending into the manhole. These are provided with heavy cover at its top to support the traffic load.

fig a.

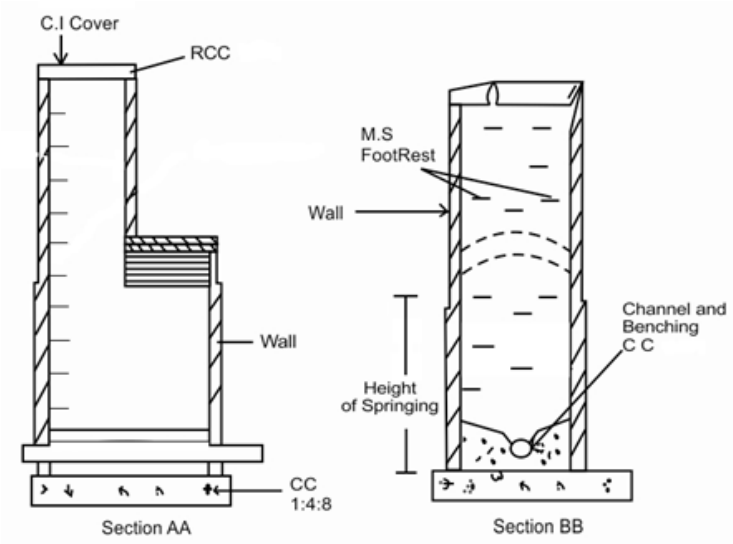


fig. b

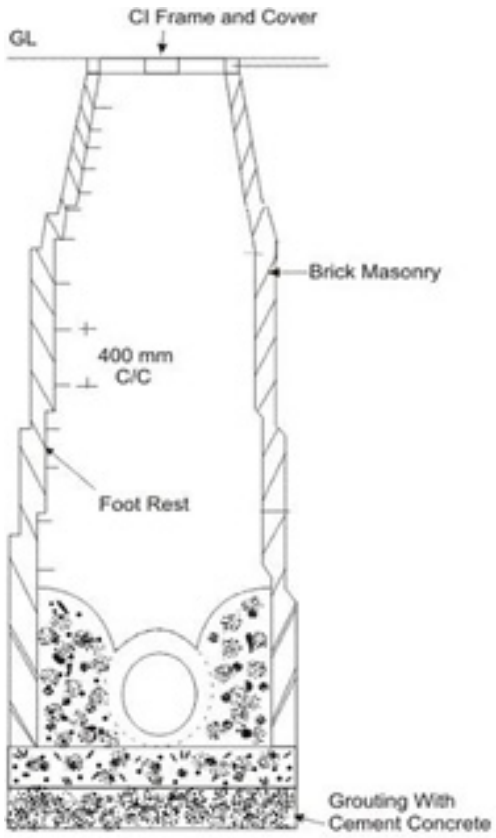


Figure 8.3 (a) Rectangular and (b) Circular deep manhole

Other Types of Manholes

Straight – Through Manholes

This is the simplest type of manhole, which is built on a straight run of sewer with no side junctions. Where there is change in the size of sewer, the soffit or crown level of the two sewers should be the same, except where special conditions require otherwise.

Junction Manholes

This type of manholes is constructed at every junction of two or more sewers, and on the curved portion of the sewers, with curved portion situated within the manhole. This type of manholes can be constructed with the shape other than rectangular to suit the curve requirement and achieve economy. The soffit of the smaller sewer at junction should not be lower than that of the larger sewer. The gradient of the smaller sewer may be made steeper from the previous manhole to reduce the difference of invert at the point of junction to a convenient amount.

Side entrance Manholes

In large sewers where it is difficult to obtain direct vertical access to the sewer from the top ground level due to obstructions such as, other pipelines like water, gas, etc., the access shaft should be constructed in the nearest convenient position off the line of sewer, and connected to the manhole chamber by a lateral passage. The floor of the side entrance passage which should fall at about 1 in 30 towards the sewer should enter the chamber not lower than the soffit level of the sewer. In large sewers necessary steps or a ladder (with safety chain or removable handrail) should be provided to reach the benching from the side entrance above the soffit.

Drop Manholes

When a sewer connects with another sewer, where the difference in level between invert level of branch sewer and water line in the main sewer at maximum discharge is greater than 0.6 m, a manhole may be

built either with vertical or nearly vertical drop pipe from higher sewer to the lower one (Figure 8.4). The drop manhole is also required in the same sewer line in sloping ground, when drop more than 0.6 m is required to control the gradient and to satisfy the maximum velocity i.e., non-scouring velocity. The drop pipe may be outside the shaft and encased in concrete or supported on brackets inside the shaft. If the drop pipe is outside the shaft, a continuation of the sewer should be built through the shaft wall to form a rodding and inspection eye, provided with half blank flange (Figure 8.4). When the drop pipe is inside the shaft, it should be of cast iron and provided with adequate arrangements for rodding and with water cushion of 150mm depth at the end. The diameter of the drop pipe should be at least equal to incoming pipe.

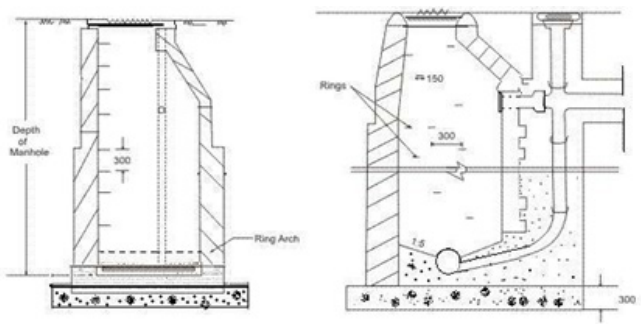


Figure 8.4 Drop manhole

Scraper (service) type manhole

All sewers above 450mm in diameter should have one manhole at intervals of 110 to 120m of scraper type. This manhole should have clear opening of 1.2 m x 0.9 m at the top to facilitate lowering of buckets.

Flushing Manholes

In flat ground for branch sewers, when it is not possible to obtain self-cleansing velocity at all flows, due to very little flow, it is necessary to incorporate flushing device. This is achieved by making grooves at intervals of 45 to 50 m in the main drains in which wooden planks are inserted and water is allowed to head up. When the planks are removed, the water will rush with high velocity facilitating cleaning of the sewers. Alternatively, flushing can be carried out by using water from overhead water tank through pipes and flushing hydrants or through fire hydrants or tankers and hose. Flushing manholes are provided at the head of the sewers. Sufficient velocity shall be imparted in the sewer to wash away the deposited solids. In case of heavy chocking in sewers, care should be exercised to ensure that there is no possibility of backflow of sewage into the water supply mains.

INVERTED SIPHONS

An inverted siphon or depressed sewer is a sewer that runs full under gravity flow at a pressure above atmosphere in the sewer. Inverted siphons are used to pass under obstacles such as buried pipes, subways, etc. (Fig.8.5). This terminology 'siphon' is misnomer as there is no siphon action in the depressed sewer? As the inverted siphon requires considerable attention for maintenance, it should be used only where other means of passing an obstacle in line of the sewer are impracticable.

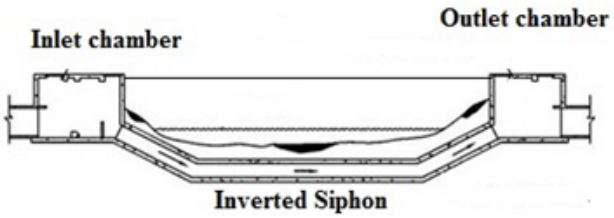


Figure 8.5 Inverted siphon

STORM WATER INLETS

Storm water inlets are provided to admit the surface runoff to the sewers. These are classified in three major groups viz. curb inlets, gutter inlets, and combined inlets. They are provided either depressed or flush with respect to the elevation of the pavement surface. The structure of the inlet is constructed with brick

work with cast iron grating at the opening confirming to IS5961. Where the traffic load is not expected, fabricated steel grating can be used. The clear opening shall not be more than 25mm. The connecting pipe from the street inlet to the sewer should be minimum of 200mm diameter and laid with sufficient slope. A maximum spacing of 30 m is recommended between the inlets, which depends upon the road surface, size and type of inlet and rainfall.

Curb Inlet: These are vertical opening in the road curbs through which storm water flow enters the storm water drains. These are preferred where heavy traffic is anticipated (Figure 8.6a).

Gutter Inlets: These are horizontal openings in the gutter which is covered by one or more grating through which storm water is admitted (Figure 8.6b).

Combined Inlets: In this, the curb and gutter inlet both are provided to act as a single unit. The gutter inlet is normally placed right in front of the curb inlets.

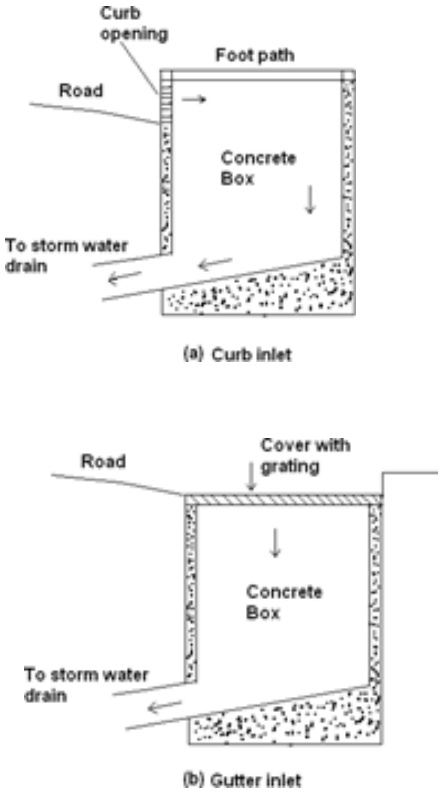


Figure 8.6 (a) Curb inlet and (b) Gutter inlet

CATCH BASINS

Catch basins are provided to stop the entry of heavy debris present in the storm water into the sewers. However, their use is discouraged because of the nuisance due to mosquito breeding apart from posing substantial maintenance problems. At the bottom of the basin space is provided for the accumulation of impurities. Perforated cover is provided at the top of the basin to admit rain water into the basin. A hood is provided to prevent escape of sewer gas (Figure8.7).

CLEAN-OUTS

It is a pipe which is connected to the underground sewer. The other end of the clean-out pipe is brought up to ground level and a cover is placed at ground level (Figure 8.8). A clean-out is generally provided at the upper end of lateral sewers in place of manholes. During blockage of pipe, the cover is taken out and water is forced through the clean-out pipe to lateral sewers to remove obstacles in the sewer line. For large obstacles, flexible rod may be inserted through the clean-out pipe and moved forward and backward to remove such obstacle.

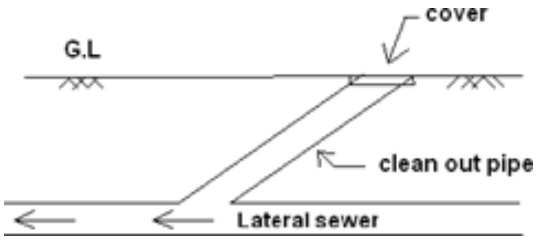


Figure 8.8 Clean-out

REGULATOR OR OVERFLOWDEVICE

These are used for preventing overloading of sewers, pumping stations, treatment plants or disposal arrangement, by diverting the excess flow to relief sewer. The overflow device may be side flow or leaping weirs according to the position of the weir, siphon spillways or float actuated gates and valves.

Side Flow Weir

It is constructed along one or both sides of the combined sewer and delivers the excess flow during storm period to relief sewers or natural drainage courses (Figure8.9). The crest of the weir is set at an elevation corresponding to the desired depth of flow in the sewer. The weir length must be sufficient long for effective regulation of the flow.

fig a.

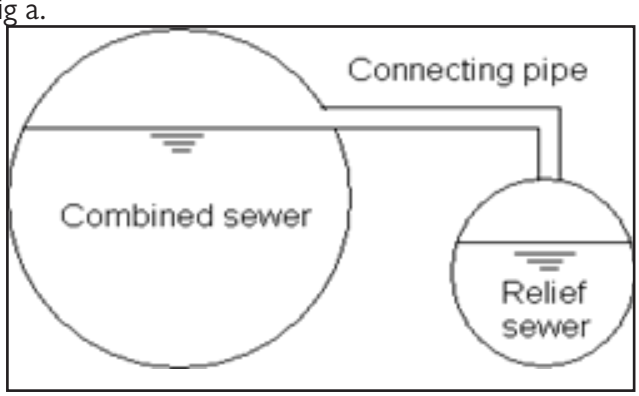


Fig b.

