- *Repeat the exercise, using the bonding gauge rod every three or four bricks for checking the perpend alignment.*
- *Check your overall course length. It should be 2.03 m.*

NOTE:
During this exercise and during its repeat, try to achieve a level bed joint of about 10 mm and keep the perpends as much as possible in a vertical line.

8.1.7 Exercise No 4

For this, turn the base board on edge and construct an eight-brick stretcher course on it, using the method of the previous exercises and the stretcher course edge of your bonding gauge rod for checking. The overall dimension of your eight-brick course should be: 1.91 m.

NOTE:
Using the board on edge, you will need to remove excess mortar from both sides of the course during the bricklaying process.

Exercise Nos 1, 3 and 4 have been described and carried out from left to right. As additional training, these exercises may be done starting from the right and building to the left also.

9 MEASUREMENT OF BRICKWORK

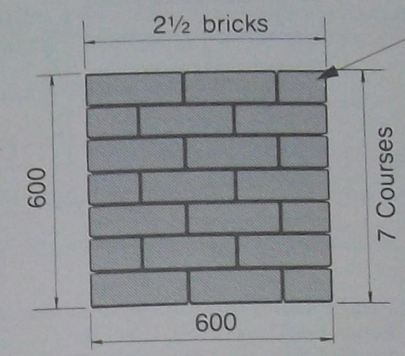
It was mentioned earlier that metric brickwork is designed to suit a 600 mm panel. This applies in plan as well as in elevation.

Brick sizes in metric have been determined to achieve that and some suit a 300 mm panel as well.

The range of metric bricks is as follows:

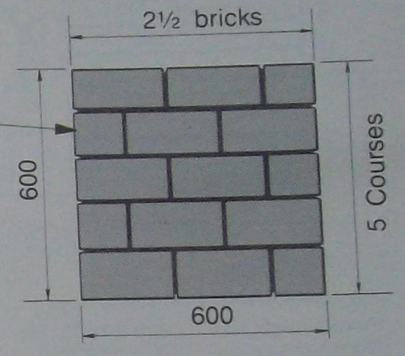
	ACTUAL SIZE (Manufacturing Size)	NOMINAL SIZE (Format Size)
Standard metric (Traditional Metric)	230 × 110 × 76	240 × 120 × 86
Modular metric 2 sizes	290 × 90 × 90 190 × 90 × 90	300 × 100 × 100 200 × 100 × 100
Modulated metric 2 sizes	290 × 90 × 65 290 × 90 × 76	300 × 100 × 75 300 × 100 × 86

The illustrations show how the various sizes of bricks fit into the co-ordinating panel in face work.



Actual brick size 230 x 110 x 76
Nominal size 240 x 120 x 86

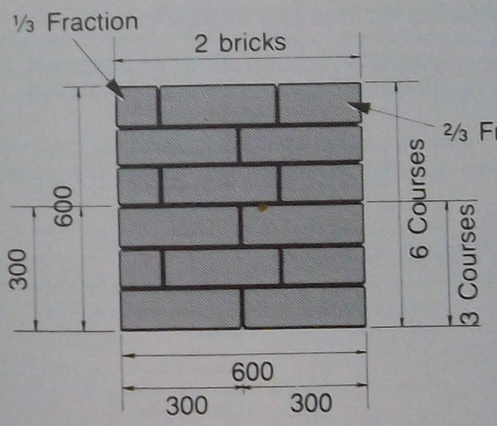
STANDARD METRIC



Actual brick size 230 x 110 x 76
Nominal size 240 x 120 x 86

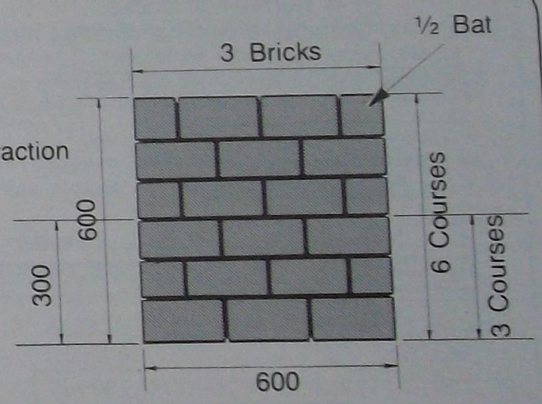
STANDARD METRIC ON EDGE

STANDARD METRIC



Actual brick size 290 x 90 x 90
Nominal size 300 x 100 x 100

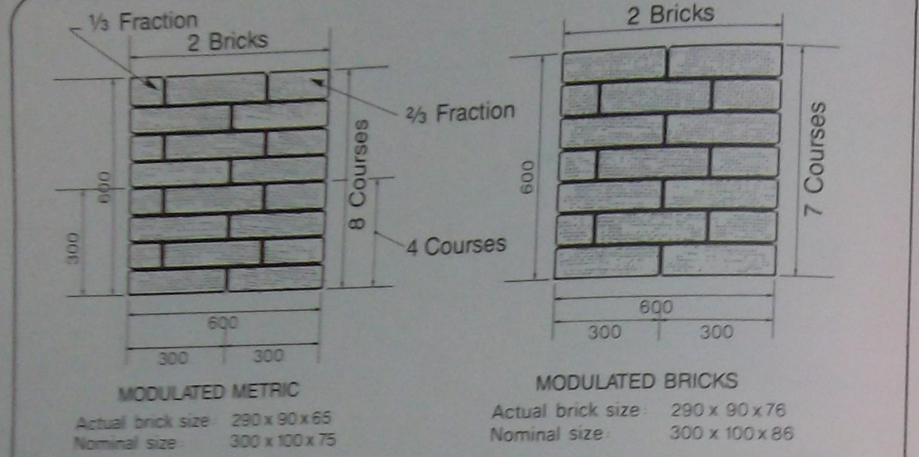
MODULAR METRIC



Actual brick size 190 x 90 x 90
Nominal size 200 x 100 x 100

MODULAR METRIC

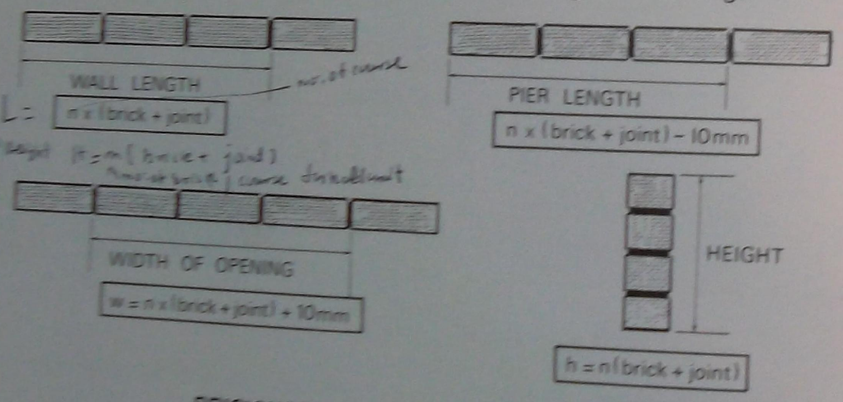
MODULAR METRIC



MODULATED METRIC

The following illustration shows how brickwork dimensions are calculated.

n = number of bricks
Nominal only. The courses must fit the 600mm grid in buildings.



BRICKWORK MEASUREMENTS

Examples of calculations

A brick wall 18 m long, 1.2 m high and 230 mm thick is to be built. How many bricks are required, using standard metric bricks?

The height of the wall amounts to two 600 mm modules and for this type of brick there are 7 courses per module. Therefore 14 courses are needed.

Or by using the formula:

$$H = n\,(\text{Brick} + \text{Joint})$$

$$1200 = n\,(76 + 10)$$

$$1200 = 86n \text{ or } n = \frac{1200}{86} = 14 \text{ courses}$$

The number of bricks per course, using the formula:

$$L = (\text{Brick} + \text{Joint}) \times n$$

$$18\,000 = n\,(230 + 10)$$

$$18\,000 = 240\,n \text{ or } n = \frac{18\,000}{240} = 75 \text{ bricks}$$

But this is only for a 110 mm wall thickness (½ unit).

For 230 mm (1 unit) thickness, the number of bricks would be twice that, therefore: 150 bricks.

For 14 courses: $150 \times 14 = 2100$ bricks.

Make sure that when using the formula you work with the same units. For instance, height and length were given in metres, but the size of the brick is expressed in millimetres. Therefore, the sizes of length and height must be expressed in millimetres also when used in the formula (18 000 and 1200 mm), or the brick and joint measurement converted to metres.

For practical purposes, the following table and the formula given are a useful and quick method for calculating the number of bricks in any wall, e.g. whether of solid or cavity wall construction.

NUMBER OF BRICKS PER SQUARE METRE

Thicknesses (Units)	Standard Metric 230 × 110 × 76	Modular Metric 290 × 90 × 90	Modulated Metric 290 × 90 × 65
½	50	34	45
1	100	68	90
1½	150	102	135
2	200	136	180
2½	250	170	225
3	300	204	270

Formula: Number of bricks (N) = Length of wall (L) × Height of wall (H) × Bricks per square metre (B) or $N = L \times H \times B$.

Example: For a wall 6 metres long, 3 metres high and 1½ units thick in standard metric brick:

$L = 6$, $H = 3$, $B = 150$ (from table)

then $N = 6 \times 3 \times 150 = 2700$ bricks

Joint thickness is nominally taken to be 10 mm. Architects may well specify thinner or wider joints depending on the effect they wish to obtain. They may be as thin as 6 mm or as wide as 12 mm.

Also to fit the 600 mm module, there will have to be slight variations in the nominal size of the bed joints. For instance, 7 courses of standard metric brick, using 10 mm joints, would amount to a height of $7 \times 86 = 602$ mm to the top of the 7th course.

Therefore, it will be helpful to mark the 300 mm and the 600 mm module dimensions on the gauge rods so as to keep the brickwork closely within these limits.

10 BUILDING A SIMPLE WALL

Having learned how to place a brick into mortar, the trainee has now to proceed to the stage where he can construct an assembly. In building up his first brick work, the beginner faces a number of difficulties which he must master. These are:

- the wall must rise vertically;
- the courses must remain horizontal;
- the joints must be regular and full.

Before attempting the building of a wall, it is good practice to provide trainees with a set of reference points as guides to the construction of proper brickwork. Providing them with profiles will assist in their overcoming the first difficulty. Even where practice facilities exist which feature fixed and permanent vertical profiles, it is advisable for trainees to learn how to make profiles, how to erect them and how to use them on the job as an aid for starting a wall accurately and keeping it vertical.

NOTE:

It does not matter whether profiles are used or not on the job in various regions; profiles are a means to facilitate training.

10.1 BUILDING A PROFILE

Material requirement for one profile:

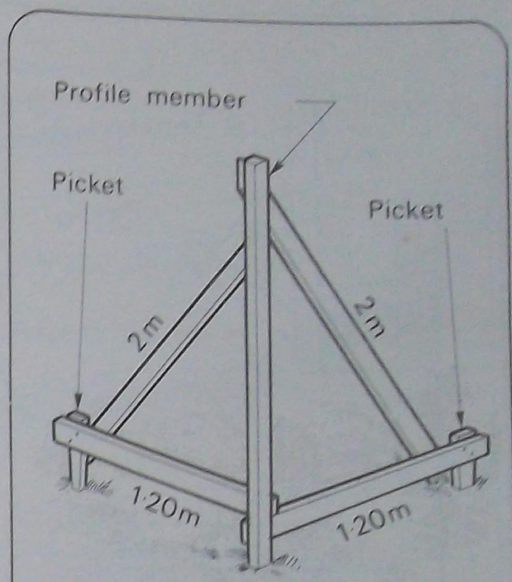
Dressed timber: 80 × 90 mm	2.5 m long	1
Boards (old floor boards)	1.2 m long	2
Boards	2 m long	2
Pickets		2
Nails — as required		

Procedure

- Adjacent to the ground selected as the base for the construction of the wall, drive in the long piece of timber until about 2 metres protrude above ground (or base) level.

  — Where the soil is too hard for this, dig a hole of sufficient depth and lower the timber into it. Then, while supporting it vertically, replace and tamp the soil around until the timber remains self-supporting.

- Nail on the two lower boards, making sure they do not protrude past the two timber faces which will act as guides.
- Nail on the two braces.
- Drive in the pickets, but do not nail them at this stage.
- Check the post for plumb on one of its guide sides with either a spirit level or a plumb bob. Adjust the post face in the vertical, then nail the picket to the lower board.



CONSTRUCTION OF A PROFILE

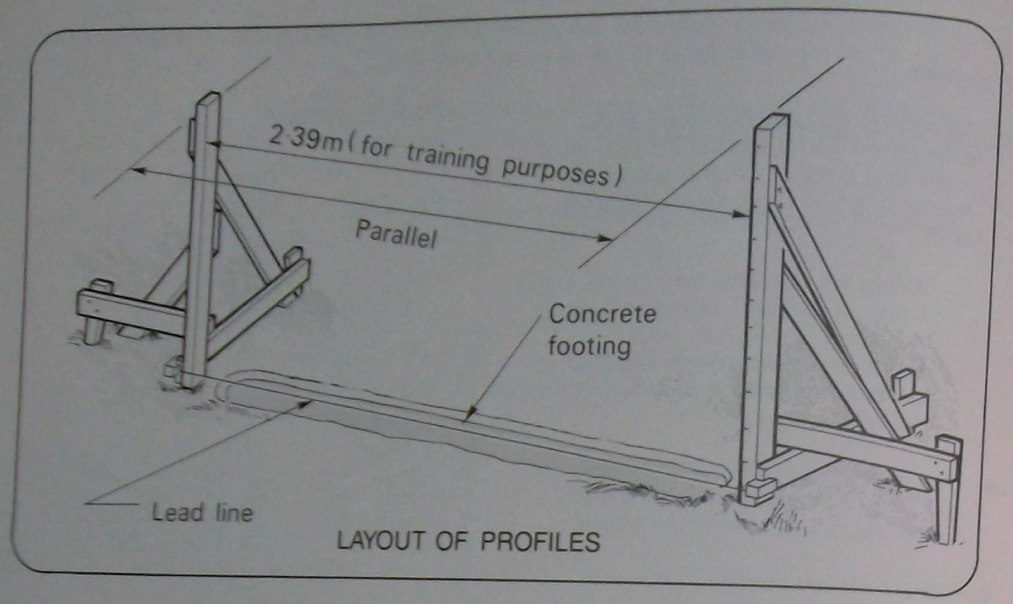
- Repeat the process for the other guide face. Adjust the post, then nail the picket to the board.
- Check that all nails are driven home and that any protruding nails on the other side are properly clinched to avoid accidents later.
- Recheck the profile for plumb, adjusting it by light hammer blows on the appropriate pickets as required to bring the profile into the vertical.

The illustration shows a completed profile in position.

During the construction of the profiles, make sure the two inner guides remain parallel to one another and that the two front faces line up to the required lead line. A straight board can be used for lining up the faces.

It is not strictly necessary to drive the profile into the ground. It can be left to rest on the ground. If this method is used, then the lower supports and the braces must be nailed to the profile before erecting it, final securing being done by means of the pickets.

As an extra insurance against possible sinking of the profile, it is advisable to place a brick externally against the base of each profile, and to mark on the profile the level of the upper face of the brick (a peg driven in the ground can also be used). That way, any sinking can be immediately noticed. Check the line-up frequently as well as the plumb of the profiles.



LAYOUT OF PROFILES

The illustration shows the relative position of the two profiles between which the wall construction is to be carried out.

NOTE:

Such profiles can be used for outdoor practice and for training purposes. The distance between profiles has been chosen at 2.39 m, giving a course of 10 stretchers or 20 headers for standard metric bricks.

By marking the course height on the profiles, it is now possible to use them as gauge rods as well, after having determined the base level for the first course of bricks to be laid.

10.2 BUILDING SIMPLE WALLS BETWEEN PROFILES

The aim of the following exercises is to teach trainees to:

- lay bricks in superimposed courses;
- keep the horizontal joints and perpends level and regular in thickness;
- stretch and work to the line;
- select the proper brick and its outer face;
- cut bricks to size.

10.2.1 Building a ½-unit wall

Material requirements and tools:

Standard metric bricks — approx. 100.

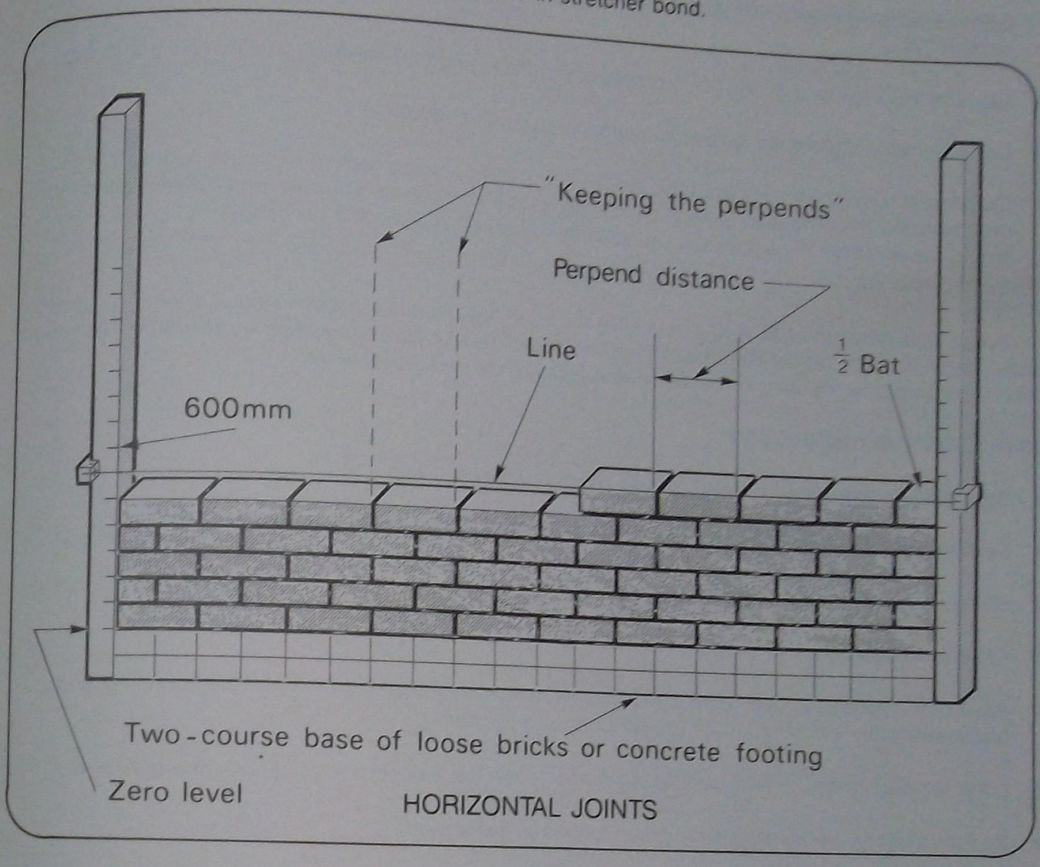
Mortar — sufficient for 100 bricks.

Perpend gauge rod (bonding rod).

Standard bricklaying tools.

Exercise

Build a 9 course, ½-unit wall between the profiles in stretcher bond.



HORIZONTAL JOINTS

Aim: To make regular horizontal joints.

Having organised your work post in the proper manner, the instructor will show you how to stretch and locate the line for the first course. When told to do so, proceed as follows:

- Lay and spread the mortar for four bricks.
- Starting at one of the profiles, select a brick and lay it in the approved manner, taking care that:
  - its best face shows where the outer face of the wall will be;
  - the arris of the brick is level with the line, but does not touch it. The distance between arris and line should remain equal to the thickness of the line.
- Remove excess mortar, then, having buttered the next brick header face after selecting the best stretcher face, lay it in the same approved fashion.
- With the perpend gauge, check the size of the perpend and adjust if necessary.
- Continue the process until you have laid the full first course.
- Throughout, check that each brick you lay does not tilt up or down at the rear arris (the one opposite the line).

Before starting on the second course, remove the line and locate it at the second mark.

- Select a suitable brick, mark and cut it into two half bats, using one of the methods detailed in section 7.4.
- Lay a ½ bat next to a profile, then proceed with the laying of 9 stretchers followed by a ½ bat.
- Carry out your checks on perpends and brick levels throughout.
- Continue the exercise until you have reached 9 courses, taking care to alternate course 1 with 2 and ensuring the perpends in each course coincides as much as possible with the vertical centre line of the stretcher face above and below (this is called keeping the perpends).

