ELEMENTARY PRINCIPLES OF BRICKWORK CONSTRUCTION

Volume One

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AUTHOR'S PREFACE

THE exceedingly small opportunity afforded the bricklayer of recent years, to display the better qualities of his craft, has caused the layman wrongfully to regard bricklaying as a trade possessing little or no craftsmanship. This lack of opportunity which may be attributed, partly to the existence of a state of emergency in which rapid erection of temporary buildings became essential and partly to the type of work required by the style of certain modern buildings in which plain surfaces predominate, has caused considerable deterioration in the standard of craftsmanship by the restriction of work to a very simple, almost mechanical type. Not only have craftsmen been unable to practise their craft in its entirety but apprentices have not had an opportunity to obtain adequate training to qualify their becoming really proficient. The result is, the brickwork craft has practically lost the art which at one time it possessed, an art which can only be appreciated by observing the type of work done, many years ago, in our stately buildings. Such work required more than the common, monotonous process of assembling standard brick units; it involved specialised treatment based upon sound principles of construction coupled with artistic arrangement.

When the time comes, most probably in the near future, to remodel the style of our buildings to produce structures possessing stability, beauty and utility in combination, then there will be a call for good craftsmen. Unless the call is answered by those having ability and a comprehensive knowledge of their craft, all efforts to produce such structures will be futile while the trade will be treated with even greater disrespect.

It is the hope of the Author that, given the opportunity, those entering the trade will realise their responsibility towards attaining a high standard of craftsmanship so that they can assist in reviving and maintaining that genuine art of brickwork deserving recognition.

J. G. V. PROUDMAN

WIGAN
October, 1943.

NOTE

THIS book is intended to serve as an introduction to the basic principles of brickwork construction. To supplement the theoretical treatment, the work should be executed in practice subject to the supervision of a qualified instructor.

Since the construction of buildings is governed by regulations or byelaws, the student should acquaint himself with the regulations applicable to the district in which he operates. The principal work of this book is intended to observe the regulations contained in the Ministry of Health, Model Byelaws, Series IV (Buildings), from which certain clauses have been reproduced by permission of the Controller of H.M. Stationery Office.

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DRAWING

(REFERENCE, PLATES 1 & 2)

To appreciate fully every constructional detail contained in this book, the descriptive matter should be followed in order and corresponding reference made to the illustrations which should be reproduced by drawing. The work of reproduction is intended for exercise in learning method of construction while the reproduced drawings may act partly as testimony of the student's knowledge.

It is expected that a basic knowledge of drawing has already been acquired and that the necessary drawing equipment is available. Where the student has little or no knowledge of drawing, Plates 1 and 2 are specially arranged to provide an introduction to reduced-scale drawings[1] in orthographic, isometric and oblique projections. The isometric projection used in the above plates is of a simple type in which all lines, other than vertical lines, are drawn at 30 degrees to the horizontal; since this type of projection is of a pictorial nature it probably has greater attraction than that known as orthographic. The latter, however, is used for working drawings[2] and therefore the student should acquaint himself with this type of projection in which an object is graphically represented usually by three views, namely, plan, front elevation and side or end elevation.

Sometimes the latter elevation is displaced by a sectional elevation which is a projection representing the appearance of an object when a section plane or an imaginary cutting plane has passed through the object to divide it into two parts, one part being removed to view that remaining. (See Plate 2. Fig. B.)

Oblique projection is a combination of orthographic and isometric projections to the extent that the main features of the object are drawn in orthographic projection while the remaining parts are drawn in isometric projection. (See Plate 2. Figs. C. to M.)

[1]A reduced-scale drawing is one in which the dimensions are in reduced proportion to those of the object represented.

[2]Working drawings form indispensable guides to the correct construction of buildings. Drawing practice will enable the student to become proficient in the interpretation of working drawings.

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BRICKS

(REFERENCE, PLATES 1 & 2)

Manufacture.—General building bricks are made chiefly from prepared clay or shale[1] which is termed brick earth ; the constituents are chiefly, alumina,[2] silica,[3] lime, iron, together with small quantities of other substances.

Briefly, the processes of manufacture are :—

1. Clay getting and preparation.
2. Moulding (manual or mechanical).
3. Drying.
4. Burning.

Process 1.—First the clay is excavated and should be broken up for exposure to weather ; it is then transferred to a mill where stones are removed and with the addition of sufficient water, brought to a plastic state. Where shale is used it is necessary to include a process of grinding in addition. Modern methods call for quick manufacture and in most cases the time for exposure is either reduced to a minimum or entirely eliminated.

Process 2.—When the brick earth has been converted to the correct state of plasticity the process of moulding follows.

Hand Moulding.—Wood or metal moulds of suitable size and shape, open at the top, are used to receive the prepared brick earth which is cast into the mould, pressed to fill all corners and any excess struck off level with the top of the mould by a blunt edged strip of wood or metal ; before filling the mould, the sides are sprinkled with fine sand to prevent the clay sticking thereto ; alternatively, the mould may be dipped in water. A thin wood pallet, slightly larger in length and breadth than the brick, is placed on top of the mould previous to turning over ; on removing the mould, the " green "[4] brick remains on the pallet to facilitate transportation to drying sheds. Another type of mould has vertical sides only and where this is used, placing on the pallet is done before filling. The dimensions of moulds are slightly in excess of those required of the

[1]Shale is a hard dry clay.
[2]Alumina is aluminium oxide.
[3]Silica is quartz or sand.
[4]The term " green " is applied to an unburnt brick.

finished brick and the corresponding excess in the green brick allows for shrinkage which occurs in the succeeding processes.

Machine Moulding.—This is fundamentally the same as hand moulding but the operation is done by mechanical means. Filling the mould is usually done with great pressure when the bricks so produced are known as " pressed " bricks.

An alternative method of machine moulding is done by forcing the prepared brick earth through an aperture, 9 in. by 4½ in. approximately, and as it emerges, suitably spaced wires cut it into blocks of the required size ; the resulting bricks are known as " wire-cuts " and have flat bed surfaces without " frogs."[1]

Process 3.—The green bricks are carefully stacked, with space between them, in drying sheds which have open sides for the passage of air ; the period required for this method of drying varies between three and four weeks according to weather conditions, after which time the green bricks are moderately hard. Another type of drying shed has closed sides for the retention of heat supplied by warm air. Where rapid production requires a shorter drying period the green bricks are subjected to more intensive heat in a kiln[2] or hot chamber.

Process 4.—The final process of burning or baking is done in a kiln of which there are several types. The dried bricks are stacked inside the kiln in a manner that will expose a reasonable amount of the bricks' surfaces to heat in order to obtain uniform burning. The process occupies about two weeks after which the burnt bricks are removed from the kiln when they are ready for delivery.

Nature and Characteristics.—The main characteristics by which the quality of general building bricks may be judged are, shape, size, soundness, strength, porosity, colour and texture.

Bricks should be reasonably true to shape and size ; for soundness they should be free from cracks, lumps of embedded lime or stones and possess sufficient strength to withstand the pressure intended to be put upon them. They should not be highly porous when intended for use in damp situations, since the ensuing absorption will probably lead to a loss of strength. Colour and texture usually go together to produce an appearance and surface finish compatible

[1]The sunk bed surface of a brick is termed a " frog." Bricks may have one, sometimes two, frogs while bricks intended to support heavy loads are usually without frogs.

[2]A kiln is a brick structure composed of one or more chambers each connected to a source of heat which is generated inside the kiln and controlled by dampers. There are openings for fuelling, loading with bricks and unloading. During the burning period, which occupies about two weeks, the openings are closed in order to retain the heat.

with good personal taste. True shape and size are essential to good jointing and bonding.

Where lumps occur in bricks, there is an indication of improper manufacture. When moisture reaches a lump of lime in a brick, expansion of the lime is liable to occur, causing the brick to fracture. Cracks may be due to improper manufacture and usually occur during the burning process.

Strength is usually indicated by high density or weight as also is low porosity. A material containing small holes is said to be porous and capable of absorbing moisture,[1] the extent of which varies from $\frac{1}{15}$th to $\frac{1}{4}$ the dry weight of a brick; the latter may range between 5 lb. and 10 lb., with a density varying between 100 and 140 lb. per cubic foot.

Colour may be uniform or otherwise and is affected, chiefly, by the chemical composition of the brick earth.

Texture is the term applied to the surface finish, either smooth or rough. The latter finish is a form of rustication which is intended to produce relief by means of light and shade; further, it need not be too regular in shape and may be multi-coloured. In contrast to the *rustic* brick, the smooth faced brick is suitable for work in smoky atmospheres, where the rough-faced rustic bricks would develop an objectionable appearance arising from the collection of soot; colour is usually uniform while shape and size are regular.

A simple practical test for soundness is to strike two similar bricks together when a clear ringing sound should be made.

To test the porosity or absorption, take a dry brick and after obtaining its weight immerse in water for, say, 24 hours after which it is taken out, any free surface moisture wiped off, and the weight of the wet brick obtained. The difference between wet and dry weights gives the weight of water absorbed, which for good facing bricks or bricks for use in damp situations should be small compared with the dry weight of the brick.

There are two reasons for the provision of frogs :—

1. To form a key or joggle with mortar to prevent sliding of the bricks on their beds. (See Plate 2. Fig. D.)

2. To reduce the weight of the brick and thereby economise in the cost of transport.

In regard to the first reason, bricks having smooth bed surfaces and low porosity do not adhere to the mortar joints so effectively as

[1]Absorption is further described in the chapter dealing with damp-proof courses.

bricks with rough surfaces and high porosity, consequently, there is a tendency to sliding when horizontal thrusts occur.

Although bricks of low porosity (or high density) possess great strength, their adhesion to mortar is usually poor and consequently, the ultimate strength of the brickwork in which they are used is reduced. High porosity is advantageous in bricks used for work in partitions built on beams since there is less weight to support. Porous bricks have other advantageous qualities which cannot be suitably described at this stage.

Types of Bricks in Common Use.

COMMON bricks are those used for ordinary work which is not exposed to view ; they are usually machine-made.

SELECTED COMMON bricks are those common bricks which have been selected as being suitable for work of an ordinary character exposed to view.

FACING BRICKS are those which are specially made for good class work exposed to view.

BLUE BRICKS being of very low porosity are suitable for resisting dampness and heavy loading.

ENGINEERING bricks have qualities similar to those of blue bricks, but are usually of a red colour ; they are used in work where great strength is required and are usually frogless.

Brick Dimensions.—The dimensions and shape of bricks vary according to requirements of the purpose which the bricks are intended to serve. Where bricks varying in size are used together, the task of the bricklayer is made difficult on account of the additional care required to produce work of good appearance ; to overcome the difficulty, bricks should have standard dimensions, but even the most up-to-date methods of manufacture inevitably produce slight variations in size. The recognised standard dimensions are, $8\frac{3}{4}$ in. long, $4\frac{3}{16}$ in. wide and $2\frac{5}{8}$ in. or $2\frac{7}{8}$ in deep.

Fig. A, Plate 1, illustrates the dimensions of a standard brick in general terms where

L denotes length
W ,, width.
D ,, depth.

The Elevation, Fig. B represents the "stretcher" face of the brick, the End View represents the "header" face, while the Plan represents the normal bed surface, which, in the case of a wire-cut brick is frogless.

Bats and Closers.—Standard bricks may be arranged in various ways to form walls, but in certain cases these bricks require to be reduced in size and altered in shape ; this is done with the use of cutting tools. When a brick is cut to a reduced size it is known either as a " bat " or a " closer " according to its shape. Figs. C to H, Plate 1, illustrate the various bats and closers the use of which can be seen in the work to follow. It may be noticed that in the case of a bat the cut extends across the width of the standard brick while a closer generally has the cut extending from one header face to the other, except in the " king closer " when it runs from a header face to a stretcher face. The cut surfaces of bats and closers are usually concealed when properly arranged in a wall.

*

MORTAR

Definition.—Mortar for brickwork is a mixture of a fine aggregate, usually sand, and an adhesive, either lime or cement, sometimes both, together with sufficient water to render the mixture plastic.

Classification.—There are three main classes of mortar used for general brickwork :—

1. Lime mortar.
2. Cement mortar.
3. Cement-lime mortar.

Lime Mortar is composed of lime and sand ; the proportions of the two materials vary according to their nature and the required quality of the resulting mortar.

The usual average proportion is 1 part lime to 3 parts sand, measured by volume.

Cement Mortar is composed of cement and sand in varying proportions as for lime mortar.

Cement-lime Mortar, as the name implies, is a mixture of cement, lime and sand in suitable proportions. Sometimes it is termed " compo."

Purpose.—Mortar is used to provide a means of assembling brick units into mass formation. In addition, loads are distributed more uniformly than they would be otherwise by eliminating the mortar beds and placing the bricks with their somewhat irregular bed surfaces together. Further, mortar joints contribute to stability and act as a resistance to weather.

Characteristics.—Good mortar should be of a mixture which will give :—

(*a*) Proper plasticity and workability to ensure sound work.
(*b*) Strong adherence to the bricks.
(*c*) Durability.
(*d*) The requisite strength to the brickwork ; and resistance to weather-action.

Preparation.—Mortar may be prepared by either manual or mechanical means.

Manual preparation should be done on a clean, smooth surface of wood, concrete, metal or other suitable material which is practically non-absorbent and free from open joints. Mechanical preparation may be done by a machine equipped to produce a mixing action or a combined grinding and mixing action.

Lime mortar may be prepared in several ways according to the type of materials used. Lime may be in any of the following forms :— lump, powder, or paste.

Further information on these kinds of lime may be found under the heading, Lime, page 16.

The improved modern method is to use the powdered lime which has been scientifically prepared and only requires mixing with sand together with the necessary water.

Further information regarding sand may be found under the heading, Sand, page 19.

In the case of manual preparation of mortar, using powdered lime, the required quantities of sand and lime are taken and heaped together on the mixing surface. The mixing process is done by using the spade to turn over the heaped materials ; to ensure thorough mixing, which is most important, the heap should be turned not less than three times before adding water ; the application of water should be in the form of a continuous light spray, distributed uniformly throughout the mass and of such quantity as will produce the required plasticity. To ensure the uniform distribution of water, additional turning or agitation of the mass will be required ; a long handled rake is most effective for the purpose.

The mechanical mixing of this type of mortar is done in a revolving drum fitted with blades to produce a churning action.

Where the lime is of paste form, the manual preparation is carried out by arranging the sand in a basin-like formation having a diameter of four to six feet and a depth of about one foot, into which the correct proportion of lime is placed. With use of the rake, the lime is brought to a state of thick liquid by the addition of water and afterwards the surrounding sand is raked into the centre and thoroughly mixed with the liquid lime.

The preparation of mortar from lump lime and sand, is best carried out by mechanical means in a grinding and mixing mill. The process is one in which the required quantities of lime and sand, together with water, are thrown into a revolving pan fitted with rollers for crushing the lumps; these rollers in conjunction with deflecting blades ensure thorough mixing. The lump lime, before entering the mill, may require to be heaped, sprayed with water and covered with sand, after which it stands for several days to enable an action known as hydration to occur.

This action is further explained under the heading, Lime, below.

In industrial districts, finely ground engine ashes or furnace clinker are introduced in certain proportion to the lime and sand and the resulting mortar is of a dark grey colour. Mortar which is practically black can be produced by adding black sand which has been used in iron foundries; the adhesive value of such mortar is reduced owing to the presence of graphite in the sand.

Cement mortar may be prepared either manually or mechanically as described for powdered-lime mortar. Owing to the comparatively quick setting action of cement this type of mortar should be made in quantities which will enable complete use before the setting time has elapsed; having once set, cement mortar cannot be converted to a plastic state and still possess the essential setting properties.

Water used in the preparation of mortar should be clean and free from impurities which may impair the necessary characteristics of good mortar. Such impurities as salt, oil and earthy matter are most harmful since they reduce the adhesive property.

Lime.

Production of Lime.—Lime used in the preparation of mortar is produced by burning limestone or chalk (calcium carbonate) in a kiln for a period of three to four days at a temperature of at least 900 degrees Centigrade; this process is known as "calcining" and the resulting substance, usually of lump or powder formation, is termed "quicklime" (calcium oxide).

When a certain quantity of water is applied to quicklime heat is generated, the lime expands, disintegrates and finally falls into powder; with the addition of further water the powder may be converted into a paste formation which is termed "lime-putty." The action which occurs is termed "hydration" and the process is known as "slaking"; this is done in a pit or container of suitable size.

It is possible for hydration to occur when quicklime is sufficiently exposed to the moisture which is normally contained in the atmosphere, when the process is specifically known as "air slaking."

Hydrated lime is nowadays scientifically prepared at the works by special plant and supplied in bags as a fine, dry powder ready for use. There are advantages to be gained by using this lime as may be seen from the following facts :—

(*a*) It is absolutely reliable.
(*b*) It is properly burnt and thoroughly hydrated.
(*c*) Requires no preparation before mixing with the sand, thus saving time and working space on the job.
(*d*) Can be stored for a reasonable length of time without serious deterioration and may be mixed as needed.
(*e*) Usually produces better results than either lump lime or lime-putty.

A serious disadvantage of lump lime is the tendency to "blowing" or "popping"[1] after completion of work. These defects are attributed to unslaked quicklime particles which are common to this kind of lime after the process of hydration; they are the result of improper or delayed slaking action followed by the characteristic expansion which causes fractures.

Air slaking is not to be considered absolutely satisfactory since thorough hydration cannot be guaranteed.

The time required for slaking varies according to the quality of the lime which may be classified as either, "quick slaking," "medium slaking" or "slow slaking"; the slower slaking limes are less pure than those which are quicker slaking.

Classification of Lime.—The varying qualities of lime used for brickwork are classified as :—

(*a*) High calcium lime.
(*b*) Semi-hydraulic lime.
(*c*) Eminently hydraulic lime.

[1]The terms "blowing" and "popping" are applied to the expansion of small lumps of lime causing fractures in finished work.

High calcium lime is known also as "White" lime or "Fat" lime and may be classed as quick slaking due to its being a practically pure lime, i.e., its composition is almost entirely calcium. An outstanding characteristic of this grade of lime is the high degree of workability which can be obtained.

Semi-hydraulic lime, or "Grey" lime, does not possess the same high calcium content as White lime and consequently has correspondingly less plastic properties.

Eminently hydraulic lime, or "Lias" lime, contains an even greater proportion of impurities than the semi-hydraulic lime and therefore it follows that these impurities reduce the plastic properties making it more difficult to work. Sometimes the term "Lean" lime is used.

The existence of certain, so called, impurities in lime used for brickwork does not necessarily infer a reduction in quality, in fact, they aid the setting properties and are therefore considered very suitable for work in which strength is essential. In some instances lime contains a comparatively large proportion of magnesia when it is known as magnesian lime and possesses better hardening properties than high calcium lime.

The Setting of Lime.—The term "setting" is applied to an action of lime which occurs after slaking and depends upon the slaked lime absorbing carbon dioxide from the atmosphere. The nature of the action is such that the particles of slaked lime are changed into comparatively hard crystals of calcium carbonate. Hence, it follows that the lime, having firstly existed as calcium carbonate is next changed, by burning, into calcium oxide (quicklime) and further, by the addition of water, the quicklime is converted into a plastic state (hydrated) to render it workable; upon exposure to the atmosphere evaporation and crystallisation occur causing the lime to return somewhat to its original state, namely, calcium carbonate. During the changing action, the crystals unite by cohesion causing the resulting calcium carbonate to be of lump formation but lacking its original soundness. The presence of moisture is essential for proper crystallisation and cohesion.

This applies also in the setting of mortar. Therefore, mortar must remain moist during the period of crystallisation and absorbent bricks should be sufficiently wetted immediately before use to prevent their extracting, from the mortar, the moisture which is essential to crystallisation and adhesion.

By the addition of sand to lime in certain proportion as in the preparation of mortar, crystallisation is induced in the setting action together with the characteristic adhering tendency which is greatest on rough surfaces. Further reasons for adding sand are, to economically increase the bulk and strength by introducing a suitable material which is less costly, and to reduce the amount of shrinkage that would occur with the use of lime alone.

Hydraulic limes have the peculiar property of hardening without exposure to the air and for this reason eminently hydraulic lime can be used in cases where setting has to take place in damp situations.

Sand.

Properties of Sand.—The properties of sand influence, to a large extent, the quality of mortar. In selecting a sand suitable for general brickwork the following points should be observed :—

The sand should be

(*a*) Clean, i.e., free from impurities such as those stated for water.
(*b*) Sharp, i.e., having angular shaped grains.
(*c*) Well graded, i.e., having proportionate amounts of varying sized grains combined to give the required texture, neither too fine nor too coarse.

Sand which is not clean may reduce the adhesive property of the mortar ; dirty sand can usually be made suitable for use by washing, a process in which water is used to separate and convey the impurities from the sand. A simple test for cleanliness can be carried out if a small quantity of sand is stirred in, say, a glass jar containing clean water ; if the water becomes discoloured the presence of impurities is indicated ; oil or grease will rise to the surface.

Sharp sand, obtainable from pits or quarries, produces mortar of greater adhesive strength. Sand found in sea and river beds has rounded grains due to the continuous action of moving water ; these grains are not only round but smooth and consequently cause a reduction in the adhesion between the lime and sand. The use of sea sand should be avoided since it contains salt. With practice, sharpness can be tested by rubbing the grains between the fingers.

Well graded sand tends to produce strength and workability with a minimum of lime. The varying sized grains can be seen by close observation. To test for good grading, take two containers of equal cubic capacity and fill each with sand obtained from two sources. (Simply pour in the sand without tamping or shaking.) Pour water into the containers in turn, taking care to prevent overflowing; the sand and water should be stirred to extricate air and sufficient water added until it rises to the top of the containers; the amounts of water used for filling in each case should be noted and compared. The better graded sand will be the one requiring the smaller quantity of water. The principle upon which the test is based may be stated thus :—

Water absorbed into the sand fills voids which previously existed between the grains while the amount of water required in each case indicates the volume of voids. From these amounts the comparative quantities of voids can be obtained, the smaller amount being that of the well graded sand.

The effect of voids is further explained under the heading, Concrete, page 23.

Sand grains for ordinary mortar should not have a dimension exceeding $\frac{1}{10}$ in., otherwise they cause mortar to have a coarse texture.