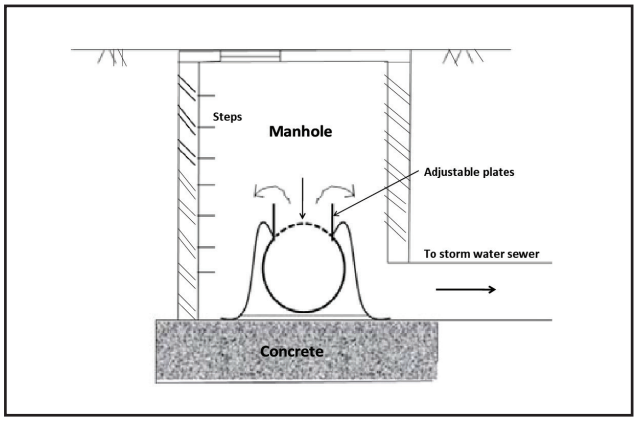


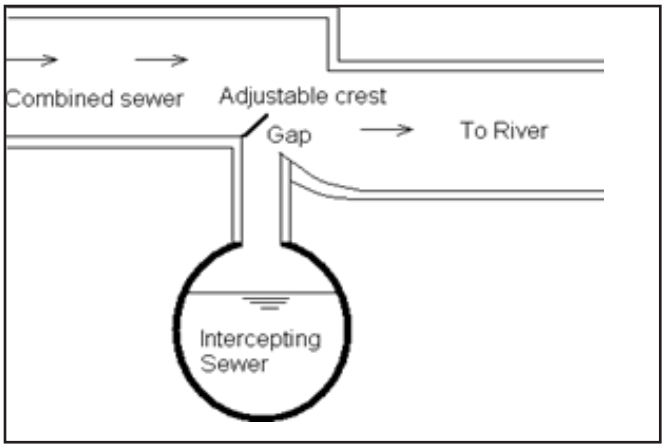
Figure 8.9 (a) Side flow weir (b) Overflow weir arrangement

Leaping Weir

The term leaping weir is used to indicate the gap or opening in the invert of a combined sewer. The leaping weir is formed by a gap in the invert of a sewer through which the dry weather flow falls and over which a portion of the entire storm leaps. This has an advantage of operating as regulator without involving moving parts. However, the disadvantage of this weir is that, the grit material gets concentrated in the lower flow channel. From practical consideration, it is desirable to have moving crests to make the opening adjustable. When discharge is small, the sewage falls directly into the intercepting sewer through the opening. But when the discharge exceeds a certain limit, the excess sewage leaps or jumps across the weir and it is carried to natural stream or river. This arrangement is shown in the Figure 8.10.

Float Actuated Gates and Valves

The excess flow in the sewer can also be regulated



by means of automatic mechanical regulators. These are actuated by the float according to the water level in the sump interconnected to the sewers. Since, moving part is involved in this, regular maintenance of this regulator is essential.

Siphon Spillway

This arrangement of diverting excess sewage from the combined sewer is most effective because it works on the principle of siphonaction and it operates automatically. The overflow channel is connected to the combined sewer through the siphon. An air pipe is provided at the crest level of siphon to activate the siphon when water will reach in the combined sewer at stipulated level (Figure8.11).

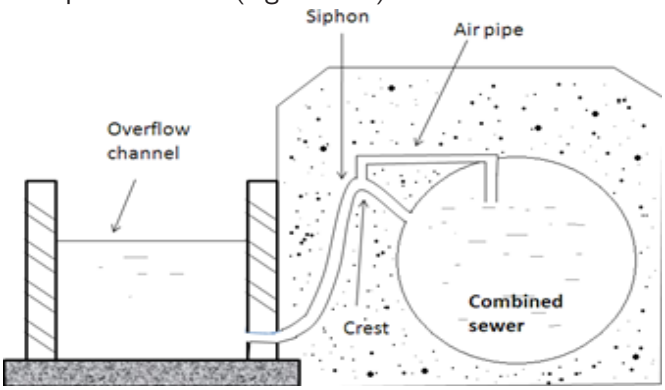


Figure 8.11 Siphon spillway

FLAP GATES AND FLOODGATES

Flap gates or backwater gates are installed at or near sewer outlets to prevent back flow of water during high tide, or at high stages in the receiving stream. These gates can be rectangular or circular in shape and made up of wooden planks or metal alloy sheets. Such gates should be designed such that the flap should get open at a very small head difference. Adequate storage in outfall sewer is also necessary to prevent back flow into the system due to the closure of these gates at the time of high tides, if pumping is to be avoided.

SEWER VENTILATORS

Ventilation to the sewer is necessary to make provision for the escape of air to take care of the exigencies of full flow and to keep the sewage as fresh as possible. In case of storm water, this can be done by providing ventilating manhole covers. In modern sewerage system, provision of ventilators is not necessarily due to elimination of intercepting traps in the house connections allowing ventilation.

LAMPHOLE

It is an opening or hole constructed in a sewer for purpose of lowering a lamp inside it. It consists of stoneware or concrete pipe, which is connected to sewer line through a T-junction as shown in the Figure 8.12. The pipe is covered with concrete to make it stable. Manhole cover of sufficient strength is provided at ground level to take the load of traffic. An electric lamp is inserted in the lamp hole and the light of lamp is observed from manholes. If the sewer length is unobstructed, the light of lamp will be seen. It is constructed when construction of manhole is difficult. In present practice as far as possible the use of lamp hole is avoided. This lamp hole can also be used for flushing the sewers. If the top cover is perforated it will also help in ventilating the sewer, such lamp hole is known as fresh air inlet.

6.6 CARPENTRY AND JOINERY

DOOR AND WINDOW FITTINGS

i. **Frames:** There are two basic types of door and window frames: the traditional system of interlocking wood members and the integral-flange metal sections. Variations of the latter include metal clad and plastic coated, but they are similar in sections and dimensions and equal in performance. Also, among the metal types are those designed to be installed in wood-frame buildings and those designed for concrete openings. We will not deal with those frames that are designed for concrete-type openings, except to mention that they are not intended (we hope) to be installed in wood-frame buildings. To use this type of section in wood-frame buildings is to invite disaster. If such installations are required, the designer must pay very close attention to the detailing.

ii. **Doorsills:** In general; door openings should be handled in the same way at the head and jambs a are windows. Sills require somewhat different treatment. The sill portion of wood-frame door assemblies is susceptible to water penetration and must be correctly detailed. Sometimes door sills are made from decay-resistant wood or metal, and are not susceptible to decay. However, water penetration under the sill and in the surrounding framing members is particularly troublesome.

iii. **Installation of Membrane Around Doorsills:** Special attention should be paid to the jamb-sill corner at the door sill. This edge condition, when not properly detailed, will allow water penetration to the wall interior. (Figures 8-IA to 8-IG) illustrate the proper installation of felt membrane around a door sill in a step-by-step manner.

WOOD FRAMES

To make a watertight frame head condition, two facts should always be remembered: water wants to run downhill, and wind will push it horizontally or up vertically. If the designer keeps these facts in mind and makes provision for them, particularly at corners or intersections, the opening probably will perform well. Other important considerations are the following:

1. Elements of a Good Wood Door

Sill Detail

The wood door sill should be made from naturally decay-resistant wood or should be chemically treated. Adequate sill sections can be milled from clear vertical grain stock (see Figure 8-5 for a good sample section). The sill should be cut so that it covers the exterior siding material by at least 3/4 inch. If the sill does not provide such coverage, or if the sill is exposed to severe environmental conditions, metal flashing should be used to protect the joint from wind-driven rain. The underside of the sill should be sloped downward at least 12 degrees; otherwise a drip cut should be provided. To be effective, a drip cut must be at least 1/4-inch-wide by 1/4 inch deep. To further protect against wind-driven rain, the felt membrane behind the siding material should continue to run under the door sill as illustrated. Figure 8-6 illustrates a poorly designed wood door sill section.

METALFRAMES

General

Because of the wide detail venison in metal doors and windows, it is almost impossible to give general guidelines that will govern all conditions. However, having said that, now let us try. At the risk of being repetitious; water wants to run downhill and that wind will push it both horizontally and vertically. Pay attention and make provisions for this, particularly at corners and intersections.

i. When possible, use units with welded corners that have a continuous, unbroken nailing flange. These units provide an easier task of keeping the water out of the building framing. Simply follow the guidelines set forth in membrane installation in Chapter3.

ii. (iWhen welded comers are not feasible, such as in sliding door units and other knockdown assemblies, other steps must be taken:

- √ On the backside of the frame, apply large, heavy globs of sealant continuously along all metal-to-metal joints. This sealant must be applied to clean metal and must lap surfaces at least 3/8 inch to obtain good adherence to both legs. Sealant must also have enough body to withstand the racking of the frame during installation, plus future movement.
- √ Sealant can also be used when nailing flanges are mitered.
- √ When nailing flanges are notched (as in most door cases), a metal comer piece set in sealant is the most foolproof. However, pressure¬ sensitive waterproof tape can also do a good job. Again, allow lots of overlap of tape to metal.

Windows

Figure 8-7 illustrates the desirable characteristics of a good metal window with nailing flanges. The length of the flange should be "A" dimension (see Table 3-1 in Chapter 3). The horizontal ledges should be sloped a minimum of 12 degrees. Weep slots and drip edges are also desirable to remove collected water.

Metal Window in Plywood Panel Siding (Figures 8-8 to 8-10)

If trim is desired in apply wood panel system, it should be of a solid lumber stock (i.e., not plywood) and should be sloped on top at least 12 degrees. In addi¬tion, sealant should be provided at the top of the trim to keep moisture away from the inner surface in between the siding and the trim; this area is vulnerable to decay. Sill trim should also be sloped on the top sur¬ face and sealant applied to this area to protect against wind-driven rain that pushes moisture over

the edge of the panel and wets the backside.

Metal Window in Lumber Siding (Figures 8-11 to8-13)

In a lumber siding system, flashing should be provided over the head trim. Optimally, the top of the head trim should be sloped and should extend to the outer edge of the jamb trim. Lumber siding should be butted against the head while it is covered by the jamb trim. This avoids an open joint between the jamb trim and the siding, where the membrane will be exposed. As usual, drip cuts should be provided where needed, and all horizontal ledges should be sloped to aid drainage.

Elements of a Good Metal Door Sill Detail

Extruded aluminum sills are good alternatives for wood sills because they are unaffected by moisture. From the many commercially available sections, sill sections with a longer "leg" on the exterior side are preferable. This leg covers the upper edge of the exterior siding material and protects this joint from wind-driven rain (see Figure 8-14). If a sill without a leg is used, or if the leg covers less than 3/4 inch of the exterior material, flashing should be provided (see Figure 8-15). Figure 8-16 illustrates a poorly designed metal door sill detail. Metal sills are usually fastened to the subfloor by long screws. The screw penetration holes are vulnerable points because they are not watertight. The felt membrane should be continuous under the sill and extend beyond the screw holes.

6.7 BUILDING FINISHES

WINDOWS

BASIC TYPES OF WINDOWS

Windows can be classified into types based on their configuration, or by the material they are made of.

FIXED WINDOWS

This is the simplest type of window. It cannot be opened or closed, which makes it the most weather-proof of windows.

CASEMENT WINDOWS

A casement window is one that is hinged on its side, and normally opens outwards rather than inwards. This makes it very easy to operate. Since it opens outwards, it cannot be used in some situations, such as when the window opens out into a corridor, as it will block movement. These windows are designed to resist rain and wind from the outside in, so their direction cannot be reversed.

SLIDING WINDOWS

A sliding window moves within its own plane. These may require effort to move them back and forth, and so may not be best suited for use by the elderly. A disadvantage of sliding windows is that they cannot be opened fully, in the sense that there is always a fraction of the window that is closed. Most often, this fraction will be one half, one third, or one quarter. Each shutter rides in its own track, like trains. These windows can be named by the number of tracks they have: double track sliding windows, or triple track sliding windows. It is possible for more than one shutter to ride in the same track: for example, a four-shutter sliding windows can have two tracks; the maximum opening will be one half. One advantage of sliding windows is that they do not require any space outside the plane of the window, so they are ideal for use between two internal spaces, such as between an office cabin and a corridor.

SINGLE HUNG WINDOWS (VERTICALLY SLIDING)

A hung window is one that slides vertically. A single hung window has one fixed pane and one sliding shutter. The fixed pane is typically above the sliding shutter, so only the bottom half is openable. These are similar to sliding windows in that a fraction of the window is not open to the outside.

DOUBLE HUNG WINDOWS (VERTICALLY SLIDING)

A double hung window has two sliding shutters, one above the other. Either the top or bottom half can be opened. Such windows are not very common, as it is unusual to want the top half of the window to be opened. The term hung windows is common in the United States; these are called sash windows in Europe. A sash is a frame, usually filled in with glass, that forms the moving part of the window. The fixed part is the window frame.

AWNING WINDOWS OR VENTILATORS

An awning window is hinged on its top edge, so that it opens upwards and out. These are also called ventilators. An awning window can be difficult to operate, especially if it is heavy. These require stays to keep them open; their weight naturally forces them to close.