NOTE:

Should an arris touch the line at any time after the brick has been laid and levelled, it should be gently tapped back until the proper distance is obtained again. This so-called crowding must not be allowed to occur as it results in irregular and shoddy face appearance of the brickwork.

NOTES FOR THE INSTRUCTOR

- Stress again the need for full, regularly spaced and even joints.
- Demonstrate the use of the line, and how by stretching it taut, sag is eliminated.
- Stress the need to avoid crowding.
- Ensure trainees work to the line.
- Assist the trainees to overcome the difficulties which may arise from laying bricks quickly and accurately after selection of the proper brick and its face.
- Look for and correct any causes which may prevent the trainee from acquiring the proper rhythm.
- Ensure that the elementary movements are made instinctively.
- Do not allow too much tilt of the bricks in the direction of the wall thickness. Make the trainee correct it before proceeding further.

10.2.2 Building a one-unit wall

Material requirements and tools:

Bricks 240 (or 216 + 24 × ¾ bats).

Mortar — sufficient for 240 bricks.

Perpend gauge rod (bonding rod).

Standard bricklaying tools, plus a good spirit level.

NOTE:

The ¾ bats may have been cut to size before the start of the exercise and made available to the trainee. Alternatively, he may be required to cut them himself during or before the exercise.

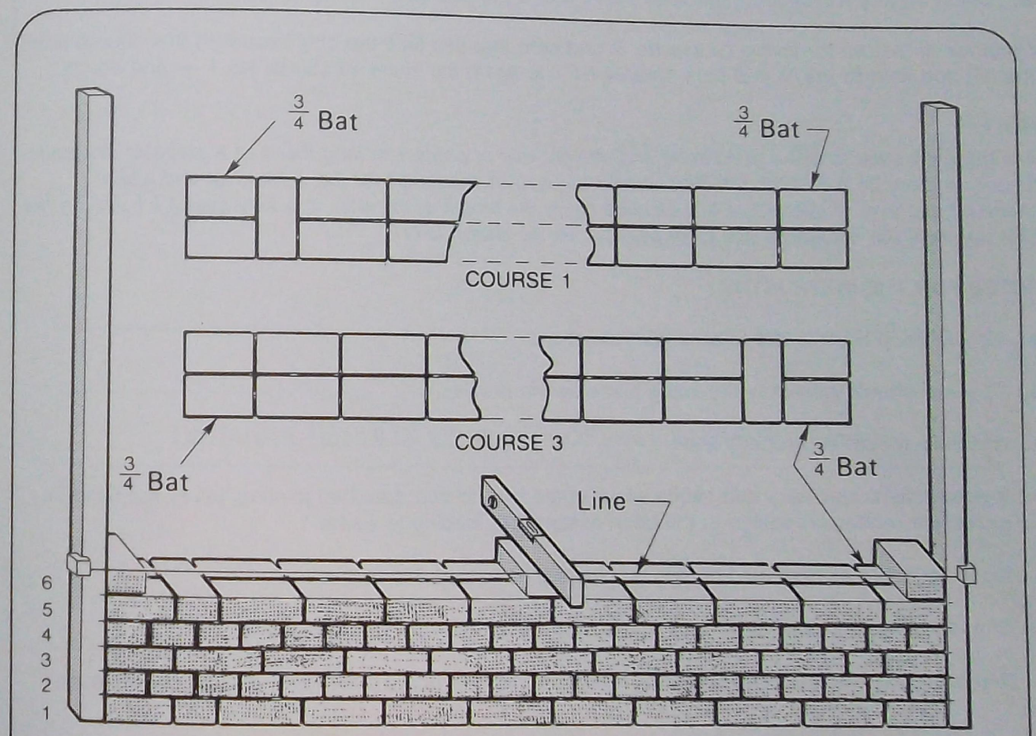
Exercise

Build a 12 course high, 1-unit thick wall (230 mm) between the profiles used for the exercise at 10.2.1.

Aim: To lay bricks horizontally along the line and across the thickness of the wall.

Procedure

- Organise the materials and tools you require in your work post.
- Locate and stretch the line for laying the first course.
- Lay the first course according to the principles of bricklaying you have learned in the previous exercises and to the course pattern shown in the illustration.
- Start at the profile (left side) with the ¾ bat lining up the front to the line.
- Use the spirit level to check and adjust the bricks so that they are horizontal and that their faces are truly perpendicular and in the plane of the wall.
- Use the perpend gauge to check the width of joints along the face of the wall towards you.
- Make sure all joints are filled.



BUILDING A ONE UNIT WALL

When you are satisfied that all bricks are level in both directions, proceed with the laying of the second course, which as all even numbered courses are in this exercise, is a course of headers.

For laying the second course, proceed as follows:

- Locate and stretch the line for course 2.
- Lay a header next to the profile on the left-hand side, level it in both directions.
- Lay another header next to the profile on the right-hand side, level it in both directions.
- Lay a third header midway across the centre perpend of the stretchers in course 1, level it in both directions.
- Finish the second course by laying the remaining bricks between the first three by sighting only, but working to the line.
- Keep a check on your perpends by using the face set-up of the first course or by an occasional check with the gauge rod.
- Having completed the course, check each brick for level across the wall thickness. Adjust as necessary, but watch the front alignment to the line when doing so.
- Clean off any mortar from the brick faces with a rag or piece of bagging.

Continue as before for laying course No 3, and note that this time the only header in this course is on the left and next to the ¾ end bats. Course No 5 is again the same as course No 1 — and so on.

NOTE:

It is good practice to use a good solid and straight rule of about 1 m long made of a piece of dressed timber of about 25 mm × 50 mm. This should be used as a support for the spirit level and when checking the level of every 3 or 4 bricks laid along the length of the wall. It is very useful for use on the side opposite the line and it has other uses as will be shown later.

NOTES FOR THE INSTRUCTOR

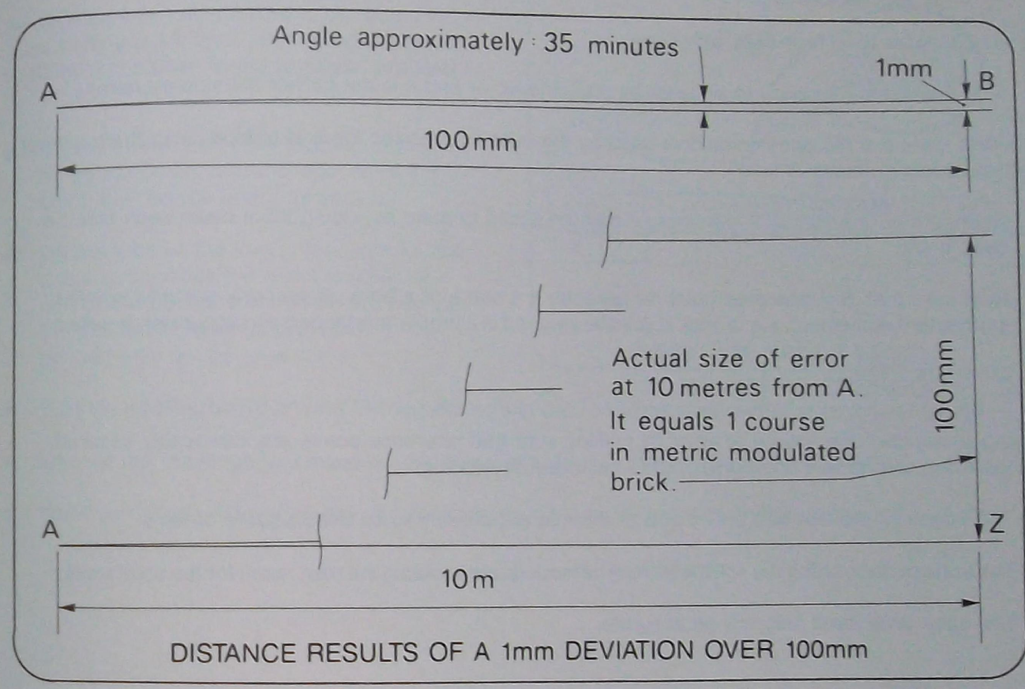
- Ensure each brick is laid level in both directions.
- The wall should remain in the same plane as the profiles.
- All joints should be properly filled.
- Immediately correct any bad habits which could lead to improper bed jointing, joints not filled in, excessive mortar droppings at the base of the work leading to waste.
- No great importance should be laid on bonding pattern at this stage.
- Stress the need for maximum use of line, spirit level and rule during this exercise.
- Demolish faulty work and let the trainee repeat the exercise until a satisfactory standard is achieved.

11 TRANSFERRING LEVELS

Except perhaps in the construction of arches, it can be said that all bricklaying is done 'on the level', that is to say, horizontally. In brickwork horizontal means exactly horizontal. The 'near enough' approach creates problems not only for the bricklayer as the job proceeds, but also for other tradesmen later.

Do not assume that any foundation or footings are so level that they form the horizontal reference line from which bricklaying can proceed without any further preliminary checks. Continuous precautionary controls at all levels are a must. Before any bricklaying is done, the bricklayer has to establish a reference point from which the horizontal will be determined and then maintained throughout the construction.

The results of even a slight variation are shown in the illustration. Accuracy in setting out your first level is of the greatest importance.



DISTANCE RESULTS OF A 1mm DEVIATION OVER 100mm

NOTES

11.1 LEVELLING TOOLS AND INSTRUMENTS

To determine levels, the following tools and instruments are used:

- The levelling board, about 2.5 m long, made of well-seasoned and dressed timber of about 40 × 100 mm in cross-section.
- The rule.
- The spirit level.
- The flexible water level, usually made up from a length of hose into which glass tubes have been inserted at both ends.
  - — When filling it, do it slowly, as any air bubbles trapped inside will give false reading. Ensure air is evacuated before using it. It can be used to check levels established with rule and spirit level.
- The Cowley level (not dealt with here).
- The theodolite (not likely to be used by a bricklayer — and it is not further considered here).

The first three are the ones commonly used by the bricklayer on the job and before using them it must become second nature to him:

- to ensure no mortar, brick particles or any dirt sticks to them by wiping them clean each time he uses them;
- to ensure that any reference point he uses, be it a stake or a brick, is properly secured against inadvertent movement, e.g. a brick should be secured in a proper mortar bed and accurately levelled.

11.2 SOURCES OF ERROR

Having eliminated one source of error by making sure that reference points are immovably secured, the following still remain and could lead to mistakes developing.

- The edges of the levelling board and of the rule are unlikely to be dead square or level.
- The surface supporting the spirit level may be inadequate to obtain the best reach for the spirit level.
- The spirit level itself may not be accurate.

11.2.1 Eliminating the first source

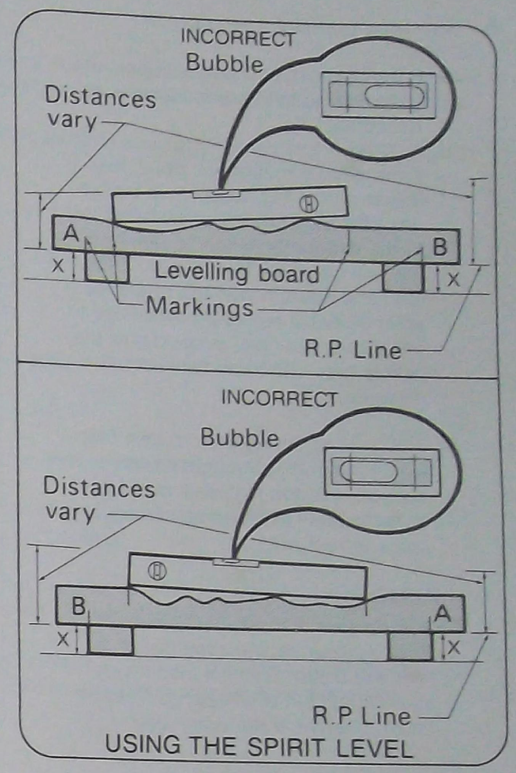
Even if one part in the middle of the levelling board is straight and level, this does not mean that the ends are in this condition.

On the other hand, one edge could be straight and level, but the centre of the other edge need not necessarily be so.

Using a spirit level, which is relatively short, without taking corrective steps, will result in the errors shown. Using a spirit level with the levelling board and taking only one reading will also result in errors.

To overcome possible errors in the board when setting out a level, and assuming the spirit level has been found accurate, proceed as follows:

- On the board, mark the location of the reference points and the location of the spirit level on the board as shown.
- On the tube of the level, mark with as fine a line as possible the exact location of one of the bubble ends which are beyond the standard markings provided permanently on the level glass.



USING THE SPIRIT LEVEL

- Turn the levelling board around 180 degrees so that end A is where B was and B where A used to be.
- Line up the markings you made on the board exactly with the reference line supports.
- Make sure the spirit level is within the marks made for its proper location on the top edge of the board.

- Now read the spirit level again.

  — If the deviations 'd' of the bubble are the same as before the supports are horizontal.

  — If the deviations are not equal, then adjust one of the supports in such a way that the bubble comes in line with ½ the excess deviation 'e' between the two readings. In our case, if the left hand support was the reference point (fixed), it would be necessary to move the right-hand support until the bubble came half-way between distance 'e'.

  — If 'e' was to the right of 'd' then that would mean that the right-hand support was too high and would have to be lowered until the bubble again came to rest at ½ 'e'.

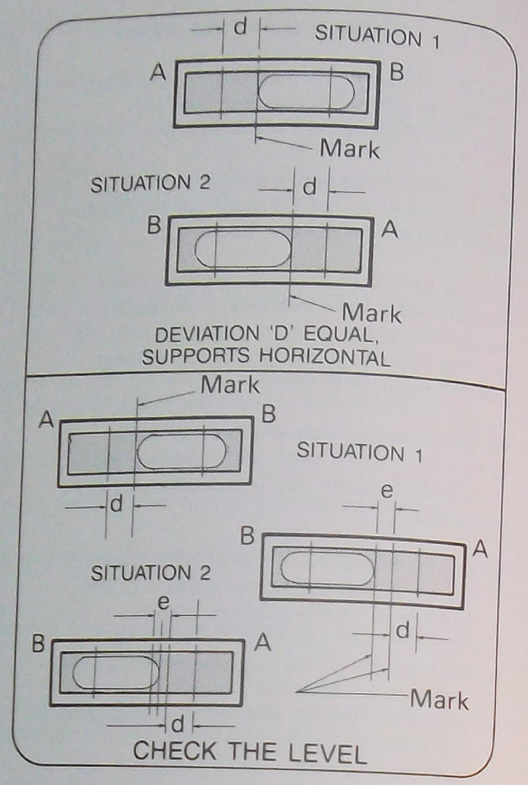
NOTE:

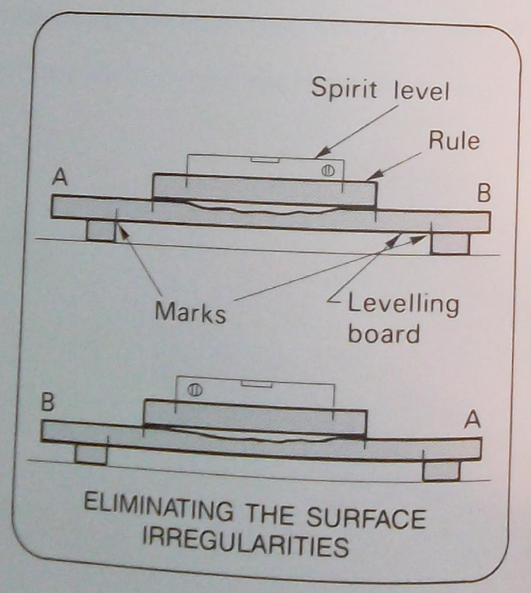
It is obvious that provided the spirit level is accurate, the condition of the levelling board does not matter very much at all, but two readings must be taken to arrive at the exact level.

11.2.2 Eliminating the second source

From what we have seen in 11.2.1 it is also obvious that because the level is relatively short, minor irregularities on the levelling board over the distance covered by the spirit level base can throw this one out considerably over a rather short distance to be levelled.

To overcome this and to increase the 'range' or 'reach' of the spirit level, use is made of a rule about 1 metre long, made of well-seasoned, well-dressed timber and properly squared edges. It is used on top of the levelling board as shown. Regardless of how accurately this rule may have been made, it is nevertheless necessary to take two readings, as was done for just the levelling board and spirit level, each time a level is to be established and the same precautions for accuracy taken as before. The use of a good reliable rule assists in the elimination or reduction of errors which could creep in without its use.





11.2.3 Eliminating the third source

The third source of error can be in the spirit level itself. As it is an instrument for control of the work, it must be accurate and reliable. It should be treated with great care and frequently checked for accuracy.

Some spirit levels have means of adjusting the bubble location accurately between the permanent marks on the bubble glass.

The procedure for checking and adjusting a spirit level is similar to that explained at 11.2.1.

- Place the level on a reasonably level surface.
- Mark the location of the level and of the bubble.
- Turn the level around 180 degrees, place it accurately within the marks made.
- Read the location of the bubble in the new position.

  — If the deviation in both cases is the same, the level is accurate.

  — If the deviations differ, then adjust the bubble end so that it comes to rest half-way between the difference of the two marks made for the checking.

  — Means of adjusting varies with each brand of spirit level. Your instructor may be able to show you a range of adjustable levels and how each can be adjusted.

  — If the level is non-adjustable, it is advisable to make a mark on it which is half-way between the difference in deviations so that guesswork to establish a true level is eliminated.

NOTES FOR THE INSTRUCTOR

Because of the great number of errors which can arise when checking or setting out levels, stress must be laid on the need to carry out this work accurately and with great care. Insist on the application of proper procedures and the exercise of meticulous care.

- Demonstrate to the trainees that the method is sound by checking a true level previously established by other means (flexible water level, theodolite, etc) with the method described.

  — For this it is advisable to use a faulty levelling board, a rule which is higher at one end than the other and a faulty spirit level.

  — Allow the trainees to carry out the check for themselves. This will give them confidence in the method and prove its reliability regardless of the faulty equipment used.

- Arrange a number of preliminary exercises before engaging the trainees on the actual transferring of levels under actual working conditions. Three exercises are suggested.

  — Transfer an existing level (RP) at 1 metre from floor level on wall to a point maximum 4 metres away on that wall.

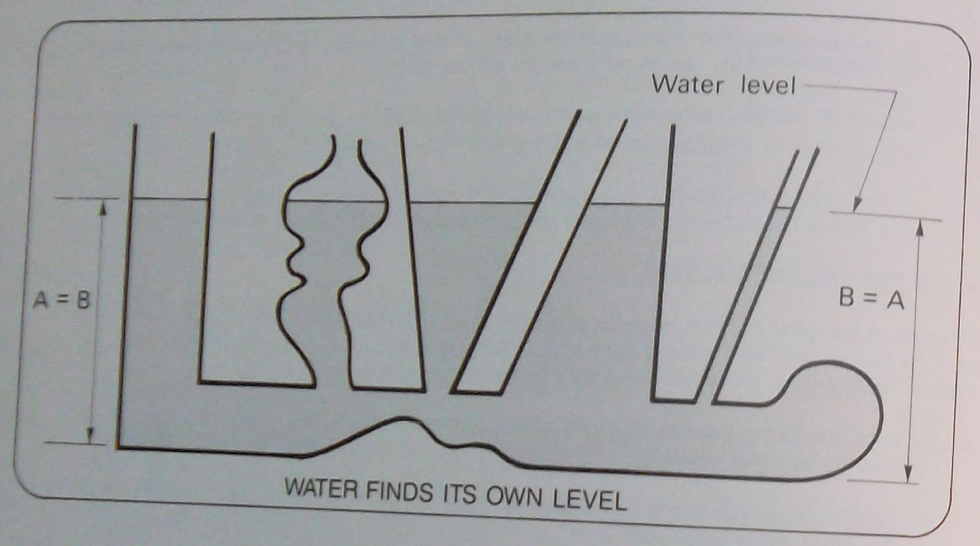
  — As above, but now over three points each 4 metres distant from one another. By comparing first and last levels on a sight line, an immediate check of the operation is available.

- Transfer a level at 1 metre from floor level over 7 metres length from one wall to another.
- Check the trainee's work with the flexible water level at the same time introducing it to them and giving them the opportunity to become familiar with its use by checking the work done themselves.
- Transfer of levels at ground level and over a number of points can be left for later exercises if desired, or may be introduced here.