Colour of Sand.—Sand obtained from different sources may vary in colour from reddish-brown to pale yellow while in some cases there is almost an absence of colour; the term "silver sand" is applied to the latter. Normally, the colour of sand influences the colour of mortar but where, in the latter, special colour is required the appropriate coloured cement can usually be obtained for the purpose.

Sand Substitutes.—Sand substitutes may be provided by crushing brick, sandstone, furnace clinker or other suitable material. In districts where sand is difficult to obtain, the substitutes are used with very satisfactory results.

Mortar Composition and Proportions.—As previously stated, the proportions of the materials vary according to their nature, e.g., a certain kind of sand may require a greater proportion of lime than a certain other sand, in order to produce mortar having the required strength and workability. Consequently, a fixed proportion cannot be wisely stated unless the nature of the materials to be used is known, but it is accepted that proportions can be safely stated between certain limits in accordance with regulations.

The following clauses of the Ministry of Health Model Byelaws Series IV (Buildings), state the requirements for various classes of mortar :—

Lime mortar shall be composed of sand and either :—

(*a*) High calcium lime, used either as putty of normal consistence from sound hydrated lime or as sound matured putty of normal consistence from properly run quicklime, in the proportion of *one part* of putty to not less than *two* nor more than *four parts* of sand measured by volume ; or

(*b*) Magnesian lime, properly slaked, in the porportion of *one part* of lump quicklime to not less than *two* nor more than *three parts* of sand, measured by volume ; or

(*c*) True moderately hydraulic lime, used as sound dry hydrated lime or properly slaked quicklime, in the proportion of *one part* of hydrated lime or slaked quicklime to not less than *two* nor more than *four parts* of sand, measured by volume ; or

(*d*) Eminently hydraulic (lias) lime, properly slaked, in the proportion of *one part* of lime to not less than *two* nor more than *four parts* of sand, measured by volume of the materials when dry.

Cement mortar shall be composed of cement and sand in the proportion of *one part* of cement to not less than *two* nor more than *four parts* of sand measured by volume of the materials when dry.

Cement-lime mortar shall be composed of Portland cement or Portland-Blast furnace cement, and either high calcium lime or true moderately hydraulic lime (either in the form of properly slaked lime putty of normal consistence or sound dry hydrate), and sand. The proportion of cement to lime shall be *one part* of cement to not less than *one* nor more than *three parts* of lime measured by volume of dry cement, dry hydrate or lime putty respectively : the proportion of the mixture of cement and lime to sand shall be *one part* of the mixture to not less than *two* nor more than *four parts* of sand measured by volume.

Black mortar shall consist of high calcium lime or hydraulic lime and a filler consisting of clean furnace clinkers reasonably free from unburnt coal, soot or flue refuse, with or without sand. The lime shall be used either as sound dry hydrated lime run to putty of normal consistence, or as properly slaked quicklime run to sound putty of normal consistence or as fresh quicklime. The lime shall be thoroughly and finely ground with the filler and with water in a suitable mill. The mortar shall be composed of *one part* of lime putty to not less than *two* nor more than *four parts* of the filler measured by volume, or *one part* of fresh quicklime to not less than *four* nor more than *eight parts* of the filler measured by volume.

Wise craftsmen will adjust the proportions, between the specified limits, to the best advantage, but in so doing it must be remembered that mortar should be so compounded that its ultimate strength is practically equal to that of the bricks to be used ; usually it is slightly less.

Mortar containing moisture can be detrimentally affected by the action of frost before and after setting is complete ; the cause arises from the contained moisture changing to ice on freezing.

In the case of freezing before setting is complete, defectiveness is due to the prevention of crystallisation.

Where moisture, having been absorbed, is contained in mortar after setting, frost action causes an expansion in volume of the moisture and thereby creates internal pressure which results in disintegration of the mortar. A similar action can occur in other granular materials such as bricks, stone and concrete, particularly those which absorb proportionately large amounts of moisture.

Arising from these facts is a rule which states that operations which entail the preparation and use of either mortar or concrete in a wet state, should be suspended during the time when the temperature falls below *forty degrees* Fahrenheit. When this rule is ignored and, say, a brickwork wall is attacked by frost action, it would probably be found that, although the work had been erected with a truly vertical face, the result would be a distorted and unsafe wall.

Other weather actions, caused by excessive rain, wind and high temperature, can be harmful ; consequently, precautionary measures should be taken and adequate protection provided for materials and work in progress.

Cement.

Composition and Manufacture.—Cement for general use is produced from chalk (or limestone) and clay (or shale) together with small quantities of other ingredients, including iron oxide and magnesium oxide, and is strictly known as Portland cement.

The manufacturing processes may be briefly described as follows :—

The raw materials, in definite proportions, are converted into a liquid state by grinding, mixing and watering ; the resulting mixture, termed "slurry," is conveyed to a kiln for subsequent drying and burning. The burning process changes the slurry into clinker which is afterwards passed on to mills for grinding to a fine powder in its final process. Tests are made from time to time to ensure high quality.

Setting.—The setting action of Portland cement commences immediately after the addition of water, consequently, any mortar which contains cement should be used within approximately four hours[1] after mixing, otherwise the value of the cement will be

[1]This period of time applies to mortar in which ordinary Portland cement is used ; where special quick-setting cement is employed the length of time is considerably less.

practically lost. Setting will also occur when cement is exposed to a damp atmosphere, therefore dry storage becomes essential; it is also important to avoid storing over a long period in order to reduce the risk of contact with moisture.

Portland cement resembles eminently hydraulic lime in composition and also in its power to set in water but with greater strength and a shorter setting time. Hence the need for cement in mortar to be used in damp situations; also where high strength and weather resistance are required.

The use of cement-lime mortar needs due consideration where it is desirable to avoid efflorescence; this will be dealt with in Volume II.

Much importance is attached to the uses of Portland cement, consequently it is necessary for stringent tests to be made so that a consistently high quality can be maintained and also to ensure that the properties of the cement reach a specified standard.

The necessary tests and specified standard will be dealt with in Volume II.

Concrete.

Definition.—Concrete is a composition of comparatively small pieces of inert material, termed the "aggregate," and a binding material, known as the "matrix." The aggregate may consist of crushed natural stone, broken brick, gravel or suitable blast-furnace slag, while the matrix is usually cement which is rendered plastic by the addition of water, sufficient to produce a paste for covering the surfaces of the aggregate. On setting, the cement adheres to the aggregate uniting it in a homogeneous mass.

Proportions.—The proportion of aggregate to cement varies according to the nature of the materials and the requirements of the purpose to be served by the concrete. The following table shows the requirements of the Model Byelaws in respect to the proportions of aggregate and Portland cement in cement concrete:—

Type of Concrete	Proportions of Materials.	
	Aggregate	Cement.
Foundation Concrete	15 cu. ft.	112 lb. (minimum)
Site Concrete	10½ cu. ft.	112 lb. (minimum)

Note.—In the case of site concrete the 10½ cu. ft. of aggregate shall be composed of 3½ cu. ft. fine aggregate and 7 cu. ft. coarse aggregate.

When cement is poured into a gauge-box[1] in the normal manner the weight per cubic foot is 80 lb. approximately; thus, the proportions, by volume, of aggregate to cement for foundation concrete may be expressed as 11 : 1.

Grading and Size of Aggregate.—Proper grading of the aggregate is essential to the ultimate strength of the concrete and to the economic use of cement. The minimum size aggregate to be that which would be retained on a ⅛ in. square mesh screen, while the maximum size will vary according to the type of concrete required; that for foundations and mass concrete should pass a 1½ in. square mesh; for finer work and work where steel is incorporated, the aggregate should pass a ¾ in. mesh.

Clean Materials.—It is important that clean aggregate be used, while rough angular pieces are better than those which are smooth and round. The water used should be clean and free from impurities which would impair the quality of the concrete.

Mixing.—Mixing may be done either manually or mechanically. Manual mixing is usually adopted for small quantities only or where mechanical means are not available.

For manual mixing the method which should be adopted is as follows:—

Measure the requisite quantities of dry materials in gauge-boxes and place in one heap on a suitable smooth, hard surface as stated for the manual mixing of mortar. (Alternatively, the proportion of cement may be measured by weighing.) The proportioned mass of aggregate and cement is next turned over several times until the dry materials are thoroughly mixed, shovels being used for the purpose.

With further turning, water is added by lightly spraying over the mass, continuing until the required consistency is obtained. It is important to distribute the water uniformly and in quantity which does not exceed that required to produce the correct consistency; an excess of water reduces the ultimate strength of concrete.

To ensure thorough mixing the amount of turning is usually specified as, three times *dry* and twice *wet*.

Mechanical mixing is done by a special concrete mixer which consists, in the main part, of a revolving drum, hopper, water-tank and motor. The hopper is filled with the dry materials in correct

[1]A gauge-box consists of four wooden sides, without top and bottom pieces, and is made to contain a certain volume of material. It is used for gauging or measuring the amounts and proportions of materials.

proportions and raised in order to feed the drum ; at the same time a determined amount of water is added. The mass is churned until thoroughly mixed when it is ready for discharging and placing in position. The drum should revolve for a specified time at a given speed which is based upon the requirements for proper mixing.

Placing the Concrete.—Since the Portland cement has a rather quick setting action, the wet concrete should be placed, immediately after mixing in the required position and consolidated by punning[1] or ramming.[2] No further movement should be caused during the period required for setting, neither should any load be applied until the concrete has developed sufficient strength. The concrete should not be dropped from a height nor subjected to conditions which would tend to either separate the materials or change the consistency.

Protection.—After placing and until sufficiently hard, the concrete should be protected against inclement weather. Where high temperature and rapid drying prevail, the concrete should be kept damp by spraying or the application of damp sacks. Concreting operations should not be carried out where temperatures fall below *forty degrees Farenheit* since the resulting frost action would cause disintegration of the concrete and loss of strength.

Grading of Materials for Concrete.—Grading of materials for concrete is the choosing of coarse aggregate and sand of certain sizes and in certain proportions so that the resulting concrete possesses properties relative to density.

High density implies high strength ; load bearing concrete which, of course, requires high strength should therefore be graded to obtain maximum density.

The basic principles of grading for high density may be briefly stated as follows :—Voids existing between the pieces of coarse aggregate are filled with fine aggregate, usually sand, while those existing between the sand grains are filled with cement the amount of which should be small where well graded sand is used. The cement has to fulfil a further purpose by way of providing each grain of sand and each piece of coarse aggregate with a thin coat which will eventually act as a matrix in binding together the coarse and fine aggregates.

Where the above principles are carried out maximum density

[1]Punning is an action in which the concrete is compacted by repeated application of weight in the form of an implement having a heavy flat base, about 1-ft. square, and a vertical handle, about 4-ft. long, made from either wood or metal.

[2]Ramming compacts the concrete by creating movement in the mass and is done by ram rods. This method is most suitable for mass concrete.

should be obtained, but since voids exist in set cement the resulting porosity of the concrete, neglecting the porosity of the materials, depends upon that of the set cement. Hence, a small proportion of cement will tend to reduce the resulting percentage porosity of the concrete, but when determining this proportion, care must be taken to provide sufficient for the binding coat and the filling of voids remaining in the mixed aggregates. Thus, there must be a necessary minimum of cement ; to use more than this amount is unwise since higher porosity and loss of strength will arise together with greater cost for cement.

The amount of water used in mixing also has some effect upon the ultimate porosity of the concrete. In setting, the concrete gives up the water which previously occupied part of the bulk volume and at the same time assumes a rigid form. Thus, when a proportionately large amount of water is used, there will be an equally large amount of voids remaining when the water has been given up ; therefore the quantity of water should not be excessive. There must be, however, a necessary minimum and this depends upon the degree of workability required.

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JOINTING AND BEDDING

(REFERENCE, PLATE 2)

JOINTING of brickwork is classified as either, (*i*) thickness jointed or (*ii*) gauged work. In the former class the joints are usually about $\frac{3}{8}$ in. thick while in the latter case, which is generally adopted for special face work, the thickness of the joints is not more than $\frac{1}{8}$ in.

Special bricks are used for gauged work ; these are termed "rubbers." Other types of brickwork having $\frac{1}{8}$ in. thick joints are not classed as gauged work.

Bedding of bricks which are thickness-jointed is done by preparing a mortar bed upon which the bricks are laid and rubbed into position ; vertical cross-joints are applied either to the brick which has been laid or to the brick to be laid.

Most types of bricks require wetting before use in order to wash off any free surface dust and to allow the bricks to absorb sufficient moisture to prevent rapid absorption of water from the mortar. Dust prevents adhesion of the mortar to the bricks while the too rapid drying of the mortar reduces its ultimate strength.

It is essential that all joints should be solidly filled or flushed with mortar. For thin walls jointing is done with the trowel but for thick walls "larrying" or "grouting" is preferable. This latter procedure is carried out in the following manner:—

The face or outer bricks forming the thickness of the wall are laid by use of the trowel; semi-fluid mortar, termed "grout," having been previously prepared is then poured into the space surrounded by the face bricks and upon this bed of grout the filling-in bricks are placed in proper order. If the correct amount and consistency of mortar is used it will be found that the vertical joints, cross and collar joints[1] in the thickness of the wall become filled by the rising grout.

Bedding of gauged brickwork is done by carefully dipping the bed surface of the brick into lime putty and then placing and rubbing into position.

Mortar on setting gives up its moisture and, for a previously stated reason, should be prevented from doing so rapidly. The moisture having previously occupied part of the volume of the wet mortar causes voids to remain in the set mortar; under such conditions the resulting mortar will be porous and is liable to absorb moisture and rain-water. As a result of the absorption and weather-action the mortar joints will, in time, disintegrate; as a counter-measure, excessive water should not be used for mixing the mortar and, the face joints should be consolidated and left smooth with the trowel or other suitable tool before the mortar sets or becomes too stiff. Alternatively the face joints may be raked out to a depth of about ½ in. as the work proceeds and on completion replacement and finish are done by a similar or stronger mix of mortar. When the joint finish is done as the work proceeds the operation is termed "jointing," but when deferred until a later stage it is termed "pointing."

When pointing is done, the joints should be cleanly raked out to the previously stated depth, brushed and the face of the wall thoroughly washed down with clean water before replacing the mortar. The operation should commence at the top of a wall, working downwards and applying water from time to time as required to keep the brickwork damp.

Joint Finishes.—Various types of joint finishes are shown on

[1]Cross-joints are those vertical joints which are at right-angles to the length of wall. Collar joints are those vertical joints which are parallel to the length of wall.

Plate 2. The type shown by Fig. E is very suitable for good external work known as " weathered struck and cut " and is done by applying suitable mortar in sufficient quantity, by means of a trowel, to overlap the top arris of each brick to the extent of about $\frac{1}{8}$ in. In order to ensure a regular overlap a bevelled-edge rule may be used as a guide to either cut off the mortar or to place it.

Fig. F represents a " weathered struck " joint which is used extensively for external work. Its weather-resisting qualities are not so good as the weathered struck and cut joint since defectiveness is liable to arise from shrinkage cracks occurring between the brick and the mortar at the lower edge of the joint where there is a minimum thickness of mortar.

The joint shown by Fig. G is done by a steel jointing tool. Its weather-resisting qualities are similar to those of the weathered struck joint. The concave surface produces soft shadow as distinct from the sharp shadow cast by the two previous types of weathered joints.

Where surface texture is required the joint shown by Fig. H is suitable. Since its surface is of a slightly rough nature and consequently liable to the effects of weather, it should be carried out with good mortar. The joint should be absolutely flush with the face of the bricks and its finish obtained by a " drag,"[1] usually of wood, which is drawn over the face of the brickwork to remove projecting mortar and raise the sand grains to the face of that which remains.

A recessed joint is shown by Fig. J. Its weather resisting qualities are not good since it offers a lodging place for water.

The joint shown by Fig. K is usually adopted for internal work. It is carried out with the trowel and is absolutely flush thus giving a flat surface continuous with that of the brickwork. To reduce the amount of skill and labour required in forming the flush joint, bricklayers are inclined to adopt a struck joint, usually an inverted weathered struck joint, which is liable to collect dust and thereby produce an objectionable result contrary to the object of the flush joint.

Tuck pointing, shown by Fig. L is a somewhat out-of-date finish used for reconditioning old work.

A more recent method for reconditioning, is to flush point with mortar to tone with the colour of the bricks and by the use of a steel jointing tool, " S "-shaped, which is drawn along a suitably placed straight-edge rule, a small impression is made as shown by Fig. M.

[1]A " drag " is a bevelled-edge tool usually about 6 in. long, 2 in. wide and $\frac{3}{8}$ in. thick.

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BONDING

(REFERENCE, PLATE 3)

Definition and Purpose.—The overlapping arrangement of bricks or blocks in order to unite or tie them together in a mass of brickwork or masonry, is known as "bonding."

Good bonding should have a minimum of "slit"[1] joints in any part of the work, since they are a source of weakness and therefore should be avoided where possible. Craftsmen sometimes concentrate solely upon the face bond and disregard the internal bond; it is most essential to have good bonding both internally and externally. Certain cases arise, however, where slit joints are unavoidable.

Bond, in addition to uniting, distributes the load from, say, a beam placed upon any individual brick in a wall, to an increasing number of bricks forming the wall below, thereby reducing the tendency to settlement.[2] (See Plate 3. Figs A, B, C).

Kinds of Bond.—There are several kinds of bond; some are employed to obtain maximum strength while others are used for their appearance or economy.

Stretching Bond (Fig. A).—In this kind of bond each successive course is formed with bricks so laid, that their stretcher faces appear in elevation; the amount of overlap is half the length of the bricks and is obtained by commencing each alternate course with a half-bat.

It is suitable for half-brick (4½ in.) thick walls and cavity walls.[3]

Heading Bond (Fig. D).—Each successive course is formed with headers, i.e., bricks so laid that their header faces are parallel to or, appear in the elevation of the work; the overlap, which is half the width of the brick, is obtained by introducing a three-quarter bat in each alternate course at quoins. It is seldom used for straight walling, but is suitable for walls which are curved on plan; it is always used in brick foundations.

English Bond (Fig. E).—Header courses alternate with courses appearing as stretchers on the outer face or elevation. The header course is commenced with a quoin header followed by a queen closer

[1]Slit joints are caused by the vertical joints between bricks in successive courses falling in the same straight line or plane.

[2]Settlement is depression of the brickwork due to intensive loading.

[3]Cavity walls are those built in two separate thicknesses with an intervening space. (Their treatment is dealt with later.)

and continued with successive headers. The stretcher course is formed, on its outer face, of stretchers having a minimum lap of one-quarter their length over the headers.

Flemish Bond (Fig. F).—Successive courses are formed with alternating stretchers and headers. In order to obtain the lap, which is one-quarter the length of the bricks, a queen closer is introduced next to the quoin header in alternate courses followed by a stretcher; the succeeding course commences with a stretcher followed by a header which is placed centrally on the stretcher below.

Garden-wall Bonds (Figs. G and H).—These bonds are named according to the kind of bond to which they are related.

English Garden-wall bond consists of a course of headers, with the necessary queen closer next the quoin header, to three, sometimes five, courses of stretchers in series running the full height of the wall.

Flemish Garden-wall bond consists of alternate courses composed of one header to three, sometimes five, stretchers in series throughout the length of the courses. The lap is obtained either by introducing the necessary queen-closer next the quoin header or by the use of a three-quarter bat. Headers, other than quoin headers, are placed centrally on the centre stretcher of the series. Flemish Garden wall bond is also known as Sussex bond and Scotch bond. Fair face to both sides of one-brick thick walls is more easily attained with Garden-wall bonds than it would be by using the true English or Flemish bonds.

Comparison of Bonds in Respect to Strength and Load Distribution.—Stretching bond, although restricted to half-brick and cavity walls, possesses the ability to distribute loads over a maximum length of walling in a given number of courses.

Heading bond does not possess the above stated ability, but since it is adaptable to walls of one-brick or more in thickness, lack of longitudinal distribution is compensated by transverse distribution according to the thickness of the wall.

English bond presents a minimum of slit joints and therefore is very suitable for supporting great loads. Load distribution is effected both longitudinally and transversely.

Flemish bond, although sufficiently strong for most types of average work, is not so strong as English bond since it presents a number of unavoidable slit joints. The load distributing value of this kind of bond is moderately good.

Garden-wall bonds possess considerably large slit joints which consequently reduce the strength values. Load distribution is moderate.

Perpends.—The term perpends is applied to the vertical cross-joints which should appear in the same, but not continuous, straight parallel lines throughout the height of the work (Fig. J).

Return Wall.—This is the term applied to a wall the length of which lies at an angle to the length of a main wall, the intersection of the two walls forming a quoin (Fig. J).

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FOUNDATIONS

(REFERENCE, PLATE 4)

Definition.—The term "foundation" is applied in a general sense to :—(1) the "natural" foundation and (2) the "artificial" foundation.

Natural foundation means the ground which receives and supports a structure, while the artificial foundation is usually the extended base of the structure.

Where brickwork of an ordinary character is erected on solid rock the extended base is unnecessary.

Purpose and Principles.—There are two main reasons for providing a foundation :—

(1) To distribute the weight of a structure and its applied loads over the natural foundation in such a manner as to prevent unequal and unnoticeable settlement.

(2) To provide a level bed from which erection of the superstructure may be suitably commenced.

Settlement in foundations is due to the natural foundation yielding under load. Most types of ground become depressed when a structure is erected thereon, thus causing a certain amount of settlement; providing the settlement is uniform and not excessive (comparative with the laws of stability) there is little or no cause for alarm. The amount of depression varies according to the nature of the ground and the weight placed thereon.

Assuming the weight of a structure is transmitted to its base and acts vertically downwards, to produce stability the supporting ground must provide resistance amounting to the downward acting weight. When the resistance value of the ground is less than such weight (which term, for the sake of example, includes any applied load) the structure will settle. There is a well known fact that to drive the point of a nail into, say, a piece of timber requires less effort than to drive the flat head. This is due to the point having a lesser bearing surface in contact with the timber. Comparing this example with the foundation of a structure, it may be seen that the extension of the base will provide a greater bearing area and consequently less tendency to settlement. It is also well known that an impression is made more easily in soft sand than in solid rock; therefore, it is obvious that the sand possesses less bearing value, or resistance, than the rock and consequently the greater need for a wide extension of the base when erecting a structure on soft ground. By increasing the area of the base in contact with the ground, the intensity[1] of the downward acting weight is correspondingly reduced. It may be said that ground resistance acts vertically upwards to counteract downward acting weight and it acts against the bed surface of the extended base.