PIVOTING WINDOWS

A pivoting window rotates on a vertical axis, which is usually placed in the exact centre of the window, so that the window is properly balanced. Pivoting windows are sometimes found in old church buildings (in warm climates), as they have windows that are very narrow and tall. These windows are rarely used in residential or office construction in contemporary times. They are unique in the sense that half the window opens inside, and half outside, and the frame of the window has to be designed to accommodate this function.

SLIDING FOLDING WINDOWS OR BI-FOLD WINDOWS

These are high-performance windows; they hinge out as well as slide on a single track. They are used for some very wide openings; the window system can be slid to one or both sides, thus creating an unobstructed view to the outside. Every alternate shutter is attached to a roller that slides along the upper track of the window.

MATERIALS FOR WINDOWS

Windows can be classified into types based on their configuration, or by the material they are made of. Windows are most commonly made of the following materials:

i. Aluminum
ii. Wood
iii. uPVC and similar plastics
iv. Steel
v. Glass-fiber-reinforced plastic (GFRP)

When we say "a window is made of...", we are referring to the frame. The infill is usually glass, but can also be of other transparent materials, such as polycarbonate.

ALUMINIUM WINDOWS

Aluminum is a light, strong material that is excellent for windows. It does not warp, expand or shrink in the presence of moisture, as wood does. It is easy to cut and join together. It can be powder coated or anodized in the factory so that it never needs painting during its lifetime. It is also corrosion resistant. The one drawback of aluminum is that it conducts heat rapidly, and so causes heat to be lost to the outside in cold climates. The solution for this is to design the window sections with a thermal break, or a layer of a non-conductive material that prevents the flow of heat. Aluminum is made into extrusions at the factory. An extrusion is long piece of aluminum that has the same cross section along its entire length. These can also be called sections in the building trade. An extrusion is made by melting ingots of aluminum, and then pushing the molten metal through a die that gives it the desired cross-section. Key factors in the popularity of aluminum windows are: they are light, which allows easy operation, they are attractively finished, and need little or no maintenance.

WOODEN WINDOWS

Wood has been the material of choice for windows for many centuries. It is readily available, is easily worked on at site, and is a poor conductor of heat. Its drawback is that it is expands or shrinks with changes in moisture. This can cause windows to jam or warp. It can also decay in the presence of continuous moisture. Wood also needs painting or polishing to maintain its appearance. While wood was abundantly and cheaply available till the middle of the twentieth century, it is now both expensive and difficult to procure high quality, defect free wood sections. It is likely that the use of wood in windows will decrease in the future.

UPVC AND SIMILAR PLASTIC WINDOWS

Plastics are becoming increasingly common in residential windows. Plastics are light, do not warp, shrink, or decay, and have a reasonably attractive finish that does not need maintenance. However, plastics are weak compared to aluminum or steel. This is why plastic windows are often reinforced with galvanized steel sections that are hidden within the plastic tubing. Plastics also have a high coefficient of thermal expansion, which can cause problems for windows. Many plastics are also not resistant to UV light, a component of sunlight. Plastics in windows have to be specially formulated to ensure they do not become brittle, crack, or change color during exposure to sunlight. this is called making materials UV stable. In general, plastic windows are cheaper than aluminum or wood.

STEEL WINDOWS

Steel is a very strong material, which allows steel windows to have the thinnest possible frames of all materials, maximizing views. Unlike aluminum, it is difficult to cut and work, so site work has to be kept to an absolute minimum. Steel corrodes in the presence of moisture, so it must be galvanized or treated with a high-quality moisture resistant painting process. Like aluminum, it is a good conductor of heat, so steel windows must have thermal breaks put in.

GLASS-FIBRE-REINFORCED PLASTIC WINDOWS (GFRP)

GRFP windows are a recent addition to the range of window solutions. These are made of high-quality plastics that are reinforced with glass fibers, giving them high tensile strength and stiffness. As such, they share a mixture of the good qualities of metals (high strength, low weight) and plastics (no warping, no corrosion, good finish). As they are a new entrant, it remains to be seen how they will perform in the long run.

OTHER MATERIALS

Windows can also be made of other metals, such as bronze and stainless steel.

WALL RENDERING

Introduction

Renders are external coatings applied to buildings. As with mortars for bedding and pointing, these must allow for flexibility and the evaporation of water. In Ireland, apart from major public and ecclesiastical buildings, whose exteriors are often of exposed ashlar stonework, the most common external finishes to buildings are renders applied to rubble stone walls. This finish, in its varying forms, gives an overall sculptural effect and contributes to the character of buildings of town and countryside. Renders are less expensive to apply than good quality stonework and they often hide poor quality work. They are extremely practical in providing an extra layer of protection while themselves remaining porous. They are also a medium for decoration, both painting and applied modeled/decorative work.

Brief History

Renders commonly used in this country are:

a. A simple buildup of lime washes
b. Weak/thin coatings used on vernacular buildings
c. Rough cast which is a wet dash otherwise known

as 'harling'

d. Oil mastic stucco

e. Lime and cement stucco/Roman cements

a), b) and c) are the oldest form of coatings; d) was developed around the mid-18th century. Various oil mastics were made from mixes of sands, limestone, dust, whiting and powdered pottery. Mixes were gauged with oil immediately prior to application in the form of thin coats to a background pre- coated with linseed oil. The coating was pressed on in suitable widths with a floating tool. These coatings are difficult to distinguish visually from others and only by examination do they become evident. This material was also used for modeling/decorative work; was developed towards the end of the 18th century. There is also applied decoration, in particular to facades in towns and modeled architectural features to door and window surrounds and cornices, adding distinctiveness to individual houses and terraces. Coad stone - an artificial, cast 'stone' - in the roof of panels and features was also usedA.t the end of the 18th century there was much experimentation with various compositions for surface coatings. Roman cement was commonly used, ruled out to give the appearance of stonework. This was often painted but sometimes left unpainted. The stucco finish of the buildings of many Irish towns, as they stand today is highly appropriate and imparts an overall uniformity and integrity. Stucco has been described as the most well-mannered finish for town buildings.

Common Problems and Solutions

1. Surface crazing
2. The use of strong, dense and impervious materials or dirty aggregate, allowing renders to dry too quickly are among the causes of surface crazing on render. The ideal solution is to render the wall correctly.
3. Renders separating from their backing Problems of renders separating from their backing can be due to lack of sufficient key; inadequate control of suction during work; incorrect order of strength of coats applied; and the practice is equally disastrous in the application of over thick coats. The wall should be re rendered where necessary. It is better to re render to straight rather than ragged edges, even if this means removing a little of the sound old render.
4. Rising damp Walls built up to the mid-19th century - later in some instances - are unlikely to have damp proof courses inserted. his omission can lead to problems of rising dampness which introduces salt, sand causes blistering and powdering on surfaces Solutions which introduce dense waterproof barriers do not help matters. Water trapped behind impervious renders and joints can set up decay in the stonework/backing material. For details on how to deal with rising damp see booklet No. 11 Rising damp and timber decay.

Removal of renders

The all too common practice of removing renders to expose the stonework beneath is most regrettable. Not only is the integrity of a street or terrace visually disrupted at one stroke but the stonework beneath, often of poor visual quality, is incorrectly repointed, then coated with layers of clear impervious "water repellents" thus preventing it from behaving naturally. A most unfortunate aspect of all this is the loss forever of an historic material which today is impossible to reproduce. The practice is equally disastrous in vernacular buildings. The replacement of their soft lime renders with modern hard regular surfaces also diminishes their character bit by bit the distinctive qualities of whole areas are being eroded such continued inappropriate alterations.

Repairs to Renders

General

The decision to re render must be made in the same light as decisions for repointing. Only problem areas where plaster is loose and defective need be redone. The retention of sound work is important because of

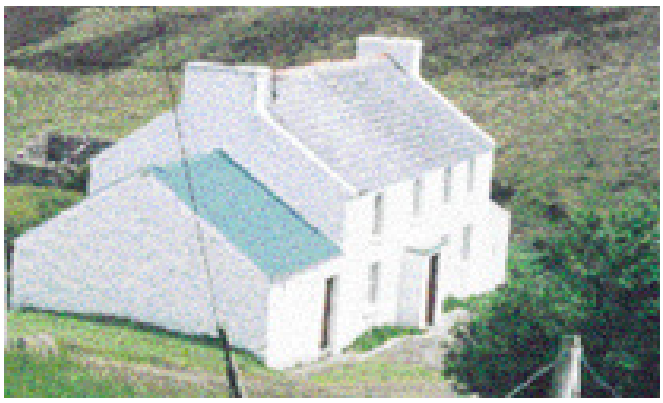
authenticity and historical value. Where problems as already described occur it is important to get to the root cause of these so that they can be dealt with. This is essential since otherwise repairs will only be of a superficial nature and problems will be likely to recur. Render must never be stronger than the background to which it is applied successive coats must not be thicker or stronger than previous ones and can be weaker. The background and each subsequent coat must be pre-dampened before applying the next to avoid suction. Coats must not be over thick. All organic growth must be treated prior to commencement of work. Carrying out work during frosty or over dry, windy or very sunny periods should be avoided.

Procedure

Cut out defective work to a regular edge slightly undercutting the top and sides in ruled out work results will be neater if removal is taken to ruled lines. Ensure an adequate key by raking out joints, scoring background, etc. A mechanical key is more desirable than the use of binding agents, such as PVA. The number of coats to be applied should ensure that the face of finished work comes flush with that existing three coat work is usual the overall thickness of the render usually being a minimum of 25 mm. The first coat is applied to a thickness of 9 - 16 mm and combed to give a key for the next coat. Remaining coats can be from 6 - 10 mm thick. In rough cast, the final coat which is a mix of sharp sand and pebbles is thrown. If wished, this can be applied in two stages – the first, butter coat to improve adhesion of the thrown material. The final coat which is thrown from a hawk must be applied carefully to ensure a relatively even surface where aggregate forms clumps. In ruled out stucco work, lining out is carried out to the finishing coat by the use of a straight edged rule and jointing tool, heights and widths of lines should match adjacent work or, in the case of new work, dimensions should match similar local work. The final coat should be finished with a wooden float and not overworked. This method can also be used to repair oil mastic renders.

Where stucco is painted, color matching is not of importance. Where color of unpainted stucco work must be matched, the use of masonry cement and sand or cement sand and plasticizer may produce a more satisfactory result than mixes with lime. Analysis of existing work may indicate the color of sands and the use of materials such as crushed glass, etc., the inclusion of which can improve final results

House with traditional render



Note on lime

It should be noted that there may be instances where the use of lime would be unsuitable because of incompatibility, for example, it can have a damaging effect on some stone types such as sandstones such as problems will be discernible on examination, and, if present, indicate that the use of lime should be avoided. For the vast majority of traditional/historic buildings likely to be dealt with, the use of lime is essential.

Conclusion

Effective and pleasing pointing and rendering are the result of experience and practice using careful procedures and appropriate tools and materials.

Dos and Don'ts

Dos

- use mature lime putty
- use clean sharp sand
- use clean potable water
- work in correct climatic conditions
- ensure appropriate mortar strengths

- ensure clean organic-free backgrounds
- flush fill joints or keep within the original joint widths
- use the correct tools
- match existing or adjacent work when carrying out repairs.

Don'ts

- use raised pointing
- smear mortar over surface of joints
- use too much water
- use strong Portland cement mortars.

6.8 FLOOR SCREEDING

Introduction

Screeds and toppings are commonly used as a means of providing smooth flat floors in residential, commercial and industrial buildings. Toppings may also be used to increase the structural depth and strength of the base slab. The aim of this publication is to provide the information needed by architects, engineers and contractors for specifying and laying floor screeds and toppings of acceptable quality. Information is provided on monolithic, bonded and unbonded screeds and toppings.

Definitions

The following definitions are used in this document:
Screed: -A layer of well compacted material, commonly a mixture of cement and fine aggregate, that is applied to a base at the appropriate thickness and that has a surface suitable for receiving a floor finish.

Topping:

A layer of high-strength concrete designed:

a. to provide a dense, abrasion-resistant surface on a concrete base, or
b. to increase the structural depth and strength of abase

Leveling a concrete topping. Reinforcement and temporary screed battens in the foreground.

Specification

Suitability of screeds and toppings
Screeds are essentially light-duty flooring elements and are suitable for:

- Wearing surfaces of floors of utility rooms in domestic premises (e.g. store rooms, garages)
- Floors covered with carpets, plastic tiles or linoleum, etc. and subjected to relatively light traffic such as in offices, shops and hospitals.

Screeds are generally not suitable as wearing surfaces in commercial buildings, schools etc. or in industrial premises. Preferred methods of floor construction for such premises are full-thickness troweled concrete or a topping on a concrete base. Screeds and toppings should be specified only where placing and finishing the concrete floor to acceptable standards is impracticable.