11.3 THE FLEXIBLE WATER LEVEL

It is a fact in nature that the level of water in a series of interconnecting vessels open to atmosphere will be the same regardless of their shape, size (except very thin capillary tubes), or distance from one another. This is commonly expressed as 'water finds its own level'.

It is on this principle that the flexible water level is based and used to good purpose in checking levels for brick work.

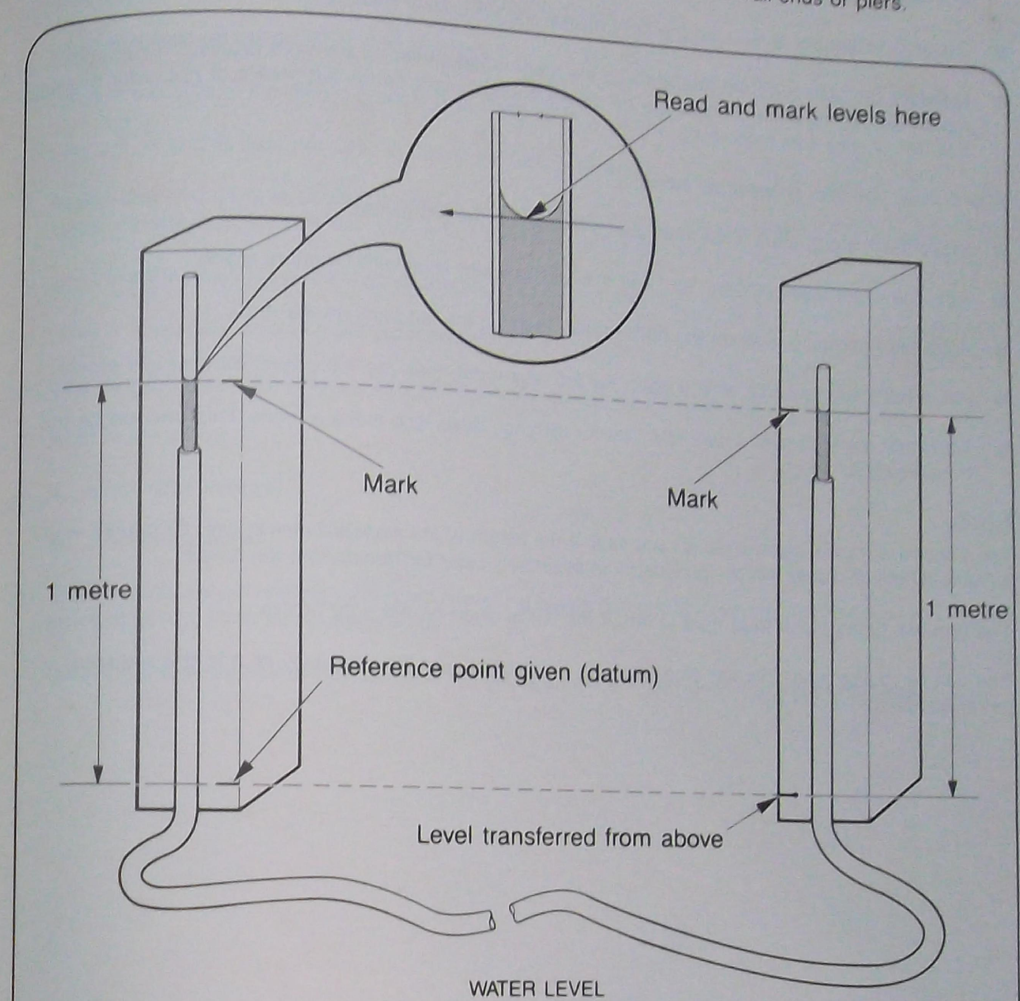


WATER FINDS ITS OWN LEVEL

11.3.1 Making and using a flexible water level

The easiest way to make one of these useful instruments is to acquire a suitable length of clear plastic tubing. This avoids the need to obtain glass tube inserts for the tube ends and it shows at a glance whether air bubbles remain in the tubing, so making their expulsion easier and more thorough.

Study the illustration and let us assume for the purpose of the exercise that the two uprights are profiles already fixed in position for the job. They could also of course be wall ends or piers.



FLEXIBLE LEVEL IN USE

On the left profile, a reference point (RP) or datum is given and the task is to transfer the level of that point accurately to the right profile. Obviously we cannot transfer it directly with the water level — the RP is too low for that.

There are two ways in which this task can be tackled:

- Transfer the level established at the RP from left to right using the rule and spirit level method, then locate this level found on the right profile by a mark.
- From the RP make a mark accurately at 1 metre above it on the left profile.
- After having carefully filled the flexible water level and expelled air bubbles, affix one end to the left profile or have someone hold it there securely.

- Align the other end of the level end to the right profile by careful movement up or down, until the level of the water on the left aligns exactly with the mark made earlier.
- Observe where the level is on the right profile and accurately mark it.
- Measure the distance from that mark to the mark made earlier on the right profile. This should match exactly the distance from the RP to the 1 metre mark on the left profile. If not, your original transfer of level was incorrect.

Alternatively you may proceed as follows:

- Make the 1 metre mark accurately above the RP on the left profile.
- Affix the water level left-hand end and line-up the water level with the mark made.
- Align the right-hand level on the right profile, keeping the left level on the mark.
- Allow the levels to settle, check again the left alignment, then mark the level on the right profile.
- From that mark, measure carefully 1 metre distance down and make a mark. This one will be the transferred RP level.

NOTE:
The 1 metre distance is preferred for use as it is the length of the standard metric rule. Of course any suitable length of timber will do, provided it is accurately used for transferring the levels.

The process takes place from right to left, if the RP is given on the right profile.

You can of course also affix the tube empty to the profiles and then carefully fill it to the required marked level above the RP.

REVISION QUESTIONS

1 List the sizes and names of the bricks in the metric range.

2 What is meant by the nominal size of a brick?

3 What is the size of the metric module in building work?

4 Why are ½ and ¾ bats not used in metric modular brickwork?

5 Sketch the various face set-outs possible with the range of metric bricks within the standard metric module and indicate the ones which comply with the 300 mm module.

6 What are the three main features of good brickwork in a wall?

7 What is 'crowding' and why should it not occur?

8 What are the two main reasons why joints should always be full joints?

9 What is meant by:

- a stretcher course?
- a header course?

10 Given a faulty set of levelling instruments (levelling board, rule and spirit level), describe how you would arrive at establishing an accurate level.

11 Describe the sequence of operations when using a flexible water level in transferring levels.

12 MORE BUILDING EXERCISES

12.1 RACKING

In racking, a portion of a masonry wall is carried higher than the remainder in a series of steps, each one course in height. This makes the bonding of the courses to be added much easier.

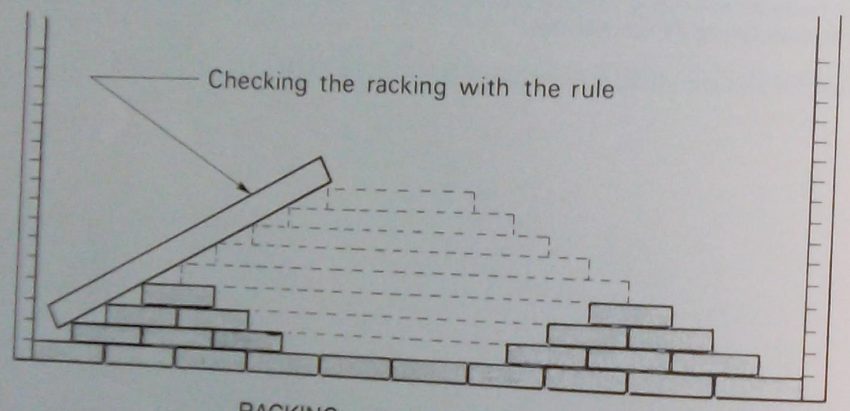
12.1.1 Exercise No. 1

This exercise and the next introduce an added difficulty to be overcome; the care to be taken of constructing the bond accurately and keeping a regular pattern.

This job is nowadays made a lot easier than in the old days because bricks are made to more accurate dimensions, giving far less variation in the actual size of one brick against the next one in a stack. Nevertheless, care is still a prime requirement.

From here on, no further mention will be made of the materials and tools required for any particular exercise. The trainee is now expected to study the illustrations given and decide for himself what he needs for doing the job properly.

First a ½-unit wall, racked as shown at A, is to be constructed. It will be 9 courses high and built between profiles using rule, spirit level, line and perpend gauge as instruments of control.

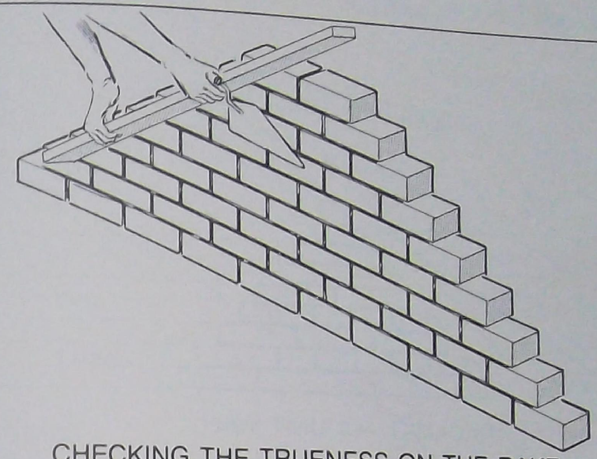


RACKING — ½ UNIT WALL

Proceed as follows:

- Lay the first course of stretchers between profiles to the line.
  - — Ensure regularity of perpends, full joints and bricks levelled in two directions.
- Move the line to the next course marking.
- Starting at either profile and at a distance of ½ a unit + 1 joint, lay another course of three bricks as shown.
  - — Lay the first brick of this course carefully so that the centre line of the stretcher face lines up with the centre line of the perpend below.
  - — Regularly check your perpends distances with the bonding rod.

- Continue with two bricks in the next course, finishing with one brick in the fourth, all the while taking the same precautions to ensure accurate perpend and face work alignment.
- Place the rule diagonally along the top arrises of the bricks laid and check the alignment of the steps. They should all be in line and touch the rule if the job has been done correctly.
- Check the face of the rake for trueness as shown.

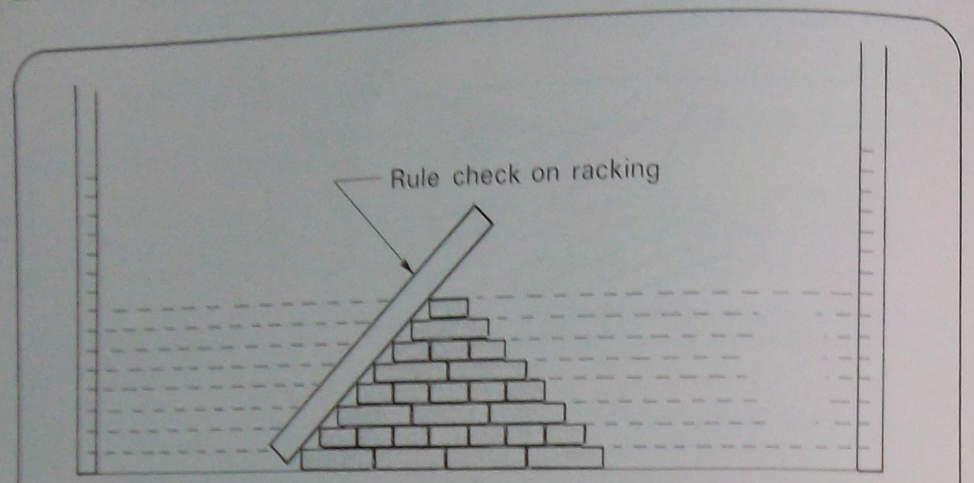


CHECKING THE TRUENESS ON THE RAKE

- Return to course No. 2, and with the aid of the line, fill in the gaps between the bricks laid so far until course No. 4 has been finished true and level.
  - — Keep the perpends.
- Lay a full six-brick course at No. 5 and continue until you have reached No. 9 course, ending with two bricks.
  - — Throughout, keep level, line up your perpends accurately and check the face plumbness.
- When finished, check the line-up of the racking as shown and adjust where necessary. The face set-out should show a regular bond pattern with the brickwork face in the plane of the profiles.
- Should the racking not check out, or the face work not be true (because of crowding), and No. correction possible, demolish the work up to the faulty course and start again.
- Correct the work as you go along rather than removing a brick at a later stage from mortar which has already begun to set. This weakens the bond existing between the particular brick with its mortar, the adjacent bricks and the course below.

12.1.2 Exercise No. 2

As for No. 1 exercise, but now the construction is to be made in 1-unit thickness, the first stretcher course of four bricks to be laid centrally between the profiles and the wall built up to eight courses.



RACKING — 1 UNIT WALL

Procedure

- Midway between the profiles exactly, build up the wall portion shown in full outline according to the method of exercise No. 1 and carrying out the same checks as for that exercise.
- When you have carried out the checks and the brickwork proves to be exactly correct, complete the remainder of the wall between the profiles as indicated by the dotted lines.
- Continuously check the brickwork as you go along as indicated for exercise No. 1.

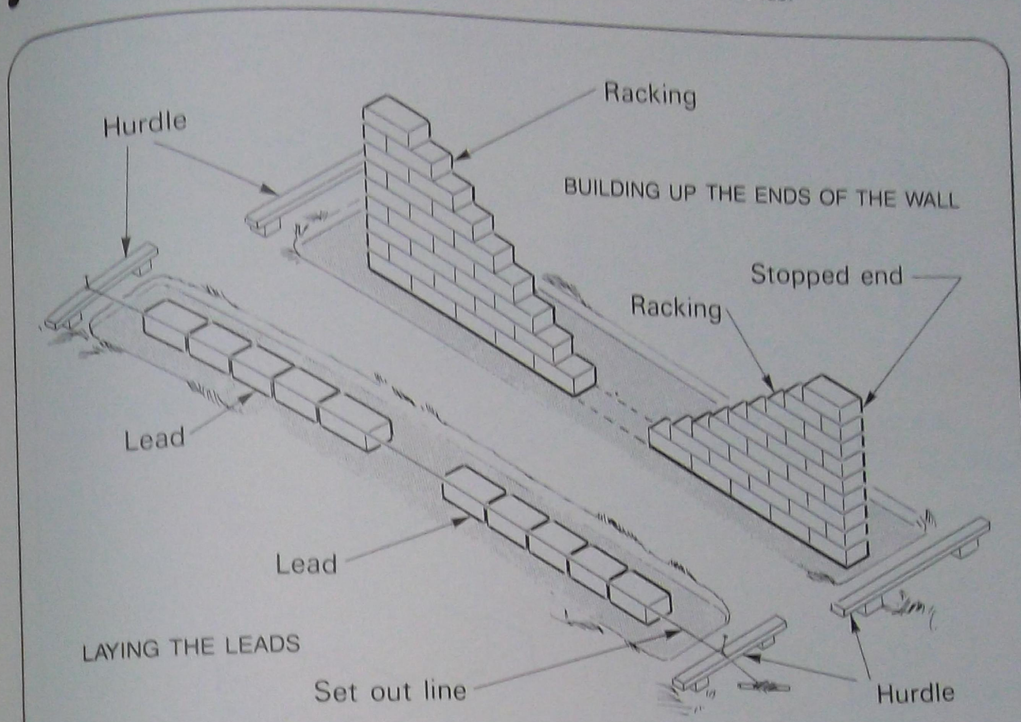
12.2 BUILDING A SIMPLE WALL WITHOUT USING PROFILES

In this exercise no use is to be made of profiles. The wall is to be built on a level base already existing either inside or outdoors. Preferably it should be outdoors where the trainee can gain some experience in setting out his levels under conditions close to the actual working situation under which he will operate in the trade, such as illustrated by the use of hurdles and the provision of a trench with the concrete footing in place.

Procedure

Having organised your working post and assembled the necessary materials, it depends on the types of brick you are going to use whether these need a thorough wetting or not. Normally the softer, more porous bricks need wetting to assist the setting action of the mortar and to prevent the bricks from absorbing too much water from the mortar. Usually most of the extruded and many of the stiff plastic pressed bricks have low suction rates, and, for these, wetting before laying is not required.

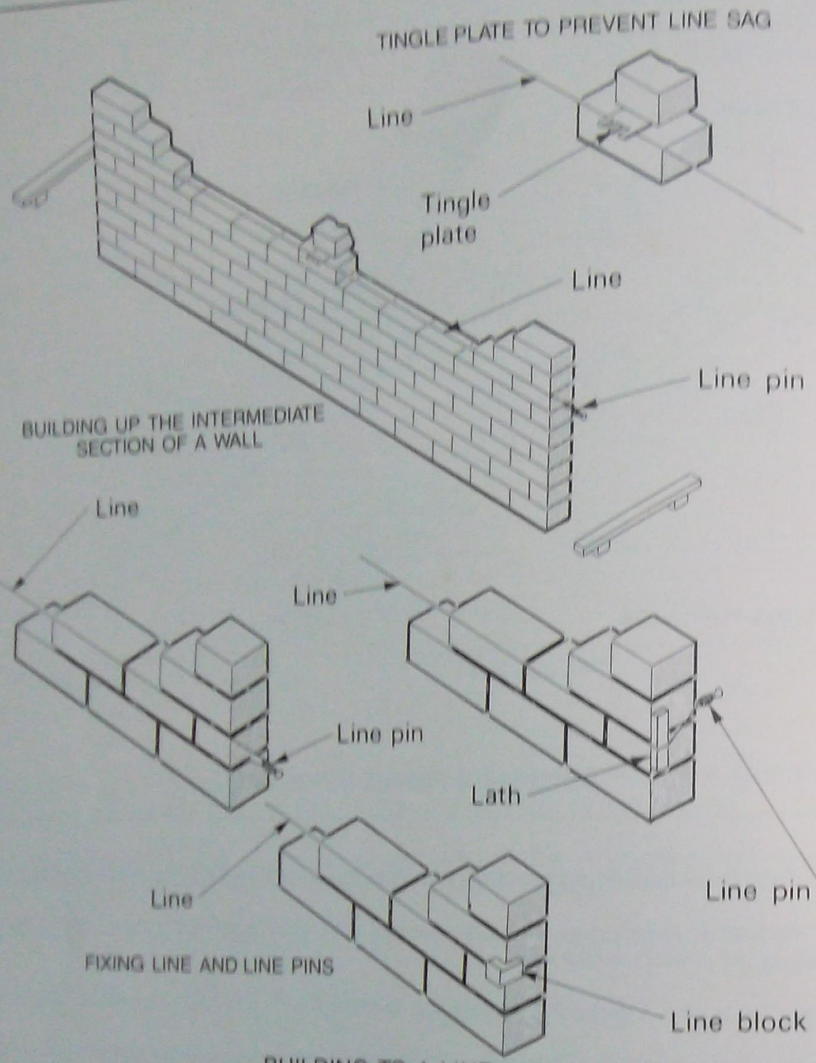
- Set out the wall by determining by measurement the position of both ends.



BUILDING A SIMPLE BRICK WALL

- Set out and check the level, then stretch the line to guide you in the laying of the 'leads' (see illustration).
  - — The 'lead' is always used for starting a wall. It consists of a number of bricks laid to the line along the direction of the wall.
- Lay two leads of five bricks at each wall end, level them and check the perpends for distance.
- Build up both ends of the wall to the line as illustrated. Continuously check perpends, the rate on the face for trueness and the alignment of the racking as well as your course height, using the necessary tools at your disposal.

Note that each even numbered course begins with ½ bat.



BUILDING TO A LINE

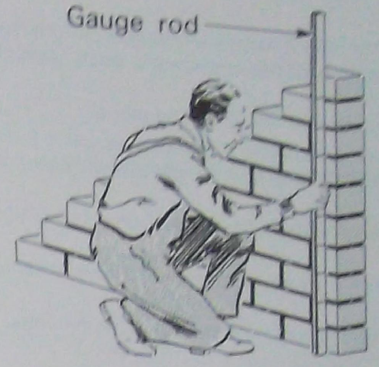
When the ends are found to be plumb, level and true, proceed with the building up of the intermediate section of the wall as follows:

- Stretch the line between the newly built ends of the wall for each course, using either the line block, line and pin or line and pin with a lath to prevent the line sinking into the soft mortar.
- If necessary on the higher courses to be laid and to prevent the line from sagging, place a brick halfway and sufficiently packed to make up the thickness of the bed joint.
- Place the tingle on it and secure it with another piece of brick.
- Complete the first course.
- Continue to build up the wall by filling in the intermediate sections until the required height is obtained.

- Continually check for 'crowding', ensure each brick is plumb and level and observe regular bonding by checking perpends frequently, height of each course and the trueness on the rake as shown.