The construction of a foundation should be such that it can withstand all the forces to which it is subjected; it may be constructed of brick, stone, concrete or a combination of these materials. The amount of extension, or width, of the base may be calculated by taking the weight of the structure together with its applied loads and dividing by the recognised safe resistance value[2] of the ground to receive it; the result is the area of foundation required from which the width is obtained after dividing by its length. Thus, if the structure be a wall weighing 60 tons including its foundation which is 20 ft. in length and the safe resistance value of the ground known to be 1 ton per square foot, for every foot length the width of the foundation would need to be at least 3 ft., to guard against settlement. Sufficient width is an important factor as also is the depth. When the extension is made entirely by bricks, these are arranged in courses, termed "footings," having regular 2¼ in. offsets or projections (see Fig. B). The minimum number of footings is equal to the number of half-brick dimensions in the thickness of the wall; this number causes the width of the lowest footing-course to be twice the wall thickness. In addition, walls of more than one brick in thickness are required by regulations to have a further course of brickwork (see Figs. G and K). This arrangement usually provides a base of sufficient depth, but where

[1]Intensity denotes the amount of weight acting on a unit of area, say, one square foot.

[2]There are recognised values for the various classes of ground; these will be dealt with in Volume II.

concrete forms the base it is possible, but not permissible, to give the required extension with insufficient depth.

The need for sufficient depth may be gathered from the following example. Compare the concrete base with a strip of wood, say 18 in. by 3 in. by $\frac{1}{8}$ in., which is lying upon a bed of soft sand and with a 14 lb. weight concentrated at the centre of its broader surface. It may be found that the strip bends slightly under load. If the procedure be repeated with a greater thickness of timber, say 1 in., but with equal length and breadth to the previous strip, it will be noticed that there is less tendency to bending. If the amount of bending in the thin strip be increased sufficiently, the result would be a fracture of the timber. Let the 14 lb. weight represent the wall-load and let the support given by the sand represent the resistance of the ground : thus, with the upward acting resistance, part of which acts against the under surface of the extended portions of the concrete base, where there is little or no downward acting weight, tendency to bending arises in the concrete which, if insufficient in depth or strength, will be liable to fracture. Supposing fracture did occur, the extension of the base would be reduced and the intensity of pressure on the ground correspondingly increased. Sufficient depth and strength of concrete overcomes the bending tendency and distributes the weight of the wall and its load through the concrete in outward and downward directions, to the entire width of the extended base. In all cases, whether the base be formed of brick, stone, concrete or a combination of these materials, minimum dimensions are enforced by regulations. (See Figs. A to L.)

Depth of foundation below surface of ground is another important factor, since seasonal changes cause slight movement in most types of ground. To guard against the harmful effect of this movement, which occurs at or near the surface, the foundation should be placed at such a depth as to be immune from such effects ; for ordinary work in the English climate a depth of 1 ft. 6 in., to 2 ft. is sufficient. The foundation must be in firm ground which is not usually found at or near the surface ; it must also be at such a depth as not to be affected by vibration caused by traffic. Under no circumstances should the footings appear above ground level and it is recommended that the top of the concrete, where used, be at least 1 ft. below the surface.

Where soft patches occur in the natural foundation they should be taken out and the holes filled with suitable concrete. Should the depth of the foundation be exceeded by error during excavation, the excavated material should not be returned to make good, but additional concrete used to make up the extra depth or, an additional amount of brickwork where brick footings are used.

As far as possible, all bricks in footing courses should be laid as headers, so that three-quarters their length remains embedded in the footings after the succeeding offset is made. (See Plate 5.) Where an odd half-brick dimension occurs in the width of any footing course, it should be arranged in or near the middle of the width. (See Plate 5. Fig. C.) Exceptions to this rule occur in :—

(1) A 13½ in. wide footing course, when the odd half brick is placed as a stretcher alternately on the opposite sides. (See Plate 5. Fig. B.)

(2) The additional course below footings, where stretchers are used on the outer faces with either a header bond or diagonal bond filling. (See Plate 5. Fig. E.)

Diagonal bond overcomes the lack of longitudinal load distribution which is a fault of header bond.

Bricks used in footings and foundation walling[1] should be sound, well burnt and of high density.

Requirements of the Model Byelaws in Respect to Foundations.

(ILLUSTRATED, IN CERTAIN CASES, ON PLATE 4. INTERPRETATION OF TERMS, PAGE 36.)

Byelaw 22.—The foundations of every building shall be :—

(1) So constructed as to sustain the combined dead load of the building and the superimposed load and to transmit those loads to the subsoil in such a manner that the pressure on the subsoil shall not cause such settlement of the building or any part of the building as may impair its stability ; and

(2) Taken down to such a depth or so constructed as to render the building immune from damage from movements due to seasonal variations in the content of moisture in the ground.

Byelaw 23.—(1) Every structural wall (including a pier[2] forming part of the wall) shall rest upon :—

(*a*) Solid undisturbed rock ; or

(*b*) A layer of cement concrete of sufficient width and thickness ; or

(*c*) Proper footings of sufficient width built directly on suitable ground ; or

[1]Foundation walling is the portion of a wall between the top of its artificial foundation and the ground level, or basement floor level.

[2]The definition of the term " pier " is given at the end of these Byelaws and illustrated on Plates 15-19.

(*d*) Proper footings built on a layer of cement concrete of sufficient width and thickness ; or

(*e*) Proper footings built on a layer of lime concrete of sufficient width and thickness ; or

(*f*) A sufficient raft of cement concrete properly constructed and where necessary suitably reinforced ; or

(*g*) A layer of cement concrete of sufficient width and thickness on suitable piles driven to a proper depth ; or

(*h*) A bressummer of sufficient strength ; or

(*i*) Some other not less sufficient substructure as a foundation.

(2) In the case of a domestic building the walls of which are constructed otherwise than with framework, the requirements of sub-paragraphs (*b*), (*c*) and (*d*) of paragraph (1) of this byelaw shall, where the wall is not more than *fifty feet* high and the bearing capacity of the ground under its foundation is not inferior to that of firm clay or coarse sand, be deemed to be satisfied if :—

(*a*) (*i*) The width of the bottom of the foundation (except where an adjoining wall or pier interferes) is not less than *twelve inches* or not less than *twice* the thickness of the wall in the lowest storey, whichever is the greater ; and

(*ii*) Where there is a pier forming part of the wall, the foundation is carried round the pier on all sides so as to project at least to the same extent as it projects beyond the wall ; and

(*b*) The foundation is situated centrally under the wall or pier (except where an adjoining wall or pier interferes) ; and

(*c*) The height from the bottom of the foundation to the base of the wall or pier is not less than *nine inches* or not less than *one and one-third* times the projection of the foundation from the base, whichever is the greater ; and

(*d*) Where there are footings of brickwork, the footings :—

(*i*) Are built in cement mortar ; and

(*ii*) Are either in regular offsets from the face of the wall or pier or in one offset ; and

(*iii*) Where they are built directly upon the ground, and the wall is more than *nine inches* thick, have a further course of brickwork at the bottom of the footings ; and

(*e*) Where there are footings built upon cement concrete, the thickness of the concrete is not less than *one and one-third* times the projection of the concrete from the footings.

Byelaw 24.—A pier which does not form part of a wall shall rest upon one of the foundations specified in paragraph (1) of the last preceding byelaw.

Interpretation of Terms.

Dead Load means the weight of all walls, floors, roofs, partitions and other like permanent construction.

Superimposed Load means all loads other than the dead load.

Pier means a brick structure, either isolated from or attached to a wall, having a width (greater horizontal dimension) not exceeding six times the thickness.

Bressummer means a beam or girder which carries a wall.

Domestic Building means a dwelling-house, shop, office building or any other building which is neither a public building nor a building of the warehouse class.

Base, applied to a wall, means the underside of that part of the wall which immediately rests upon the footings or foundation or upon any bressummer or other structure by which such wall is carried.

Piles are similar in form to large stakes which are driven into the ground for the purpose of forming a foundation. (Pile foundations will be dealt with in Volume II.)

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TIMBERING TO SHALLOW TRENCHES

(REFERENCE, PLATE 6)

THE bricklayer is not generally recognised to be directly concerned with the work of timbering, but in numerous cases, particularly small jobs, he is entrusted with the supervision of its erection. Therefore, the inclusion, in this book, of a chapter dealing with timbering is justified on the grounds that a knowledge of the subject is essential to the bricklayer.

Definition and Purpose.—Timbering to trench excavations is usually a temporary arrangement of wooden units, of various sizes, intended to support the sides of excavations during building operations and until filling or other means of support can be provided.

Types of Timbering.—There are various types or arrangements of timbering according to requirements; these are influenced by the nature of the ground, the depth of the excavation and the amount of pressure which may be put upon the ground in the immediate vicinity. Some classes of ground will require more support than others, while in certain cases no support whatever is required. Where excavations are made in ground other than that which is reasonably stable, timbering will generally be required when the depth exceeds 3 ft.

Classes of Ground.—The various types of ground may be classified as :—

(*a*) Firm or Hard (including, rock and hard chalk).
(*b*) Moderately Firm (including ordinary chalk, clay, compact gravel and compact dry sand.)
(*c*) Loose (including loose gravel, loose dry sand, ordinary loamy soil and made-up ground).
(*d*) Running (including loose sand, loamy soil and made-up ground each containing water).

The different arrangements of timbering required for shallow trench excavations in the various classes of ground may be seen from the illustrations on Plate 6. That for loose and running ground employs a greater number of members than that for the moderately firm, while firm ground requires no timbering where the trench is shallow and other conditions are normal.

Names of Members and Dimensions.—The members are named according to the purpose which they serve or the position they occupy.

Poling Boards are members placed vertically against the faces of the excavation; their cross-sectional dimensions vary from 7 in. by 1 in. to 9 in. by 1½ in., while the length is governed by the depth of the excavation.

Walings or *Walers* are timbers placed horizontally against either the face of the excavation or the poling boards; cross-sectional dimensions may vary from 4½ in. to 9 in. in depth and from 2 in. to 4½ in. in thickness, while any convenient length may be used.

Struts are horizontal members driven between either poling boards or walings in order to retain the timbers in position against the sides of the excavation; they should be of stout cross-sectional dimensions to resist the thrust, from the sides of the excavation, caused by earth pressure. Suitable cross-sectional dimensions for use in narrow trenches would be 4 in. by 3 in., increasing as their length increases; this latter dimension should be slightly in excess of the horizontal distance between the poling boards or walings, as the case may be, so that by driving the strut into position the timbers are tightened against the sides of the trench. Slight batter is usually given to the sides of excavations so that where there is a tendency towards the timbers becoming loose, their weight, combined with the batter, causes a wedging effect whereby the timbers become self-tightening. Struts should be arranged at a minimum distance apart of about 6 ft. horizontally to allow working room for the excavator; an exception to this rule occurs where walings are joined in their length. Where pairs of struts are required in the depth they should be arranged in vertical planes throughout the length of the excavation and at distances from the top and bottom of the trench of not more than one-quarter the depth.

Sheeting is formed of horizontal boards placed closely together against the faces of the excavation and held in position by means of poling boards and struts; the boards should have cross-sectional dimensions varying from 6 in. by 1 in. to 7 in. by 1½ in. while the normal length should be not less than 8 ft.

Wedges, varying in size from 6 in. long by 4 in. wide by 1½ in. thick (maximum) and upwards, may be required for maintaining timbers in position especially where the ground is very loose and running. Normally, firm and moderately firm grounds do not call for the use of wedges.

The dimensions stated above, for the various members are intended to serve as a guide in determining the sizes required for normal conditions; any sound timbers of approximately the sizes stated may be used. The timber may be of a rough nature providing, it possesses sufficient strength.

Placing of Timbers.—Firm and moderately firm grounds will usually allow the excavation of shallow trenches to be made the entire depth before the placing of timbers is required; loose and running grounds will require timbering as the excavation proceeds.

In the case of loose ground it will probably be found, that a depth of not more than 1½ ft. can be excavated before timbers are required to support the sides; consequently, the procedure becomes one of excavating to whatever depth the looseness of the ground will allow without falling and then placing the timbers to such depth. These operations are repeated until the required depth is reached. Strutting will be temporary in the early stages and until the required amount of sheeting is placed, when poling boards and struts can be secured in their more permanent positions as shown by Fig. D.

The procedure to adopt for timbering to running ground is as follows. Commence the excavation to the allowable depth, which may be only several inches and then place, closely together, chisel-ended poling boards vertically against the sides of the excavation with walings lightly strutted to hold the poling boards in position ; the length of poling boards required will be, say, nine inches in excess of the depth of the excavation, to enable their lower chisel ends to be eventually driven below the bottom of the trench. The poling boards are next driven into the ground, to a depth of about one foot or to whatever depth the nature of the ground will allow ; a large mallet, termed a " maul," is used for striking the upper square ends of the poling boards which should be bound with hoop iron to prevent splitting. Excavation follows to within about four inches of the bottom of the poling boards and then the walings and struts are carefully lowered together. This procedure of driving and excavating is repeated until the required depth is obtained, when the necessary walings and struts are lowered to their proper positions and given additional tightening blows. Due to the running nature of the ground the timbers will require further tightening from time to time, to prevent their becoming loose ; it is for this purpose that wedges are used.

The arrangements illustrated on Plate 6 are typical for shallow trenches, but since working conditions vary, slight modifications may be required.

Removal of timbering should be done with care after the building work is sufficiently set and filling-in commenced. The earth should be returned to both sides of the walling, where required, and rammed solid, avoiding displacement of the brickwork.

*

BONDING OF STRAIGHT WALLS, QUOINS, JUNCTIONS AND STOPPED-ENDS

(REFERENCE, PLATES 7, 8 & 9)

Correct bonding is one of the most important features of good brickwork, especially where maximum strength is required ; in many cases it will present difficult problems which may be solved by application of the rules and recognised arrangements of bonding.

Before entering into the rules and arrangements, certain terms and their definitions should be understood :—

Quoin.—The intersection of two walls forming an angle on plan.

Junction.—There are two main types, namely, Tee-junctions and Cross-junctions. A tee-junction is an intersection of two walls which, on plan, has a T formation, while a cross-junction has a + formation.

Stopped-end.—The termination of a wall usually finished with a flat surface similar to that of the wall face.

Quoins, junctions and stopped-ends are classified as either "square" or "squint" according to their plan formation. Those in the square class form angles of 90 degrees while the squint class form angles other than 90 degrees. The former class only will be dealt with at this stage.

The recognised bonding arrangements for straight walls, square quoins, square tee-junctions and square stopped-ends for walls of 13½ in., 18 in. and 22½ in. thickness, are shown in English bond on Plate 7 and in Flemish bond on Plate 8 ; these arrangements, shown chiefly on plan, may be adapted to other thicknesses by slight modification.

At this stage the student should be thoroughly conversant with face bonding of straight walls, as shown on Plate 3, and by acquiring the additional knowledge of plan bonding, an ideal combination can be formed. Correct bonding on plan and elevation is essential.

Wall thicknesses are sometimes stated in terms of bricks rather than inches, e.g. :—

Half-brick	thick walling		=	$4\frac{3}{16}$ in.	
One brick	,,	,,	=	$8\frac{3}{4}$ in.	including
One-and-a-half brick	,,	,,	=	$13\frac{5}{16}$ in.	$\frac{3}{8}$ in. thick
Two brick	,,	,,	=	$17\frac{7}{8}$ in.	joints.

For convenience the above dimensions are stated as 4½ in., 9 in. 13½ in. and 18 in. respectively.

Fig. A, Plate 7 shows the plan arrangements, in English bond, of alternate courses of a one-and-a-half bricks thick wall with a return wall of similar thickness, a square stopped-end and a one-brick thick junction wall ; the return and junction walls are terminated by toothings.[1]

[1]Toothings are projections formed by alternate courses and occur where walls are temporarily discontinued (See Plate 3, Fig. F). Toothings should be avoided as much as possible since they cause a weakness when the work is continued at a later date. A more satisfactory method to employ is "racking back" as shown in Fig. E, Plate 3.

In order to see clearly how the units of the two courses are arranged to avoid slit joints, the student should take a tracing of one course and superimpose on the other course, making the corresponding external lines coincide.

By closely observing the examples shown on Plates 7 and 8 and then attempting the arrangements in practice with bricks, one course superimposed on the other, the student will doubtless find the work more interesting and less difficult to follow than by learning from descriptive matter. Where the facilities for execution of this practical work are not available, then it should be substituted by drawing. In either case, the work should be commenced by setting out the bounding lines.

Further arrangements should present little or no difficulty if the following rules are observed :—

1. Avoid slit joints as far as possible ; where these unavoidably occur try to attain a minimum.
2. The amount of lap to be one-half of the brick length in the case of Stretching bond and one-quarter of the brick length for the several bonds in which headers are used, including Heading, English and Flemish bonds. In the two latter a header should be placed centrally over a stretcher, except a quoin header.
3. Keep the perpends correctly in position.
4. Where a header course appears on the external face of a wall, it becomes a stretcher course[1] on the external face of the return wall ; this applies also to walls with stopped-ends and junctions. It will be found that this rule cannot always apply to internal faces ; e.g., where the two wall thicknesses differ to the extent of one-half brick or where a junction wall is of an odd half-brick thickness.
5. Commence a header course with a header at the quoin or stopped-end and, in the cases of English and Flemish[2] bonds) follow with a queen closer. (See Plate 3. Figs E, F and J., Certain exceptions are made to this rule, e.g. :—
   (*a*) In English bond—the stopped-end to a one-and-a-half bricks thick wall as shown on Plate 7, Figs. A, D and G ; also, the one-brick stopped-end.

[1]A stretcher course appearing on the face of a thick wall is usually backed by headers. When a course is termed a header course, it is so determined by its appearance on the most important face of the work ; similarly with the stretcher course.

[2]Although Flemish bond is formed of courses which have alternate headers and stretchers, those which commence with headers are, for convenience, termed header courses ; the term does not infer that a particular course consists entirely of headers. (See Plate 3, Fig. F.)

(*b*) In Flemish bond—the stopped-ends to the one, one-and-a-half, and two bricks thick walls as shown on Plate 8, Figs. A, B, D and E, or Figs. F, G, H and I. A queen closer must not commence a course.

6. Where an odd half-brick occurs in the stretcher course of a stopped-end, it should not be placed as a quoin header. (See Plate 7. Figs. C and F.)
7. At least every alternate cross-joint should be in a continuous straight line through the wall thickness. These straight line joints should not be confused with slit joints.
8. Where the thickness of a wall, in English bond, contains an odd half-brick, this should be arranged as a stretcher course alternating on opposite faces of the wall ; it should not be placed at or near the middle of the thickness as in the case of footing courses and stopped-ends. (See Plate 7. Figs. A and C.)
9. Junction walls should be bonded with the main wall so that there is a lap of not less than 2¼ in., for the whole thickness of the junction wall in each alternate course. The bonding of a junction wall with a main wall is sometimes termed " tying-in."

Flemish bonding to the stopped-end of a one-and-a-half bricks thick wall offers alternatives as shown in the elevations, Figs. G and H, Plate 8. Both arrangements are somewhat faulty in so much as the appearance of that shown in Fig. G is unmistakably like English bond, while that in Fig. H resembles Stretching bond from the fact that the amount of lap is 4½ in. Since no other suitable arrangement can be made, individual taste must decide between the two alternatives.

The two-and-a-half bricks thick wall may have alternative arrangements in Flemish bond, as shown on Plate 9, Figs. A and C ; these alternatives are also shown in the isometric views E and F. Both arrangements present a similar face appearance, but there is some difference in the resulting slit joints. To obtain a comparison, observe the number and lengths of slit joints which occur in a unit of bond[1] in both examples, Figs. B and D ; (slit joints are indicated by thick lines). Where stopped-ends occur, the arrangement shown in Figs. A and E enables faultless bonding to be done, but the other arrangement presents a fault as may be seen where the three-quarter bats occur in Fig. F.

[1]A unit of Flemish bond is equivalent to the area containing the diagonal lines in Figs. B or D. A unit of English bond is of one brick length by the thickness of the wall.

*

DAMP-PROOF COURSES AND VENTILATION OF HOLLOW GROUND FLOORS

(REFERENCE, PLATE 10)

Definition and Purpose.—A damp-proof course is a continuous layer of damp resisting material, the chief object of which is to protect the super-structure of a building against dampness.

Most building materials are liable to be adversely affected by dampness, consequently, it is essential to provide a suitable means of insulation. In addition, the health of the occupants of a damp building may become seriously affected by the insanitary conditions which can arise therefrom.

Cause of Dampness.—One of the chief causes of dampness is the absorption of moisture by the materials of the structure. Most building materials are of a granular nature, i.e., they are composed of fine grains held together by either cohesion or adhesion. Minute spaces, termed voids, usually exist between the grains so held together. These voids, when appearing on the outer faces of a material, provide a ready means of access for moisture with which they come in contact. The voids existing within the material may be linked up with the surface voids in such a manner as to provide very fine channels through which moisture can pass, in which case it would be possible for the moisture to travel from the surface to the interior. The small diameter channels create that peculiar action known as "capillary attraction" by which the moisture may be drawn in all directions through the material, thus tending to cause saturation. The quantity and rate of travel of the moisture so drawn will depend upon the number of voids and their dimensions. Penetration will occur when the channels run continuously through the material.

Further causes of dampness may arise from defects in construction, materials and workmanship.

Prevention of Dampness.—The damp-proofing of a wall near its base requires to prevent the rise of dampness, which may be drawn from the ground, into the brickwork forming the foundation and foundation-walling; it also requires to prevent dampness being caused by splashing rainwater which rebounds after falling. The placing of a suitable damp-proof course horizontally in a wall at a level of 6 in. above the adjoining ground level usually fulfils the above requirements. Since it is essential to protect floor timbers against dampness, it may be found necessary to provide damp-proof courses at different levels and also in vertical positions.