Surface finish

Screeds

The surface of the screed should be finished according to the type of wearing surface or flooring that is to be laid. For mastic asphalt, wood block and strip,

and some textile floor coverings, a non-slip finish is appropriate, while thin sheet and tile floor coverings usually require a smoother, steel troweled surface. If a designer specifies the use of a thin sheet or tile floor, then the use of a smoothing compound needs to be specified in certain circumstances.

Toppings

The surface of the topping should be finished to meet the abrasion requirements of the facility. Guidance is given in Table 3.

Specifying tolerances in levels and surface regularity

When specifying departure from datum and surface regularity, taking into account the types and thicknesses of the flooring and the screed or topping, the designer needs to consider:

- the finished floor surface;
- the screed/topping/direct finished slab surface;
- the base slab to receive a screed or topping.

Some variations in surface regularity can be allowed without detriment to the satisfactory application of the flooring. The permissible limits associated with surface regularity and departure from datum depend on many factors. In general, the thinner the applied flooring the higher the class of surface regularity required. Maximum permissible departure of the level of the screed or topping surface from datum and the required class of surface regularity should be included in the job specifications.

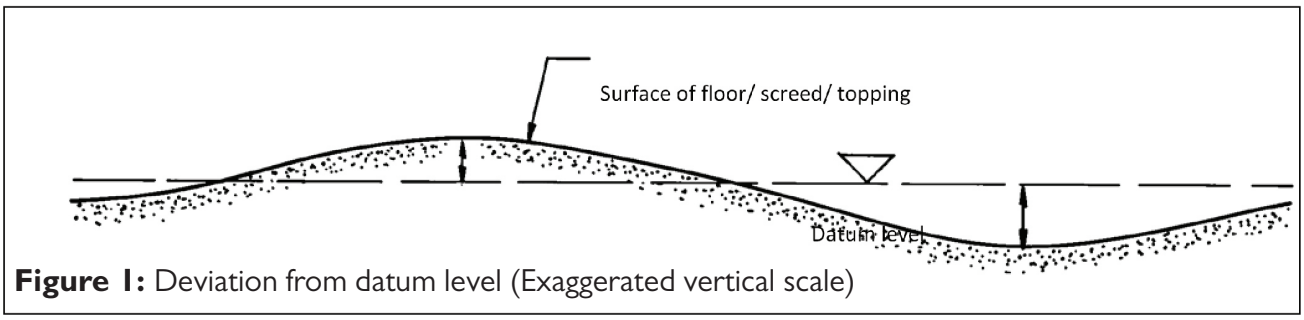


Figure 1: Deviation from datum level (Exaggerated vertical scale)

Deviations from datum level (see Figure 1).

Permissible deviation from datum level depends on the area of the floor and its intended use. For large areas for normal purposes ±15 mm from datum should be satisfactory. Greater accuracy may be required in small rooms, along the line of:

Maximum permissible deviation from a 3m long straight line joining two points on the surface	
3	Class 1; suitable for floors requiring minimum irregularity, e.g. television studios; may necessitate the use of special methods and will require close supervision
5	Class 2; suitable for the major proportion of construction work
10	Class 3; suitable for floors where regularity is not important

Table 1: Classification of surface regularity of floor partition walls, in the vicinity of door openings and where specialized equipment is to be installed directly on the floor and in the case of high tolerance industrial floors.

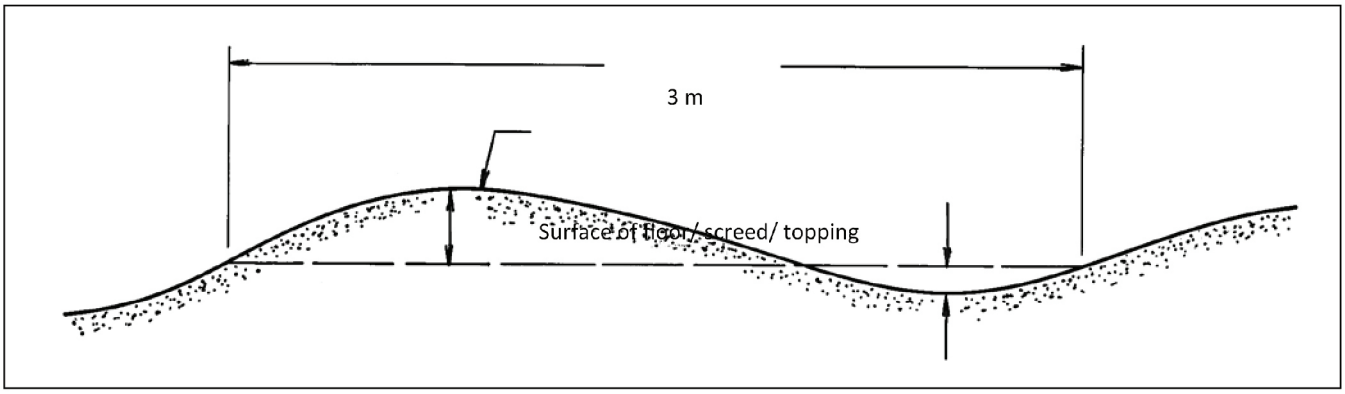


Figure 2: Deviation from a straight line 3 m long joining two points on the surface (Exaggerated vertical scale)

The designer should specify the maximum permitted abrupt change in level across joints in direct finished slabs and screeds and toppings taking into account the type and thickness of the flooring to be applied. For some types of floorings, a maximum of 2 mm would be acceptable, taking into account the surface preparation necessary to receive the flooring. For other types of flooring, especially thin floorings, or where no flooring is to be applied, it would be appropriate not to have any changes in level across joints. Readings should be taken as soon as possible after completion of the screed or topping. Various methods of specifying surface flatness and levelness are discussed in Further Reading number 7.

Specifying the strength of screeds and toppings

Screeds

The strength of a hardened sand-cement screed can be tested with the "BRE screed tester". Specifying an acceptance criterion before the start of the job is advisable as this could prevent disputes after completion. The "BRE screed tester" consists essentially of a mass which is dropped on a standard foot piece which is placed on the surface of the screed. See Figure 3. The indentation resulting from four impacts of the mass is measured and is an index of screed strength. Acceptance limits for various strength categories are given in Table 2.

Toppings

Concrete for a topping should have a characteristic 28-day compressive strength appropriate to the desired abrasion resistance (see Table 3), or designed compressive or flexural strength, but of at least 20 MPa where abrasion is not a consideration. The coarse aggregate used should be of nominal size 6,7 mm for monolithic toppings of nominal thickness25 mm and of nominal size not exceeding 9,5 mm for separate bonded toppings of nominal thickness 30 mm. If the nominal thickness of the topping exceeds 40 mm, however, the nominal size of the coarse aggregate should be increased to one-quarter of the thickness of the topping, subject to a maximum of 19 mm.

Types of screeds and toppings

In this publication three types of screeds and toppings are discussed:

- Monolithic screeds and toppings which are applied to the floor while the concrete in the base is still in a plastic state.
- Bonded screeds and toppings which are applied to hardened concrete floors.
- Unbonded screeds and toppings which are used when it is impossible to ensure a good bond between floor and screed or topping. In this case the screed or topping is separated from the floor by insulation boards or an impervious membrane.

While all three types have many characteristics in common, they also differ in some important ways. These are dealt with in the following sections.

Maximum permissible depth of indentation after dropping the mass four times, mm	Strength category	Description
3	A	Areas expected to take relatively heavy traffic and/ or where any disruption at a later date would be unacceptable; examples are hospital operating suites and corridors; rooms requiring microbe- or dust-free environment
4	B	Public areas such as lift lobbies, circulation areas within shops, foyers, canteens and restaurants; public rooms in residential accommodation; hospital wards
5	C	Offices, consulting rooms, domestic premises

Table 2: Screed-strength acceptance limits using the "BRE screed tester"

Monolithic screeds and topping:

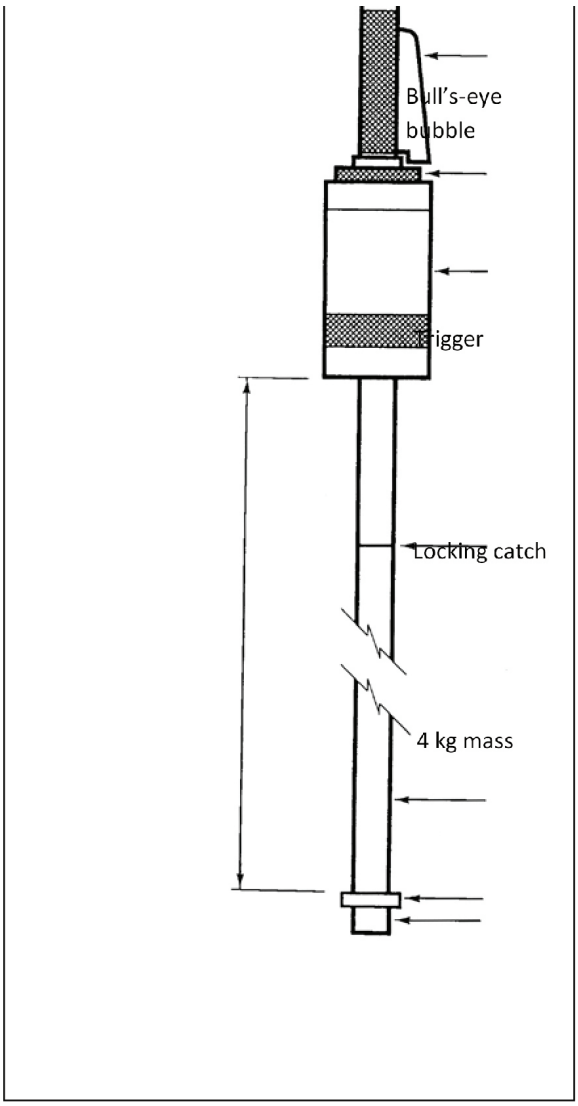
As defined above, these screeds and toppings are applied at the time when the underlying concrete floor is placed. Screed thickness should be approximately 25 mm but not less than 15 mm or more than 40 mm. The minimum thickness of a monolithic topping at any part should be 20 mm.

The actual thickness required may depend on structural requirements. In some circumstances, the design thickness of a topping may have to be increased to more than 40 mm, but then there will be an increasing risk of loss of adhesion to the base, due to differential shrinkage stresses. In attempting to achieve good adhesion between screed/ topping and base concrete, it is important to take cognizance of the phenomenon of bleeding of fresh concrete. Bleeding causes

water to accumulate on the top surface of the fresh concrete and the presence of this water layer may impair adhesion unless suitably dealt with.

The screed/topping should therefore be laid at one of two stages:

- either immediately the concrete has been compacted and leveled off and before bleed water appears on the surface ("immediate placing");
- or after bleeding of the concrete has ceased and bleed water has evaporated or has been removed completely by mopping up ("delayed placing").



Immediate placing requires careful timing but has the advantage that no preparation of the concrete surface is required.

Timing of delayed placing is not as critical but the surface of the concrete does require some preparation: laitance should be loosened by light brushing, with a wire brush or a brush with stiff bristles, and thoroughly removed by sweeping, or preferably, by vacuum cleaning. Delayed placing should however be done within an hour or two after the end of the bleeding period.

Bonded screeds &toppings

As defined previously, bonded screeds and toppings are applied to hardened concrete. The hardened concrete is also known as the base concrete. Screed thickness should be not less than 25 mm or more than 50 mm. The minimum thickness of a bonded topping at any part should be 35 mm. The actual thickness required may depend on structural requirements. In some circumstances, the design thickness of a topping may have to be increased to more than 60 mm, but then there will be an increasing risk of loss of adhesion to the base, due to differential shrinkage stresses. In these circumstances, the use of a reinforcing mesh (ref. 193 or 245) as close to the upper surface as is permissible will assist in restraining differential shrinkage and in controlling cracking.

Base-concrete requirements

The concrete on which the screed or topping is to be laid should be hard and strong (i.e. characteristic strength of at least 20 MPa). Weak, friable concrete is not suitable as a base for a screed or topping as the achievement of adhesion between such material and the screed or topping is not possible.

The base concrete should be free of random cracking. Floor screeds or toppings are unable to bridge over cracks in the base and such cracks will in time reflect through the screed or topping. The surface of the base concrete should be reasonably accurate to the required level so that it is possible to place the screed or topping to a uniform thickness.

Preparing the base concrete

The base concrete should be prepared in such a way that it is left with a surface that is uniformly hard, clean, and free of dust, oil or other contamination. Any screeds or toppings applied previously to the base should be removed completely. The laitance on the base concrete should be entirely removed by mechanical scrabbling or scarification in order to expose cleanly the coarse aggregate. All loose debris, dirt, and dust should be removed using vacuum equipment. These operations should be delayed until shortly before the screed or topping is laid, in order to prevent any contamination or accumulation of dirt.