NOTE:
You would have now completed the first section or rise of a wall that could be built higher.

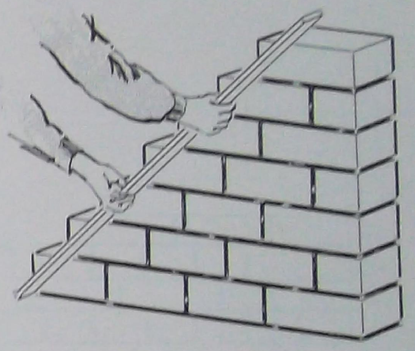
If the height of this wall had to be increased, you would proceed by building up the ends again as done before, followed by filling in the intermediate sections. To enable a wall to set evenly, do not build up the ends and the intermediate sections in excess of 1.20 m in height at a time.



CHECKING HEIGHT OF COURSES



CHECKING PLUMBNESS



CHECKING FOR TRUENESS ON THE RAKE

12.3 GROUP EXERCISE FOR THREE

This exercise is designed to give trainees the opportunity to practise how to:

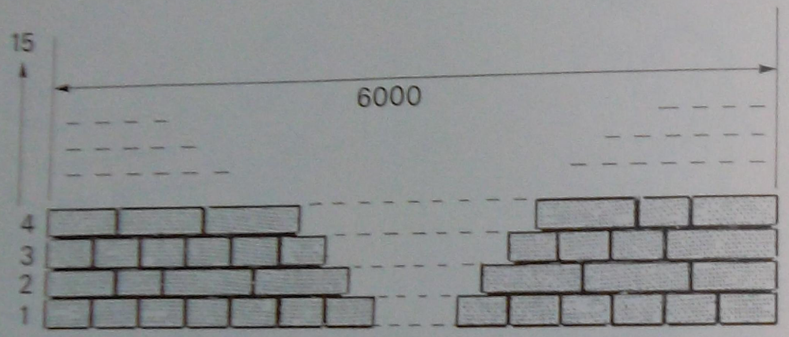
- Erect profiles properly.
- Establish and transfer the datum level accurately.
- Build a long wall as a team, ensuring that levels, perpends and bond are observed as well as achieving a satisfactory link-up.
- Determine the number of bricks and mortar required.
- Cut bricks to the required size.

12.3.1 The task

To build a one unit thick wall, 6 metres long between profiles and 15 courses high in standard metric brick by a team of three bricklayers, each bricklayer doing 2 metres of the wall.

The task consists of the following steps:

- Calculate the number of bricks required.
- Erect the profiles (and, if necessary, construct them) (see para 10.1).
- Establish the three work posts to best advantage for the job to be done.
- Mix the necessary mortar in suitable batches.
- Establish the level for the first course after selecting the appropriate reference point (see para 11).
- Construct the wall.



GROUP EXERCISE BOND PATTERN

12.3.2 Material calculations

Refer to the illustration showing the bond pattern.

Number of Bricks (see section 9).

$N = L \times H \times B$

H = 15 courses

N should be: 774 bricks.

Volume of mortar ingredients

Usually 0.6 of a cubic metre of sand for every 1000 bricks to be laid is the figure taken for standard metric brickwork. A little less will be required for modular work for the same wall size because there would be fewer cross joints and possibly bed joints.

One bag of cement amounts to 40 kilograms and there are approximately 38 bags per cubic metre of cement. One bag of lime amounts to 25 kilograms and there are roughly 25 of those to a cubic metre.

Sand Formula

$$\text{Sand in cubic metres} = \frac{\text{Number of Bricks}}{1000} \times 0.6$$

The amount of cement and lime will vary according to the mix specified.

Suppose we have chosen a 1:2:9 mortar mix and have found we need 6 cubic metres of sand to do a specific job.

The proportions of the mix tell us then that for every 9 parts of sand we need one part of cement and two parts of lime. Here the 9 parts of sand amount to 6 cubic metres and we will need ⅑ of that in cement and ⅔ of that amount in lime.

For the cement: ⅑ × 6 = ⅔ cubic metre (0.67 m³)

For the lime: ⅔ × 6 = 1⅓ cubic metre (1.33 m³)

We also know there are 38 bags of cement per m³ and since we only need ⅔ of that, the number of bags is found by multiplying the volume needed by 38.

Thus ⅔ × 38 = 25⅓ bags. Say 26 bags.

For lime, we need here 1⅓ cubic metres and therefore we need:

1.33 × 25 = 33.25 bags. Say 34 bags.

Now apply these formulas to calculate what you need for the wall you are to build. Done correctly your answers should be as follows:

Sand = 0.464 m³ (say ½ of a cubic metre for practical purposes)

Cement: 0.05 (1/20 of a bag)

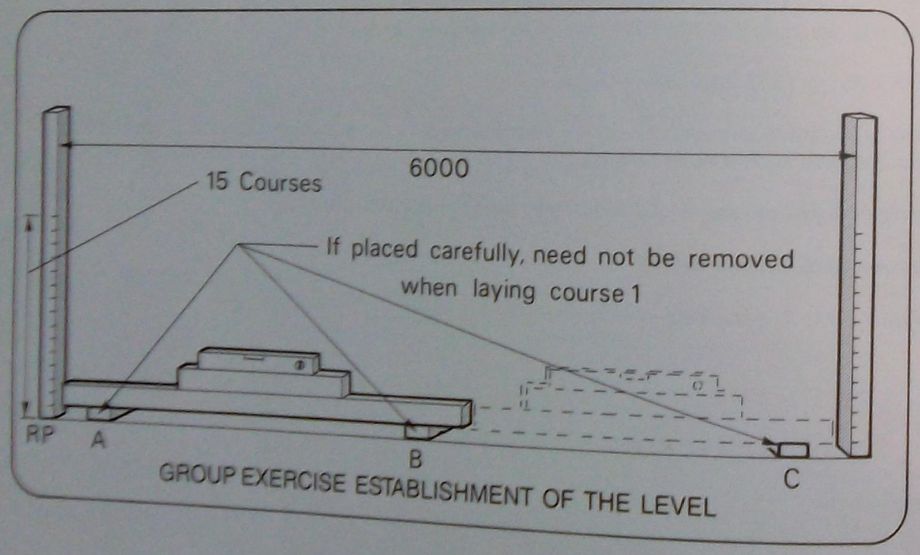
Lime: 0.1 (1/10 of a bag)

12.3.3 Establishing the level

Having erected and aligned the profiles accurately, determine the datum or reference point (RP) and mark on the profile the level course (left-hand profile chosen here).

Determine the base level as follows:

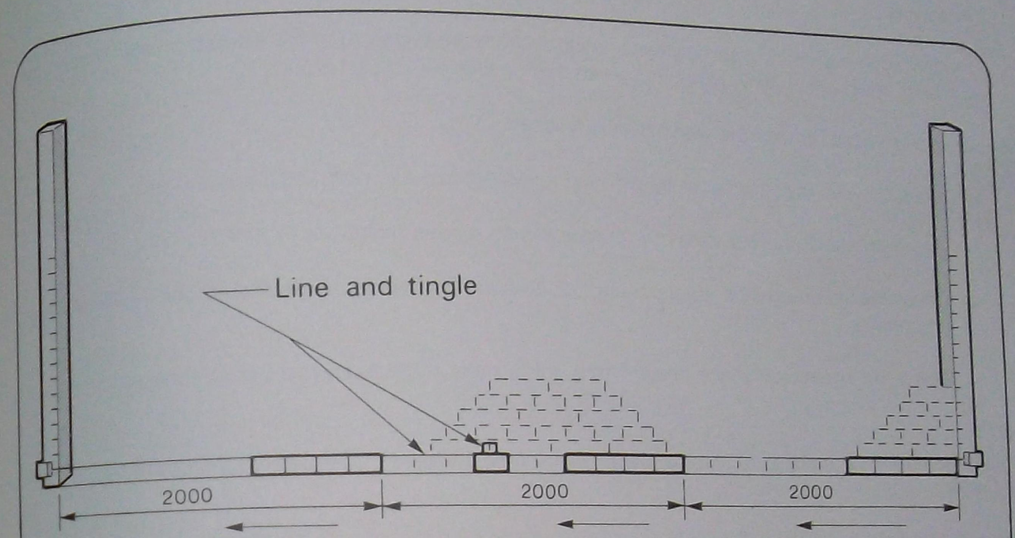
- Prepare a bed of mortar for one header (A), lay the header and accurately level it to the line on the profile.
  - — By careful measurement locate this brick so that it need not be removed when the course will be laid. Use your perpend gauge for this.
- At some distance away, and within the reach of your levelling board, lay another header (B) in the same way as for (A).
  - — Again, locate this one carefully so that it can remain in place when the course is being laid.
- Using the levelling method explained at para 11 for the use of levelling board, the rule and the spirit level, establish the level of (B) to that of (A) by taking two readings and adjusting (B) until it lines up exactly with (A) on the level.
  - — Ensure the faces of (A) and (B) are in line with the face of the profile. Check this with the line.
- Repeat the procedure with a third and, if necessary, with a fourth header (C) and (D) (not shown), by levelling (C) with (B) and (D) with (B) until, by checking with the spirit level, all three or four bricks are on the same level.
- Carry out a final check with the use of a water level at each profile, then, stretching a line between the top of the two outer bricks, check by sighting along the line, the level of the bricks in between. Adjust where necessary.



GROUP EXERCISE ESTABLISHMENT OF THE LEVEL

12.3.4 Constructing the wall

Having now established the proper level for the first course, with the use of the gauge rod make the necessary markings on the profile as a guide for locating the line in the build-up of the wall.



GROUP EXERCISE WALL UNDER CONSTRUCTION

- Stretch the line for the first course and support it in the approved manner by one or more tingles as necessary.
- At every 2 metres between the limits of the profiles make a mark to indicate that length of wall to be built by each bricklayer.
  - — Each bricklayer trainee will now build up the wall within these limits and tie-in his work with that of his neighbour at those boundaries.
- Working from right to left as shown, lay the lead (first course) to the line.
  - — Check your perpends and levels in two directions all the time and be sure to fill in the joints properly.
- When course No 1 is finished, relocate the line for course 2, stretch it taut and support it with tingles as for course 1.

Course 2 is a stretcher course with two ¾ bats at each end. If the bats have not been previously cut for the job, each trainee working on the ends will cut the necessary bats for this course. The left-hand man will work from left to right, the right-hand man from right to left. The centre man has the choice to go either way.

- Commence laying course No 2, making sure that the stretcher perpends are located exactly mid-way between the centre line of each first and third header below as shown in the bond pattern illustration.
  - Continuously check your perpends, levels in both directions, remove excess mortar, keep your brick faces clean, fill in joints and finish them neatly as you go along.
- Repeat the process until the whole wall is finished.
  - Keep up your regular checks as the work proceeds (levels, perpends, joints).
  - Regularly check the wall faces for plumbness as it rises higher (both sides).
  - Check that the perpends of alternating courses are in a vertical line throughout — 'keep the perpends!'
  - Watch the alternation of the header from left to right in the even-numbered courses.

NOTE:
It is advisable for the trainees to change places every 2 or 3 courses to accustom them to working from either left or right.

After the exercise is completed and the work has been assessed and discussed, the wall may be demolished, the bricks cleaned and stacked for the next exercise.

As an additional or optional exercise, it may be useful to rebuild the same wall, but this time by building up the wall ends and the centre to the line as a practice in racking, then filling in the intermediate sections by sight only in three 5-course heights.

This is shown in dotted outline in the illustration.

NOTES FOR THE INSTRUCTOR

This exercise constitutes a good revision of the knowledge and skills acquired so far.

The use of team work also induces the slower worker to work faster to keep up with a faster worker. However, this could lead to a lowering of the quality of the work and this will have to be watched carefully.

The instructor will have to decide in each particular case whether it is best to group the trainees together who are of the same standard or whether to place a slower one with those who work at a faster pace.

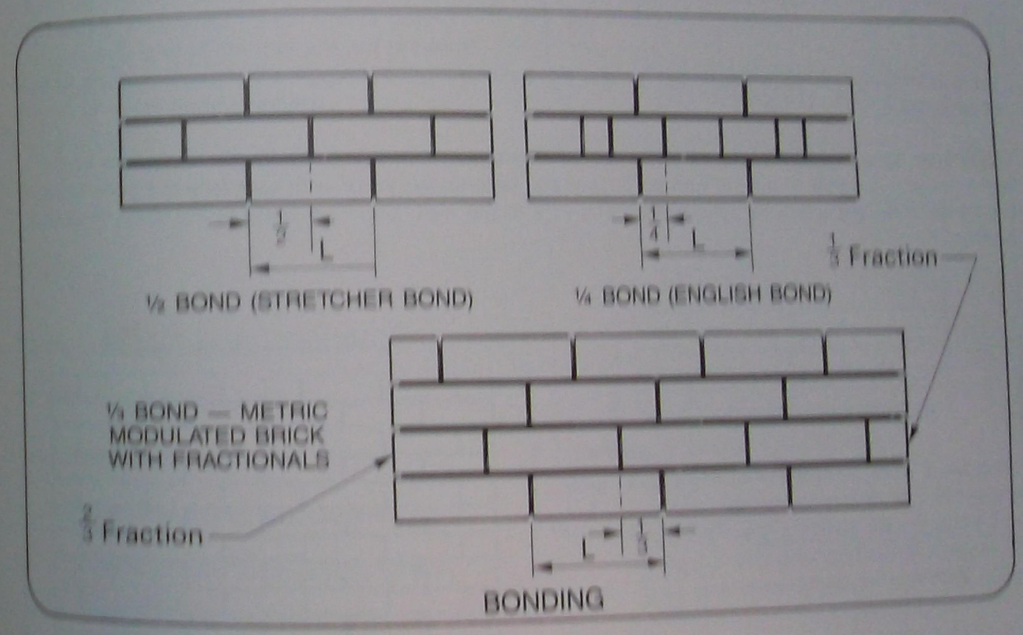
Trainees will tend to carry out their checks of the surface of the wall by moving to that side of it. It is well to get them accustomed to overhand working situations and to make them carry out their checks in that manner also. (Overhand work, especially at heights, may be legally banned in some areas.)

Do not allow faulty work to proceed further. Have it demolished up to the level where faults occurred and let the trainee start again.

13 BONDING AND TYPES OF BOND

The need for bonding was explained in section 8. Depending on how the overlapping of the bricks is arranged in successive courses, we speak generally of ¼ bond, ½ bond and now, with the introduction of modulated metric bricks and their fractional units, also of ⅓ bond.

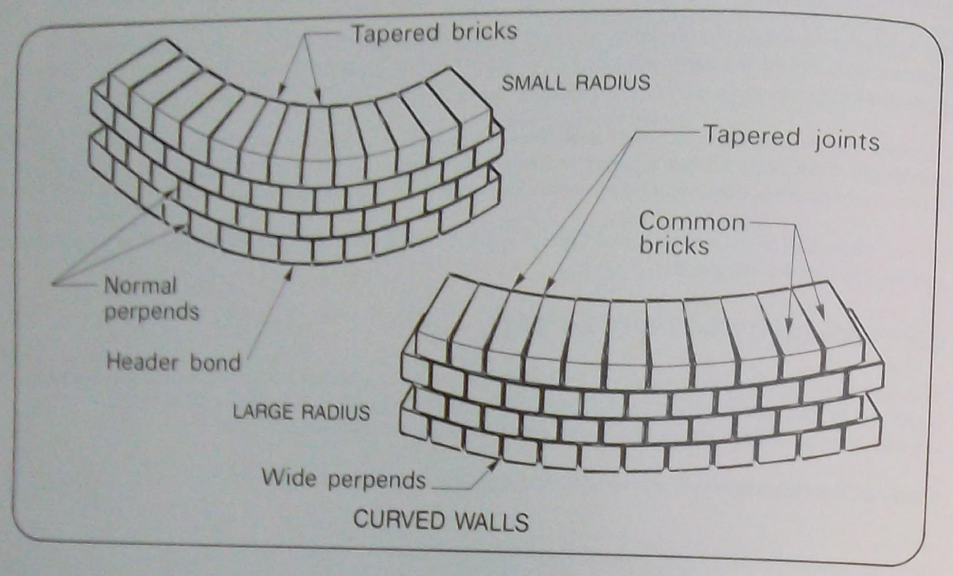
Study of the illustration will reveal why and how this comes about.



The ⅓ bond shows alternating a ⅓ fraction with a ⅔ fraction every second course. It is of course possible to keep either one on the one side and so altering the face pattern from that shown.

13.1 THE HEADER BOND

Each course consists of headers. It is used in curved walls — and where the curve is not sharp enough to require the cutting of bricks to a taper, the use of wider perpends on one side than on the other is usually acceptable to achieve the required results.



CURVED WALLS

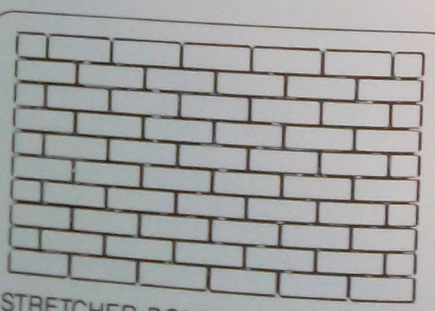
This is a ¼ bond with good transverse (across the wall) strength but longitudinally not as good as stretcher bond.

The header bond makes it easier to follow a curve than any other bond. Where the curvature of the wall is small it is better to build it with purpose-made tapered bricks or with specially cut ones to avoid having too wide and unsightly perpends on one side of the wall face. This bond is not used in straight walling.

13.2 STRETCHER BOND

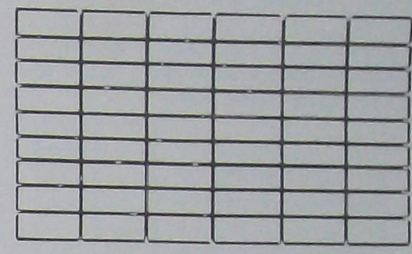
In this bond, all bricks are laid as stretchers on the wall face, giving an overlap of ½ a brick length on the vertical joints. This bond is the simplest form of bonding and is used for ½-unit walls and for facing work as is now mostly done in modern building construction (e.g. brick, veneer, cavity walls, facing of concrete main structures).

This bond is sometimes referred to as ½ bond.


STRETCHER BOND (½ BOND) ALL STRAIGHT JOINTS IN ONE UNIT WALL EXCEPT WHERE HEADERS SHOW

13.3 STACK BOND

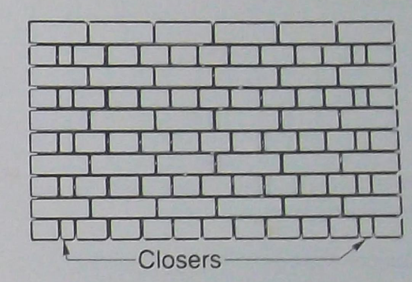
Only used for ornamental panel filling-in work where the panel so constructed has no load to bear.


STACK BOND — NOT FOR LOAD BEARING WORK. FOR ORNAMENTAL INFILLING PANEL ONLY

13.4 ENGLISH BOND

This consists of alternating a header course with a stretcher course. It is a ¼ bond and it is obtained by the use of queen closers inserted in the header course between the 2 headers at each end of the wall.

Because of the absence of straight joints and bats it has been considered by some to be the strongest bond. It should be remembered that bonding depends to a great extent on the craftsmanship with which the joints are made. Any bond is weakened by the use of poor quality mortar and joints that are not properly filled. A disadvantage of the English bond is the use of many queen closers.