Various ways of damp-proofing near the bases of walls are shown on Plate 10, Figs. B to M. Fig. A represents the part Key Plan of a house, in which the floors of the living-room and hall are constructed as hollow timber floors, while the kitchen floor is of the solid type; the construction is illustrated in Figs. E and F. It may be seen that in the case of a solid floor, Fig. E, the whole flooring has direct bearing upon the ground immediately below; this is not so in hollow floor construction, Figs. B, C and D, where the members are supported at points only, on sleeper walls and corbels.[1] Below the floor timbers is a space for the passage of air which is used for ventilation in the preservation of the timbers against possible decay, such as "dry rot." Ventilation inlets and outlets are provided by either special perforated bricks or galvanised metal gratings built into suitable openings in the external walls.

To facilitate the free distribution of air throughout the under-floor space intervening walls, such as sleeper walls, are perforated in a honeycomb fashion as shown in Fig. C; other load-bearing walls such as that between hall and living-room, may be perforated as indicated by the "vents" in Fig. A. Between the under-floor space and ground is a layer of concrete known as "site" or "surface" concrete; this is provided to prevent ground gases, which are detrimental to health, rising into the building; to a lesser extent the concrete, if of good quality, tends to prevent the rise of ground dampness. In Fig. G it may be seen that a 6 in. thickness of concrete is used while in Fig. B an alternative is given by way of a 4 in. thickness of concrete upon a 3 in. thick layer of dry rubble or hard-core, such as broken stone or brick.

To obtain adequate ventilation throughout the entire under-floor space care in placing the ventilating openings is required; they should be arranged to avoid "dead" pockets of stagnant air. A suggested layout is shown in Fig. A from which it may be seen that the arrangement will induce the in-going air to travel in somewhat the same direction as that of the length of the joists. Where adjoining rooms have solid and hollow floors respectively, it may be found

[1]Corbels are projections which extend the thickness of brickwork for the purpose of providing a bearing surface. To ensure stability the projection of each course of brickwork forming a corbel should not exceed 2¼ in. and be arranged in Heading bond. The load which the corbel is intended to carry must not cause the corbel to overturn.

necessary to provide ducts below the solid floor, in order to supply sufficient ventilation to all parts of the hollow floor ; this occurs when the hollow floor construction does not extend to the two opposite external walls, as in one part of the floor of living-room, Fig. A. The construction of the ventilating duct under the kitchen floor is shown in Figs. H and J.

Figs. B, C and D illustrate a method of supporting the hollow ground floor of the living-room, together with the ventilation and damp-proofing necessary for the floor timbers and brickwork. The foundation walling, Fig. B, is corbelled out in order to provide a 4½ in. wide wall-bearing for the wall-plate, while a damp-proof course, continuous through the length and thickness of the brickwork at a level of 6 in. above ground level, provides the means of damp-proofing for both floor timbers and brickwork. A ventilating opening, provided with a 9 in. by 6 in. grating, is placed in a position which affords direct ventilation to the floor timbers and at the same time, gives a height of 6 in. above ground level ; this height should be regarded as a minimum to guard against splashing rainwater gaining access to the under-floor space, through the grating which is of the louvre type and intended to prevent the access of driving rain. By forming the base of the ventilating opening with an inclination as shown in Fig. B will cause any water that may have passed through the grating to run outwards rather than inwards. Anything which would tend to obstruct the passage of air should not be placed against the ventilating opening. Perforated sheet metal, galvanised or otherwise suitably treated to prevent rusting, may be fixed in the opening to guard against the admittance of mice and the like. Care should be taken to prevent an under-floor ventilator opening into a room ; wall-plates and joists should be distant, say, half an inch from the wall in order to provide ventilating space for such timbers.

Fig. C shows a sleeper wall acting as an intermediate support to the joists. It may be seen that a damp-proof course is provided below the timber wall-plate and that honeycombing in the wall gives free passage for ventilation. Where the load from the floor is not excessive the sleeper-wall may be built on the site concrete and without the usual foundation, providing the concrete immediately below the wall is of sufficient strength to act as a foundation ; where the site concrete is of the least allowable thickness, i.e., 4 in., it is good practice to provide additional thickness as shown.

In Fig. D the brickwork receiving the floor timbers is built on the site concrete, but is carried out with Header bond in the same way as corbels; this arrangement gives additional strength. The ground level occurs at the same height as that of the bed of the wall-plate, consequently, it becomes necessary to arrange the damp-proof course at two levels in the wall thickness, one 6 in. above ground level and the other immediately below the wall-plate; this may be done in two ways:—

(*i*) By having two separate damp-proof courses at the previously stated levels, or
(*ii*) By one continuous layer running horizontally and vertically as shown.

The latter method is the better since it gives additional protection against splashing rain-water. By placing the vertical portion of the damp-proof course in the thickness of the wall, there is protection against damage by external means.

Fig. E shows the external wall and solid floor of the kitchen. The damp-proof course is arranged at the floor level, which is 6 in. above ground level. Since ordinary concrete as used for floors is not impervious, dampness may be absorbed thereby from the ground and conveyed to other materials with which it is in contact; consequently, it is essential to place the damp-proof course of a wall adjoining a solid floor, at the highest level of the concrete in order to prevent dampness rising above such level. By placing a bed of hard, dry rubble, such as clinker, broken brick or stone, under floor or site concrete, dampness has a lesser tendency to rise.

Fig. F shows the wall between kitchen and living-room together with the respective solid and hollow floors. The damp-proofing in this case needs to be a combined arrangement, in order to fulfil the requirements of the two types of flooring; thus, it may be seen, that the damp-proof layer runs horizontally through the full thickness of the brickwork at the wall-plate bed level and vertically between the brick wall and concrete floor up to the height of the floor level. In this way, dampness rising from the ground, through the foundation walling and concrete floor, is prevented from reaching the floor timbers and partition wall.

Fig. G shows the arrangement of damp-proofing and ventilation required where the ground level coincides with the level of the wall-plate bed. It may be seen that the damp-proof course is arranged at two different levels with a vertical connecting layer. In order to place the ventilation grating at a height of 6 in. above ground level and also arrange the ventilation opening on the internal face of the wall below the hollow floor level, a drop is required in forming the opening. Where a ventilation opening is formed with such a drop, which may be called a shaft, special care should be taken to prevent rain-water gaining access to the under-floor space.

Fig. H shows a ventilation opening with drop-shaft of greater depth than the one shown in Fig. G, but is connected to a horizontal duct formed by drain pipes embedded in concrete below the solid floor level ; the ventilation shaft and duct is in connection with that part of the space under the living-room floor which adjoins the solid floor of the kitchen ; the necessity for the duct has been previously explained. The damp-proof course in this case is in one horizontal layer arranged at floor level and perforated where the ventilation shaft occurs.

Fig. J shows the damp-proofing required for the wall between kitchen and living-room. The vertical portion of the damp-proof course is perforated to allow the ventilation duct, which is placed under the kitchen floor, to pass through to the under-floor space of the living-room.

Fig. K shows the damp-proofing arrangement where the solid floor level is more than 6 in. above the adjoining ground level. A horizontal layer at the usual 6 in. above ground level runs through the thickness of the external wall and turns up the internal face to the height of the floor level. An alternative arrangement would be to have one horizontal layer only placed at the floor level, but since this would allow dampness to rise in the brickwork to such level a greater amount of the work would be affected by dampness and consequent defectiveness. The internal wall between kitchen and hall is also shown and it may be seen that the wood joists of the hall floor run in such a direction as not to require support from this particular wall. As a result, the damp-proof course need not be placed below the lowest timber forming part of the hall floor, but at the floor level corresponding to the adjoining solid floor. The foundation walling of the half-brick thick internal wall, is increased to one brick thick in order to retain the filled-in earth or rubble which would otherwise tend to displace or overturn a half-brick thick foundation wall in course of erection. Filling-in is not required to raise the ground to receive the site concrete under the hollow floor, consequently, additional depth is provided in the under-floor space.

Where a building intended for human habitation is to be erected, the site to be covered by such building should be excavated to an average depth of four to six inches for the purpose of removing vegetable matter before laying site concrete. Where the site is free from such matter the ground will require excavating in order to prepare an approximately level surface upon which to lay the site concrete. When vegetable matter is allowed to remain and decay the resulting obnoxious gases arising therefrom, will become a nuisance ; when the roots of a tree are allowed to remain, growth may continue to the extent of forcing upwards the site concrete or any other part of the building with which contact is made.

The Model Byelaws, Series IV, require that :—

(*a*) The ground surface enclosed within the external walls of a domestic building shall, unless the exceptional condition of the site or exceptional nature of the soil renders this requirement unnecessary, be :—

(1) Properly asphalted ; or
(2) Covered with a layer of spade-finish cement concrete, at least six inches thick, or four inches thick if properly laid on a bed of clinker, broken brick or similar material ; or
(3) Covered in a suitable manner with some not less suitable material, and

(*b*) The floor of the lowest storey of a domestic building, if it is a boarded floor and is not a solid floor composed of boards, planks or wood blocks laid or bedded directly upon concrete or other similar dry and impervious foundation, shall be so constructed that there shall be, between the underside of every joist on which the floor boards are laid and the upper surface of the ground or of the asphalt, concrete or other material with which the ground surface or site of the building is covered, a clear space of not less than three inches in every part if the ground is covered with asphalt, concrete or other material, and of not less than nine inches in every part if the ground is not so covered, and such space shall be thoroughly ventilated by means of suitable and sufficient air-bricks or by some other effectual method.

Figs. L and M show alternative methods of supporting hollow floors. In one case the wall-plate is supported on suitably strong wrought iron brackets, built in the mortar joints as the brickwork is erected ; these brackets, which should be treated to prevent rusting, extend 9 in. into the wall and project 4½ in. beyond the internal face in order to receive a 4 in. wide by 3 in. deep timber wall-plate with an allowance of ½ in. for air space between the brickwork and timber. The spacing of the brackets depends upon the load due to the floor and its superimposed load but under normal conditions at distances of about 2 feet. The brackets are turned up to the extent of 1 in. at the one end to receive the wall-plate while the end which is built into the wall, is turned either up or down to fit into a collar joint.

In the method shown in Fig. M the joists have their bearing upon a 3 in. wide by $\frac{3}{8}$ in. deep steel wall-plate, which is built into a cement mortar joint and treated against rusting. No additional thickness of brickwork is made to provide a projection on which to bed the wall plate while the joists extend 4 in. into the wall to obtain their bearing. A pocket is formed in the brickwork where each joist occurs, the size being sufficient to provide a $\frac{1}{2}$ in. wide air space around all faces of the timber which extend into the pockets.

Both the methods shown in Figs. L and M effect a saving of brickwork by eliminating the projections on which wall-plates are bedded.

Materials for Damp-proof Courses.—Material for use in damp-proof courses should be permanently impervious to moisture and durable. When placed in the wall it should be capable of resisting the loads put upon it which tend to cause crushing or other damage and should not induce the wall to develop a sliding action; the latter may arise when the damp-proofing material has a smooth surface and the wall is subjected to horizontal or inclined thrusts.

Suitable damp-proof courses may be formed by the proper use of the following materials:—

(*a*) Asphalt, or other suitable bituminous material. Asphalt is a limestone impregnated with bitumen. It is rendered plastic for laying by heating.

(*b*) Sheet lead, weighing not less than four pounds per square foot, properly bedded in suitable mortar and any joints to be overlapped not less than three inches. Certain grades of lime and cement are liable to cause corrosion of the lead and therefore should not be used for bedding.

(*c*) Sheet copper, weighing not less than one pound per square foot, soft tempered and properly bedded in mortar. Overlaps for joints to be not less than three inches.

(*d*) Two or more courses of sound slates laid so as to break joint and properly bedded in cement mortar.

(*e*) Two or more courses of blue bricks or other engineering bricks suitably bonded and properly bedded in cement mortar. The bricks should not absorb more than three per cent. of moisture when submerged for twenty-four hours after previous drying at one hundred and five degrees Centigrade. Thus, if a brick weighs 10 lb. after the stated drying, then it should not weigh more than $10\frac{3}{16}$ lbs. after being submerged for twenty-four hours.

(*f*) Bituminous felt of suitable quality, properly bedded in mortar and any joints to be overlapped not less than three inches. This material should consist of a woven hessian base which is impregnated and covered with bitumen. There are several qualities of bituminous felt some of which are inferior and unreliable ; the best quality has an intermediate layer of lead foil.

The above forms of damp-proof course materials may be divided into two groups according to their nature :—

1. Flexible.
2. Rigid.

The lead, copper, bituminous felt and asphalt constitute the flexible type while the slate and blue or engineering bricks form the rigid type.

Flexibility is desirable where a damp-proof course requires to be shaped to a given form and also where it is required to withstand, without fracture, the effect of settlement. Flexible type damp-proof courses containing bitumen are more or less plastic, a property which can be disadvantageous especially when high temperature and pressure prevail ; under these conditions there is tendency to melting and squeezing out which leads to possible defectiveness. The characteristic disadvantage of the flexible types is their smooth surfaces which afford little or no key in binding the damp-proof course to brickwork but form a probable slipping surface. Copper is more objectionable than lead in the latter respect but both are impervious.

Of the rigid type, those formed with such materials as slate and blue or engineering bricks bedded in suitable mortar, are capable of withstanding intense pressure, while they are extremely durable and practically impervious. In addition, it is possible to obtain a satisfactory key between the damp-proof course and the brickwork to prevent the possible sliding action. By using the blue or engineering bricks, the damp-proof course is formed of structural units which displace an equal number of ordinary bricks. Although the rigid type damp-proof course possesses several advantageous qualities the following are its disadvantages :—

(*a*) Liability to cracking, particularly at mortar joints and in the case of using thin slates ;

(*b*) The resistance to dampness depends, partly upon the mortar joints ;

(*c*) Not easily applied to undulating surfaces, while joints, which may prove faulty, are usually required at each change of direction.

The mortar used for bedding and jointing rigid damp-proof courses, should be no less impervious than either the brick or slate and must not shrink on setting to the extent of causing capillarity. Cement mortar composed of two parts sand and one part Portland cement, with a necessary minimum of water to produce a stiff consistency, is usually used ; as an additional precaution, a water-proofing cement or compound may be used. Where convenient, the vertical joints between bricks may be left open, say, one-quarter of an inch wide thereby preventing the rise of dampness.

These open joints may be suitable for ventilation purposes in place of vent bricks.

The suitability of a brick for use in damp-proofing is judged mainly by its strength and imperviousness. Its strength should be sufficient to safely carry the intended load to be placed upon it, while the absorption should be not more than 3 per cent. of its dry weight. When bedded and the mortar set, there should be no tendency to sliding.

Slate for damp-proof courses should be flat, reasonably uniform in thickness, free from cracks or other defects and should give a clear ringing sound when struck. The percentage absorption should not exceed 0.3 per cent. approximately.

When laying a slate damp-proof course, it is important to bed solidly by rubbing rather than striking.

Since asphalt is applied by spreading in a plastic state, it is particularly suitable for damp-proofing work on vertical, circular and undulating surfaces.

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DOOR AND WINDOW OPENINGS
(IN SOLID WALLS)

(REFERENCE, PLATES 11 & 12)

THE work around openings requires special treatment in the several parts. The parts are :—

Threshold or sill—the lowest horizontal member ;

Head—the highest member spanning the opening ;

Jambs—the vertical side members extending from the threshold, or sill, to the head.

The head may be either straight or curved. The lower horizontal member of a window opening is termed a sill (or cill) while the term threshold is applied to the similar member of a door opening.

Alternative methods of treatment for thresholds are shown on Plate 11, Figs. A, B and C ; in the method illustrated by Fig. A stone is used, while in the other two cases, Figs. B and C, bricks are employed.

The top surface of a threshold should have a slight inclination which will cause any water, that may collect thereon, to drain off and away from the building ; for this purpose a fall of ¼ in. in 1 ft. is satisfactory. It is considered good practice to allow the front or external edge of a threshold to project about 1½ in. beyond the external face of the wall, while the back or internal edge should occur in such a position as to be covered by the door when closed.

Where the vertical height from ground level to ground-floor level is not more than, say 7 in. one step will be sufficient, but as the vertical height increases so the number of steps should increase in order to facilitate an easy approach to the building ; Fig. C shows a method of constructing a series of three steps for such a purpose.

A series of steps without change in size, shape or direction is termed a " flight."

The top surface of a step is known as the " tread " while the front vertical face is termed the " riser."

The vertical dimension of a riser in a flight of steps should be not less than, say, four-and-a-half inches and not more than seven inches while the tread should be not less than nine inches and not more than twelve inches, measured at right-angles to the length of the step.

The essential function of a threshold is to provide a step with a wear-resisting surface and to prevent the entry of water into the building. Thresholds may be of brick, stone, slate, concrete, timber or any other suitable material which provides the necessary hard-wearing qualities. If of stone it should be hard York stone or similar ; suitable bricks would be Engineering, Blue or hard burnt pressed bricks set in cement mortar ; where concrete is used the aggregate should be granite and the adhesive cement, while the tread surface may be advantageously finished with carborundum powder ; if of timber, oak would be suitable. The material which most effectively resists wear without presenting a slippery tread-surface should be selected.

Thresholds and sills are most advantageously fixed at the completion of the main building operations, i.e., when there is less liability to damage arising from falling debris or other accidental means. To enable the ends of these members to be inserted, it is usual to make the necessary provision in the early stages of building, by laying several bricks loosely in sand instead of mortar so that they may be easily withdrawn when required. In cases where it is found necessary to insert thresholds or sills as the building work proceeds, precautions against damage should be taken not only against falling debris but against damage arising from settlement. Damage arising from the latter cause is in the nature of a crack, at or about half the length of a single unit threshold or sill and is due to the mortar joints immediately under the ends of the sill compacting and settling under the load of the brickwork forming the jambs, while the mortar joints which occur centrally under the sill are not subjected to as much loading and therefore do not settle to the same extent, the result being a tendency towards bending of the sill. If the material does not lend itself to bending, cracking may occur. The precaution to take in such a case is in providing each end of the sill with a mortar bed of about four-and-a-half inches in length, leaving the remaining intermediate length void. By this means slight settlement could occur at the ends without any stress arising to cause cracking. The space which exists under the sill as a result of the partial bedding can be filled with mortar when the main building work is complete and compacting of the mortar joints has ceased.

Sills which are not intended to act as steps, need not have the wear-resisting qualities essential to thresholds, but must be capable of resisting the entry of water into the building. In respect to the latter characteristic, the material of a sill should be selected for weather resistance, while the shape should induce water to run off and drip clear of the wall below. To produce the latter requirements, sills should be "weathered," "throated" and "grooved" as shown in Fig. G. The weathered surface causes water to run outwards from the building, while the throating prevents water, which tends to run under the sill, reaching and entering the bed joint by causing it to drip from the lower front edge rather than run upwards into the throating. The groove is intended to receive a 1 in. by ¼ in. galvanised metal bar which extends half an inch into the groove, while the remaining half inch of the depth projects upwards into a corresponding groove formed in the wood sill of the window frame; the bar and frame are bedded in red lead and the complete arrangement prevents penetration of water through the joint occurring between sill and frame. The weathered surface should terminate at each end against "stools" or "stoolings" which are raised horizontal seatings intended to provide bed surfaces for the jambs. (See Figs. D and G.)

Fig. E shows a form of brick sill in which purpose-made bricks are used to form the weathering and drip; these bricks are shown in section, Fig. F and are termed plinths and drips respectively.

Further examples of purpose-made bricks for use in forming sills are shown in Figs. H and J, while Fig. K shows the section through a sill composed of brick and plain roofing tiles. The arrangement in the latter case cannot be considered so effective as the former examples since there is an absence of a proper throating; to compensate for this defect, the nibs which occur at the head of each tile are utilised to form an improvised drip as shown in the section and part elevation, Fig. K.

Sills used internally are not required to be weathered, throated and grooved.

Jambs may be classified under the following headings:—

1. Square.
2. Splayed.
3. Rebated.
4. Moulded.

The treatment of splayed and moulded jambs will be deferred to Vol. II.

Fig. A shows the lower part of a door opening with square jambs, while rebated or recessed jambs are shown in Fig. B. The purpose of the recess is to receive the door frame and provide protection from weather action. The return face of a jamb is termed a "reveal" ; a rebated jamb has two reveals, namely, the outer reveal (next the external face of wall) and the inner reveal (next the internal face) as shown in Fig. B.

Square jambs are actually square stopped-ends and the bonding thereof will be similar to that shown on Plate 8, for square stopped-ends according to the thickness of wall in which the jambs are formed. Several examples of bonding applicable to rebated jambs of various dimensions are shown on Plate 12 ; Figs. A to F, inclusive, show the arrangements in English bond, while the remaining examples are in Flemish bond. The student should closely observe the arrangements and note the use of the several closers and bats, including, king, queen and bevelled closers, three-quarter, half and bevelled bats ; in addition, the arrangements should be carried out practically as previously suggested for the examples given on Plates 7 and 8.

Heads of door and window openings are described in the following chapter.

*

LINTELS AND ARCHES

(REFERENCE, PLATE 13)

THE head of a door or window opening is a member bridging across such opening and providing a means for supporting and transmitting the weight of imposed material. Two methods of construction are used for the purpose :—

1. A horizontal member supported at its two ends by the jambs and termed a "lintel" (sometimes spelt lintol) ;
2. An arrangement of wedge-shaped units, mutually supporting each other in the form of an arch which takes its support from the jambs or abutments.

In some instances, intermediate supports are incorporated in the above methods. Lintels and arches may be used in combination.

Lintels.—Lintels may be composed of one or more units of brick, stone, concrete, steel, timber or other suitable material possessing sufficient strength; brick, stone, plain concrete and timber are suitable for small openings, while steel encased with concrete is most suitable for large openings[1] where heavy loads have to be supported.

Lintels, when loaded, tend to bend and when the amount of bending reaches a certain limit fracture occurs; steel and timber may be subjected to greater bending than brick, stone or plain concrete before fracturing. But the dimensions of a lintel have some effect upon the amount of bending; slender proportions will be attendant with excess bending. Since lintels must not noticeably deflect, or bend, the proportions should be such as will provide sufficient stiffness or resistance to bending. In this respect the depth must be not less than 3 in. increasing according to load and distance apart of the supports. Not only should lintels be of sufficient strength but also their supports; in addition, the amount of bearing which the supports provide for the ends of lintels is an equally important factor. A simple rule states that the ends of a lintel shall extend beyond the opening to a distance not less than 4½ in. on each side or 1½ in. for every foot of span, whichever is the greater. The ends of bressummers should bear upon templates.[2]

Brick lintels are suitable only for openings not exceeding 3 ft., but with the combined use of steel they may be used for larger openings. Fig. A shows the elevation of a brick lintel. Bricks having frogs in their bed surfaces are most suitable, since the frogs, when filled with cement mortar, form joggles which increase the strength of the lintel by resistance to shearing of the joints. The bending tendency of a lintel under load, causes a tensile stress in the lower half of the depth; to resist such stress, the mortar and bricks should possess requisite strength and adhesive properties. The tops of lintels should coincide with a horizontal bed joint of the surrounding work; this may require the cutting of bricks to length.