1	2	3	4	5	6	7	8
Class	Service condition	Application	Type of finish	Concrete grade MPa	Type of coarse aggregate	Type of fine aggregate	Finishing process
Special	Severe abrasion and impact	Very heavy-duty engineering workshops, etc.	Proprietary toppings	Proprietary toppings cannot be classified by strength grade or minimum cement content, and may contain aggregates that do not comply with SANS 1083. Special finishing techniques may be used. The suitability of concrete bases in this class should be established with the manufacturer of the proprietary topping or with the contractor.			
AR1	Very high abrasion: Steel wheel traffic and impact	Heavy duty industrial, workshops, special commercial, etc	High strength concrete toppings or proprietary toppings	50	Aggregates complying with SANS 1083 for concrete subject to surface abrasion	Sand complying with SANS 1083	Troweling twice or more, followed by curing
				When relevant, the suitability of concrete bases in this class should be established with the manufacturer of the proprietary topping or with the contractor.			
AR2	High abrasion, steel or hard steel or hard plastics wheel traffic	Medium duty industrial and commercial	Direct finished concrete bases with or without dry-shake finish, or concrete toppings	40a	Aggregates complying with SANS 1083 for concrete subject to surface abrasion	Sand complying with SANS 1083	Troweling twice, or early age grinding followed by curing
AR3	Moderate abrasion: rubber-tyred traffic	Light duty industrial and commercial	Direct-finished concrete bases with or without dry-shake finish		Aggregates complying with SANS 1083 for concrete subject to surface abrasion	Sand complying with SANS 1083	Troweling twice, or early age grinding followed by curing
The grade may need to be higher for structural purposes.							

Bonding of screed or topping to base

The use of a sand-cement grout, if properly applied, should give good results and is described below. (If a proprietary bonding agent is used, it should be applied strictly in accordance with the manufacturer's instructions). The grout should consist of equal volumes of fine, clean sand and loose cement mixed thoroughly with sufficient water to achieve a consistence similar to PVA paint. It must be stirred continuously, and used within 30 minutes of making. The day before laying of the screed or topping is to start, the base concrete should be tested for absorptiveness by pouring about a cupful of water onto the surface.

If, during the next few minutes, it is clear that water is being absorbed, the suction of the concrete should be regarded as being high. In that case the procedure is: Wet the area on which the new screed or topping is to be laid and keep it wet for four hours or more.

a. Remove all free water on the surface.
b. Allow the surface to become visibly dry so that the base achieves saturated surface-dry condition.
c. Apply the grout to the surface.

On the other hand, if the test water is not visibly absorbed by the concrete during the first few minutes after application, the suction of the concrete should be regarded as being low and the grout may be applied to the dry concrete. Concretes with 28-day characteristic strengths of 25 MPa and over, if properly compacted and cured, can be regarded as non- absorptive. In such cases, toppings have been successfully applied without a bonding grout provided the surface is clean and adequately prepared.

The grout may be slushed over the area where it is needed, but must then be worked thoroughly into the surface of the concrete by scrubbing with brushes and then brushed out to leave only a thin coating on the concrete without pools of grout in depressions. The brushes used for grouting should have bristles about 60 to 100 mm long and flexible enough to reach down into all the irregularities of the surface of the concrete. (Stiff "carpet" brushes are suitable, as are some garden brooms provided the base concrete is sufficiently even. Bass or yard brooms are not suitable because their bristles are too stiff and too close together. "Hair" brooms are too soft to be effective.)

Because the screed or topping mix must be laid on the grouted surface while the grout is still visibly wet, i.e. within 10 to20 minutes of applying the grout, grouting must be done over small areas at a time, just ahead of laying of the screed. The grout must be made up in small quantities at a time, as needed.

NOTE: Under no circumstances should the grout be allowed to dry out before placing the screed/ topping as this will cause debonding. If there is any doubt about the possibility of a delay occurring, it is better to omit the grouting operation.

Unbonded screeds and Toppings

Screeds

Where screeds are, or have to be laid on a damp-proofing membrane or separating layer, the minimum thickness of the screed should be at least 50 mm. Where they are laid on a compressible layer, such as insulation boards, the minimum thickness should be at least 70 mm.

Topping

Where a concrete topping is required over a damp-proof membrane, an unbonded overlay of minimum thickness100 mm should be used in order to minimize the risk of curling. The grade of concrete for a direct-finished overlay should be in accordance with Table 3.A similar unbonded overlay should be used where a base has become contaminated (e.g. with oil), and bonding is not possible. The concrete used for an overlay intended to support a high- strength concrete topping should have a 28-day compressive

strength of at least 35 MPa.

Screeds in general

Materials for screeds

Sand

The quality of the sand, i.e. its concrete-making properties, has a large influence on the quality of the resulting screed. It should be a "concrete" sand – not a "plaster" sand – but the largest particles should be removed by sieving the sand through a sieve with openings about 5 mm wide to facilitate finishing.

Where possible, the sand should be tested in a laboratory beforehand. It should then, in a mix of 3,5 parts of dry sand and 1 part of cement by mass, produce a plastic, easy-working, cohesive mortar of plastering consistence (i.e. a slump of about 40 mm) with a water content per cubic metre of not more than 320 l but preferably not more than 300 l. (The higher the water requirement, the lower the strength of the hardened screed and the greater the drying shrinkage and tendency to crack). To produce a mix that is easy to finish to a smooth surface, it may be necessary to blend two or more sands. Commonly a blend consisting of 4 parts of crusher sand, sieved as above, and 1 part of a clean "plaster" sand, gives good results.

NOTE: Sieving must be done on horizontal sieves which are shaken, or on cylindrical sieves which are rotated. The practice of throwing the sand onto a sloping sieve with a shovel is unacceptable because it is inaccurate, unreliable and wasteful.

Cement

Use cement complying with SANS 50197-1 type CEM I or CEM II A. To use other cements, first obtain expert advice.

Admixtures

Commercially available admixtures, especially of the water-reducing type, may be used, but preferably only on the recommendation of the laboratory which tests the sands, and only where adequate control of dosage on site can be guaranteed.

Batching

Mix proportions should be: Sand, measured in the moist, loose state: 130l Cement: 50 kg Water: sufficient to achieve a plastic, workable consistence. The capacity of a builder's wheelbarrow is 65 l so batches consisting of two barrow loads of sand and one bag of cement are convenient for mixing by hand or in a sufficiently large concrete mixer. The volume of compacted screed mix produced by such a batch is approximately 115l.

The size of the batch should never exceed the amount that can be used up within 45 minutes of mixing. Apart from wheelbarrows, containers such as buckets, boxes or drums of known volumes may be used for batching. Batching containers should always be filled flush to the rim. Sufficient containers for a complete batch should be provided to avoid the possibility of errors in counting.

Smaller batches may be made up as follows:

Sand measured in the moist loose state	20	30	40	50	60	70	80	90	100	110	120
Cement measured in the loose state,	6	9	12	15	18	22	25	28	31	35	37
Water	Sufficient to achieve a plastic workable consistence										
Approx. yield, l	18	27	35	44	53	62	71	80	88	97	106

Mixing

Machine mixing is preferable and each batch should be mixed for not less than three minutes if this method is used. With hand mixing, the sand and cement should be mixed without adding water until the color is uniform, then only may the water be added, the quantity used being just sufficient to produce a mix of the desired consistence. Hand mixing should be carried out with shovels on a smooth concrete floor or a steel plate. Mixing directly on the ground should not be permitted as this results in contamination of the mix with earth and/or organic matter.

Placing and compacting

Control of levels

Narrow strips of screed mix, laid 3 to 4 m apart and compacted to finished level, should be used as guides to establish the level of the screed. The screed should be placed and compacted immediately after laying the guide strips.

Where the edge of a guide strip forms a day, work joint it should be formed or cut to produce a vertical joint. Alternatively, and especially for bonded screeds, timber or metal screed battens, carefully leveled and trued, should be fixed at the correct height for the required thickness of screed. At day work joints all bedding screed beneath the battens should be cut away to form a vertical joint.

Panel sizes and joints

Screeds should be laid in areas as large as possible in one operation, consistent with achieving acceptable surface regularity and the levels required, to minimize the number of joints. Although screeds laid in large areas may crack at random intervals as they dry and shrink, these cracks are more acceptable than the curling which may occur at vertical butt joints if screeds are laid in small panels.

Where joints are present in the base concrete, they should be continued through the screed so that joints in screed and base line up exactly. Where screeds are placed on precast concrete elements this may not be practicable. In such cases, the use.

of a reinforcing mesh in the screed may be used to control cracking of the screed and applied floor finishes, along joints between precast units, provided panel sizes do not become excessive. This is particularly important if the applied finishes are brittle, or the slab is subject to external influences, such as thermal stresses, which could cause movement.

Joints may be formed with screed battens if screeds on each side are cast at different times, or by cutting through the partially stiffened screed mix with the edge of a trowel before the screed sets if both sides are laid at the same time. If the screed is not to be covered subsequently, edges at joints should be rounded to a 3 mm radius.

Time Limits

The time which elapses between the start of mixing a batch and when that batch is placed and compacted should not exceed 45 minutes, and during that time the mix should be protected from drying out. Batches not placed and compacted within this time, or which have stiffened to a degree that their workability (consistence) cannot be restored fully by turning them over a couple of times with spades, should be discarded.

Consistence of the fresh mix and means of compaction

It is essential that, during laying, the fresh mix be compacted fully. The consistence of the fresh mix and the means of compaction must therefore be matched to ensure that this is achieved. Generally, therefore the fresh mix should be nearly as soft and plastic as a cement plaster (slump about 40 mm).

Spreading and compacting can then be done with relatively light timber screed boards operated by one or two workmen. The screed mix should be dumped on the base concrete (freshly grouted in the case of bonded screeds) and spread somewhat thicker than the final required thickness. It should then be compacted using a screed board with a vertical chopping motion. Extra compaction with hand tampers is recommended along the edges of panels and adjacent to screed strips. Once the screed has been compacted it should be taken to the correct level with a screed board riding on the screed strips or battens (or side forms in the case of monolithic screeds). The surface can then be wood floated to remove any ridges made by the screed board.

NOTE: The use of stiff semi-dry mixes, laid with light screed boards, is a particularly common cause of weak screeds because such mixes are not adequately compacted. Semi-dry mixes can however produce very superior screeds, but only if they are compacted by power operated equipment such as vibrating screed boards and the consistence is correct.

Toppings in general

Materials

Aggregates

Aggregates for concrete should comply with the requirements of SANS 1083. The coarse aggregate should be of nominal size 9,5 mm for a topping of nominal thickness 30 mm. However, if the nominal thickness of the topping exceeds 40 mm, the nominal size of the coarse aggregate should be increased to one quarter of the thickness of the slab, subject to a maximum of 19 mm.

Cement

Cement should comply with the requirements of SANS 50197-1. Cement extenders should comply with the requirements of SANS 1491. The choice of appropriate cement type depends on the type of floor and the environment in which it is to be used. Of prime concern are adequate early strength for cutting of joints and adequate abrasion resistance.

In floors with sawn joints, concrete has to achieve a certain strength to enable sawing of the joints. With mixes of low early strength, the time taken to reach this strength is increased. The longer the period between casting and saw-cutting, the greater the possible moisture loss from the concrete and the higher the risk of shrinkage cracks occurring before the concrete can be sawn. Cement types and/or cement contents promoting sufficient early strength for sawing should be chosen.

Because floors have a large surface-to-volume ratio they are prone to rapid surface drying with the attendant loss of abrasion resistance at the surface. Effective curing is therefore essential. Concrete made with cements having a low early strength or site blended cements may require adjustments in the concrete mix design to ensure adequate early strength for cutting of joints, particularly in cold environments. Curing methods and regimes may also have to be improved to ensure adequate abrasion resistance, especially in adverse weather.

Pumping a concrete topping onto precast flooring. Reinforcement and screed battens in foreground.

Concrete topping being placed on a precast floor.

Admixtures

Commercially available admixtures, especially of the water-reducing type, may be used, but preferably only on the recommendation of the laboratory which tests the sands, and only where adequate control of dosage on site can be guaranteed.

Mixes

A topping should have a characteristic 28-day strength appropriate to the desired abrasion resistance (see Table 3), or designed compressive or flexural strength, but of at least 20 MPa where abrasion resistance is not a consideration.

Laying

After screed battens surrounding the panels on which the topping is to be applied have been attached to the prepared base and the bonding agent has been applied as described above, the topping should be spread, compacted, screeded and bull floated as for a concrete floor.

Panel sizes and joints

Monolithic toppings

Monolithic toppings should be laid in panels of the same size as those of the base. Full-depth isolation joints should be formed in monolithic toppings against walls, columns and other fixed objects. Such joints should have the same width as those in the base, but not less than 20 mm. Other joints in monolithic toppings should coincide with those in the base, be of the same type and width as those in the base and extend through the full depth of the topping.