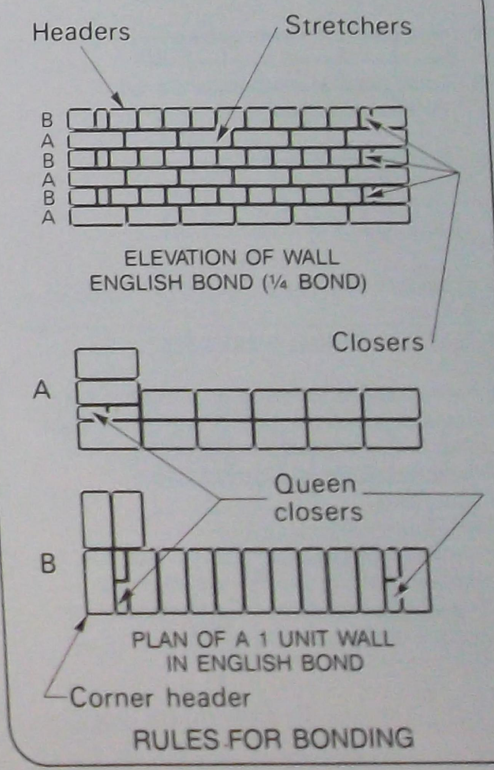
ENGLISH BOND (¼ BOND) NO STRAIGHT JOINTS

13.5 RULES FOR BONDING

13.5.1 Closer rules

Remember these 4 rules:

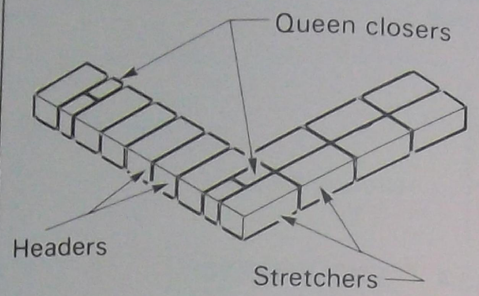
- A closer creates the quarter bond.
- A closer is always located next to the corner header.
- The size of its face equals half a header face.
- The closer runs through the full thickness of the wall in which it is located.



RULES FOR BONDING

13.5.2 Corner rule

With every change of direction at quoins (corners), the bond changes from header to stretcher course or vice versa.



CORNER OF A WALL 1 UNIT THICK IN ENGLISH BOND

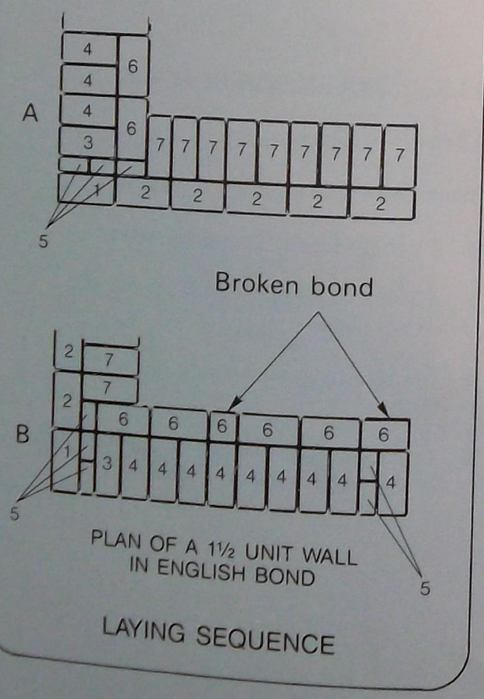
13.5.3 Setting-out rules

When all levels and lines have been set out, the bricklaying rules will apply:

- Position the corner (quoin) brick (1).
- Complete the stretcher face (2).
  - — It is easier to lay to the line and to square off than the headers.
- Complete the header course (4).
- Fill in the closers through the full thickness of the wall (5).
- Back up the stretcher course (7).

13.5.4 Broken bond rules

- When the bond has to be broken in the face of a wall because of wall dimensions, the break is located in the centre of the wall length (or as close to it as is possible).
- When there are openings in a wall, the broken bond is usually located at the opening jambs and above and below the centre of the wall opening.

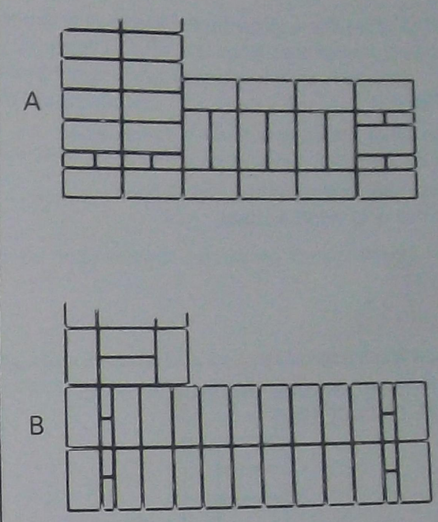


PLAN OF A 1½ UNIT WALL IN ENGLISH BOND

LAYING SEQUENCE

13.5.5 Face rules

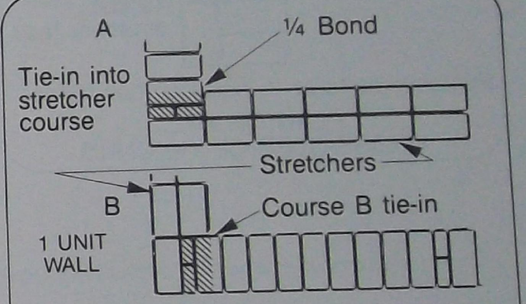
- Where the wall thickness is one unit or a whole multiple of a unit (e.g. 1, 2) there will be in the same course:
  - — Headers on both sides of the wall.
  - — Stretchers on both sides of the wall.
- Where the wall thickness is an add multiple of ½ a unit (e.g. 1½), there will be in the same course:
  - — Stretchers on one side of the wall.
  - — Headers on the other side of the wall.



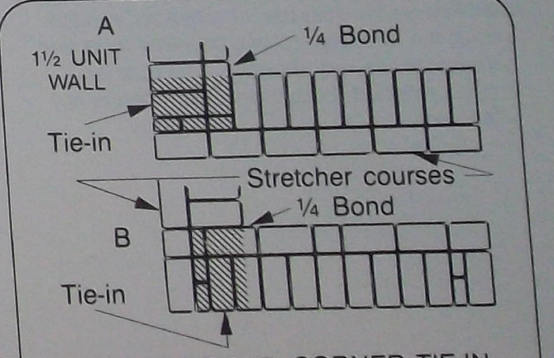
PLAN OF A 2 UNIT WALL IN ENGLISH BOND

13.5.6 Tie-in rules

- Always tie-in into the stretcher course, except in Dutch bond where, in order to maintain face set-out throughout and to avoid having to use closer, tie-in is done into the header course.
- Always lay each course of each wall as if the other wall did not exist.
- On the header course, the wall or pier butts onto the header face at ¼ bond.



ENGLISH BOND CORNER TIE-IN



ENGLISH BOND CORNER TIE-IN

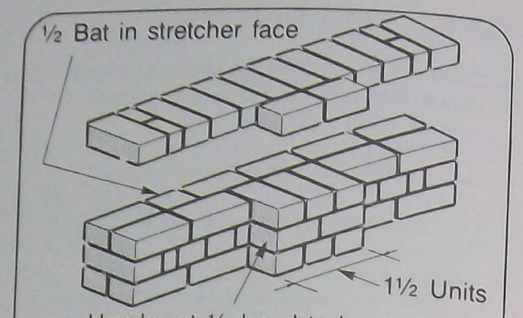
- If a wall or a pier is of ½ a unit or odd multiples of ½ a unit (e.g. 1½, 2½, etc), then a ½ bat will appear in the face of the stretcher course.

- The stretcher course butts onto the header course at ¼ bond.

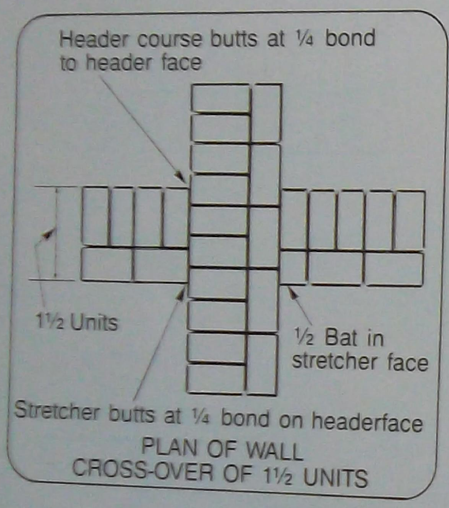
NOTE:

These tie-in rules apply to all ¼ bonds when done in standard metric bricks.

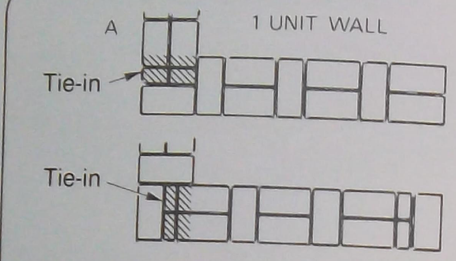
For modular metric bricks, the ¼ bond becomes a ⅓ bond instead.



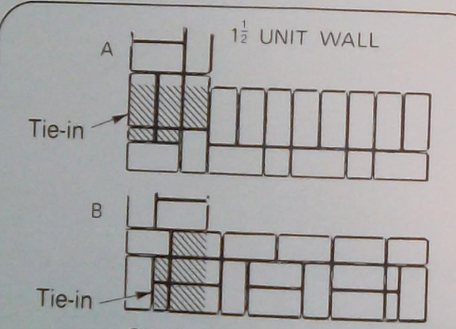
Header at ¼ bond to header face
PIER



PLAN OF WALL
CROSS-OVER OF 1½ UNITS



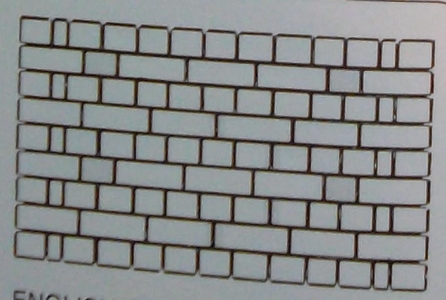
DOUBLE FLEMISH
BOND CORNER TIE-IN



SINGLE FLEMISH
BOND CORNER TIE-IN

13.6 ENGLISH CROSS BOND

A variation of the standard English bond in which every second stretcher course is modified by the insertion of a header at each end of the stretcher course onwards from and adjacent to the last stretcher. The quarter bond is retained throughout. This bond is not often used.



ENGLISH CROSS BOND (¼ BOND)
NO STRAIGHT JOINTS

13.6.1 Bonding problems

Problems arise when certain features of the building, such as specifically defined dimensions of walls, openings, piers and breaks do not permit proper full bonding.

This necessitates cutting certain bricks, and it is to this that the term 'broken bond' applies. Because broken bond is sometimes unavoidable it is not wrong to resort to it. In doing so, however, it is most important that the following rules should be strictly adhered to in order to maintain the maximum amount of strength, without spoiling the appearance of the face work.

Always endeavour to avoid broken bond, which at times can be done by:

- Closing or opening the cross joints (perpends).
- Lengthening or shortening the wall (this should not be done without consulting the architect).
- Reversing the bond at one corner or in one angle.

Never, under any circumstances, use a cut brick of less than the size of a half bat in face brickwork. Even this, although permissible, should be avoided if possible. The minimum size at which to aim is a three-quarter bat.

Contrive to conceal the presence of broken bond by:

- Making cuts as large as possible.
- Keeping perpends plumb, i.e. never letting a cut brick wander to another section of the wall.
- Taking advantage of openings and other features whose size and position not only assist in concealment but in reducing the number of cut bricks.

Briefly, the principles which apply to the treatment of broken bond are:

- avoidance;
- big cuts;
- concealment.

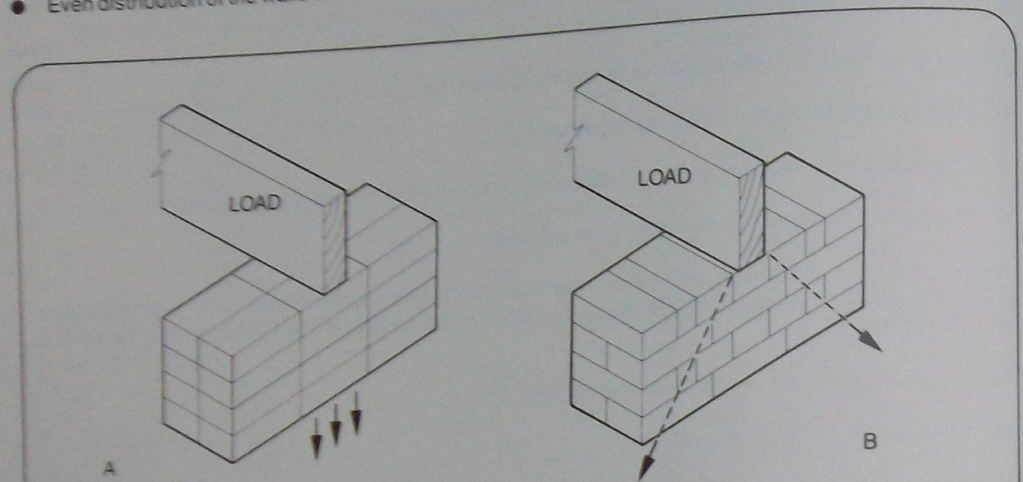
13.6.2 Strength of walls

The strength of brick walls is influenced by the over-lapping of bricks in alternate courses.

This over-lapping is referred to as bonding.

The bonding of bricks provides:

- Assisting in binding bricks together.
- Resistance to cracking due to movement caused by wind pressure or settlement of foundations.
- Even distribution of the walls and loads and supported by the wall over the footings and foundations.



DISTRIBUTION OF LOAD

In illustration 'A', bricks laid straight on top of one another give no strength to the total wall.

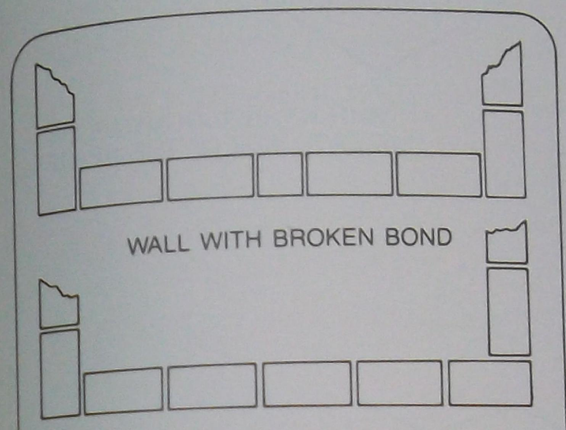
In illustration 'B', bonded brickwork evenly distributes the load.

NOTES

13.6.3 Bonding traditional bricks (230 × 110 × 76)

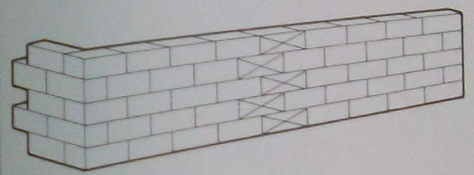
When using traditional bricks the bonds used are:

- Half bond (brick on flat) B.O.F.
- Third bond (brick on edge) B.O.E.
- Quarter bond (brick on flat) B.O.F.

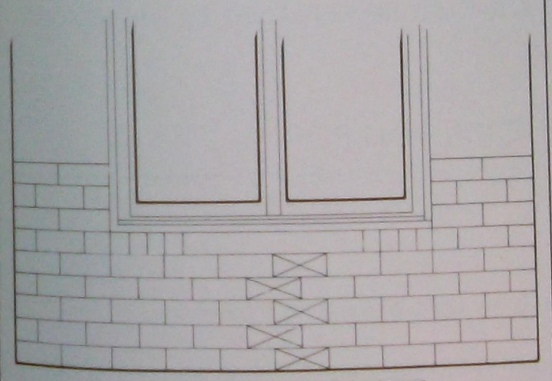


WALL WITH BROKEN BOND

REVERSING ONE CORNER BRICK

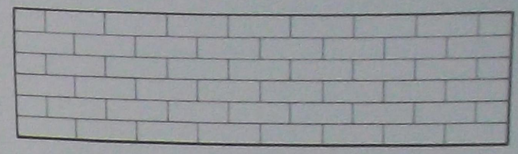


THREE QUARTER BAT

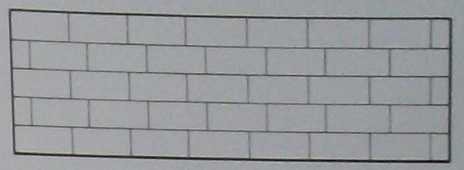


BENEATH THE CENTRE
OF A WINDOW OR OPENING

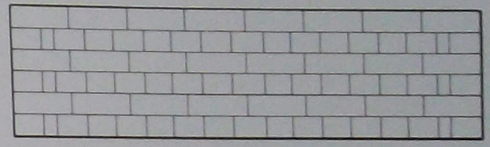
BROKEN BOND



STRETCHER BOND



THIRD BOND



ENGLISH BOND

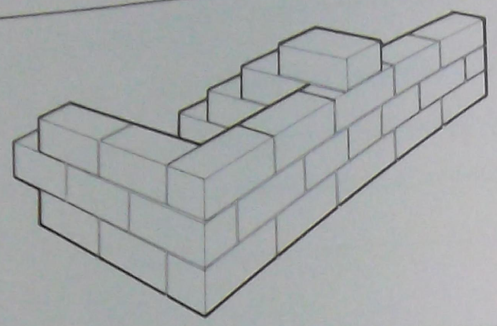
BONDING TRADITIONAL BRICKS

13.6.4 Broken bond: traditional bricks

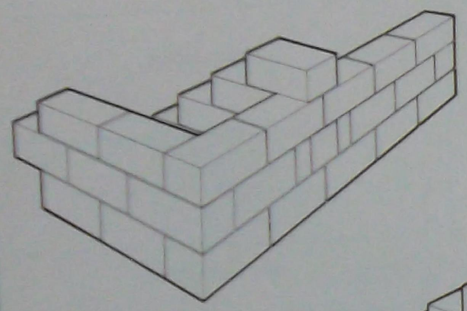
When using traditional bricks the normal bonding is frequently interrupted when wall lengths or openings in walls occur which do not work to whole bricks. When the bond is broken in half bonded brickwork it is not good practice to include a closer (quarter brick) in the wall.

When the bond is broken in a wall it is good practice to work the piece to the centre of the wall or beneath the centre of a window or opening.

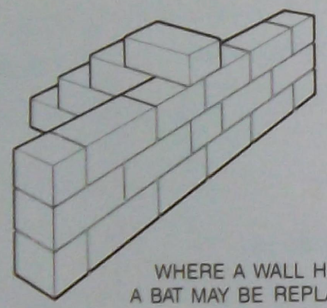
13.6.5 Bonding of junction walls



WITH A THREE QUARTER BAT
AT EACH SIDE OF THE HEADER



WITH A CLOSER AT EACH
SIDE OF THE HEADER



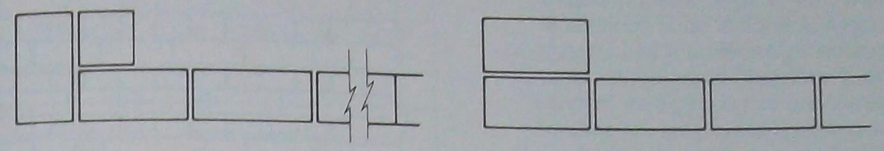
WHERE A WALL HAS A HALF BAT IN IT
A BAT MAY BE REPLACED BY THE HEADER

BONDING OF JUNCTION WALLS

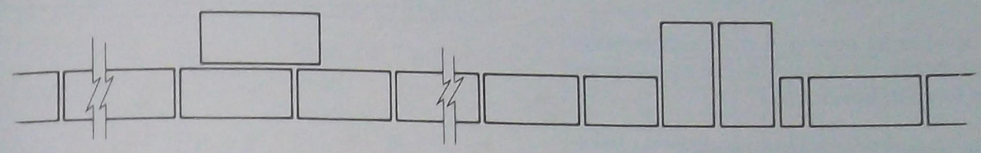
13.6.6 Bonding piers to walls

Problems may be encountered when attaching piers to brick walls of variable thickness.

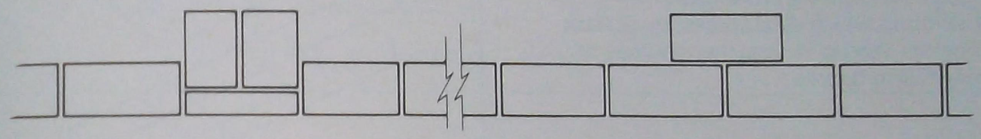
A common practice of using wire ties so as to tie the pier to the wall must be seen as second rate when compared to a full brick tie as a correctly bonded pier construction.