Fig. B illustrates the construction of a joggled brick lintel. The bricks are temporarily supported, during assembly, on a timber bearing piece, or center. Mortar joints are made along three of the outer margins of each frog, leaving the remaining part of the joints open at the top. When all the lintel bricks have been assembled and their joints become set, grout is run into the spaces formed by the frogs, thus forming joggles when set. The centering should not be

[1]A lintel of large dimensions is termed a "bressummer" or "beam."

[2]Templates (or padstones) are usually blocks of hard stone or concrete, larger in size than the standard brick and used to distribute the load from a bressummer, over a sufficiently large area of the jamb or support, in order to reduce intensity of pressure.

removed until the joggles are set and sufficiently strong to support the lintel and the load which it is intended to carry.

Fig. C illustrates three alternative ways of introducing steel to reinforce brick lintels, enabling them to be used over openings of dimensions which are beyond the recognised maximum for plain brick lintels. The steelwork, whether of flat bar, angle or rod formation, should have wall bearing not less than 4½ in. in length at each end and should be suitably protected against rusting; in cases where the round rod reinforcement is used the bricks are usually purpose-made, being holed to receive the rod. Wall bearing in the case of plain brick lintels is provided by the mitred surfaces at the ends of the lintels as shown in Figs. A and B.

The strength of plain brick lintels depends upon that of the mortar joints; hence, the need for good quality mortar.

Arches.— Arches vary in shape from straight to curved and are generally named according to their shape. They are further classified in respect to the nature of their finished appearance and the labour entailed :—

1. Rough.
2. Fair-axed.
3. Rubbed and Gauged.
4. Purpose-made.

Rough arches include those which have their mortar joints unfinished or rough and of V-shape; the latter is due to the use of standard uncut bricks in curved arches.

The head of an opening composed of units which are not wedge-shaped cannot be considered a "true" arch.

Fair-axed arches are formed of standard bricks neatly cut to a wedge-shape and the joints of constant thickness.

Rubbed and Gauged arches have a high grade finish, being formed of special bricks termed "rubbers" which are cut to a gauge or pattern and rubbed down to a true surface on a flat stone, enabling very fine joints of a constant thickness not exceeding ⅛ in. to be used.

Purpose-made arches are those in which the bricks are specially made to wedge-shape and therefore do not require cutting.

Rough arches are used in concealed positions; fair-axed and gauged arches are used for facing only; purpose-made arches are for general use but chiefly facing and are particularly suitable where the nature of the bricks renders cutting difficult and costly, as in the case of engineering bricks and the like.

The shapes of arches may be divided into two main types :—

1. Single.
2. Compound.

A "single" arch has one centre of curvature only (see Fig. H) from which point all the main joints radiate. A "compound" arch has two or more centres of curvature and the joints radiate from more than one point.

Compound arches will be dealt with in Vol. II.

Dutch Arch.—The elevation of the Dutch arch is shown in Fig. D from which it can be seen that the joints are parallel and therefore do not radiate from a point ; hence, it is not a true arch but may be successfully used for small openings. Its appearance is considered to be unworthy of a place in good work.

Flat-Camber Arch.—The Flat-Camber arch, Fig. E, is somewhat similar in shape to the Dutch arch, but different in the arrangement of its joints as can be seen from the half external elevation[1] ; these radiate from a common point and therefore the arch is said to be true. The appearance is considered very good and worthy of its inclusion in the highest class of brickwork, namely, gauged work ; purpose-made bricks are also used for this type of arch. The name is derived from the flat top and the slight curve, termed camber, which is given to the bottom of the arch.

The purpose of camber in this instance is to prevent an optical illusion arising ; a perfectly flat arch combined with inclined joint lines would produce a sagging appearance which increases as the distance between the jambs increases. The camber has a rise of $\frac{1}{8}$ in. per foot of the distance between the jambs. It is desirable to apply camber to the Dutch arch and also brick lintels.

The section, Fig. E shows that the arch is only a facing and that it is backed by a lintel of concrete reinforced with three steel rods. The half internal elevation shows the lintel in position and forming a recess at the back of the arch ; this recess is similar in depth to that formed in the jambs shown in plan. Any short joints running crosswise to the main radiating joints should be arranged, as far as possible, in this and other types of face arches, to match the bonding of the surrounding brickwork ; sometimes imitation joints are cut into the face of the bricks to a depth of, say, $\frac{1}{4}$ in. and filled with lime, putty or mortar. The flat-camber arch is considered most suitable for openings not exceeding 4 ft. and since its strength increases as

[1]For convenience the elevation, Fig. E, is a combination of one-half the external elevation and one-half the internal elevation.

the depth increases, this latter dimension should be proportional to the distance between the jambs. The tops of flat arches should coincide with a horizontal joint of the surrounding brickwork.

Segmental Arch.—As the name implies, this type of arch is mainly segmental in shape; it is considered suitable for most sizes of opening. Fig. G shows half elevations of alternative segmental fair-axed arches. In one case the top is segmental, while the alternative has a flat top coinciding with a horizontal bed joint of the surrounding brickwork. The joints of a segmental arch radiate from a common point which is equidistant from all parts of the arch curve.

By comparing Figs. E and G, it can be seen that the arrangement of the radial joints is similar; from this it may be assumed that the flat-camber arch is related to the segmental arch and has been derived therefrom, partly by substituting horizontal lines in the place of curves. It should also be observed that the joints of gauged work are depicted by single lines, while those of fair-axed and thickness jointed work are shown by double lines; radial joints between bricks which are not wedge-shaped, are indicated by V-joints as in rough arches.

A Segmental Rough Ring arch, partly shown in Fig. F, is formed of half-brick rings; when used over a lintel, as shown, it is distinctively termed a "relieving" arch since its purpose is to relieve the lintel of the weight of material above; sometimes the alternative term "distributing" is applied, due to the arch distributing the imposed load to the brickwork beyond the ends of the lintel. The space between the top of lintel and bottom of arch is filled with a brick core. Half-brick rings are used to reduce the excessive width of joints that would occur in the upper part of the arch if a full brick ring be used; it will be found that the number of units in the upper ring is slightly in excess of that in the lower, due to the extension in length of the upper ring. The number of rings varies according to the depth of arch required, the load to be carried and the distance between jambs.

Although the relieving arch and wood lintel provides a satisfactory means of forming the head of an opening, the reinforced concrete lintel used independently can serve the same purpose in a most effective and simple manner without presenting the common defects of wood lintels, such as arise from shrinkage, decay and the action of fire. The use of the relieving arch and wood lintel is illustrated in Fig. F while Fig. E shows the reinforced concrete lintel.

Semi-circular Arch.—The semi-circular arch is another example where the name is derived from the shape and the radial joint lines commence from a common point; like the segmental arch it is suitable for most sizes of opening. Where semi-circular arches are joined together in a series, as shown in Fig. H, their junctions require special treatment; instead of a vertical joint occurring at the intersection, the arches should be bonded together by "saddle" bricks as indicated.

Rampant Arch.—Fig. J shows a quadrant (quarter-circle) arch placed in a position whereby the two extremities of the arch curve are at different levels, when it is termed a rampant arch to distinguish it from the ordinary quarter-circular or segmental arch. One of the uses of the rampant arch is in the support of flights of steps over open areas, when the length[1] of the arch may be, say, 3 ft. or more. In Fig. J the elevation of the face arch is broken, for illustration only, to show the rough ring arch which is used as a backing.

A rampant arch can be other than a quadrant arch; it may be a compound arch.

Arch Terms and their Definitions.

VOUSSOIRS: The arch bricks or blocks which together form the arch.

KEY: The voussoir occupying the central position; sometimes it has distinction in size and shape.

INTRADOS: The lower or inner curve.

EXTRADOS: The upper or outer curve.

CROWN: The highest point on the intrados.

SPAN: The horizontal distance between the jambs.

SPRINGING LINE: An imaginary straight line, usually horizontal, between the extremities of the intrados.

SPRINGING LEVEL: The level or height of the springing line.

SPRINGING POINTS: The extremities of the intrados.

RISE: The vertical distance between the springing line and crown.

DEPTH: The distance across the face, from intrados to extrados, measured on a radial line. (In the Dutch and Flat-Camber arches, measured vertically.)

LENGTH or THICKNESS: The horizontal distance between the external and internal faces.

SOFFIT or SOFFITE: The under surface.

ABUTMENTS: The brickwork or masonry immediately beyond the extremities of the arch; their purpose is to support the arch and resist the thrusts therefrom.

[1]For definition of "length," see "Arch Terms" following.

SKEWBACKS: The inclined surfaces of the abutments prepared to receive the arch.

HAUNCHES: Portions of the arch situated centrally between the key and skewbacks.

CENTRE OF CURVATURE: A point from which the arch-curve is described and the joint lines radiate.

RADIUS: Distance from centre of curvature to intrados.

SPANDRIL: The brickwork, approximately triangular in shape, on the haunches of adjoining curved arches.

Arch Construction.—Arches are usually erected upon temporary timber supports termed "turning pieces" or "centers"; these rest upon vertical props which take their support from the sill and are held in position by tightening against the jambs with struts. To facilitate easing[1] and removal of the center after the arch is erected, pairs of folding wedges are placed between the props and center as shown in Fig. B. Since the carpenter is responsible for making centers, further description on their construction will not be given in this book.

The general procedure in erecting an arch may be briefly stated as follows:—The skewbacks are first prepared and the assembly of the previously shaped voussoirs follows by commencing from each skewback and proceeding towards the crown, finally inserting the key which locks all the other voussoirs in position and secures the shape of the arch; proper bedding of the voussoirs is most essential to ensure strength and stability. When the key has been inserted the center should be eased by slackening the wedges sufficient only to lower the center, say, $\frac{1}{8}$ in. thus allowing the voussoirs to settle upon their beds. No material should be imposed upon the arch until the mortar joints are sufficiently set, when the centering may be removed. The method of bedding the voussoirs will vary according to the nature of finish; rough and axed arches will be done in the manner of bedding for thickness jointed work, while gauged arches will be bedded as for gauged work; (these methods are described in the chapter dealing with Jointing and Bedding). Special care should be taken in placing the voussoirs of face arches to keep the joints in their correct lines of radiation; this may be done by using a cord or straight lath attached to a nail driven in a piece of timber which is so secured as to cause the nail to occupy the position of centre of curvature of the arch. By pivotting the cord or lath on the nail, each voussoir can be tested for correct radiation at the time of bedding.

[1]Easing is a slight movement which, in the case of arch construction, is made in a downward direction.

Where it is permissible to adjust the springing level, this should be arranged to avoid difficult cutting in the surrounding brickwork; skewback cutting is simplified when the springing line occurs about 1 in. distant above or below a horizontal bed joint, while circular cutting over the extrados can be made less difficult if the thickness of the brick that is to be placed over the highest point of the extrados has a minimum thickness of approximately 1 in.

Setting-out.—Before cutting and shaping the voussoirs, a pattern or templet is required; the size and shape is obtained from a full-size scale drawing of the arch made, by setting-out, upon a suitable surface. Usually, one half only of the arch is needed in the setting-out, the remaining half being somewhat a repetition.

In setting out the Dutch arch, Fig. D, for a given span, the skewback inclination may vary between 45 degrees and 60 degrees with the horizontal; the angle or bevel required for the voussoirs will be the same as that of the skewbacks. Depth of arch should be not less than 9 in. vertically, but will increase as the span. In arranging the bond to resemble that of the surrounding wall, it should be observed that the maximum dimension of a unit will be equal to the length of the bricks to be used. A vertical joint usually occurs at the middle of the span in the lower part of the arch depth.

To set out the Flat-Camber arch, Fig. E, determine the positions of the vertical centre-line springing line, springing points and the top of arch. Having decided upon the inclination of the skewbacks, which may be an angle between 45 degrees and 60 degrees,[1] draw a line, to represent the skewback, passing through the springing point and continuing below until an intersection is made with the centre-line produced; the point of intersection of these lines is the centre of curvature from which all the bed joints will radiate. From the point where the line of skewback intersects the horizontal top line of arch describe a circular arc towards the centre line using the centre of curvature and a radius equal in length to the distance between the intersecting point of skewback with top of arch and the centre of curvature; the arc so described extends equally on each side of the centre-line and is divided into an odd number of equal parts each not exceeding a length equal to the depth or thickness of the bricks to be used plus a mortar joint.

Sometimes a special key block is used in which case division of the arc should be made accordingly.

[1]The variation in the angle of skewback is made in accordance with the span and depth of arch. While 60 degrees is considered suitable for the smaller spans, the inclination should be reduced as the span increases and, at the same time, the depth of the arch should increase.

Lines radiating from the centre of curvature through each of the points of division on the arc will mark the bed-joint lines of the arch. To determine the intrados which is a curve rising $\frac{1}{8}$ in. per foot of span, either of the following methods may be used :—

1. Bending a lath to the required curve making contact with the springing points and crown ; or
2. By the use of a triangular frame having an apex angle equal to that formed by lines which pass through each springing point and the crown. Two nails or pins are fixed, one at each springing point, against which the frame glides whilst either chalk or pencil held at the apex and passing through the crown traces and marks the curve.

Although the voussoirs will vary in size and shape, they each have the same taper ; consequently, one templet only is required for gauging their thickness, but the other dimensions and bevels must be taken separately for each unit. Horizontal cross joints should divide the voussoirs proportionately to resemble the bonding of the surrounding work.

In making templets allowance must be made for joint thickness.

Segmental arches may be set out in two ways :—

1. Given the inclination and length of skewback, the procedure up to the stage of obtaining the centre of curvature is similar to that for the flat-camber arch. The intrados is described using the centre of curvature and a radius equal to the distance from centre of curvature to springing point ; the curved extrados is described in a similar manner, but with a radius equal to the distance from centre of curvature to the highest point of skewback. In the case of a flat top, Fig. G, the method of obtaining the radiating joint lines is similar to that for the flat-camber arch, while the method used for a curved top is simply the division of the extrados into the required number of equal parts to determine the points through which the radiating lines must pass.

It is important to remember that since the maximum thickness of the voussoirs occurs at the extrados, and such thickness must not exceed that of the bricks to be used, then the intrados must not be used for the division.

2. Given the span and rise, set out the centre line and springing line at right-angles ; next determine the position of a springing point by measuring half the span from the centre line, along the springing line ; also, the position of crown by setting up

above the springing line, the rise on the centre line. To obtain the centre of curvature, connect the springing point and crown by a straight line, bisect its length and from the point of bisection produce a line at right angles to intersect the centre line produced ; the point of intersection will be the required centre of curvature (see Fig. G). The remainder of the setting out is similar to that previously described in the first method.

Rough uncut arches do not require setting out for the purpose of obtaining templets but for drawing, the V-joints are formed by lines which, if produced, would be tangents to a circle of diameter equal to the thickness of the bricks and described around the centre of curvature ; such a circle is used to obtain the joints in the arch Fig. F and is shown to the left of Fig. J.

The semi-circular arches, Fig. H, have their centres of curvature at the points where their respective centre lines and springing lines intersect.

The centre of curvature of the quadrant (rampant) arch, Fig. J, occurs at the intersection of springing line and face of wall.

Skewbacks.—The cutting and setting of skewbacks for face arches should be done with the use of a templet in the form of, say, a line marked on the face of wall below the springing level and in a position relative to that shown in the half external elevation, Fig. E. It should be observed that the use of the closer is not required above the springing level.

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COMPOUND WALLS

(REFERENCE, PLATE 14)

Definition.—Compound walls are those in which two or more types of materials are used, e.g., brick, stone, terra-cotta[1] or other material ; a wall built of bricks which are of different nature or thickness is sometimes termed a compound wall.

Brickwork is comparatively cheap in most districts and therefore can be economically used as a backing to a facing of more expensive material such as stone or terra-cotta. In districts where the supply

[1]Terra-cotta is a material similar to brick, but of higher quality.

of stone is plentiful and obtainable at a moderately low price, the entire facing of a building could be economically carried out with such material, but where it is more expensive, the use of the material may be confined to dressings, such as, quoin stones, copings[1] and the like, while the remaining part of the work would be executed in brickwork. (See Fig. C.)

Bonding.—The bonding of compound walls requires careful treatment to produce requisite strength while attention should be given to the resulting face appearance.

Fig. A shows a wall in which bricks of two different thicknesses are used ; it can be seen that five courses of the backing brickwork are similar in height to seven courses of the facing brickwork. This arrangement makes the best possible use of headers in bonding the facing to the backing, a feature which must be regarded as essential in overcoming the weakness arising from an extensive amount of unavoidable slit joints ; the bonding headers should be arranged in every fifth or seventh course of the thinner bricks.

Settlement due to shrinkage of the mortar joints may occur and will be greatest in the work which has the greater number of courses in a given height ; the effect of such settlement may cause the wall to develop a leaning position after the work is erected. To counteract such a fault, precaution should be taken in building the wall to equalise the settlement by way of bedding the thinner bricks with a thin joint of stiff mortar.

Where a facing-header bonds into the backing brickwork a slate or tile course should be introduced to compensate for the deficiency in thickness of the facing bricks ; such compensation should never be made by a thick mortar joint since the corresponding shrinkage would considerably reduce the strength of the bonding between the facing and backing brickwork.

A wall faced with stonework and backed with brickwork is shown by Fig. B, in which the height of one course of stonework is made to coincide with that of three courses of brickwork ; the arrangement allows headers to occur immediately below and above the alternate wide courses of stone, thus producing the most effective bonding between the two materials. Where possible, the height of the stonework courses should be made to coincide with that of an odd number of brickwork courses, so that the bonding headers may be most advantageously employed.

Where brickwork and stonework are used together as a facing, the dimensions of the stone should be made to suit the brickwork

[1]Copings are wall coverings (see the chapter dealing with Copings).

bonding; brickwork against vertical faces of stonework should never require a closer or bat having a dimension less than 2¼ in.

The above two paragraphs may apply to walls where terra-cotta blocks or other building blocks are used in the place of stone.

Brickwork, owing to the comparatively small units, is more adaptable to slight variations in setting than stonework or other building blocks of large dimensions; consequently, it is better to build brickwork against previously erected stonework rather than follow the reverse procedure. This does not infer that all the stonework can be erected before the brickwork is commenced; usually, the two are dependent upon one another in their erection.

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COPINGS

(REFERENCE, PLATE 14)

Definition and Purpose.—Copings are wall coverings or cappings intended to give protection from weather-action by preventing the downward percolation of moisture in walls which are not protected by a roof covering.

Materials.—Materials for use in copings should be practically impervious to moisture, durable and adaptable. Brick, stone, terra-cotta, concrete, cement, slate, tile or the like may be used to advantage.

Essential Features.—Copings, to be effective, should be weathered and throated, project beyond the wall faces to the extent of 1½ in. approximately and be constructed to resist dislodgement by weather-action. Mortar for bedding and jointing should adhere well and be weather resisting.

Types and Construction.—Various types of copings of brick, stone and terra-cotta are shown in Figs. A to J; they are named according to their cross-sectional shapes. The saddle-back coping, Fig. D, is formed of standard bricks cut and placed with their bed surfaces inclined to form weathered surfaces. Purpose-made bricks are used for the copings shown in Figs. E and F, while a combination of standard bricks and plain roofing tiles is shown in Fig. G. Where horizontal projections occur, as in Fig. G, cement fillets should be provided to form weatherings; where flat-top copings are used on horizontal walls a slight inclination of the coping should be made towards the back of wall.

A stone coping on a gable wall is shown in elevation, Fig. C. At the foot or commencement of the incline, a block, termed a "springer," is used; such a block forms an abutment to prevent sliding of the inclined coping. To relieve the springer of the weight of the entire coping an intermediate block, termed a "kneeler," is introduced, while the termination of the coping at the highest point is made by an "apex" stone. A method of uniting the various units of the coping is "cramping" as shown in Fig. K. Slate or non-rusting metal cramps are fitted into suitably placed housings cut in the stone, while any remaining space is filled with molten lead to secure the metal cramps and prevent lodgement of water (cement mortar is used for filling where slate cramps are fitted); as the lead cools it is caulked or consolidated with special tools used by the plumber. In addition to cramping, the cross joints are made solid with good mortar.

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ATTACHED AND ISOLATED PIERS

(REFERENCE, PLATES 15-19)

FROM the definition of the term "pier" as given in the chapter dealing with Foundations, it is important to note that there is a limiting proportion in width to thickness of a brick structure which may be classified as a pier.

The term "pillar" can be used in the same sense as pier.

Piers or pillars vary in their shape on plan; those which are circular being specifically known as "columns." An attached pier takes the form of a projection beyond the normal face of the brickwork to which it is connected, while isolated piers are independent of other brickwork.

The main purpose of attached piers is to provide additional strength and stability at points where loads and inclined thrusts are concentrated, viz., where a wall receives, say, the feet of roof trusses. Isolated piers are usually intended to support beams or arches.

Strength in the brickwork forming a pier is absolutely necessary, while the bonding requires careful attention. Although piers are essentially structural features, they can, with decorative treatment, contribute to the ornamentation of a building.

The examples on Plates 15-19 are of simple rectangular form and are given to illustrate the bonding of piers and their footings.

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CAVITY WALLS

(REFERENCE, PLATE 20)

Definition.—Walls built of two separate thicknesses with an intervening space are termed " cavity walls " or " hollow walls."

Purpose.—The chief purpose of the space or cavity is to provide a means of insulating the interior of a building against dampness and change of temperature.

Dampness occurring on the inner face of an external solid brick wall may be due to absorbed water, such as rainwater, percolating through the brickwork from the external face ; in the case of a cavity wall absorbing water from the exterior, only the outer thickness of the brickwork forming such wall is likely to become damp since the cavity does not serve in conveying the absorbed water and therefore the internal thickness of the wall will remain immune from such dampness.