Bonded toppings

For separate bonded toppings the area of a panel should not exceed 9 m2. This may not be practicable for structural toppings on precast units where joints across the span within the central two-thirds of the span cannot be permitted. This may be overcome by the use of reinforcement as discussed later in this section. The general pattern of panels will depend upon such aspects as the shape of the floor area and the position of columns. Wherever possible, panels should be square, and the length of a panel should be limited to 1,25 times its width to reduce the tendency to crack. Full-depth isolation joints should be formed in separate bonded toppings against walls, columns, and other fixed objects. Such joints should have the same width as those in the base, but not less than 20 mm. Except where intermediate joints are required in the topping to divide it into smaller panels than the base, joints in separate bonded toppings should

coincide with those in the base, be of the same type and width as those in the base and extend through the full depth of the topping. Intermediate joints dividing the topping into panels of recommended maximum dimensions should be either sawn contraction joints that extend halfway through the thickness of the topping, or butt construction joints. Where bonded toppings are placed on precast concrete elements and the above recommendations are not practicable, the use of a reinforcing mesh close to the top surface of the topping may be used to control differential shrinkage and cracking of the topping and applied floor.

Power floating a screed

finishes along joints between precast units, provided panel sizes do not become excessive. The larger the panel size and the thicker the topping, the greater is the amount of steel required.

Unbonded toppings

The maximum panel size of a separate unbonded over slab should be based on the following rules:

- Maximum joint spacing not to exceed 30 times over slab thickness, or 4,5 m, whichever is the lesser
- Length-to-width ratio of panels not to exceed 1.25

Full-depth isolation joints should be formed in a separate unbonded over slab against walls, columns and other fixed objects. Such joints should have the same width as those in the base, but not less than 20 mm. Other joints should be either sawn contraction joints that exceed a depth of one quarter of the slab thickness, or keyed construction joints. Both types of joint should be offset at least 300 mm from those in the base.

Time limits

The time which elapses between the start of mixing a batch and when that batch is placed and compacted should not exceed 45 minutes, and during that time the mix should be protected from drying out. Batches not placed and compacted within this time, or which have stiffened to a degree that their workability (consistence) cannot be restored fully by turning them over a couple of times with spades, should be discarded.

Finishing

The resistance to wear of a concrete finish is significantly influenced by the method of finishing and the care with which finishing is carried out. Under no circumstances should cement or a dry cement-sand mixture be sprinkled directly onto the surface of a finish in order to absorb bleed water or laitance, since defects such as surface scaling may occur later. Surface water should not be troweled back into the finish and, similarly, water should not be applied between troweling operations, since this may cause surface weakness.

Three types of surface finish are described below; the choice being made according to circumstances.

Ordinary non-slip

The surface is left as finished with wooden floats, except that if it is too open or too coarse it may be given a few passes with either Perspex or aluminum floats to close the surface without smoothing it. Over-working should be avoided.

Steel-troweled

If a hard, smooth finish is required, the surface will have to be steel-troweled, using the delayed troweling method. After the screed or topping has been spread, compacted and screeded to level, it should be bull floated. Bull floating should immediately follow screeding and should be completed before any excess moisture or bleed water is present on the surface. The purpose of bull floating is to eliminate ridges and fill voids resulting from straight edging.

Before further steps are taken, the finish should be left undisturbed (the delay period) until bleeding has ceased, the surface has stiffened to the extent that a footprint will barely show, and surface water has either evaporated or been removed. Following the delay period, the finish should be floated again.
The purpose of floating is:

a. To depress large aggregate below the surface,
b. To remove slight imperfections, lumps and voids and to produce a level or plane surface, and
c. To compact the finish and consolidate mortar at the surface in preparation for other finishing operations.

Floating and troweling may be carried out by hand or mechanically. When floating is done mechanically, either a disc-type float or a troweling machine with float shoes attached should be used. Troweling should be done immediately after floating. The purpose of troweling is to produce a smooth, hard surface. For the first troweling, the trowel blades should be kept as flat against the surface as is practicable. As the surface stiffens, each successive troweling should be made with smaller trowels tilted progressively more to increase the compaction of fines at the surface, giving greater density and more wear resistance.

The resistance to abrasion increases with the number of troweling operations and the care with which they are carried out. The operations should be timed to prevent an excess of laitance being produced at the surface. For the highest abrasion resistance, final troweling should be made when considerable pressure is required to make any impression on the surface. However, excessive troweling at this stage should be avoided, to prevent a polished or slippery surface.

Finishes that are not to be exposed to severe service conditions

The finish (after it has been spread, compacted, screeded to level, and floated) should be left undisturbed until bleeding has ceased and the finish has stiffened to the extent that a footprint will barely show. Surface water should then be removed from the surface, floated and steel-troweled at intervals until the desired texture is achieved. The texture of concrete finishes can be varied from a fine matt to a glossy surface, depending on the number of troweling applied. A coarse non-slip texture may be produced by brushing a freshly floated surface with a broom, but the resulting ridges may become subject to abrasion.

Troweling too soon and over-troweling should both be avoided, since they bring to the surface a thin layer rich in cement, which tends to craze and release dust particles.

Curing

Concrete has to be effectively cured if maximum surface strength, maximum resistance to surface abrasion and low impermeability of the concrete are to be attained, and the development of drying shrinkage cracks is to be avoided or minimized. Effective curing also reduces the effect of differential shrinkage, and therefore curling, by delaying the effect of differential drying until the concrete is better able to resist its effects. Curing should start as soon after final finishing as practicable, and should be done by one of the following methods:

a. Uniform application of a liquid membrane-forming curing compound at an approved rate for

complete coverage, always taking into consideration the manufacturer's instructions. Curing compounds should comply with the requirements of AASHTO M148 and should be of type 1-D or type 2. (This method may not be suitable where other finishes are to be applied.)

b. Ponding
c. Covering with thick hessian or similar clean moisture- retaining and non-staining material that is kept wet
d. Covering with polyethylene or similar vapor-proof material in large sheets, sealed at the edges of the finish and at the side laps of the sheeting

To prevent surface damage to troweled and other finishes, it may be necessary to suspend the coverings described in (c) and(d) above, clear of the surface until such time as they can be placed directly onto the surface. Care should be taken to prevent wind tunneling under coverings.

Curing should continue for at least 7 days. In cold weather, this period should be extended. Cold weather may be deemed to be conditions in which the "average" ambient temperature falls below 10°C, where "average" is defined as the arithmetic mean of the maximum and minimum ambient temperatures recorded on site within a period of 24 hours. During cold weather, the curing period should be extended by 0,5 days for each day in which the average ambient temperature falls to between 5°C and 10°C, and by 1 day for each day in which the average ambient temperature falls below 5°C.

Material quantities

Screed

The net approximate quantities of materials required to manufacture 1 m2 of compacted screed mix 25 mm thick are: Sand in moist, loose state: 281 Cement: 11 kg. An allowance of 10% over and above these quantities should be made for wastage.

Grout

For bonded screeds, allow about 1 kg of cement and 1kg of plaster sand per m2 of screeded area for the grout.

Inspection and testing of toppings and screeds

Inspection

Before the finishing work is started, the base should be checked for any departure from level, to ensure that the minimum thickness of finish can be applied. The work should be inspected during progress and after completion, attention being paid to the following points:

a. materials
b. preparation of the base, where the finish is to be bonded
c. batching and mixing
d. proper compaction
e. correct finishing) correct curing
f. making and curing cubes (see SANS 5861-3:1994) from both topping and screed mixes

Testing of the completed work

After completion of the work, the following tests should be carried out:

a. levels and surface flatness of toppings and screeds
b. adhesion of bonded screeds and toppings to the base
c. curling and lipping of unbonded screeds
d. soundness of bonded and unbonded screeds
e. testing (see SANS 5863:1994) of cubes

Levels and surface flatness

Deviation from datum may be checked with conventional survey instruments. The testing of surface regularity will depend on the type of specification used. It may be tested by straightedge, precise leveling or other specialized equipment. A straightedge at least 3 m long can be used to check surface regularity. It should be supported on two rigid blocks of identical

height (say 15 mm) placed 3 m apart on the screed surface. Deviations of the screed surface from the straight line joining the points at which the blocks are placed may be measured with suitable slip or feeler gauges. Alternatively, specialist methods may be used (see Further reading number 6).

Adhesion between separate bonded toppings or screeds and a base

The adhesion between the topping or screed and the base should be examined by tapping the surface with a rod or a hammer, a hollow sound indicating lack of adhesion. Tests to check the adhesion of a screed or topping to its base should be made as late as possible in the construction programme when the maximum effect of drying shrinkage has taken place. Account should be taken of the time for any replacement sections of screeds and toppings to be laid within the construction programme.

Curling and lipping of toppings and screeds

Toppings and screeds should be considered unsatisfactory if they have lifted by a visible or measurable amount at joints and cracks, to the extent that there is a risk of fracture under imposed loads.

Strength

Screed

The "BRE screed tester" (see Figure 3) is used to assess strength once screeds are at least 14 days old and have dried out. No less than three tests should be carried out in each area less than 20 m2 and on each 20 to 25 m2 of screed laid in larger areas. Corridors should be tested at 3 to 5 m intervals. Test positions should be selected at random, but vulnerable areas adjacent to panel joints and any shrinkage cracks, and in doorways, should be tested. Where test indentations exceed those given in Table 2, additional tests should be carried out to determine the zone of non-compliance.

Test procedure is as follows:

a. Select a sensibly flat, smooth area of screed and remove all loose dirt and grit.
b. Use the template supplied with the tester to mark the test areas
c. test position of the feet of the depth-measuring device and take the zero reading.
d. Locate the foot piece of the screed tester at the test position in contact with the screed.
e. With the guide rod held vertically, deliver four successive blows of the mass to the foot piece at the same position on the screed, dropping the mass freely from the trigger point each time.
f. After the fourth blow, measure the depth of the final indentation in the screed with the depth measuring-device.

Topping

The "BRE screed tester" is not suitable for use on high-strength concrete toppings. The strength of such toppings is determined by testing cubes taken at the time of laying, or by tests performed on samples taken from the finished topping.

Assessment of cracks and curling

Cracks should be assessed in relation to the area involved and the flooring to be applied, and likely future movement. Fine cracks are not normally detrimental to any applied flooring and do not need filling: wider cracks may need filling or other remedial work. Loss of adhesion does not necessarily mean that the screed or topping is unsatisfactory. It may, however, be critical in the case of structural toppings. Those areas of the screed or topping that are considered to be unsatisfactory should be isolated by sawing, removing and re-laying. Care should be taken to minimize the effect that any cutting-out operations may have on the adhesion of adjacent parts of the screed. An alternative method that is less disruptive and may be suitable in some circumstances, is by injection of a low-viscosity epoxy resin into the crack and the gap

under the screed or topping. This operation must, however, be carried out by a specialist.

6.9 WALL PLASTERING

Gyproc GypFine Plasters provide the ultimate skimming solutions for today's high-end finish requirements. They are formulated to suit a wide variety of backgrounds including plasterboard, fiber cement board, gypsum-based leveling plasters, sand and cement render, fair faced concrete and precast concrete panels. GypFine Plasters can be hand applied to the wall or ceiling surface from a minimum 1mm thickness to a maximum thickness per coat of 2mm giving a total overall maximum thickness of 4mm. Plaster skimming to plasterboards and cementitious surfaces is a time-tested method of providing a smooth, seamless and undulation free surface, ready to receive decorative treatment. Skim plastering gives many of the advantages of a traditional solid plaster finish combined with quick turnaround on site. They offer an enhanced level of surface uniformity and visual finish to walls and ceilings that are decorated with semi-gloss or high-gloss paints and dark colors or as a base for wall paper and other decorative finishes, especially in areas exposed to artificial or critical light.

Gyproc GypFine – Board Skim is formulated specifically for use on all pre-jointed plasterboard walls and ceilings, providing a smooth, uniform surface prior to taking a wide range of decorative finishes. Where a high level(Q4/L5) of finish has been specified, GypFine Board Skim provides the perfect surface preparation for semi-gloss, high-gloss and dark colored paints, wall coverings and those areas where troublesome, visible joints show, due to severe lighting conditions. It is a super fine plaster free from inherent shrinkage and cracking, generally applied by hand, with a working life of approximately 120 minutes depending on environmental conditions. Board Skim can be recoated approximately 2hrs after first coat application and sanded to a smooth, fine finish using 180-220 grit paper.

Gyproc GypFine–Multi Skim is formulated specifically for use on surfaces such as fiber cement board, sand and cement renders, pre-cast and fair faced concrete along with gypsum-based leveling compounds. GypFine Multi Skim provides the perfect surface preparation for semi-gloss, high-gloss and dark colored paints, wall coverings and those areas where troublesome, visible undulations and hollows show, due to severe lighting conditions. A super fine plaster free from inherent shrinkage and cracking, generally applied by hand, with a working life of approximately 100 minutes depending on environmental conditions. Multi Skim can be recoated approximately 1 ½ - 2hrs hours after initial coat application sanded to a smooth, fine finish using 180-220 grit paper.