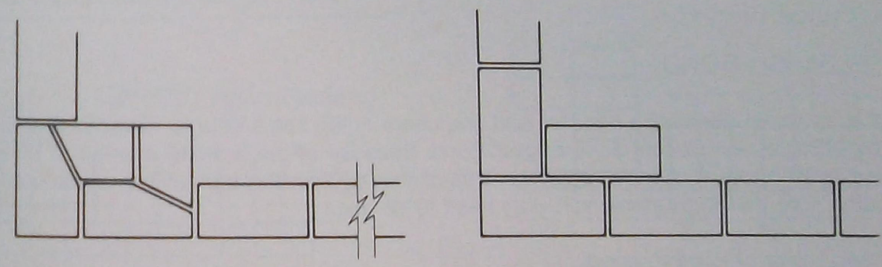
PIERS SET AT WALL END TO GIVE STRENGTH



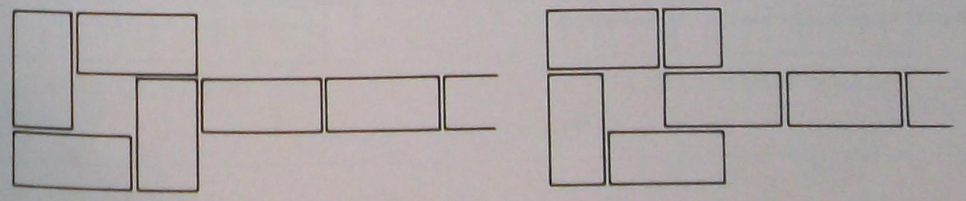
PIER SET IN MIDDLE OF WALL QUARTER BOND



QUEEN CLOSER AND THREE QUARTER BATS



KING CLOSERS TO INTERNAL PIER CONSTRUCTION



350 x 350 PIER WITH 110 WALL ATTACHED

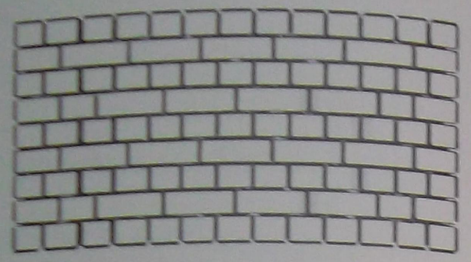
ATTACHED PIERS TO A 110 THICK WALL (NON LOAD BEARING)

13.7 DUTCH BOND

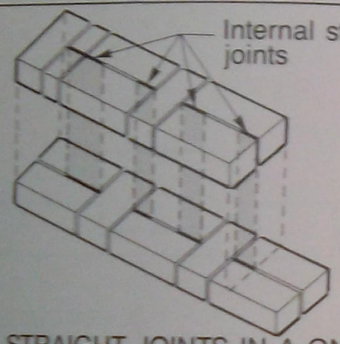
This is also a true ¼ bond without straight joints and like the English bond consists of alternating courses of headers and stretchers. It resembles the English cross bond in that it contains either one or two headers in every alternate stretcher course. This depends on whether there are an even or odd number of headers in the header course. In the first case, only one header shown in each alternate stretcher course; in the second case two headers show up in the face set-out of each second stretcher course.

This bond is as strong, if not stronger, than English bond. Its main differences compared to the English bond are:

- the absence of queen closers;
- the use of ¾ bats in the face set-out;
- the vertical joints in the stretcher courses line up in a vertical line only every fourth course as against every second course in English bond. Compare English cross-bond which also shows the vertical perpends line-up in stretcher courses at every fourth course.



DUTCH BOND (¼ BOND) NO STRAIGHT JOINTS



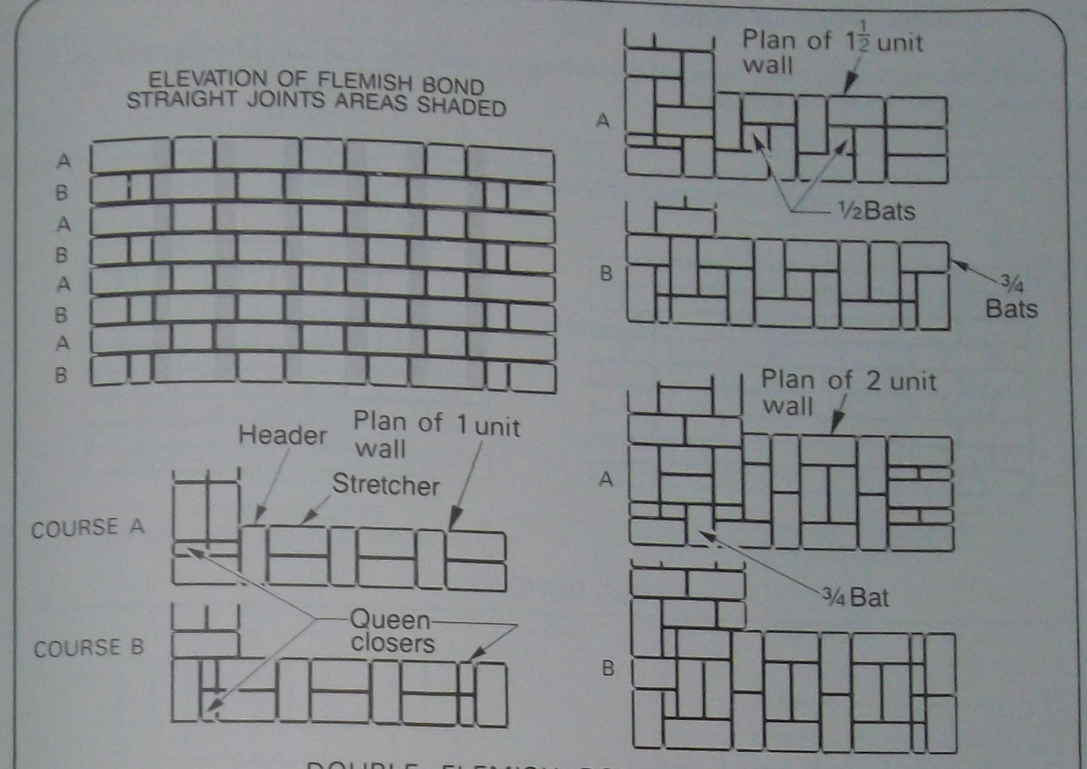
STRAIGHT JOINTS IN A ONE UNIT WALL IN FLEMISH BOND

13.8 FLEMISH BOND

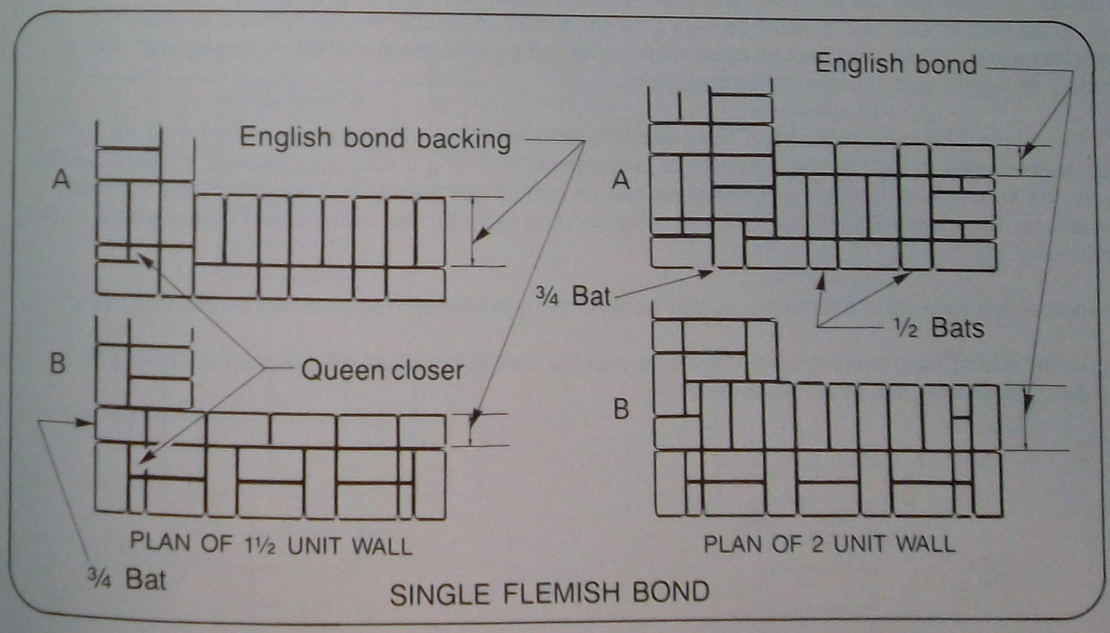
This bond consists of alternative headers and stretchers in the same course. Quarter bonding is obtained by using queen closers as in English bond. Because of the ¼ bond overlap of stretchers in each course, this shows straight joints in the area of that overlap throughout the whole wall. In 1½-unit walls, note that a great many ½ bats need to be used.

There are two types of Flemish bond:

- Double Flemish bond which shows the Flemish bond pattern on both sides of the wall.
- Single Flemish bond showing the Flemish bond on the wall face and English bond as backing. This bond is used only in walls 1½ units or over where the specified facing calls for this bond to be done in more expensive bricks for effect.



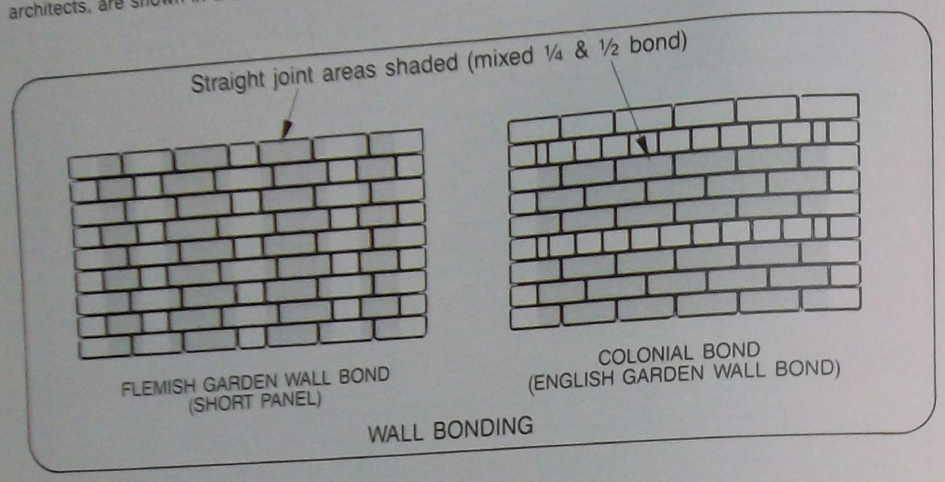
DOUBLE FLEMISH BOND WALL



SINGLE FLEMISH BOND

13.9 OTHER TYPES OF BOND

The two remaining bonds, rarely used, except perhaps for decorative purposes when specified by architects, are shown in the illustration.



WALL BONDING

Note the mixture of ¼ and ½ bond and the large straight joint areas occurring in three types of bonds.

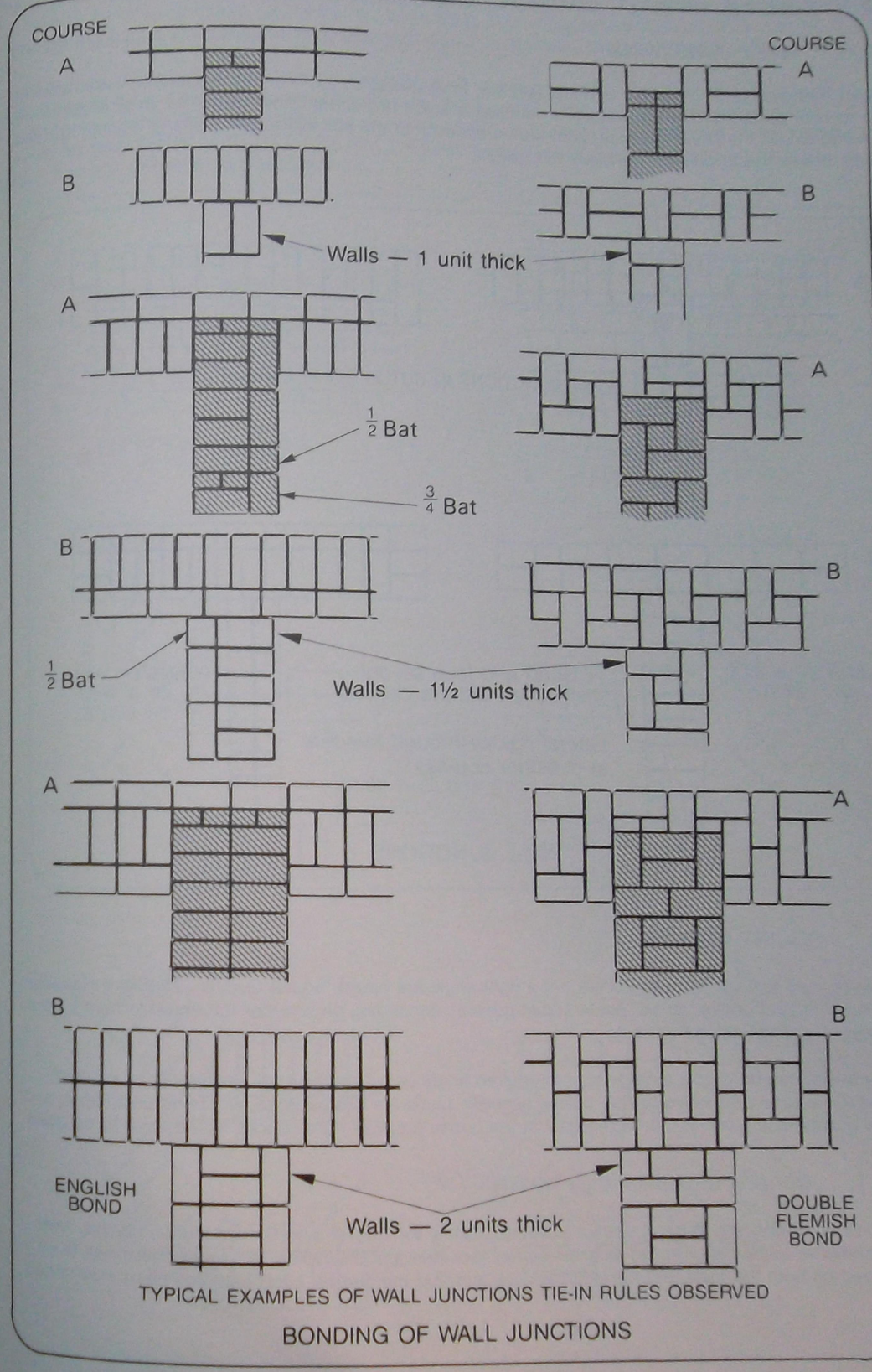
NOTES FOR THE INSTRUCTOR

The last chapter and the following one deal with very important basic fundamentals in the trade. It would be true to say that it would be very time-consuming to let trainees carry out a multitude of exercises with actual materials to enable them to acquire the necessary skills in coping with the variety of bonds and situations they may meet.

To overcome this, it is advisable to have available wooden blocks scaled down to half size to represent bricks in their actual dimensional proportions, including a variety of squints, closers, bevels, bats and so on. With these, many exercises can be carried out quickly and repeated until, for many situations, the trainee has acquired the intuitive bonding skills for his craft without undue waste of time and materials.

In addition to this or as an alternative, he may be given many problems to solve purely on drawing paper.

Frequent use of such training aids will ensure that the trainee develops an eye for the solving of lay-out problems in the actual work situation.



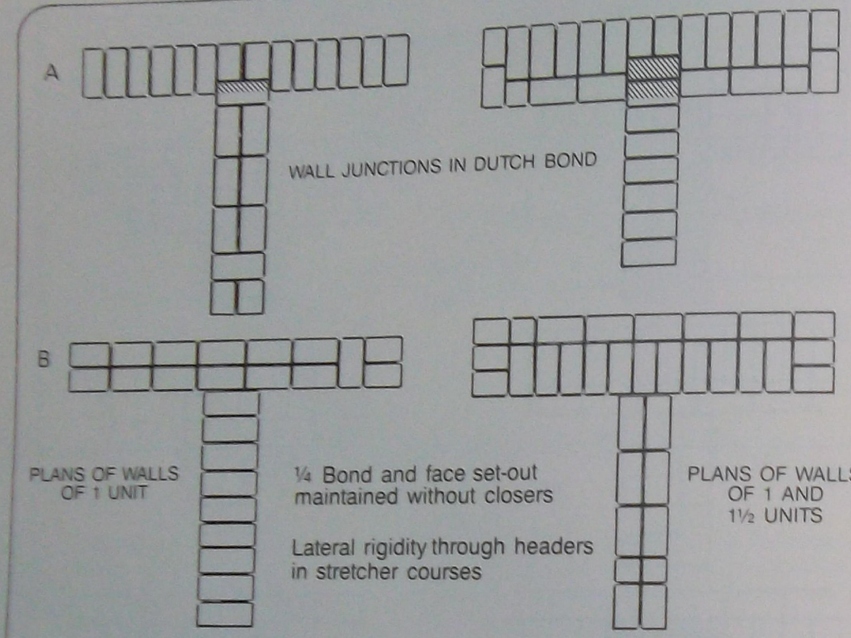
TYPICAL EXAMPLES OF WALL JUNCTIONS TIE-IN RULES OBSERVED

BONDING OF WALL JUNCTIONS

14 BONDING OF WALL JUNCTIONS AND SQUINT QUOINS

14.1 WALL JUNCTIONS

As far as possible the rules for bonding (section 13.5) should be applied. There could be cases where the relative positions of walls make this impossible and it is then up to the craftsman to arrange the bonding to suit the circumstances. With the introduction of the 600 millimetres building module and the metric bricks this condition is unlikely to occur.



WALL JUNCTIONS

14.2 SQUINT QUOINS

Angles formed in brick work which are not a right angle are called 'Squint Quoins'. They are classified as 'Obtuse squint quoins' or as 'Acute squint quoins', depending on whether the angle formed by the two joining walls is obtuse or acute.

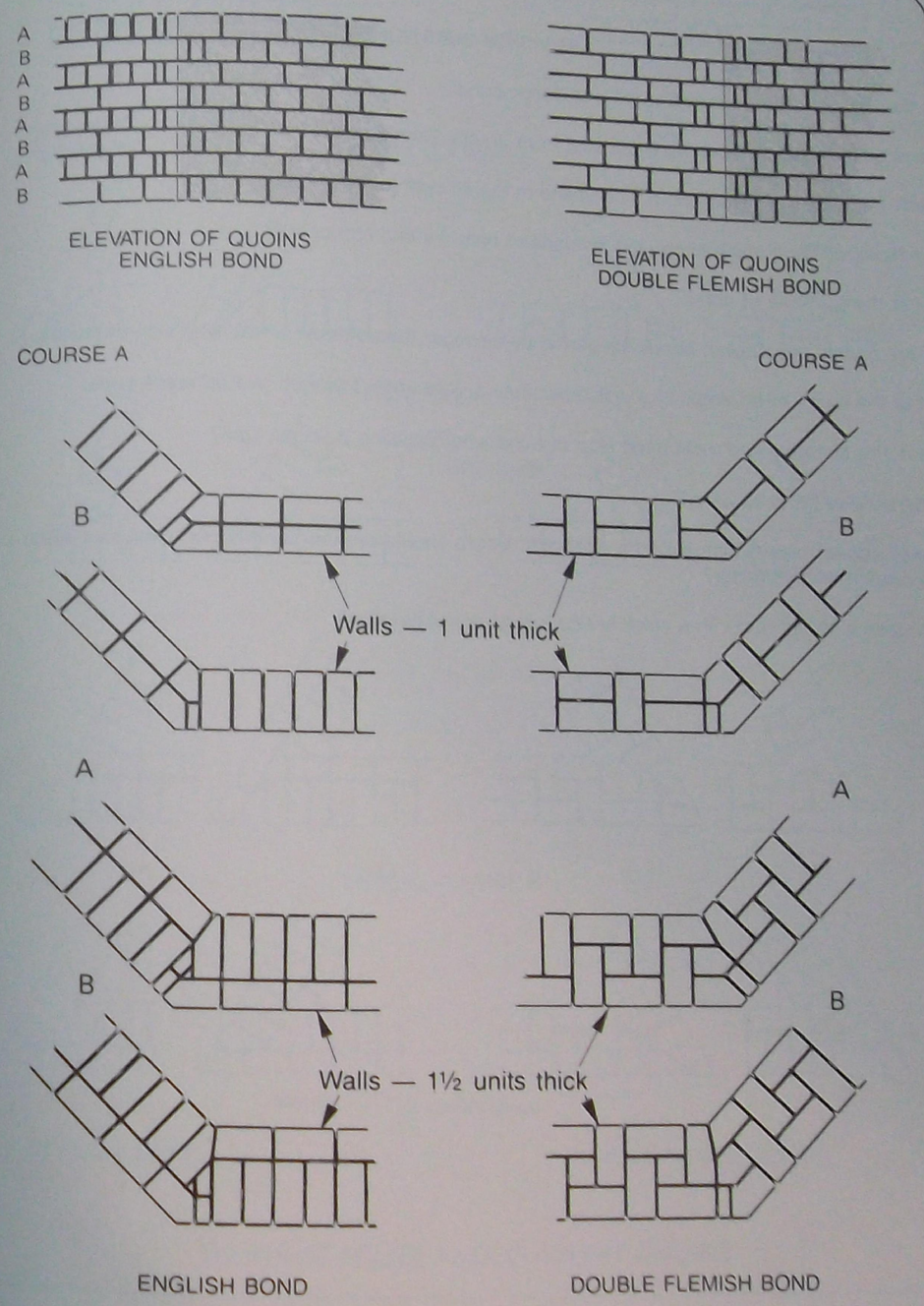
Quoin bricks can be purpose made to the required angle or cut on the spot, preferably by machine cutting. Of course perforated bricks, unless specially made for this purpose, would be unsuitable, and where quality face work would be required at the quoin, purpose-made bricks would have to be used.