Change of temperature may be caused by the passage of heat through the walls. Brickwork conducts heat more quickly than air, consequently, the air contained in a cavity wall retards the passage of heat from the interior of a building to the exterior. A cavity wall maintains a more constant temperature in the interior of a building than a solid wall having a thickness equal to that of the total thickness of solid material in the cavity wall, e.g., a cavity wall having two thicknesses of brickwork, each four-and-a-half inches, would have a total solid thickness equal to that of a nine inches thick solid wall.

The maintenance of a constant temperature in a building is of great importance to the health and comfort of the occupants.

A cavity attains its maximum heat insulating properties when it is completely sealed to prevent the admittance of external air, but when it is desired to ensure absolute sanitary conditions in the cavity, ventilation may be provided at the expense of reduced heat insulation. Vent bricks are placed near the bottom and top of the cavity to provide ventilation by upward moving currents of air; the vent bricks should be carefully arranged to be most effective so that a minimum number only need be used since excessive ventilation would defeat the object of the cavity in regard to heat insulation.

Condensation takes place in the cavities of hollow walls and provision for its exclusion should be made; this may be done, to some extent, by the provision of small holes (weep holes) through the brickwork joints placed in positions where such condensation may accumulate. Certain precautions have to be taken in the construction of cavity walls to prevent detrimental effects arising from condensation; these will be dealt with later. Ventilation of the cavity will tend to prevent condensation occurring therein.

Cavity wall construction provides an opportunity for the use of two different types and depths of bricks; those for the external face of the wall may be selected for weather resistance and appearance, while the internal portion may be suitably built with common bricks. Since it is not essential to keep bed joints of the outer and inner thicknesses at constant levels, the use of thin facing bricks is permissible.

Providing cavity walls are constructed in accordance with building regulations, their stability, compared with that of solid walls having an equal thickness of solid material, is not reduced. One disadvantage, however, is that loads from floors and the like may have to be supported entirely by the inner portion of the wall; in cases where such loads are excessive an increase in the thickness of this inner load-bearing portion may be necessary in order to provide sufficient strength and stability. As a general rule, it may be considered that the outer portion of a cavity wall is simply a protecting shell, half-brick in thickness, resisting the action of weather while the inner portion supports the weight of floors and other similar loads. Thus, the brickwork forming the protecting shell should be weather-resisting, while that forming the inner load-bearing portion of the wall should possess adequate strength. Although it is essential to employ strong brickwork to support heavy loads, some consideration should be given to the use of porous bricks for the inner portion of cavity walls with a view to providing greater heat insulation, based upon the fact that a porous brick, although not usually so strong as a dense brick, will not conduct heat so quickly providing it be kept dry.

Extracts from the Requirements of the Model Byelaws in Respect to Cavity Walls.

Where any wall or any part of a wall is constructed as a hollow wall :—

(1) The cavity between the inner and outer parts of the wall shall throughout be of a width not exceeding three inches ;

(2) The inner and outer parts of the wall shall be securely tied together with suitable bonding ties of adequate strength formed of galvanized iron, iron tarred and sanded, glazed stoneware, copper, bronze or other not less suitable material, the ties being placed at distances apart not exceeding three feet horizontally and eighteen inches vertically ;

(3) The inner and outer parts of the wall shall each be not less than four inches thick throughout, except that in a wall not exceeding twenty-five feet in length and twenty feet in height the thickness of each part may be not less than three inches throughout if all courses of less height than six inches are put together with cement mortar or with cement-lime mortar of the strongest mixture prescribed by the byelaw in that behalf[1] or the wall has at least twice the number of ties required by the preceding paragraph ;

(4) The cavity may be reckoned as part of the thickness prescribed for walls by the Model Byelaws where such thickness does not exceed eight-and-a-half inches but shall not be so reckoned where such thickness exceeds eight-and-a-half inches.

Where a wall or part of a wall is constructed as a hollow wall or with hollow blocks, all woodwork inserted in the wall so as to project into or extend across a cavity shall be effectually protected on the upper side with a layer of sheet lead or other equally suitable material impervious to moisture.

Constructional Details.—Foundations for cavity walls are similar to those for solid walls, while the foundation-walling should be made solid by either, filling that part of the cavity which occurs below ground level with concrete (Fig. A) or forming the foundation-walling of solid, bonded brickwork (Fig. J) ; the latter method is preferable for its load-distributing quality.

Wall-ties (Fig. A) should be so designed and placed as not to

[1]The strongest mixture for cement mortar or cement-lime mortar is given in the chapter dealing with Mortar.

transmit moisture across the cavity. A wise precaution is to insert additional ties around openings to compensate for the loss of strength which is caused by the formation of openings in walls. Wall-ties should, as far as possible, be arranged in staggered formation.

To prevent the escape of cavity air into a building, the brickwork around openings should seal the cavity; this usually entails solid work which should be provided with some means of damp-proofing to prevent the penetration of moisture (Figs. B and C). Special care is required in the damp-proofing at heads of openings to prevent not only penetration of moisture from the exterior, but also dampness due to the accumulation of condensation which falls from the cavity above; the introduction of sheet lead, copper, bituminous felt or the like to convey moisture to the exterior and beyond the ends of the head or lintel, will usually provide the necessary means of damp-proofing (Figs. B and K). The brickwork at the top of a cavity wall should be solid in order to seal the cavity and to provide a good bearing for roof timbers (Fig. E, F, G). Where it is possible for dampness to penetrate solid work and become detrimental, damp-proofing should be introduced.

The base of a cavity should be approximately six inches below the usual horizontal damp-proof course, the latter, in the case of cavity walls, being of two separate widths and not continuous across the cavity (Figs. H and I); a cement fillet placed at the base of a cavity, as shown, will induce accumulated moisture to run outwards through suitably placed weep holes and drain into the ground adjoining the external face of wall. If a damp-proof course be wrongly placed at the base of a cavity or likewise continuous across the cavity, accumulated moisture would most probably run inwards as well as outwards and thereby cause dampness in the inner portion of the wall; in addition, mortar droppings unavoidably accumulating on the damp-proof course during building operations, may be sufficient to block the cavity, causing part of the wall to become solid and liable to penetration by moisture.

To keep the cavity clear of mortar droppings, battens may be placed on the wall-ties to cover the cavity and catch the droppings that may accidentally fall from the bricklayers' trowels; before the succeeding row of ties are placed, the battens are raised and any mortar that may have collected thereon is removed before laying in the next above position. As a further precaution, suitably placed holes, formed by the omission of certain bricks at the base of the cavity, will provide an outlet through which any droppings that may have reached the bottom of the cavity can be withdrawn; a similar precaution may be taken over the heads of openings. This latter method of clearing the cavity comes into operation immediately after the wall is erected; by sprinkling sand on the base of the cavity in the early stages of erection, the work of clearing will be facilitated; at the completion of the work, all holes are made good.

*

MISCELLANEOUS BONDS

(REFERENCE, PLATE 21)

Dutch bond is somewhat similar to English bond in so far as it is an arrangement of header courses alternating with stretcher courses, but without use of the queen closer; overlap is formed by commencing each stretcher course with a three-quarter bat placed at the quoin. In addition, a half-bat is introduced next the three-quarter bat in alternate stretcher courses; this causes a constant angle of load distribution as may be seen from the racking back in Fig. A. The strength of Dutch bond ranks with that of English bond.

English-Cross bond, Fig. B, differs in arrangement from English bond only in the introduction of a half-bat next the quoin stretcher in alternate stretcher courses; as in Dutch bond, the angle of load distribution is constant while the strength is equal to that of English bond.

Facing bond, Fig. C, is similar to English garden-wall bond except that a queen closer is placed next the quoin header of the intermediate stretcher course; this causes the stretchers to have a maximum overlap of three-quarters their length.

Decorative bonds are arrangements of the brick units to produce patterns on the face of brickwork for ornamentation; strength is not usually considered. Three examples are given in Figs. D, E and F.

Diaper work, as illustrated by Figs. G-L is an arrangement of bricks, contrasting in colour, to form more or less regular patterns. Most bonds are adaptable to the formation of patterns, but not all patterns can be formed without some alteration to the usual bonds; Fig. H is an example where the English bonding is broken at certain points to form the particular pattern shown.

*

BROKEN BONDING

(REFERENCE, PLATE 22)

THE term " broken bond " is applied to the arrangement of bats which become necessary where the lengths of brickwork courses are not multiples of the brick length. Broken bond cannot be classified as a particular kind, since it may occur in all bonds and its arrangement should, as far as possible, follow that in which it arises. The appearance is objectionable since it deviates from the proper arrangement and therefore should be obviated, where possible, by arranging the lengths of brickwork in multiples of brick length; in addition, the width and position of door and window openings should be arranged to suit proper bonding.

When the walls of a building reach ground level the positions of all openings should be determined, disregarding their heights, and the bond arranged accordingly; by this means, unforeseen difficulties in bonding may be obviated. In setting out the bond, it is desirable to obtain a balanced arrangement in piers and openings, e.g., any one course in the width of a pier should have headers, alternatively stretchers, at its extremities.

The Key Elevation, Fig A, represents part of the elevation of a building in which there are three window openings; for the purpose of example the openings vary in width and are of dimensions which cause broken bonding, while the intervening pillars are each a multiple of bricklength.

Fig. B illustrates the work in Stretching bond. By arranging the bond in accordance with the pre-determined positions of openings, so that proper bonding can be maintained in the full height of the building through the pillars, the broken bond assumes a central position under the openings; in such a position, its objectionable appearance is less obvious than if placed in the pillars and so occur without break throughout the full height of the brickwork. By keeping the perpends as the work rises, the broken bond will re-occur centrally over the openings.

Figs. C and D, illustrate the treatment of broken bond where openings of dimensions similar to those shown in Fig. A occur in walls carried out with English and Flemish bonds.

Broken bond should be avoided in pillars, not only for its objectionable appearance, but also to eliminate the attendant weakness arising from slit joints; since there may be inevitable cases, several examples are illustrated by Figs. E-K.

From Figs. B, C and D, it can be seen that balanced bonding is obtained in the pillars and on each side of the openings, while the broken bond is arranged with a minimum lap of 2¼ in. and without closers.

*

DOMESTIC FIREPLACES AND FLUES

(REFERENCE, PLATES 23, 24, 25)

THE general form of construction employed for fireplaces and their supplementary parts is illustrated on Plate 23, which shows fireplace openings arranged in three tiers against an external wall; alternatively, the openings may be formed against an internal wall, while the number of tiers depends upon the number of floors on which fireplaces are required. Building regulations govern the construction to a great extent with the object of preventing the destructive spread of fire to other parts of the containing building or any adjoining building and also to ensure stability of structure. Before entering upon relative constructional details the requirements of the aforementioned regulations should be understood.

Extracts from the Requirements of the Model Byelaws in Respect to Chimneys and Flues.

Byelaw 54.—For the purpose of the following byelaws relating to chimneys and flues, " flue " means any duct through which smoke or other products of combustion pass, and " chimney " means the material surrounding the flue.

Byelaw 56.—Every chimney shall be constructed of :—

(1) Bricks or blocks properly bonded and solidly put together with mortar; or

(2) Other good hard and suitable incombustible material properly and solidly put together, and this requirement as to material to be used shall be deemed to be satisfied by the use of any material which complies with the test for materials for flues, furnace casings, hearths

and similar purposes prescribed in British Standard Specification No. 476-1923.

Copies of the above specification may be obtained from the British Standards Institution, 28, Victoria Street, London, S.W.1.

Byelaw 57.—(1) A chimney which is built against or forms part of a wall and extends to or below the surface of the ground adjoining the wall shall :—

(*a*) Rest upon a foundation which would comply with the requirements of Byelaw 23[1] (as to the foundations of structural walls) if the chimney were a pier forming part of the wall ;

(*b*) Have a damp-proof course if the wall is required to be provided with a damp-proof course ;

(*c*) Be properly bonded with or otherwise securely tied into the wall.

(2) A chimney which is built against or forms part of a wall, but does not extend to the surface of the ground adjoining the wall shall :

(*a*) Be properly bonded with or otherwise securely tied into the wall ; and

(*b*) Rest upon a metal or concrete beam, or on sufficient corbels of brick, stone or other hard and incombustible material if the work so corbelled out does not project from the wall more than the thickness of the wall measured immediately below the corbel.

Byelaw 58.—The jambs of a fireplace opening shall be not less than eight-and-a-half inches wide on each side.

Byelaw 59.—(1) A sufficient arch or lintel of brick, stone or other hard and suitable incombustible material, or a sufficient bar of steel, wrought iron or other not less suitable metal, shall be built over the fireplace opening to support the chimney breast.

(2) Where the chimney breast projects more than four-and-a-half inches from the face of the wall, and the jamb on either side is less than thirteen inches wide, the abutments of any arch so built shall be tied in by a bar or bars of steel, wrought iron or other not less suitable metal, of sufficient strength, eighteen inches longer than the opening, turned up and down at the ends, and built into the jambs on each side.

Byelaw 60.—(1) Where a fireplace opening is in an external wall, the back of the opening shall be not less than four inches thick.

[1]The requirements of Byelaw 23 are stated in the chapter dealing with Foundations.

(2) Where two fireplace openings are built back-to-back in a wall other than a party wall,[1] the back common to the two openings shall be not less than four inches thick.

(3) The back of every other fireplace opening shall be not less than eight and a half inches thick.

(4) The thickness required by this byelaw shall extend to a height not less than :—

(*a*) Twelve inches above the fireplace opening ; and

(*b*) If the opening is in a party wall and is constructed for use in connection with a cooking range, nine feet above the level of the hearth.

Byelaw 61.—A chimney breast and the material surrounding a flue shall not be less than four inches thick.

Byelaw 62.—Where the face of any material surrounding a flue or fireplace opening is less than two inches from any timber or woodwork and the material is less than eight-and-a-half inches thick, the face of the material, if of bricks or blocks, shall be properly rendered,[2] and, if of other materials, shall be such as to afford adequate protection from fire to the timber or woodwork.

Byelaw 63.—The inside of a chimney, if constructed of bricks or blocks, shall be properly rendered or pargeted[3] as it is carried up, and, if of other materials, shall be otherwise suitably protected, except that, where any part of the chimney is lined with fireclay or stoneware not less than three-quarters-of-an inch thick or other not less suitable incombustible material of sufficient thickness, such part of the chimney as is so lined need not be rendered or pargeted or otherwise protected.

Byelaw 64.—Where the back or outside of a chimney does not form part of the outer face of an external wall and the material of which it is constructed is less than eight-and-a-half inches thick, the back or outside of that part of the chimney which is below the roof, flat or gutter shall be properly rendered or otherwise suitably protected.

Byelaw 65.—Where the course of a flue makes with the horizontal

[1]A " party wall " is a wall forming part of a building and used or constructed to be used for separation of adjoining buildings belonging to different owners, or occupied or constructed or adapted to be occupied by different persons ; or a wall forming part of a building and standing to a greater extent than the projection of the footings, on lands of different owners.

[2]Rendered means that the assembled bricks or blocks shall be coated with mortar or similar suitable material ; such rendering is a precaution against the spread of fire or smoke through a joint or joints having become defective as the result of shrinkage or disturbance.

[3]Pargeted is similar to rendered.

an angle of less than forty-five degrees, the upper side of that part of the chimney shall be not less than eight-and-a-half inches thick.

Byelaw 67.—Where a flue is in a party wall and is not back-to-back with another flue, the material at the back of that part of the flue which is below the roof, flat or gutter shall be not less than eight-and-a-half inches thick.

Byelaw 68.—A chimney shall be carried up all round in brickwork or other not less suitable material not less than four inches thick to a height not less than three feet above the adjoining roof, flat or gutter, measured from the highest point in the line of junction with the roof, flat or gutter.

Byelaw 69.—A chimney, or group of chimneys bonded together, shall not be built higher above the highest point in the line of junction with the roof, flat or gutter of the building than a height equal to six times the least width of the chimney, or six times the overall width of the group of chimneys measured horizontally at right angles to its greatest horizontal dimension, as the case may be, unless the chimney or group of chimneys is otherwise made secure.

Byelaw 70.—An iron holdfast or other metal fastening shall not be placed within two inches of a flue or fireplace opening.

Byelaw 71.—Timber or woodwork shall not be placed in a wall or chimney breast within nine inches of a flue or fireplace opening.

Byelaw 72.—A wooden plug shall not be driven into or built into a wall or chimney breast within six inches of a flue or fireplace opening.

Byelaw 73.—No opening for the insertion of a pipe for conveying smoke or other products of combustion, or for the insertion of a ventilating valve, or for any other purpose, shall be made or left in a chimney within nine inches of any timber or other combustible substance.

Byelaw 74.—A flue which communicates with a room intended for human habitation shall not communicate with any other room :—

Provided that a flue may communicate with a single fireplace which is common to a living room and a kitchen or scullery.[1]

Byelaw 75.—A hearth shall be constructed in connection with every fireplace opening and shall :—

(1) Be fixed under and in front of the opening ;
(2) Be properly constructed of stone, slate, bricks, tiles or other incombustible material properly and securely supported;

[1]The provision made by the latter part of Byelaw 74 applies to combination stoves in which one fire provides heat for both Living-room and Kitchen.

(3) Be not less than six inches thick;
(4) Extend not less than six inches at each end beyond the opening;
(5) Project not less than sixteen inches from the chimney breast;
(6) Be so laid that its upper surface is not lower than the floor of the room in which the opening is situated.

Byelaw 76.—Timber or woodwork shall not be placed under a fireplace opening within ten inches of the upper surface of the hearth.

Where use is made in the foregoing Byelaws of covering terms such as "adequate," "sufficient," "suitable," "properly" and the like in regard to materials and construction, some variation and indecision may arise from their interpretation. The implication of such terms should be decided by the local Building Inspector or similar authorised person.

Summary of Byelaws (Chimneys and Flues)

	Reference Plate.	Fig.
Byelaw 54—Definition of "flue" and "chimney."		
,, 56—Materials.		
,, 57—Foundations, bonding, etc.	23	A
	24	B
,, 58—Jambs	23	A-G
,, 59—Lintels, arches, etc.	23	A
,, 60—Thickness of back of openings.		
,, 61—Thickness of breasts, etc.	23	D
,, 62—Rendering of brickwork.		
,, 63—Rendering of inside of chimneys.	25	C
,, 64—Rendering of outside of chimneys.	25	D
,, 65—Oblique flues.	25	C
,, 67—Flues in party walls.		
,, 68—Projection above the roof.		
,, 69—Maximum height of projection above roof.		
,, 70—Iron holdfasts, etc.		
,, 71—Woodwork in chimneys.		
,, 72—Wooden plugs in chimneys.		
,, 73—Openings for pipes, etc.		
,, 74—Flues communicating with habitable rooms.		
,, 75—Hearths.	24	A,B
,, 76—Woodwork under fireplace openings.		

Working Principles.—The construction of fireplaces and flues should conform not only to building regulations, but also to the principles of heating, especially in connection with the effect of heat upon gases (air being a gas). When a fire burns, it causes air in the close vicinity to lose oxygen, become warm, expand, lose weight and rise. Thus, when air at the base of a flue is raised in temperature, it tends to move upwards, while colder air takes its place to become warm and join in the upward movement. Greater intensity of heat will cause quicker movement of air up the flue and warm the surrounding materials. The existence of heat, in and around the flue, is essential to the success of a flue in the fulfilment of its purpose as a duct for the passage of heated air which has become charged with gases produced by combustion ; a further essential feature is the absence of obstruction to the upward movement of gases. In addition the flue inlet should provide easy access to the warm gases without admitting cold air ; the length of the flue should not be unduly increased by unnecessary bends, especially sharp bends, whilst its bore should be uniform between the inlet and outlet. The formation of the inlet is made by a quick reduction of the fireplace opening at the head ; at the outlet of the flue, the bore should reduce slightly and gradually. The latter reduction is intended to overcome the sudden retarding effect of cold air upon the warm upward-moving gases as they reach the outlet. Down-draughts may occur as the result of cold air entering the flue outlet and being forced downwards by strong deflected currents of air.[1] Such down-draughts are objectionable and may be prevented to a great extent by either, placing the outlet in a position free from downward deflected currents, or forming the outlet in a manner that will not allow it to wrongly operate as an inlet. To introduce unnecessary bends in the run of a flue with the object of preventing down-draught is a mistake ; the troublesome down-draught originates at the flue outlet, consequently, this is the point where a most effective preventative can operate. Further, bends tend to cause an obstruction to the normal flow of heated gases and if the action of the latter be regarded as a countermeasure in the prevention of down-draught, as it may rightly be, such bends become harmful. Taking into account the fact that the presence of heat in and around a flue is

[1]Adjacent sloping roof surfaces are the main cause of the deflection ; upward deflection usually occurs on the windward slope while downward deflection occurs on the leeward. A further cause can be attributed to adjacent tall building and the like. Where the outlet of a flue is placed at a level which is higher than that of the ridge of an adjacent roof, such flue should be practically free from down-draughts, providing the fireplace and flue are properly constructed.

essential to its successful working, the several flues of a building should, where possible, be grouped together on an internal wall. In this way, any flue which is not in constant use is not allowed to become cold since the surrounding materials dividing it from the other flues will conduct sufficient heat from those in more constant use. Being arranged on an internal wall prevents the excessive loss of heat which occurs when a fireplace or flue is on or against an external wall. To reduce the amount of heat lost by conduction through the materials forming the external part of a chimney, the thickness of such materials should be increased; alternatively, cavity wall construction may be employed. Adequate means of damp-proofing should also be provided.

Constructional Details.—A fireplace opening built against a wall, as shown on Plate 23, Fig A, is usually formed by two suitably placed attached piers, termed jambs, having the requisite foundations and properly bonded. The dimensions of openings vary according to the size and type of cooking range, stove or grate to be fixed therein; the depth, being the projection of the jambs from the back of the opening, is usually not less than 13½ in.; to determine the required dimensions, reference should be made to the stove-maker's catalogue. In covering the opening at the required height, a simple and most effective means is provided by the use of a reinforced concrete slab suitably holed for the flue. This form of cover is employed over the Ground Floor fireplace opening (Fig. A, Plate 23). The slab, which is supported at its ends on the jambs and on the brickwork forming the back of the opening, carries the chimney breast in which the flue is formed. The flue, in part of its length, takes an inclined course in order to make provision for a fireplace opening on the next floor above and also to prevent the possibility of rain falling directly on to the fire. Pargetting should be done in stages of 2 ft. 6 in. approximately, as the work of forming the flue proceeds, care being taken to leave a smooth, unbroken surface; normally, the thickness of pargetting need not exceed ⅝ in. The formation of the fireplace opening on the First Floor,[1] (Fig. A, Plate 23) is such that it commences at a level which is about 6 in. below the top of floor joists, is bridged by a 4½ in. thick reinforced concrete lintel, while one of the jambs accommodates the flue from the fireplace below. Since the lintel does not cover the entire depth of opening the brickwork is "gathered over" by corbelling from each jamb, commencing at the level of bottom of

[1]The "first floor" of a building is that floor next above the "ground floor" where the level of the latter is at or near the ground or pavement level.

lintel, until the opening is reduced to dimensions suitable for the flue.