Gyproc GypFine – Ultra Skim is an all-purpose, premium gypsum plaster specially formulated for use on multiple surfaces such as plasterboard, fiber cement board, pre-leveled cementitious and gypsum-based substrates. GypFine–Ultra Skim provides the convenience of primer free, skimming plaster. Ideal for situations where superior smoothness and durability is required to achieve Q4/L5 finishes, for surfaces where there is severe lighting and where semi-gloss, high-gloss, and dark colored paints or fine textured wall papers have been specified.

Skimming to Plasterboard backgrounds

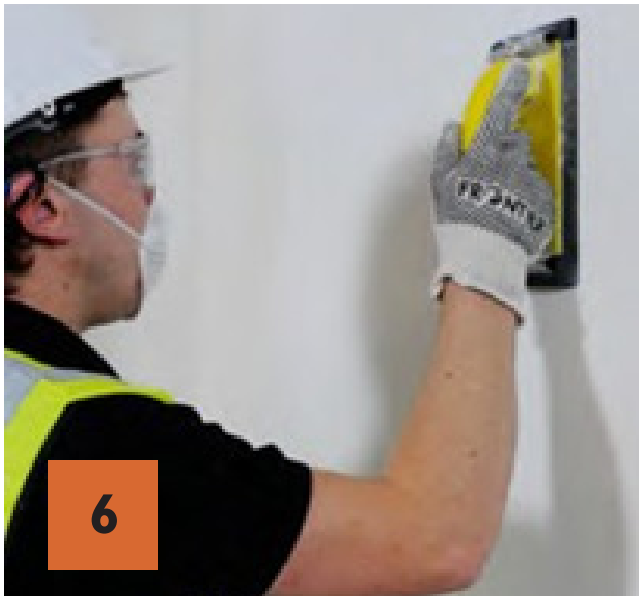
Board finishing should be completed as soon as possible after the boards have been fixed. Plasterboard partitions and ceilings should be jointed prior to application of GypFine Board Skim. Board Skim is applied with even pressure, using horizontal or vertical trowel strokes, built out to the required thickness in one or two applications, depending on site conditions and troweled to a smooth finish.

Skimming to Cementitious backgrounds

Finishing to cementitious surfaces should be completed only once the cementitious basecoat material has cured and is sufficiently dried. Multi Skim is applied with even pressure, using horizontal or vertical trowel strokes, built out to the required thickness in two applications depending on site conditions and troweled to a smooth finish.

Moisture resistant grade boards

Skim plastering is not normally specified to Gyproc Moisture Resistant and MR grade boards. These types of board are intended for use in environments of higher than normal humidity for which no gypsum plaster is designed to be suitable. Where moisture resistant board options are used in shell and core construction to provide temporary resistance to high moisture conditions, they can be skimmed at a later date after the building envelope has been made weather-tight and the board surface treated with a suitable PVA bonding agent.



Decoration

Gypsum based plasterwork must always be thoroughly dry before decorating. It is recommended that a suitable primer be applied to wall and ceiling surfaces, before applying paint or final decorative coats. Plaster surfaces can be painted with most proprietary paint finishes and provides an excellent base for wallpaper, accepting the majority of wall covering adhesives. The manufacturers' recommendations in respect of applied decorative treatments should always be followed.

Wall coverings

Gyproc GypFine Plasters provide an excellent base for receiving a wide range of wall coverings, removing unsightly undulations and imperfections which can affect the final covering finish. A suitable Primer/Sealer should be applied in a single coat to the plastered surface prior to applying the wall covering, thereby making steam-stripping at a later date a simple operation. The use of specialist adhesives, for example with cloth backed or solid vinyl wall coverings, may result in damage to the plasterboard surface during subsequent stripping. If the use of such adhesives is necessary, consideration should be given to cross-lining with lining paper before applying the wall covering. As with all wall and ceiling areas, high sheen gloss finishes will highlight variations of the surface, particularly with shallow angle lighting. GypFine plasters help minimize the effects of critical light and surface variations. The use of low sheen or matt finishes will minimize this risk. For the correct specification in respect of any applied decorative material, reference should be made to the manufacturer of that material.

Tiling

Tiles up to 20kg/m2 can be applied directly to Gyproc GypFine Plasters, except where the system includes a bonding agent. As the total weight of tiles and plaster applied over a bonding agent is limited to 20kg/m2, consideration should be given to tiling directly to the background. If plastering to provide a background for tiles, avoid polishing the surface. Polished plaster surfaces should be roughened and a suitable primer used.

Specialist training

The Saint-Gobain Gyproc Technical Academy offers comprehensive off-site training at our dedicated training centre, based in Dubai, United Arab Emirates and at site across the region by arrangement.

Planning - key factors

When applying finish coats in high temperatures above 40oC provision should be made for slightly shorter setting and drying times by slightly dampening the

wall to reduce suction. GypFine Board Skim, GypFine Multi Skim and GypFine Ultra Skim have similar setting times. Working characteristics vary slightly. A minimum thickness of 1mm should be applied for optimum performance to be achieved. Ambient and background temperatures must be maintained above 5oC until fully dry.

Levels of Plasterboard finish

(Euro gypsum / UEEP and ASTM C840)
Key factors in determining the level of finish required:

- Area of the work being done.
- The type and angle of surface illumination (both natural and artificial
- light).
- The orientation of plasterboard panels during installation.
- The type of paint or wall covering being used.
- Method of application.

Preparation

Background

- All backgrounds should be dry, free of dust, grit and contaminates such as oil and releasing agents
- When applying GypFine plasters no priming prior to application is required. In high suction areas due to extreme heat conditions, dampening or wetting of the substrate can be carried out to assist in adhesion.
- For remedial works such as skimming painted surfaces, the surface should be roughened and a suitable PVA based bonding agent applied prior to application.
- Good site practice should be followed, as outlined in BSEN 13914 –2.

Plaster thickness

In general, normal thicknesses using GypFine skimming plasters are 1mm – 2mm to pre-leveled walls and ceilings. Thicknesses of up to 4mm can be achieved by applying multiple coats of no more than 2mm, per coat.

Mixing

GypFine plasters should be mixed by adding to clean water and using clean mixing equipment. Refer to Product characteristics - page 210 for mixing ratios. Contamination from previous mixes can adversely affect the setting time and strength. Fresh contamination has more effect than old, so equipment should be washed immediately after mixing rather than just before.

Performance

Reaction to fire

Gypsum binders and gypsum plasters are classified in class A1 (no contribution to fire), in accordance with EN 13501-1 without testing when they contain 1% by weight or volume (whichever is greater) of organic materials.

Durability

GypFine Skimming plasters attain high strength during the drying process and do not suffer from inherent shrinkage cracking.

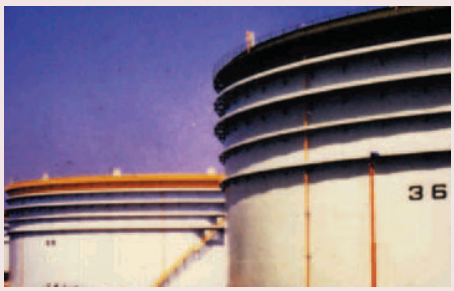
6.10 PAINTING

FUNCTIONS OF PAINT

Paintis a fluid that dries to form a continuous solid film when spread over a surface or substrate. Depending on its type and properties, paint can perform one or more of the following functions:

Figure 0.1: Functions of Paint

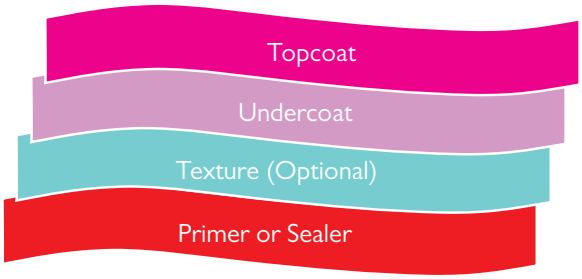
Functions of Paint

Functions of Paint	Descriptions
a) Decorative  Decorative paint for aesthetic purpose	• Paint can be used as a coating to decorate a surface or substrate. It has a wide variety of colour, texture, finishes and gross level.
b) Protective  Protective paint for fuel tanks	• Paint can be designed to protect the surface or substrate against ultra-violet rays, humidity, chemicals, corrosion, algae, abrasion etc.
c) Special Purposes  Luminous paint for emergency signage	• Paint can also be formulated for specific uses such as luminous paint that glow in the dark for emergency signage, anti-condensation paint to provide an insulating layer to minimise condensation, fire retardant paint to enhance the fire resistance of combustible surfaces such as softboard or hardboard. • For application of special paints, refer to manufacturer's recommendations.

PAINT SYSTEMS AND COMPONENTS

A paint system is basically composed of primer/sealer, undercoat and topcoat as shown in Figure 1.1. Depending on the design requirement, texture coating may be provided. Due to volume constraint, this guidebook will focus on paints that are commonly used in the local market.

The functions of each system component are illustrated in Table 1.2 below.



System Component	Function	Remarks
Primer	– To improve adhesion – To protect metal against corrosion – To reduce porosity of receiving substrate so as to prevent undue absorption of resin from subsequent coats of paints	– Primer should be used to reduce the porosity of the surface and to provide adequate moisture resistant capability – Etching Primer should be used as pre-treatment on non-ferrous surfaces such as galvanised metals, aluminium to ensure good adhesion
Sealer	– To resist alkali attack from cement based materials – To improve adhesion – To seal problematic surfaces, e.g. resinous wood – To stabilise loose surface particles – To reduce porosity of receiving substrate so as to prevent undue absorption of resin from subsequent coats of paints	– Sealers are applied to prevent migration of substances from the substrate into later coats and should be used to reduce the porosity of the surface and to provide adequate moisture resistant capability
Texture (Optional) 	– To give a distinct 3-dimensional appearance.	– If applied, this is introduced as the second coat after application of sealer/primer. Commonly applied by spray or roller – Textures are available in multiple colours to simulate the look of granite, tiles, and wallpaper – Mock-ups are important to understand the appearance of the product
Undercoat	– To impart opacity and film build – To level out minor irregularities and provide uniform texture – To improve inter-coating adhesion	– Choice of undercoat should be compatible with the primer/sealer and the finishing coats
Topcoat	– To provide the required functions of paint as discussed in Section 1.1	– This is the finishing coat of a paint system which gives the final appearance in term of colour, gloss or sheen to the substrate.

Functions of the Various Components of a Paint System

CLASSIFICATION OF PAINT

With technological advancements, the traditional classification of paints into either enamel or emulsion has become misleading. Today, the industry has enamel paints that can be diluted with water and emulsion paints that have smooth, glossy finishes. Hence, it becomes essential to identify paint by its resin components to minimize confusion, "enamel" refers to solvent-based Alkyd resin which is generally used for wood and metal surfaces.

Apart from classifying paints by their resin components, paints may also be classified in accordance with their curing mechanism, solvent used, function and market segment as shown in Table below.

Classification by	Type of Paints
Curing Mechanism	Baking or Air-dry
Solvent for the Paint	Water-based or Solvent-based
Function of System Component	Primer, Sealer, Undercoat or Finishing Coat
Resin component	Epoxy, Alkyd, Acrylic, Polyurethane, etc
Market Segment	Architectural Coating, Heavy Duty Coating, Marine or Industrial Coating

Classification of Paints

PROPERTIES OF PAINT

The properties of paint determine the general quality of the coating and its workability, ease of application and resistance characteristics. Table 1.4 shows some basic properties of paints.

Properties	Examples
Appearance	Gloss/ Matt/ Semi-gloss
Application Method	By Brush, Roller or Sprayer
Drying Time	Fast dry/ Slow dry
Adhesion	Adhesion to substrates/ Existing coating/ Intercoating
Mechanical Characteristics	Hardness/ Flexibility
Resistance	Ultra-violet/ Chemical/ Abrasion/ Fungus/ Algae
Outdoor Durability	Gloss retention/ Colour / Ultra-violet
Storage Stability	Settling tendency/ Viscosity stability

Essential Properties of Paint

6.11 POINTING & JOINTING

JOINTING

Jointing is the word used to describe the finish of the mortar joints between bricks, to provide a neat joint in brickwork that is finished fair face. Fair face describes the finished face of brickwork that will not be subsequently covered with plaster, rendering or other finish.

Most fair face brickwork joints are finished, as the brickwork is raised, in the form of a flush or bucket handle joint. When the mortar has gone off, that is hardened sufficiently, the joint is made. Flush joints are generally made as a 'bagged' or a 'bagged in' joint. The joint is made by rubbing coarse sacking or a brush across the face of the brickwork to rub away all protruding mortar and leaving a flush joint. This type of joint, illustrated in Fig. 65, can most effectively be used on brickwork where the bricks are uniform in shape and comparatively smooth faced, where the mortar will not spread over the face of the brickwork.