14.2.1 Bonding of obtuse angle quoins

The method of bonding these is shown in the illustration for English and Double Flemish Bond. Note that no mortar joints occur at the external corner face and that the typical bonding pattern has been observed on both the main and the returned wall and that the quarter bond has also been maintained.

Note also the great number of cut bricks that has to be used in the form of squints, closers (queen and king), bevels and mitres, where the two walls meet. This is necessary to produce proper tie-in and strength in the joint. The filling-in of large gaps with mortar weakens the joints and is poor craftsmanship.

At this stage it is advisable to draw-up accurately and to scale a variety of obtuse and acute-angled walls and to determine how the various tie-ins are to be made. Vary the angles, bonds and wall thicknesses working from the centre line of each wall. Use a scale of 1:10. Standard metric bricks would be represented as 23 × 11 × 7.6 mm, the joints being kept at 1 mm. Use a very sharp pencil, keep it sharp and observe great accuracy.



TIE-IN AT OBTUSE ANGLE SQUINT QUOINS

14.2.2 Bonding of acute angle squints

Like their counterparts in the obtuse-angled quoins, the acute squints will have to be specially purpose-made bricks if the architect or the specification calls for the angles to be executed as shown as typical in the illustration.

The modern execution is shown with the end bricks having been kept whole. The use of squints, closers and bevels is still required in the inside of the joints to ensure that adequate strength is maintained. Ensure that bricks are cut accurately so that the standard mortar joint is kept constant throughout as much as possible.

REVISION QUESTIONS

List the differences between English and Dutch bond.

How is single Flemish bond distinguished from double Flemish bond?

Sketch 7 courses of these bonds and shade in the straight joints areas.

What types of bond show alternative courses of headers and stretchers?

What is the purpose of bond?

Why are Dutch and English bonds alleged to be stronger than others? Show why with sketches.

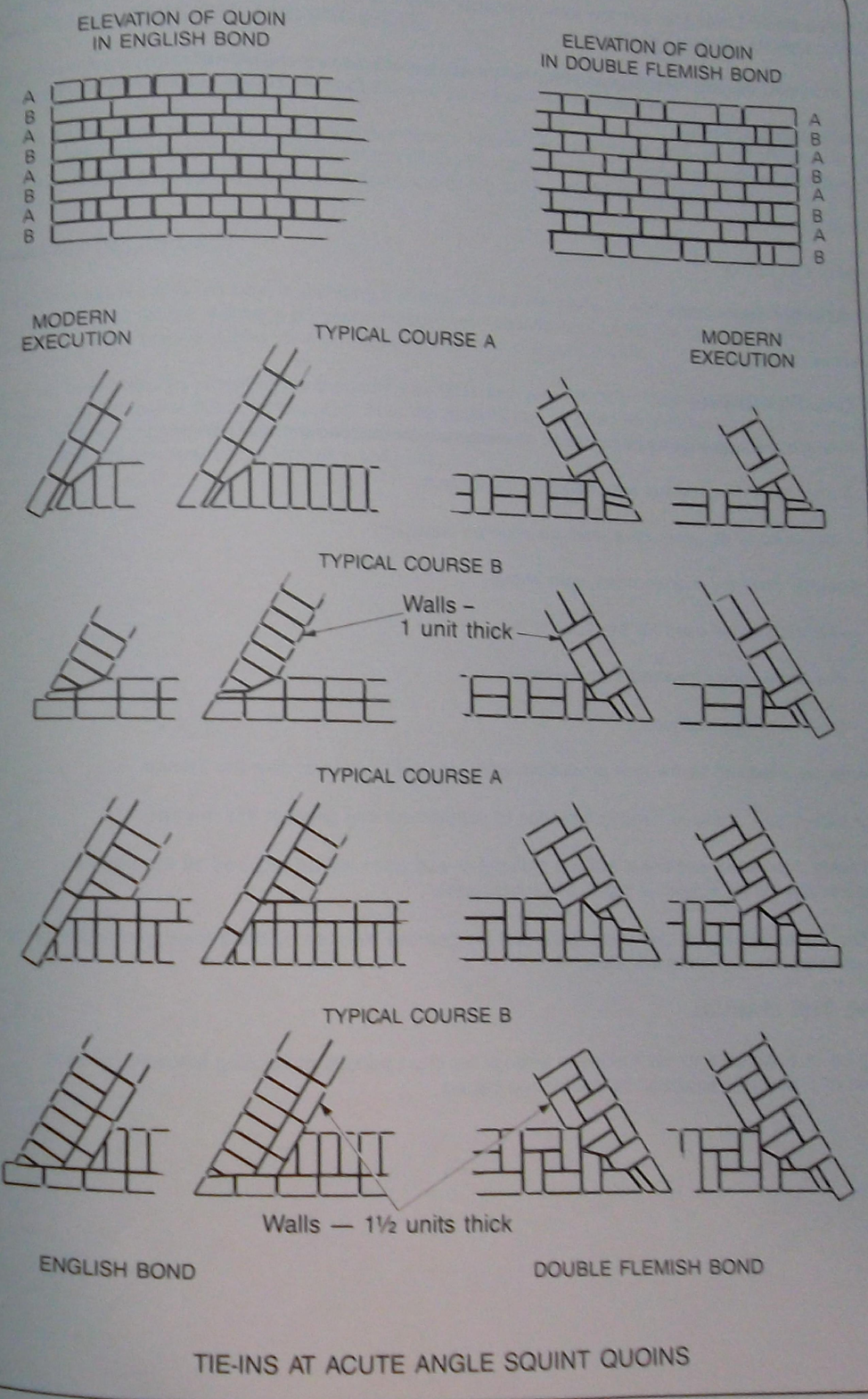
What is the name of an angle of a wall other than a right angle? Sketch two different ones.

What is the simplest and most used type of bond when building a ½-unit wall?

How is quarter bond obtained?

In a wall construction which features openings, where should broken bond occur? Why is it done and when does it always occur?

When does a ½ bat occur in a stretcher course at a wall junction?



TIE-INS AT ACUTE ANGLE SQUINT QUOINS

AUSTRALIA



BASIC TRAINING MANUAL

13-1

BRICKLAYING

Fundamentals

NATIONAL BUILDING AND CONSTRUCTION
INDUSTRY TRAINING COUNCIL

DEPARTMENT OF EMPLOYMENT, EDUCATION AND TRAINING

BASIC TRAINING MANUAL

13-1

BRICKLAYING

Fundamentals

Australian Government Publishing Service
Canberra

This manual has been revised at the initiative of the National Building and Construction Industry Training Council comprising representatives of employers, unions and government.

This manual was prepared and edited by an advisory panel consisting of:

Mr. W. Giles — Victorian Operative Bricklayers Society.

Mr. H. Burmeister — Representing Employers.

Mr. M. Vaserelli — Technical and Further Education.

Mr. S. De Hoedt — Department of Employment and Industrial Relations.

Revised text was written by:

Mr. M. Fitzgerald — TAFE Perth, West Australia.

Supervising Editor — Mr. D. G. Wilson, Department of Employment and Industrial Relations.

Editor — Mr. J. D. Cross.

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PREFACE

This manual is one of a series dealing with bricklaying in the building and construction industry. The series has been developed to progressively increase the practical skills of the trainee in bricklaying.

This manual instructs the trainee in the fundamentals of bricklaying but others in the series cover:

- reinforced brickwork;
- expansion joints;
- chimneys and fireplaces;
- gable ends and parapet walls;
- brick paving and steps.

Each manual is self-contained and is intended as an instructional guide in on-the-job training situations. It may be used by instructors or for self-teaching purposes to help the trainee to develop a particular skill to the stage where it can be applied productively. Ideally, the manual should be used as part of a course of instruction involving:

- demonstrations of practical skills by instructors or experienced tradespeople;
- planned and supervised practice in handling the tools involved;
- instruction in safe working procedures.

The manuals may be used in any order convenient to the learning needs of the trainee and may be obtained individually or in sets to cover the range of skills in the trade area.

It may be advisable to use part of this manual with sections of other manuals in this series to follow an operation through.

INSTRUCTIONS TO TRAINEE

This manual is a teaching aid to your skill development.

You should follow the general directions given by the person training you. To reach the required standard of skill, you must pay particular attention to your instructors' explanations and demonstrations. Supervised practice is essential.

Practice means making repeated efforts to improve your level of skill. Study is making an effort to learn. Every advance in skill depends on study and practice. You will make most progress by co-operating actively in the training arranged for you.

When you are told to study all or part of this manual, try to use a definite plan of study. The following plan is effective.

SURVEY: Read quickly through the headings as you turn the pages. Glance at the drawings. Get an overall view before you read.

QUESTION: Ask yourself: What do I know? What do I need to know? How will this manual help me to learn?

READ: Read right through each section carefully. Be thorough, but do not dawdle. Reading quickly will help you concentrate.

DO: Use all your senses in learning. Getting the 'feel' of a subject is essential in learning it. Follow the directions given to you; they are meant to assist you in the gaining of the skills you need.

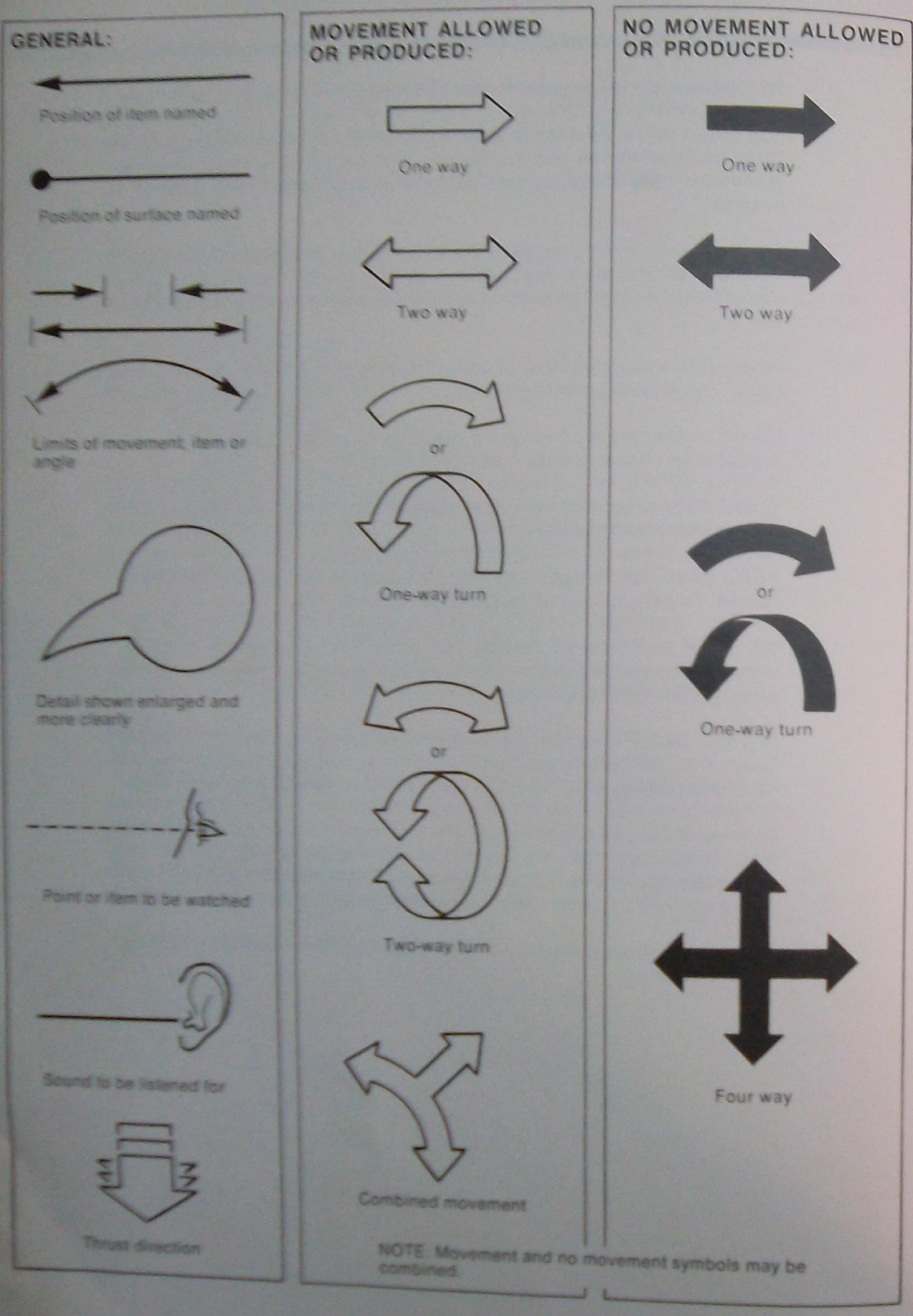
REVIEW: Shut the manual. Try to remember the main points of the section. Check if you are right. Revise points on which you are doubtful. Try a few or as many examples as you think you need, without reference to the manual.

One way of fixing important instructions in your mind is to repeat them over and over. Project exercises are included in this manual to help you test your understanding of the work. Use them intelligently. Do not fool yourself by looking up the answers too soon. Accept the challenge and try hard.

The practical work required of you in this manual will help you develop the skill to work productively.

SYMBOLS

The symbols shown are used in illustrations in these manuals.



1 INTRODUCTION

Bricklaying began a very long time ago, and the art of it has been handed down from skilled craftsperson to apprentice over many generations. The materials and tools used in bricklaying have changed over the centuries but the craft itself has remained as demanding as ever.

Nowadays, bricklayers have available advantages which their predecessors did not have; materials are better dimensionally, tools are more efficient, scaffolding safer, labour-saving devices have been introduced which make some of the physical labour requirements of the job less demanding.

The bricklayer craftspersons need also to develop personal qualities which will enable them to work and co-operate closely with other members of the trade and with all other tradespeople engaged in either small or large building projects.

A good craftsperson in any trade is judged by the way their tools are cared for. The time spent in cleaning tools at the end of the day's work is time well spent. Clean tools in good condition make for easier and better work.

A clean and tidy work area is conducive to producing good craft work and general neatness is essential to it. A good craftsperson will therefore ensure that no brick rubble and mortar droppings collect under foot. You will keep scaffold, mortar board and other tools clean and working area uncluttered as an added means to safe working conditions.

Accuracy and neatness should be the trademark of an efficient bricklayer.

As you gain more experience as a bricklayer, your speed of working will increase and you will learn short cuts and certain tricks of the trade. Where you use these to increase production while maintaining accuracy and the creation of a proper craftsmanlike job, well and good, but resist at any time the temptation to apply them when they would result in shoddy work. Remember that your work is a reflection of yourself and that it practically bears your signature. Finally, bear the following important points in mind:

- Brick work should be checked frequently to ensure that it is plumb, level and to the specified line.
- Each tool is made for a specific purpose. Use it correctly and for that purpose only so that you will obtain the best results.
- Strength of the work and its neatness are only obtained by correct bonding.
- Prevention of dampness entering a building is achieved only by good craftsmanship and the correct use of damp-proofing mortars, courses, flashing, and by keeping cavities clean, and by full mortar joints.

2 BRICKS

By bricks we usually mean clay bricks. These can be made from a wide variety of clays and shales which are composed of weathered water-containing minerals. Various impurities such as chemical salts, iron compounds and the like are nearly always present. It is the iron compounds which account for the wide range of colours that are found in the manufactured bricks. Of course, other compounds can be added to produce other colours, e.g. manganese dioxide, which will produce a range of greys and browns. After having been shaped, bricks are burnt in kilns which can vary in type. Some types, like the older ones, are divided into various compartments which enable green bricks to be stacked in one compartment while other stacks in other compartments are either drying, burning or cooling off. Depending on the clay used, the firing temperature varies from 1000°C to 1200°C, and, depending also on the kiln, the burning can take up to 10 days. Modern brick-making plant is becoming more and more automated and operates on a continuous cycle, green bricks going in one end and emerging at the other finished, ready for packing and despatch.

2.1 PROPERTIES

Good quality bricks have the following properties:

- Soundness.

  Any inclusions, such as loam or earthy matter which could weaken the brick, should not be present. A test for soundness of bricks, called the ringing test, is sometimes applied to ascertain whether a brick is sound and whether it has been properly fired. This is done by ringing 2 bricks together or striking one with a hammer. The sound brick will give a clear ringing tone. Remember, however, that it is difficult to agree upon what is a clear ringing tone and that the application of the test is only satisfactory to distinguish between well and lightly fired or sound and unsound bricks from the same production. It cannot be used to compare bricks of different origins and neither is it a very reliable test, as some perfectly fired bricks just will not ring.

- Uniformity in size.

  Properly made bricks must conform to a standard and variations in size will usually be within the limits laid down in the standard if the manufacturer has exercised adequate control. Familiarise yourself with the details of Australian Standard A21.

- Porosity.

  To some degree, this is an important property of bricks, as it assists in the adhesion of the mortar joints to the brick itself. Underburnt bricks are very absorptive and their high rate of absorption is detrimental to the proper setting of the mortar in the joints. Bricks with what is called a high initial rate of absorption have to be properly wetted to avoid poor mortar strength after setting. On the other hand, bear in mind that most extruded bricks have a low rate of initial absorption and need no prior wetting. To do so would be equally detrimental to the mortar because of the introduction of excess water. Consult manufacturers' data on this if in doubt, or consult with experts.

- Fire resistance.

  Well burnt bricks in soundly constructed brickwork have fire resisting qualities suitable for the protection of other materials, such as steel columns. Where high temperatures are to be resisted, such as in stoves, boilers, furnaces and fire places, special fire bricks, made from refractory or fire clays — and bedded in special fire clay mortar — must be used.

- Strength.

  Bricks in brickwork must be able to resist appreciable loads and stresses. Their main strength lies in their capacity to resist compression.

- Insulation.

  Bricks provide good insulation against heat and sound. This property increases with the thickness of the wall.

2.2 CLASSIFICATION OF BRICKS

Bricks may be classified under one or more of the following:

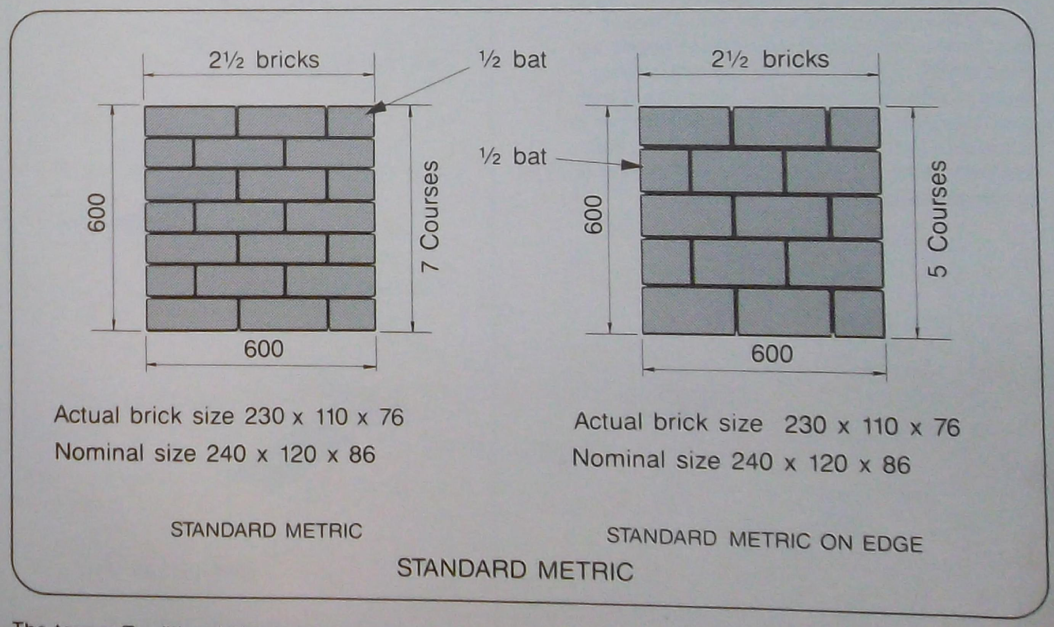
2.2.1 Size

The size of a common or standard brick is usually 230 mm × 110 mm × 76 mm, the length being twice the width plus the thickness of one mortar joint (10 mm). Dimensions may vary slightly from manufacturer to manufacturer and from brick to brick, depending on the type of clay used and the temperature at which the bricks were burnt. Modern machinery has made it possible to produce bricks to close dimensional tolerances, making bricklaying easier. Acceptable size variations differ according to localities. Australian Standard A21 for instance requires 24 bricks to be measured. For traditional bricks, tolerances are set at:

- + − 76 mm on the length of 24 bricks and + 50 mm or − 38 mm on width or depth of 24 bricks. Bricks made to other sizes are subject to proportional tolerances.