The position at which the flue first assumes its required cross-sectional dimensions is termed the " throat " ; the usual dimensions are 9 in. by 9 in. approximately, but these may be increased, if necessary, to meet the requirements of large cooking ranges.

As an alternative to bridging the fireplace opening by a lintel, an arch may be used as shown over the opening on the Second Floor (Fig. A, Plate 23). The arch, which is usually of the segmental rough-ringed type, may extend either partly or wholly over the depth of opening ; where it extends over the entire depth, a hole suitable for the flue must be provided. Since one of the jambs to the fireplace opening last referred to, projects more than 4½ in. from the face of wall and is less than 13 in. wide, while the opening is bridged by an arch, the Model Byelaws require a wrought iron chimney bar to be incorporated in a manner similar to that shown in Fig. A, Plate 23, for the purpose of tying the jambs together thereby resisting the thrust of the arch.

By arranging the opening centrally, as shown on plan (Plate 23, Fig. G) the need for such a chimney bar can be avoided since the width of the jamb on either side would be greater than 13 in. and therefore would be considered capable of resisting the thrust of the arch.

The run of each flue is indicated by the broken lines. By grouping the flues together at the level of the uppermost ceiling enables the chimney breast to be reduced in size to form the chimney stack which projects above the roof.

Tops of chimney stacks require protection against rain ; this may be provided by a suitable " capping " which acts in a manner similar to a coping by throwing off water which would otherwise penetrate into the chimney and cause dampness. There are various forms of capping, plain and decorative, but in all cases the protective characteristics should be present ; in addition, the construction should be such as will ensure soundness and stability. The capping shown on Plate 23 is a stone slab, weathered, throated and perforated to house the chimney pots ; the latter project above the weathered surface to prevent rain-water being blown across the capping into the flues, while joints between the stone and chimney pots are made water-tight. Fig. D, Plate 24, shows an alternative form of capping in which oversailing courses of brickwork are covered by a fine concrete or cement mortar weathering, termed " flaunching."

Construction of hearths varies according to the type of floor construction. The Ground Floor hearth (Fig. A, Plate 23), forms part of the concrete sub-floor since the latter is of the solid type; where hollow timber floor construction is used in ground floors support is given to the hearth by means of fender walling as shown in Figs. A and B, Plate 24. The fender walling, preferably 9 in. thick, is built on the site concrete, supports the edges of the front portion of the hearth and the ends of floor joists, and also forms retention walling when the space enclosed therein is filled with rubble to supply additional support to the hearth. The rubble filling is usual, but an alternative method, shown in Fig. A, Plate 24, employs a reinforced concrete hearth and eliminates the filling. Upper floor hearths of reinforced concrete form a simple and most effective method of construction. This mode of construction is applied to the First Floor fireplace shown on Plate 23; support to the front edge of the hearth is provided by a triangular wood fillet nailed to the trimmer joist. An alternative method is employed for the Second Floor fireplace hearth, by way of a brick "trimmer" arch which springs from the chimney breast on one side and a triangular wood fillet nailed to the trimmer joist on the other; concrete is placed on the arch and in the fireplace opening to produce a level surface to receive tiles or other finish. In cases where upper floors are constructed of concrete or other similar fire-resisting material, the hearth forms part of the floor construction.

The width and projection of a chimney breast may increase or decrease as it extends through several storeys or tiers; such alteration of dimensions is usually made in the depth of floors by either corbels or offsets.

Fig. D, Plate 24, is a sectional elevation of a chimney stack with 9 in. thick surrounding brickwork to provide additional heat insulation and stability; the construction of the capping should be observed.

Figs. E, F, G, Plate 24, are plans of alternate arrangements of a three-flue chimney stack while Figs. H and J represent the profiles of alternate forms of capping.

The plan, Fig. A, Plate 25, shows fireplace openings formed in an external wall; the arrangement requires projections to be made beyond the outer face of wall, but economy in space is effected inside the building. By means of an arch the two projecting chimneys are connected and the flues grouped together into one chimney stack. The exposed inclined surfaces caused by the grouping requires fair facing to match the adjoining brickwork and to be weather resisting; by an arrangement similar to either of those shown in Figs. A-C, Plate 25, and the use of weather-resisting brickwork, a satisfactory finish can be obtained. Where a similar connection of chimneys and grouping of flues is required on an internal wall and the work is concealed, there is no necessity for fair-facing nor matching of the brickwork; consequently, full consideration can be given to the structural aspect; Fig. D, Plate 25, illustrates a method of construction which may be suitably employed.

The grouping of fireplaces is illustrated by the alternative plans, Figs. E, F, G, Plate 25.

END OF VOLUME ONE

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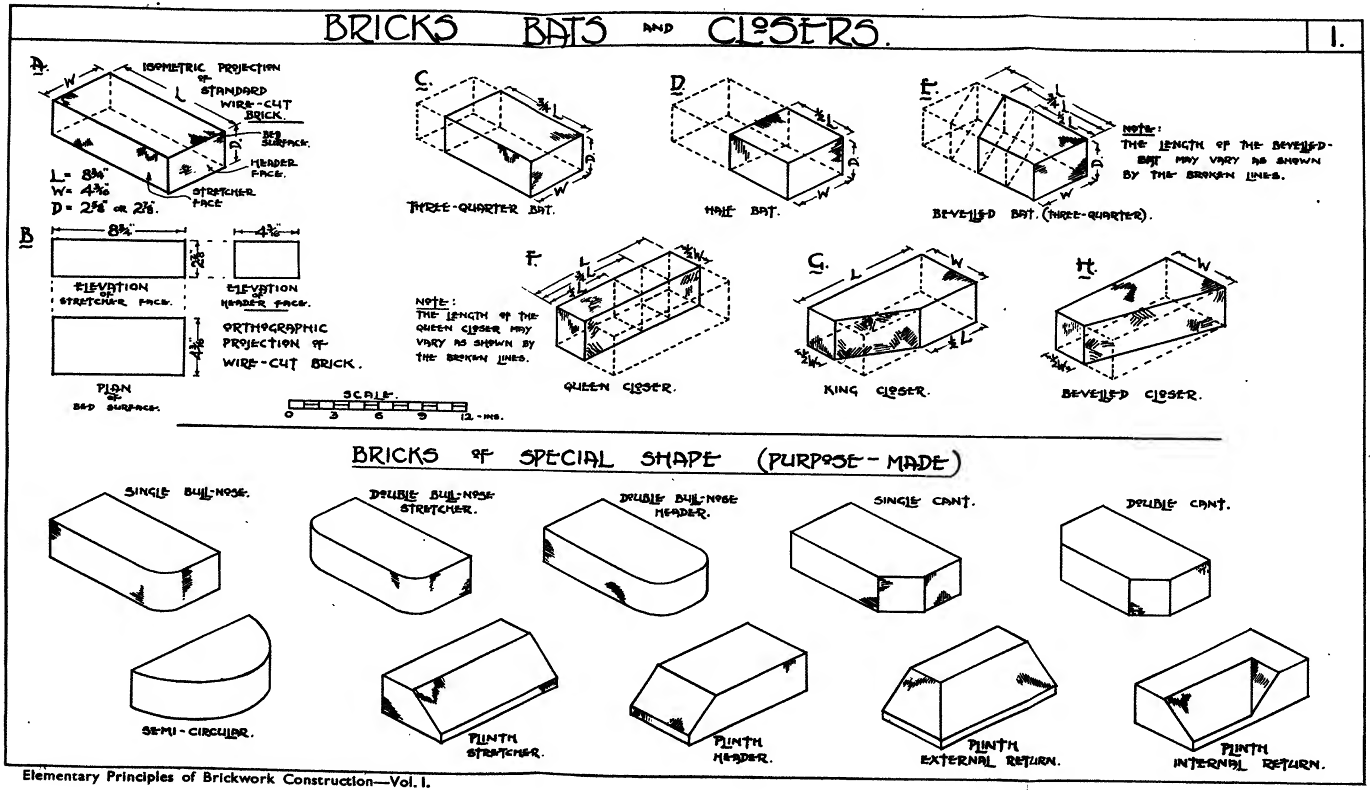
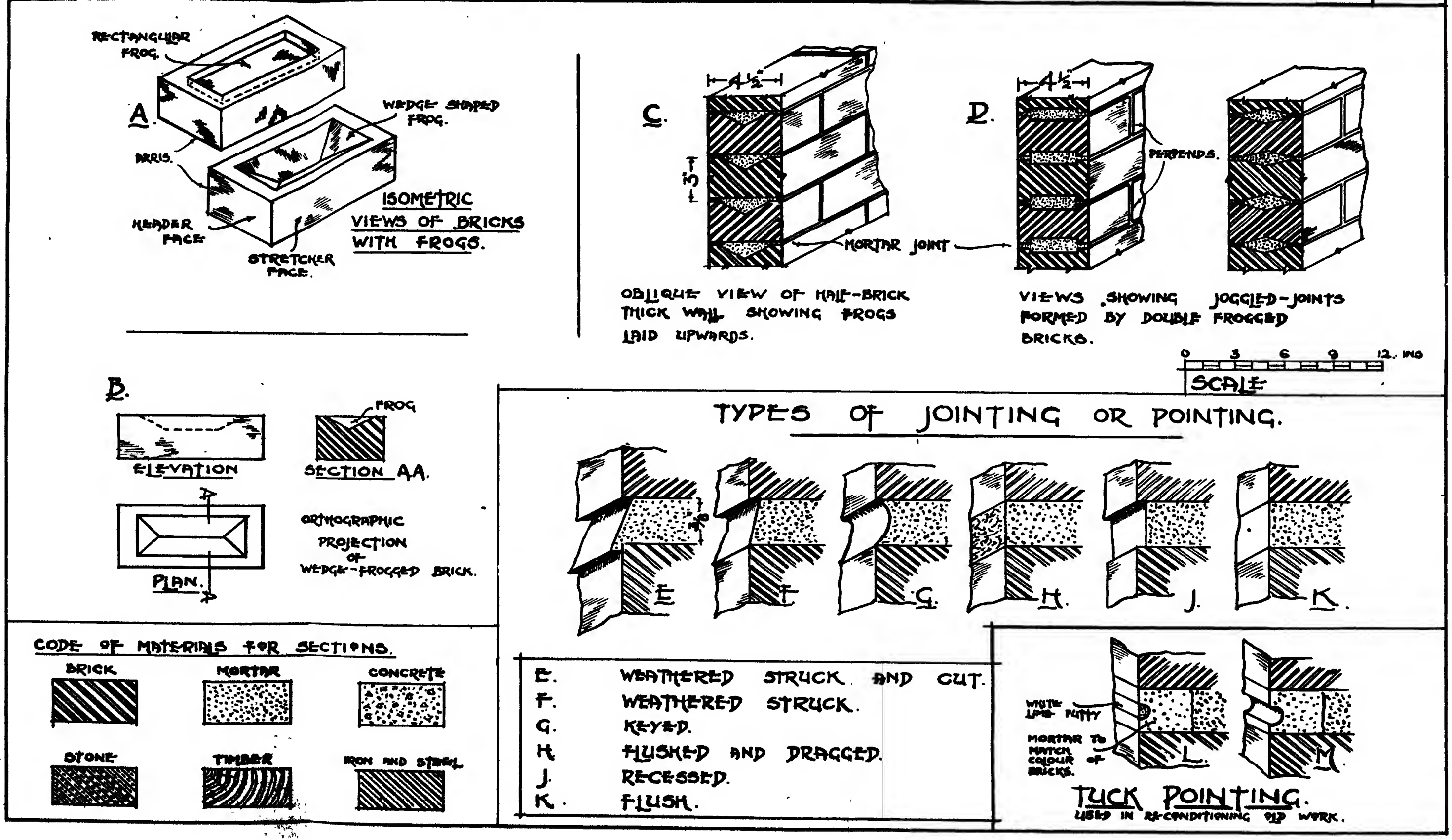


BRICKS BATS AND CLOSERS.
1.
A.
ISOMETRIC PROJECTION OF STANDARD WIRE-CUT BRICK.
W
L
D.
BED SURFACE.
HEADER FACE.
STRETCHER FACE
L= 8¾"
W= 4⅛"
D= 2⅝" or 2⅞".
B
8¾"
4⅛"
ELEVATION OF STRETCHER FACE.
ELEVATION OF HEADER FACE.
PLAN OF BED SURFACE.
ORTHOGRAPHIC PROJECTION OF WIRE-CUT BRICK.
SCALE.
0 3 6 9 12 - INS.
C.
¾L
THREE-QUARTER BAT.
D.
½L
HALF BAT.
E.
NOTE: THE LENGTH OF THE BEVELLED-BAT MAY VARY AS SHOWN BY THE BROKEN LINES.
BEVELLED BAT. (THREE-QUARTER).
F.
NOTE: THE LENGTH OF THE QUEEN CLOSER MAY VARY AS SHOWN BY THE BROKEN LINES.
QUEEN CLOSER.
G.
KING CLOSER.
H.
BEVELLED CLOSER.
BRICKS OF SPECIAL SHAPE (PURPOSE-MADE)
SINGLE BULL-NOSE.
DOUBLE BULL-NOSE STRETCHER.
DOUBLE BULL-NOSE HEADER.
SINGLE CANT.
DOUBLE CANT.
SEMI-CIRCULAR.
PLINTH STRETCHER.
PLINTH HEADER.
PLINTH EXTERNAL RETURN.
PLINTH INTERNAL RETURN.

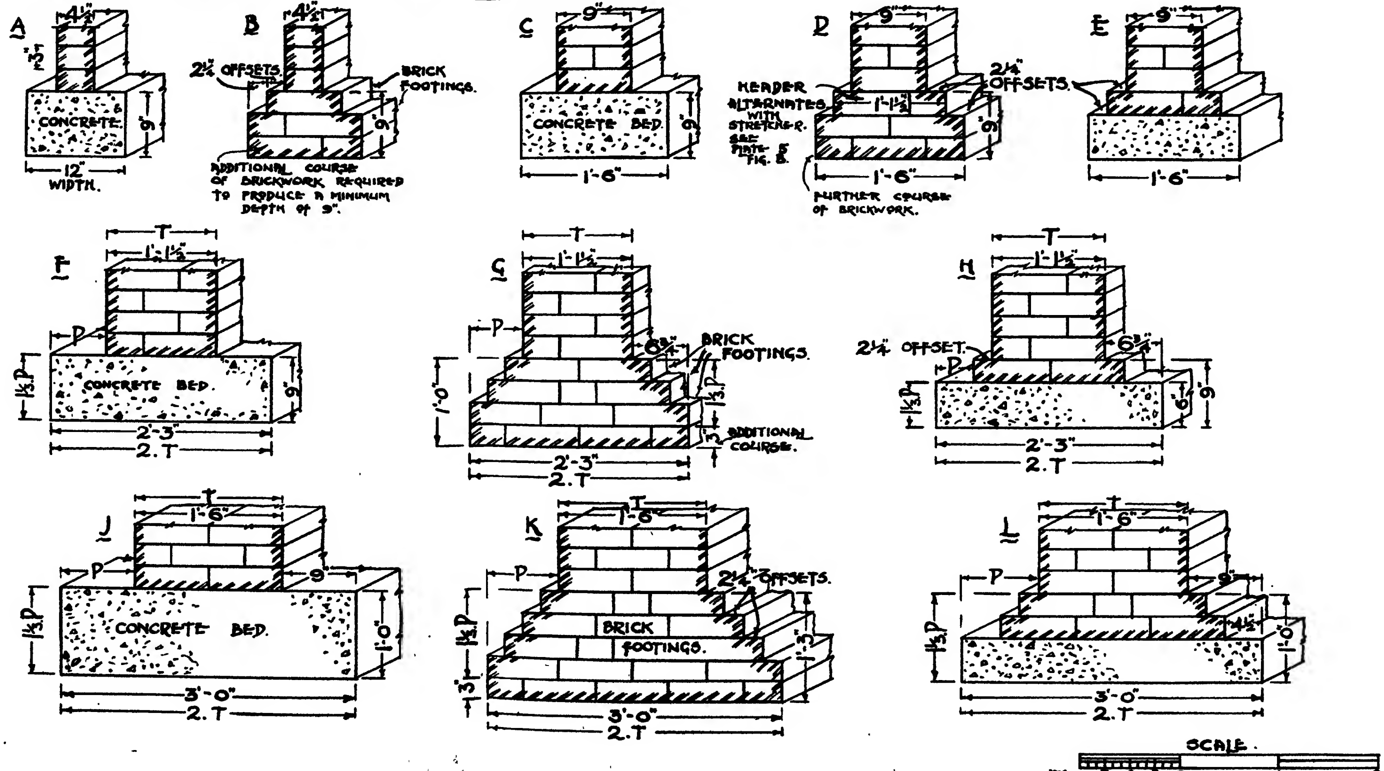
BRICKS AND JOINTS.



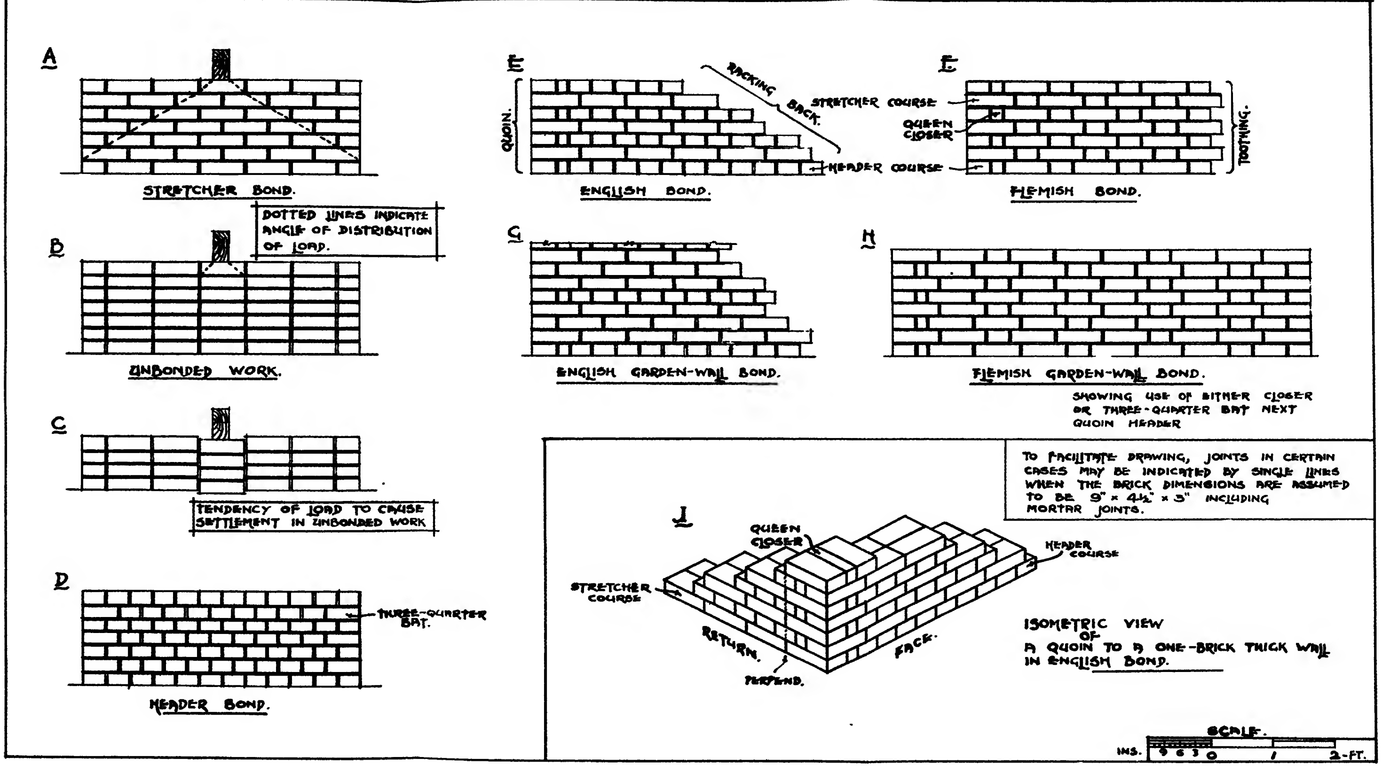
FOUNDATIONS.

DETAILS OF FOUNDATIONS

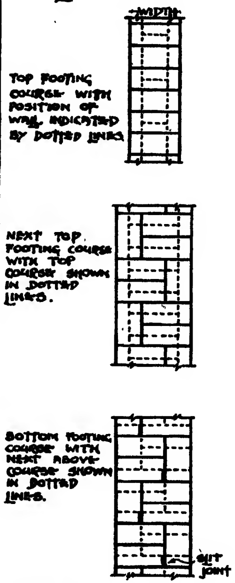
TO MINIMUM REQUIREMENTS OF THE MODEL BYE-LAWS, 1937.
FOR WALLS NOT EXCEEDING 50-FT. IN HEIGHT, ON SUITABLE GROUND.



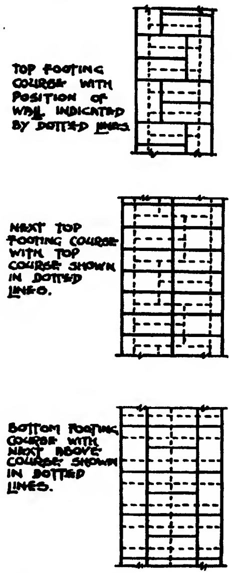
FACE APPEARANCE OF BONDS.