A bucket handle joint is made by running the top face of a metal bucket handle or the handle of a spoon along the joint to form a concave, slightly recessed joint, illustrated in Fig. 65. The advantage of the bucket handle joint is that the operation compacts the mortar into the joint and improves weather resistance to some extent. A bucket handle joint may be formed by a jointing tool with or without a wheel attachment to facilitate running the tool along uniformly deep joints. Flush and bucket handle joints are mainly used for jointing as the brickwork is raised.

The struck and recessed joints are more laborious to make and therefore considerably more expensive. The struck joint is made with a pointing trowel that is run along the joint either along the edges of uniformly shaped bricks or along a wood straight edge, where the bricks are irregular in shape or coarse textured, to form the splayed back joint. The recessed joint is similarly formed with a tool shaped for the purpose, with such filling of the joint as may be necessary to complete the joint. Of the joints described the struck joint is mainly used for pointing the joints in old brickwork and the recessed joint to emphasize the profile, color and textures of bricks for appearance sake to both new and old brickwork.

TYPES OF JOINTS

The form of the joint also influences the appearance of a facade. Of course the height of the joint plays an important role, but the depth is also important. The deeper the joint, the more it will end up in the background. This creates a shadow play between the joint and the facing brick, which especially emphasizes the color of the brick. There are various standard types of joints. The price depends of course on the labor intensiveness.

Flush joint

Working method

The mortar is generously applied and leveled in a smooth way so that the mortar is flush to the brickwork.

Effect

This form of pointing is often used with coloring on coloring joint mortars. The even surface that is desired is emphasized this way

Flush brushed joint

Working method

The mortar is generously applied but not leveled smoothly. Brushing the excess mortar creates a rougher joint with more texture.

Effect

Here also this type of pointing creates an even surface when using coloring on coloring mortar. In addition, the brushed effect creates facade with more character.

Weather struck joint

Working method

The mortar is applied partially recessed in an angle of 45°.

Effect

This creates a shadow effect. The horizontal lines of the facade are emphasized.

Recessed joint

Working method

This is an extra raked joint. The mortar is applied 2 to 5 mm deeper than the visible surface of the facade.

Effect

The emphasis is laid on the horizontal aspect of the facade, especially in combination with full vertical head joints or even no vertical head joints at all.

Raked joint

This is also a very common type of pointing.

Working method

The mortar is pressed a bit inwards so that it is approximately 2 mm recessed compared to the facing brick.

Effect

This creates more shadow between the joint and the brick and gives a very well ¬cared ¬for appearance. Can be done smooth or brushed.

Convex joint

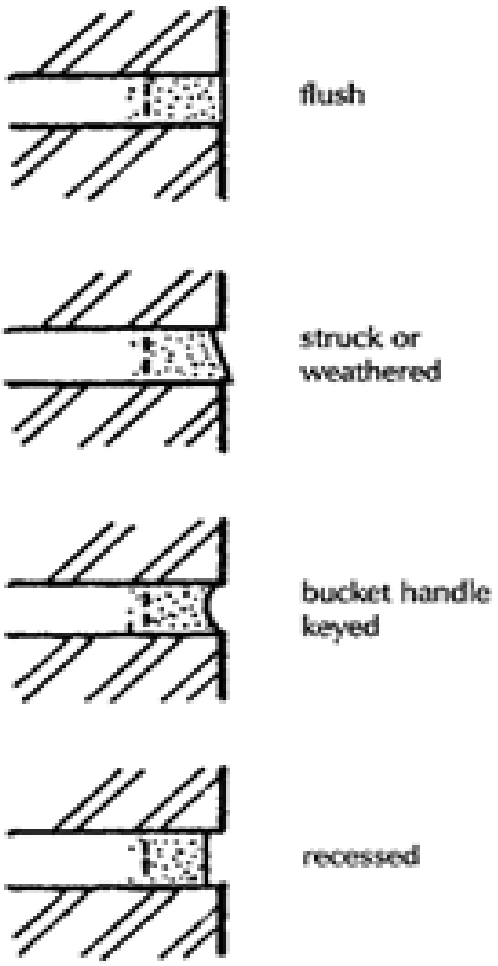
This is a type of joint that is less common because it requires more time and expertise.

Working method

The mortar is generously applied but not leveled smoothly. Brushing the excess mortar creates a rougher joint with more texture.

Effect

Here also this type of pointing creates an even surface when using coloring on coloring mortar. In addition, the brushed effect creates facade with more character.



Jointing and pointing

POINTING

The words jointing and pointing are commonly loosely used. Jointing is the operation of finishing off a mortar joint as the brickwork is raised, whereas pointing is the operation of filling the joint with a specially selected material for the sake of appearance or as weather protection to old lime mortar. Pointing is the operation of filling mortar joints with a mortar selected for color and texture to either new brickwork or to old brickwork. The mortar for pointing is a special mix of lime, cement and sand or stone dust chosen to produce a particular effect of color and texture. The overall appearance of a fair face brick wall can be dramatically altered by the selection of mortar for pointing. The finished color of the mortar can be affected through the selection of a particular sand or stone dust, the use of pigmented cement, the addition of a pigment and the proportion of the mix of materials.

The joints in new brickwork are raked out about 20 mm deep when the mortar has gone off sufficiently and before it has set hard and the joints are pointed as scaffolding is struck, that is taken down. The mortar joints in old brickwork that was laid in lime mortar may in time crumble and be worn away by the action of wind and rain. To protect the lime mortar behind the face of the joints it is good practice to rake out the perished jointing or pointing and point or repoint all joints. The joints are raked out to a depth of about 20mm and pointed with a mortar mix of cement, lime and sand that has roughly the same density as the brickwork. The operation of raking out joints is laborious and messy and the job of filling the joints with mortar for pointing is time consuming so that the cost of pointing old work is expensive. Pointing or repointing old brickwork is carried out both as protection for the old lime mortar to improve weather resistance and also for appearance sake to improve the look of a wall.

Mortar required for pointing work:

1. Lime mortar of 1:2 (1 fat lime: 2 sand or surkhi)
2. Cement mortar of 1:3 (1 cement: 3 sand) Above mortar mixes will give good results in pointing.

Preparation of surface:

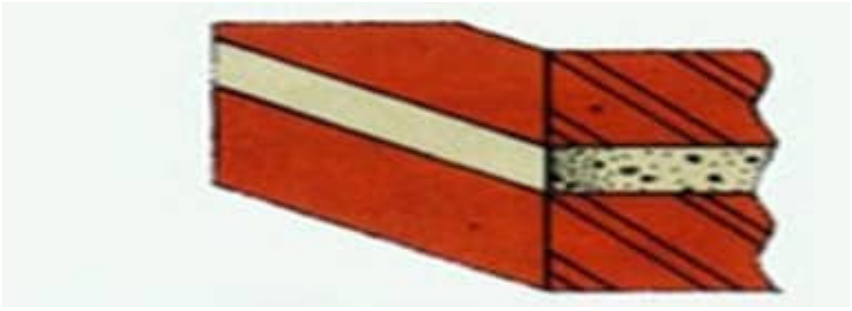
All the joints in masonry are raked down to a depth of 20mm while the mortar is still soft. The joints and surface are cleaned and then thoroughly wetted.

Methods of pointing:

After preparing the surface as mentioned above, mortar is carefully placed in joints using a small trowel. The placed mortar should be of desired shape. Whenever the fresh mortar is placed in the joints it should be pressed hardly to gain strong bond with old interior mortar. Care should be taken while using ashlar or 1st class brick work otherwise the mortar does not cover the face edges. The pointed surface is kept wet for at least a week or till it sets after application.

Types of pointing:

1. Flush pointing
2. Recessed pointing
3. Beaded Pointing
4. Struck Pointing
5. Rubbed, keyed or grooved pointing
6. Tuck Pointing
7. V- pointing
8. Weathered pointing



Flush pointing:

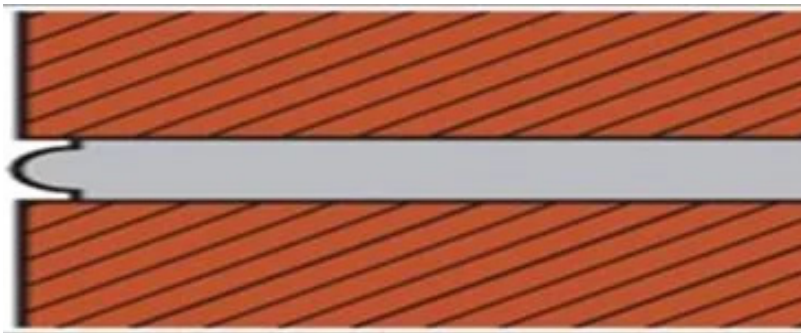
In This type of pointing mortar is pressed hard in the raked joints and by finishing off flush with the edge of masonry units. The edges are neatly trimmed with trowel and straight edge. It does not give good appearance. But, flush pointing is more durable because of resisting the provision of space for dust, water etc., due to this reason, flush pointing is extensively used.

Recessed pointing:

In case of recessed pointing mortar is pressing back by 5mm or more from the edges. During placing of mortar, the face of the pointing is kept vertical, by a suitable tool. This type of pointing gives very good appearance.

Beaded pointing:

It is a special type of pointing which is formed by a steel or ironed with a concave edge. It gives good appearance, but it will damage easily when compared to other types.

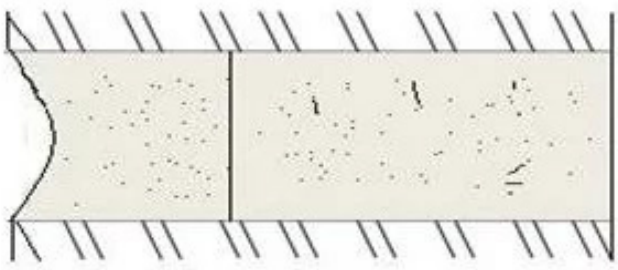


Struck pointing:

This is a modification of flush pointing in which the face the pointing is kept inclined, with its upper edge pressed inside the face by 10mm. struck pointing drains water easily.

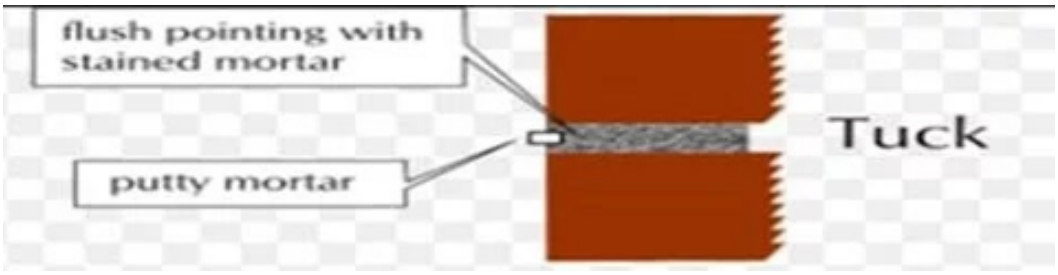
Rubbed, keyed or grooved pointing:

This pointing is also a modification of flush pointing in which groove is formed at its mid height, by a pointing tool. It gives good appearance.



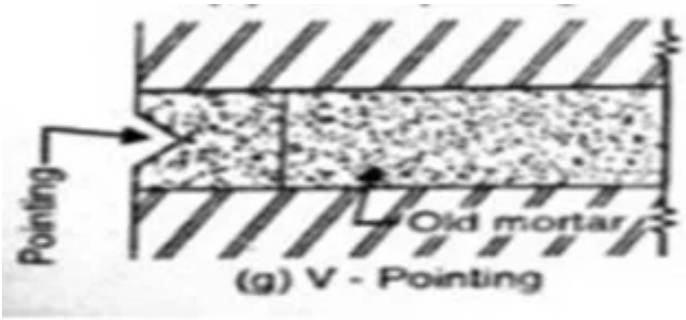
Tuck pointing:

In case of tuck-pointing mortar is pressed in the racked joint first and finishing flush with the face. While the pressed mortar is green, groove or narrow channel is cut in the center of groove which is having 5mm width and 3mm depth. This groove is then filled with white cement putty, kept projecting beyond the face of the joint by 3 mm. if projection is done in mortar, it is called bastard pointing or half tuck pointing.



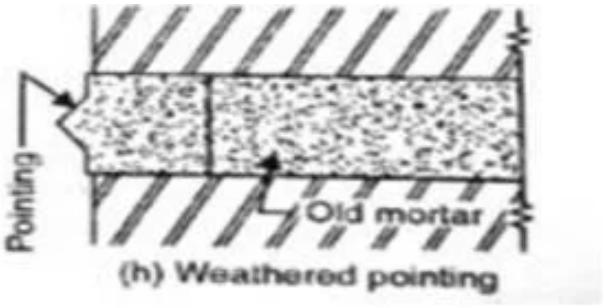
V- Pointing:

This pointing is formed by forming V-groove in the flush-finishing face.



Weathered pointing:

This pointing is made by making a projection in the form of V-shape



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