- Bricks which are thinner than 76 mm are sometimes called heelers and they can be used without affecting bond strength provided the bond is constant.

- Standard bricks conform to the 600 mm grid now used in building when laid as shown. This grid is commonly referred to as a module or panel.



The terms: Traditional Metric for Standard Metric
Manufacturing or Target Size for Actual Size
Format Size for Nominal Size are also used.

A variety of brick sizes is marketed. Some examples are:

- Modular metric.

  Actual size: 290 × 90 × 90 mm, giving an added advantage in that it conforms to a 300 mm as well as a 600 mm module and so allows for greater flexibility in design.

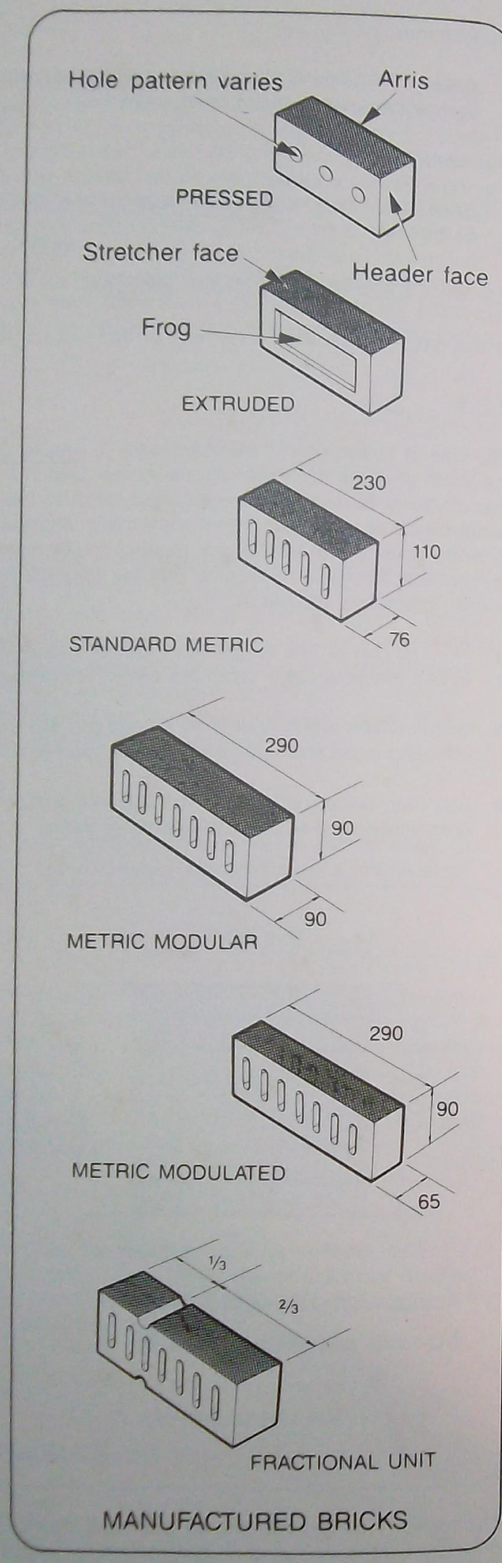
- Modulated.

  Actual size 290 × 90 × 65 mm. This makes it a more versatile brick since it also conforms to the 300 mm and to the 600 mm modules.

- Fractional units.

  Pre-grooved bricks to ⅓ and ⅔ of the length to be used in conjunction with either the modular or the modulated. The groove is an aid to quick and accurate cutting of the brick, which in the metric modular system uses ⅓ and ⅔ bricks instead of ½ and ¾ bats as for standard bricks.

Bricks may be plain, single or double frogged. Wire-cut bricks and hand-made specials have no frogs. Depending on manufacturer and machines used, bricks will show a variety of holes and slots. These perforations are necessary in manufacture to reduce the thickness of the clay through which the water must pass and evaporate from the denser structure of extruded bricks. This speeds up production, reduces the danger of cracking during firing, and it has also been found that such perforated bricks are usually stronger in compression than solid-pressed bricks. Also the perforations permit a more uniform firing of the whole brick.



MANUFACTURED BRICKS

The advantages of the frog are:

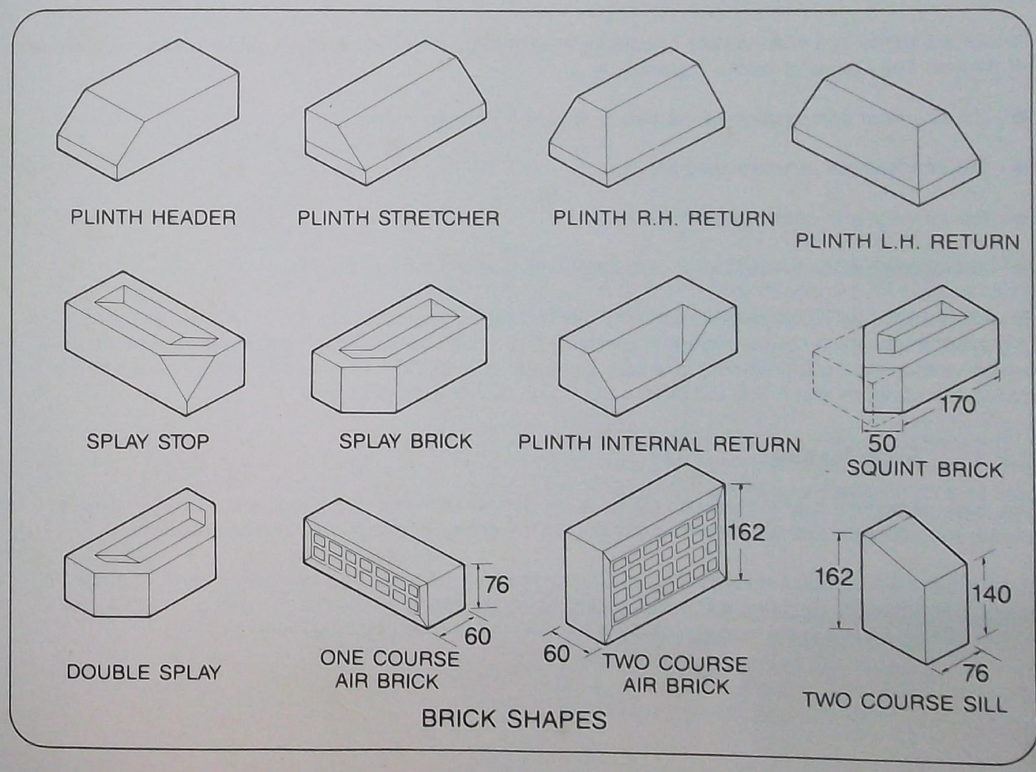
- It forces the clay to the outside of the mould during manufacture, so giving a better face finish to the brick.
- It provides a key for the mortar so that when the brick is laid there is less chance of it slipping out of position.
- It allows narrower joints to be made because most of the mortar is screened from view.

NOTE:
Single-frogged bricks are laid with the frog uppermost to avoid air pockets in the joints.

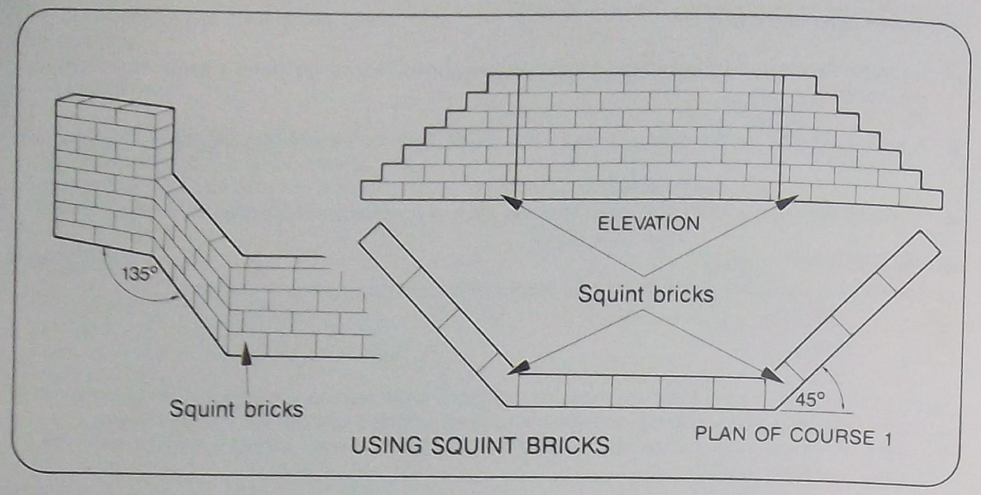
2.2.2 Shape

Special or purpose-made bricks are moulded to shapes which have to suit particular requirements of a structure such as arches, corners or angled structures, moulded cornices and the like. Round chimneys or curved walls are usually constructed with bricks which are curved slightly on the inside and outside of their faces.

As there is a limited demand for these specials, they are not usually in stock and have to be ordered and made separately. Some of the more common ones are shown.



BRICK SHAPES



2.2.3 Colour

Bricks are made in a wide variety of colours marketed by their manufacturer under a very wide range of names. The colour of bricks depends on:

- the chemical composition of the clay from which they are made;
- the temperature at which they are burnt;
- the atmospheric condition of the kiln;
- any staining prior to burning or colouring oxides added for that purpose.

Bricks can also be coloured to almost any desired shade by enamelling them. This usually gives them a glazed finish which results from the application of a thin coat of China clay on the face of the brick which vitrifies during the burning process. The body of such bricks is usually made of very fine clay called biscuit ware and it is burnt before the China clay coating is applied.

2.2.4 Face texture

The type of texture that is obtainable in bricks is almost unlimited. Such face textures are moulded during manufacture and are named according to the design of the particular manufacturer.

Bricks can also be obtained with a glazed face. It usually consists of a slightly brownish transparent glazing obtained by throwing salt into the kiln during the burning process. The salt gives off a vapour which settles on the brick face and gives it a highly impervious glazed surface.

2.2.5 Quality

Bricks from a kiln are divided into three main quality classes:

- Firsts.

  These are the best quality and usually selected by hand. They are usually used for face work.

- Seconds.

  These are selected bricks but not of the same standard as firsts because of some imperfections in colour or shape or both. Sometimes also referred to as common bricks or insides.

- Thirds.

  These constitute the remainder and include clinkers and doughboys.

  Clinkers are overburnt bricks and may be discoloured and distorted. Many clinkers are now produced in the automatic oil-gas fired process and come in extruded form. Doughboys (or callow bricks) are the underburnt bricks which remain relatively soft and are very porous. They are unsuitable for exposed work and even when used inside must be protected by good D.P.C. They cannot be used fresh from the kiln as they may grow. Must be at least 3 months old.

2.2.6 Manufacture

Bricks are made by the following methods:

- by hand;
- machine pressed (semi-dry and stiff plastic);
- machine extruded (wire-cut).

Not all brickwork is done with clay bricks. Other types of bricks are available, e.g. concrete bricks and blocks in various sizes and colours, sand-lime (Calcium Silicate) bricks and others, but all must comply with certain standards which lay down approved sizes and constructional strength (e.g. Australian Standard AS-A21).

Hand-made bricks

Traditionally made by throwing a ball of clay into a brick-sized mould and then cutting off the surplus clay. True hand-made bricks are available from some brickworks at a premium price, but today, machine-made bricks are treated to give them some part of the rough and irregular appearance of the hand-made brick.

Semi-dry-pressed bricks

This is a type of pressed brick supplied in NSW and Queensland, semi-dry-pressed (or dry-pressed bricks as they are commonly called) are made from a type of clay that, after grinding, can be combined with a small quantity of water in a way that permits separate grains of clay to flow by gravity into the die box in which they are pressed into shape. In many brick plants the pressed brick is then moved into a second box where it is re-pressed to increase its quality and strength.

Stiff-plastic-pressed bricks

This is the normal pressed brick supplied in Victoria, SA, WA and Tasmania. The type of clay from which this brick is made is such that more water must be added than is the case with the semi-dry-pressed brick, resulting in a mixture that is too sticky to flow by gravity into the mould. A simple extruded or pug-mill is used to force the clay into the mould and the resulting rough clod is then automatically moved into the die-box for its final pressing.

Concrete bricks

Made from a mixture of cement, aggregate and water, they can be solid or perforated.

After shaping, the concrete brick is either left to cure on its own or the process can be speeded up by placing them in an autoclave or other type of curing chamber. An autoclave is a pressure vessel into which steam at high temperature is introduced to speed the chemical setting action.

Sand-lime bricks

Made from clean sand and lime, pressed into shape and then autoclaved to cause the development of the calcium silicate that binds the particles together and gives the bricks their name.

REVISION QUESTIONS

1 List the properties of a good quality brick.

2 How are bricks usually classified?

3 What are fire bricks made from?

4 What is the size of a standard brick?

5 Why should underburnt bricks be avoided?

6 What is a frog for?

7 What are specially made bricks usually called?

8 How would you test a brick for soundness?

9 How does the length of a common brick compare to its width?

3 MORTAR

The purpose of mortar is to join the individual bricks into one solid mass. This function of mortar in construction of walls and piers is to give strength and make it more stable. The mortar takes up any irregularities of the bricks and makes the wall reasonably water and air-proof under ordinary weather conditions. A rule of thumb is that the mortar should not be stronger than the brick in most construction. This allows for expansion and contraction of the wall length.

3.1 COMPOSITION OF MORTAR

Basically, mortar is a mixture of three ingredients:

- an aggregate;
- a matrix;
- water.

3.1.1 The aggregate

The best aggregate is sharp clean pit sand. It should be free from loam, clay or other impurities and, if necessary, it should be washed, as the inclusion of foreign matter will weaken the mortar and affect its setting qualities.

NOTE:

AS Standard A21 does not permit more than a 10% clay content for mortar sand.

Qualities and characteristics of sand vary greatly. Pit sand is sharper than river sand. On the other hand, river sand is finer and much more suitable for plastering. Sea sand is rounded in grain and is impregnated with salt. The salt attracts moisture and dissolves. When evaporation takes place in dry weather, a white salty deposit known as efflorescence appears on the brick work and it is very difficult to clean off. Efflorescence is not necessarily the result of sea sand having been used in mortar. It often results from certain mineral salts contained in the clay with which the bricks were made being washed out by rain or dampness and subsquently drying out on the surface of the brickwork. Depending on the brick and its manufacture, some efflorescence could occur to a greater or lesser degree.

If sea sand is to be used, it must first be thoroughly washed in clear running water to remove all traces of salt.

3.1.2 Matrix

The purpose of the matrix is to bind the bricks and the ingredients of the mortar together into a hard solid mass.

The matrix can be rock lime, hydrated lime or portland cement and should always be used fresh. It should be stored under adequately dry conditions as any moisture will cause it to partially set.

It is when water is added to the ingredients which constitute mortar that the chemical reaction begins which will eventually turn the mix into a solid. This process of hardening is called setting.

Lime as a matrix provides elasticity, water retention, bond strength and flexibility to the mortar.

NOTE:

Should minute cracks develop in mortar containing lime, a chemical reaction known as autogeneous healing (self healing) starts as moisture from the atmosphere or rain reacts with the lime. This is similar to the action of water forming stalagmites, although autogeneous healing is much faster.

This is a very important process in the prevention of leaks in walls.

3.1.3 Water

Water used in the making of mortar, or concrete, should be clear drinkable water.

It should be added to the mix to the required amount to make the mortar workable to the best possible extent without affecting its setting properties. Too much or too little water added to a mix affects workability and setting adversely.

3.1.4 Lime mortar

When hydrated lime is used for making mortar, the recommended proportions are 3 parts of sand to 1 part hydrated lime plus the required amount of water. This type of mortar should not be used below ground level, or outside as fretting of the mortar will occur due to over-wetting by moisture penetration.

Putty lime is available from manufacturers and in the main makes a far better mortar in that there is generally less waste of expensive materials, and produces increased workability for the bricklayer.

NOTE:

This mortar mix begins to set as soon as water is added, therefore its use should not be unduly delayed.

3.1.5 Cement mortar

For ordinary purposes, the proportions of cement and clean sand used in this mix are 1 part of Portland cement and 3 parts of sand. The proportions may be varied depending on the strength required or as specified by the architect. Cement mortar should be mixed in relatively small quantities because setting action is rather fast and begins immediately water has been added to the mix. This 1:3 mix is practically waterproof.

Cement mortar is mixed by hand as follows:

- Mix the required proportions of sand and cement in a dry state on a wooden platform or clean paved area until an even greyish colouring of the mixture is obtained.
- Form the dry mix into a round heap and make a hollow of sufficient diameter to take the required amount of water, then gradually shovel the dry mix from the outside into the water and thoroughly mix the compound until the required results are obtained.

NOTE:

Any mortar which has been left unused and has taken its initial set must be discarded. It must never be beaten up, remixed and re-used.

Hand mixing is the same for Compo — mix all 3 dry ingredients thoroughly first.

3.1.6 Composite mortar

Usually referred to as Compo. It is a mixture of sand, hydrated lime and Portland cement mixed in various proportions which vary according to the strength required. Specifications for building usually lay down in what proportions the mortar shall be mixed. It can vary from: 1 part of cement, 2 parts of hydrated lime and 12 parts of sand or 1 part of cement, 1 part of hydrated lime and 8 parts of sand, or other combinations of these three components. The use of hydrated lime in cement mortar helps to make it smooth and fatty and easier to spread than straight cement mortar, which works short and sets rapidly.

Composite mortar can also be made from equal parts of lime mortar made from slaked rock lime and cement mortar. Compo mortar is very dense because of the lime addition and this improves its capacity for complete joint filling and making the structure more watertight, resilient and self-sealing.

3.1.7 Waterproof mortar

As stated before, the 3:1 mix is practically waterproof and because of its strength and basic ingredients of sand and cement, is recommended for use by manufacturers of most waterproofing chemical additives for mortar. These additives, however, tend to weaken the mix. It has never been a practice to include these additives with lime-based mortars. Most manufacturers of D.P.C. list the basic rules for use of their products on labels found on plastic cartons and tins. (See 13-2 Bricklaying Operations for more D.P.C. information.)

3.1.8 Coloured mortar

This can be obtained by mixing clean white or coloured sand and white cement, or by mixing clean white sand, white cement and various dry powders of mineral oxides to obtain the colour required. The required shades can also be obtained by mixing patent colour pastes with white mortar.

3.1.9 Fire-resisting mortar

Fire-resisting mortars may consist of basic ingredients depending on the area or position it may occupy in construction. Manufacturers supply and list a range of fire-resisting mortars. Ground fire clay mixed with water will give one basic type. 'Grog', which is the term used to crushed and ground clay brick particles, is also a material used to produce adequate fire-resisting mortar when mixed 50-50 to a good quality clay. This area of bricklaying is very specialised in both brick types used and mortars for sealing joints or for bonding.

3.2 BATCHING OF MORTAR

Different mortars are specified for different types of brickwork, depending on what the purpose of the construction is to be.

The proportions of the mix are usually specified and must be adhered to if trouble-free mortar is to be made. Failure to accurately measure the ingredients and to mix them thoroughly results in weak mortar and therefore weak brickwork which may have to be knocked down and rebuilt to the proper standard. It is the bricklayer who will get the blame and possibly face legal action to make good at his own expense.

The little extra time and effort required to make good mortar is well worthwhile.