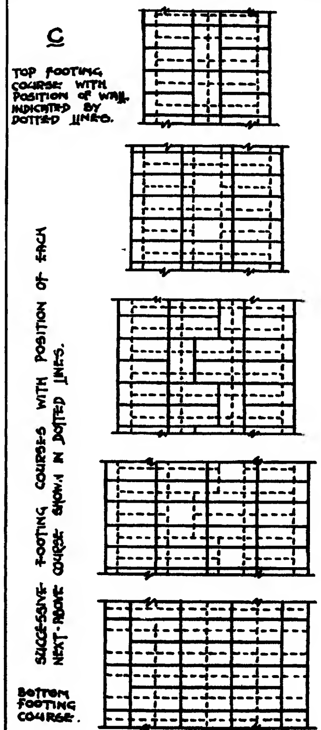
BONDING OF FOOTINGS. 5.



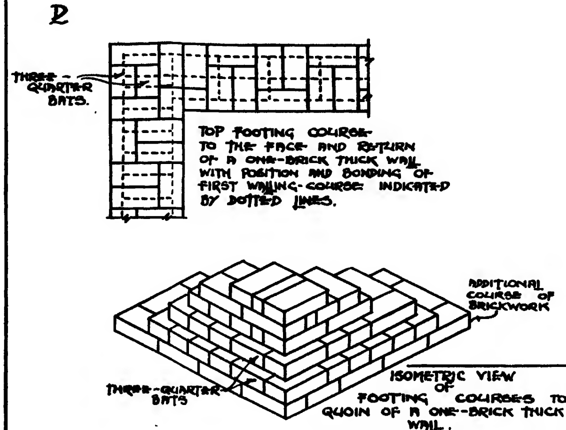
PLANS OF FOOTING COURSES TO A HALF-BRICK THICK WALL AS 'B' ON PLATE 4.



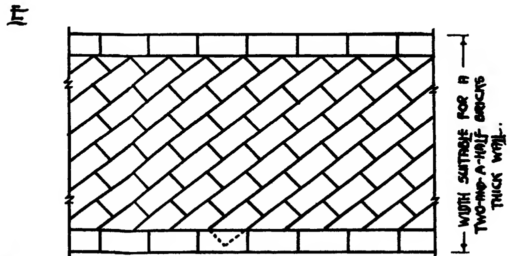
PLANS OF FOOTING COURSES TO A ONE-BRICK THICK WALL AS 'D' ON PLATE 4.



PLANS OF FOOTING COURSES TO A TWO-BRICKS THICK WALL AS 'K' ON PLATE 4.



ISOMETRIC VIEW OF FOOTING COURSES TO QUOIN OF A ONE-BRICK THICK WALL.



PLAN OF A BOTTOM FOOTING COURSE SHOWING AN ALTERNATIVE FILLING BY DIAGONAL BONDING.

SCALE. INS. 9 6 3 0 1 2 3 FT.

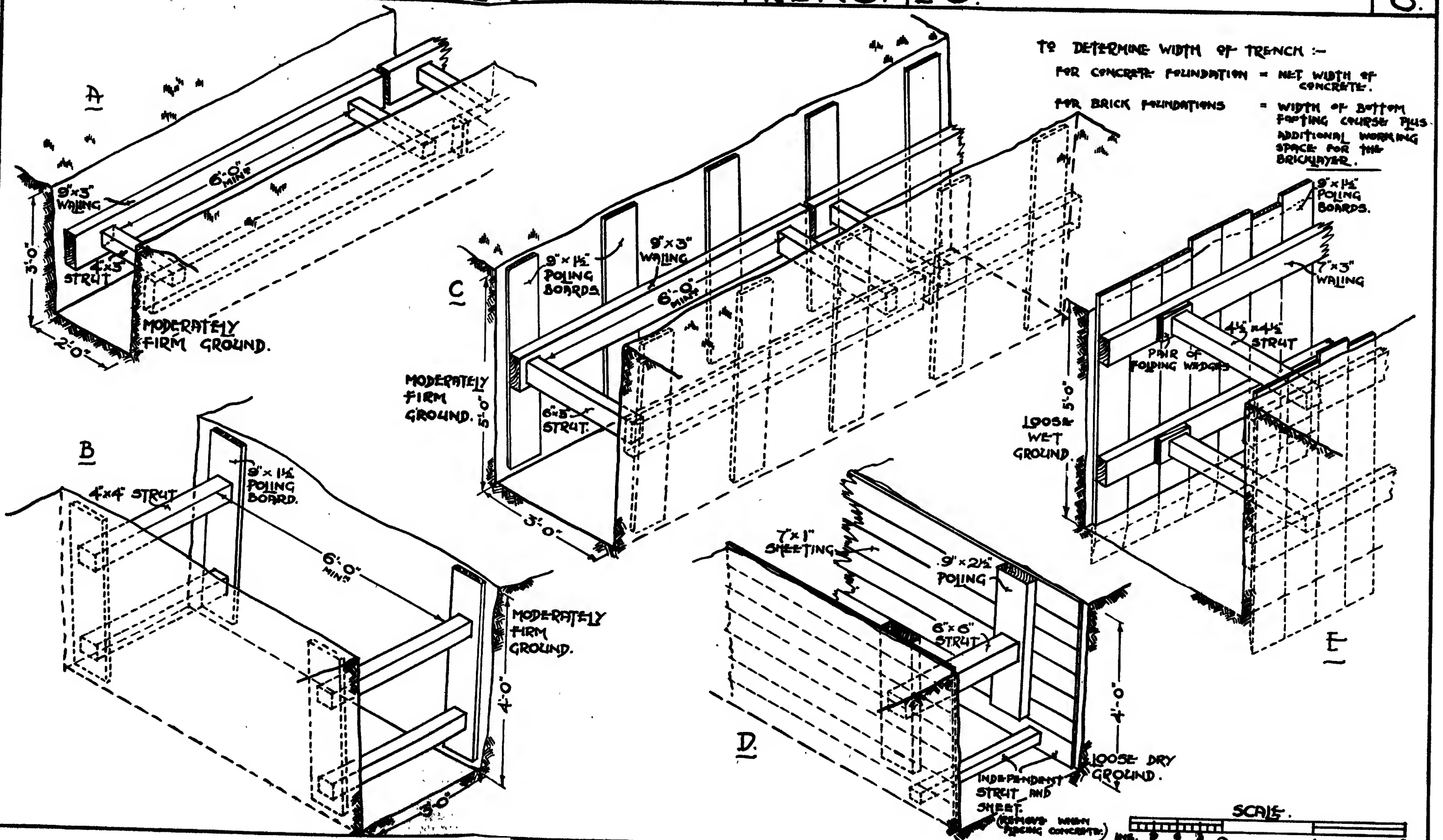
TIMBERING TO TRENCHES.

6.

TO DETERMINE WIDTH OF TRENCH :—

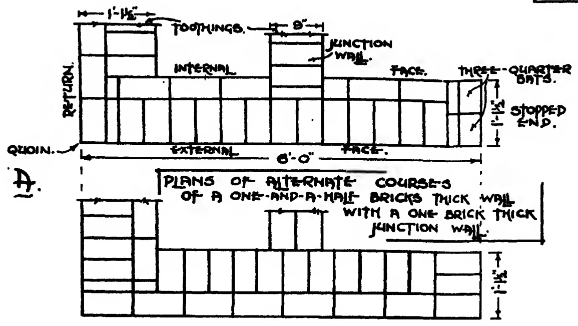
FOR CONCRETE FOUNDATION = NET WIDTH OF CONCRETE.

FOR BRICK FOUNDATIONS = WIDTH OF BOTTOM FOOTING COURSE PLUS ADDITIONAL WORKING SPACE FOR THE BRICKLAYER.

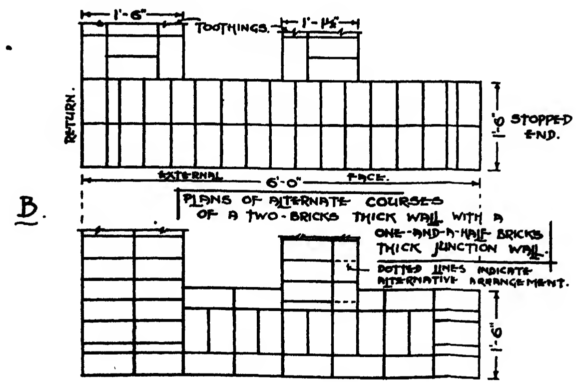


BONDING OF QUOINS, JUNCTIONS AND STOPPED-ENDS.

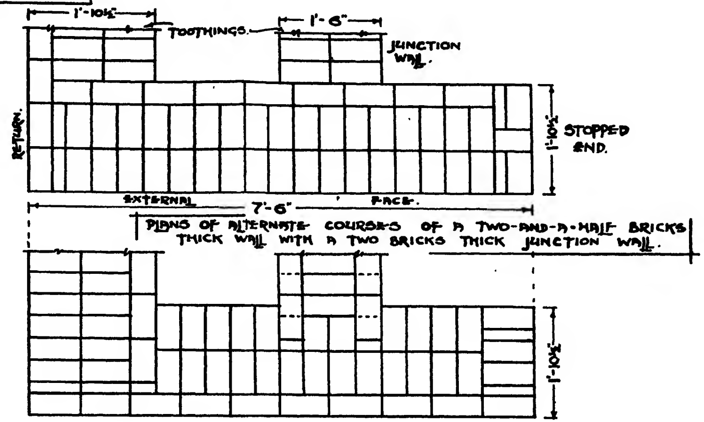
ENGLISH BOND.



A. PLANS OF ALTERNATE COURSES OF A ONE-AND-A-HALF BRICKS THICK WALL WITH A ONE BRICK THICK JUNCTION WALL.

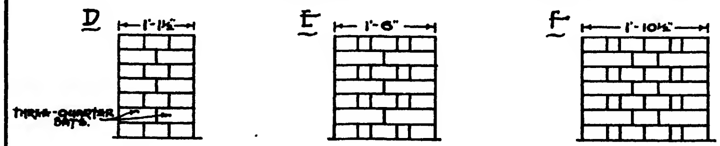


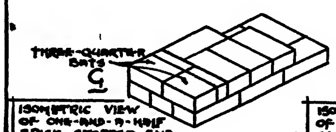
B. PLANS OF ALTERNATE COURSES OF A TWO-BRICKS THICK WALL WITH A ONE-AND-A-HALF BRICKS THICK JUNCTION WALL.



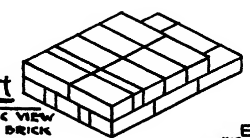
C. PLANS OF ALTERNATE COURSES OF A TWO-AND-A-HALF BRICKS THICK WALL WITH A TWO BRICKS THICK JUNCTION WALL.

FACE APPEARANCE OF STOPPED-ENDS.





G ISOMETRIC VIEW OF ONE-AND-A-HALF BRICK STOPPED-END.

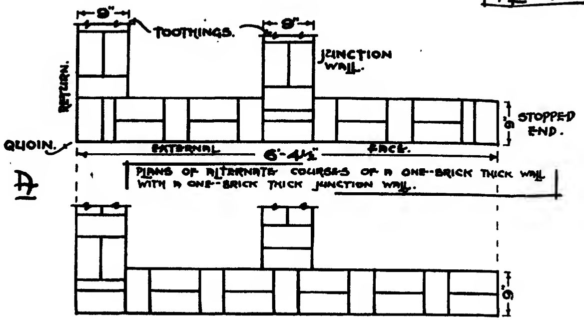


H ISOMETRIC VIEW OF TWO BRICK STOPPED-END.

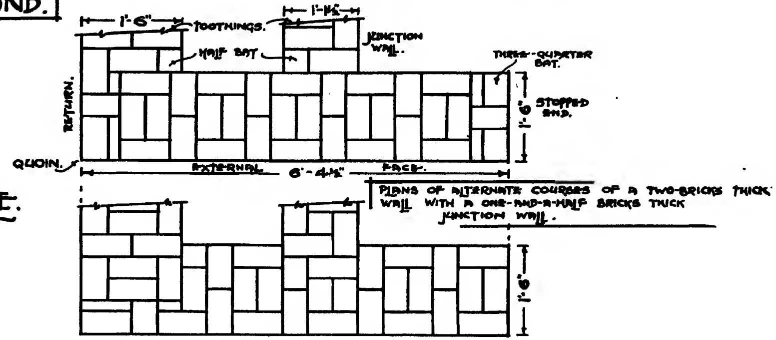
SCALE. INS. 9 6 3 0 1 2 FT.

BONDING OF QUOINS, JUNCTIONS AND STOPPED-ENDS.

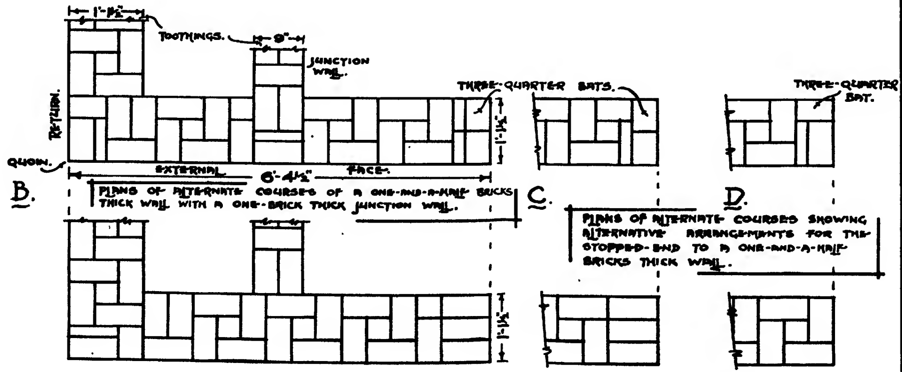
FLEMISH BOND.



A. PLANS OF ALTERNATE COURSES OF A ONE-BRICK THICK WALL WITH A ONE-BRICK THICK JUNCTION WALL.



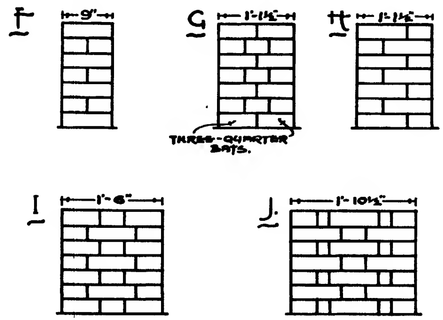
E. PLANS OF ALTERNATE COURSES OF A TWO-BRICKS THICK WALL WITH A ONE-AND-A-HALF BRICKS THICK JUNCTION WALL.

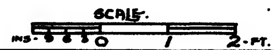


B. PLANS OF ALTERNATE COURSES OF A ONE-AND-A-HALF BRICKS THICK WALL WITH A ONE-BRICK THICK JUNCTION WALL.

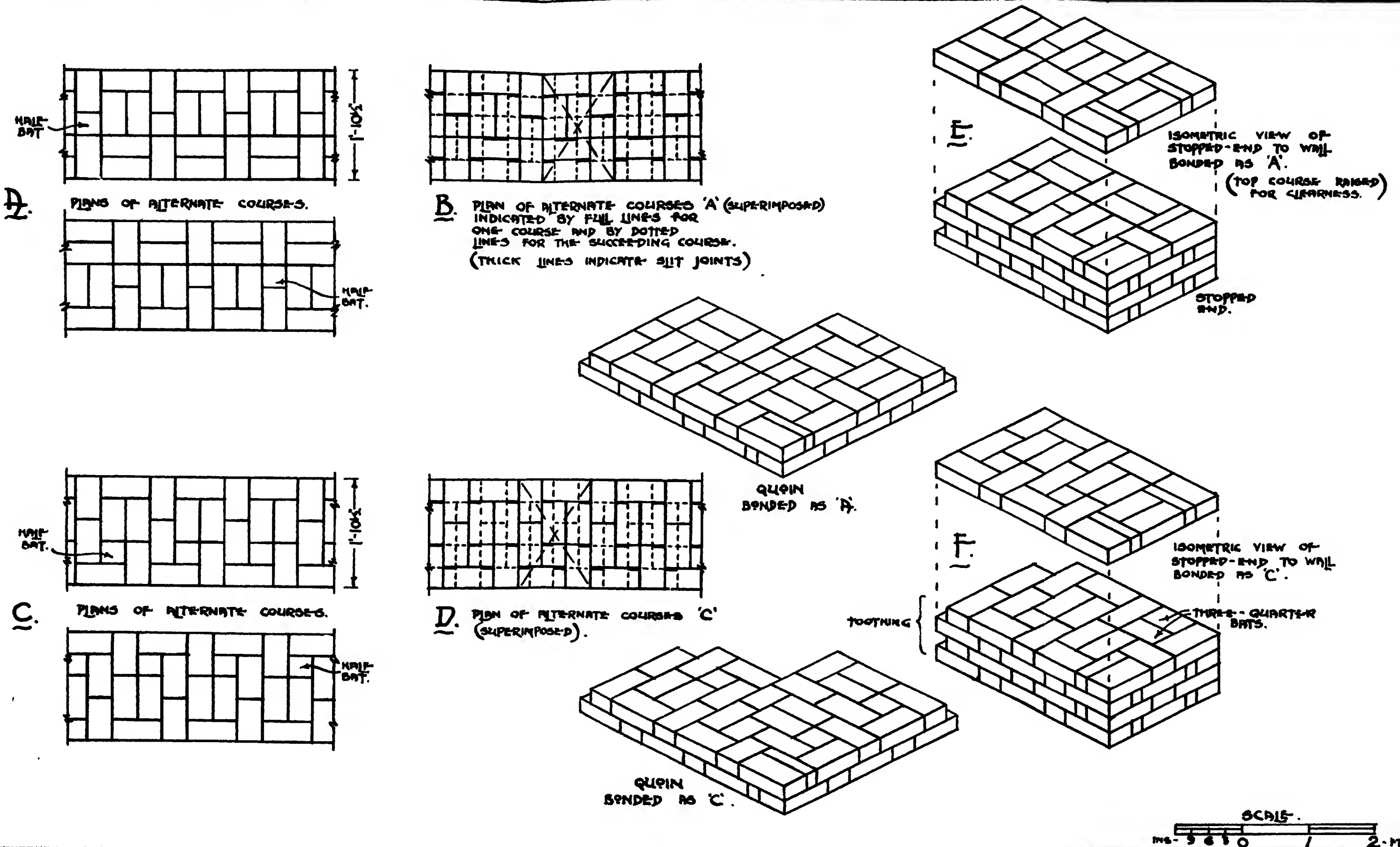
C. D. PLANS OF ALTERNATE COURSES SHOWING ALTERNATIVE ARRANGEMENTS FOR THE STOPPED-END TO A ONE-AND-A-HALF BRICKS THICK WALL.

FACE APPEARANCE OF STOPPED-ENDS.

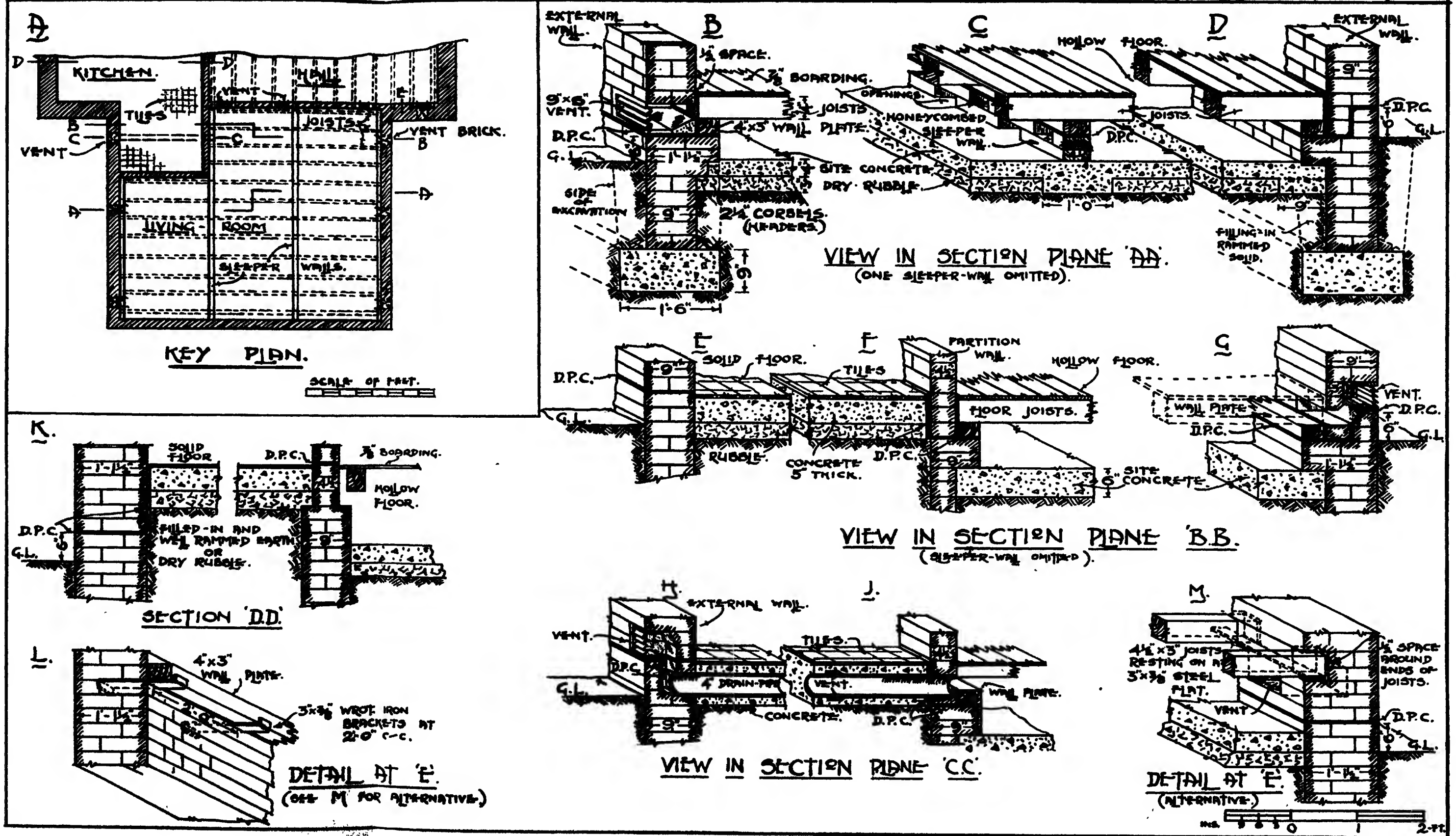




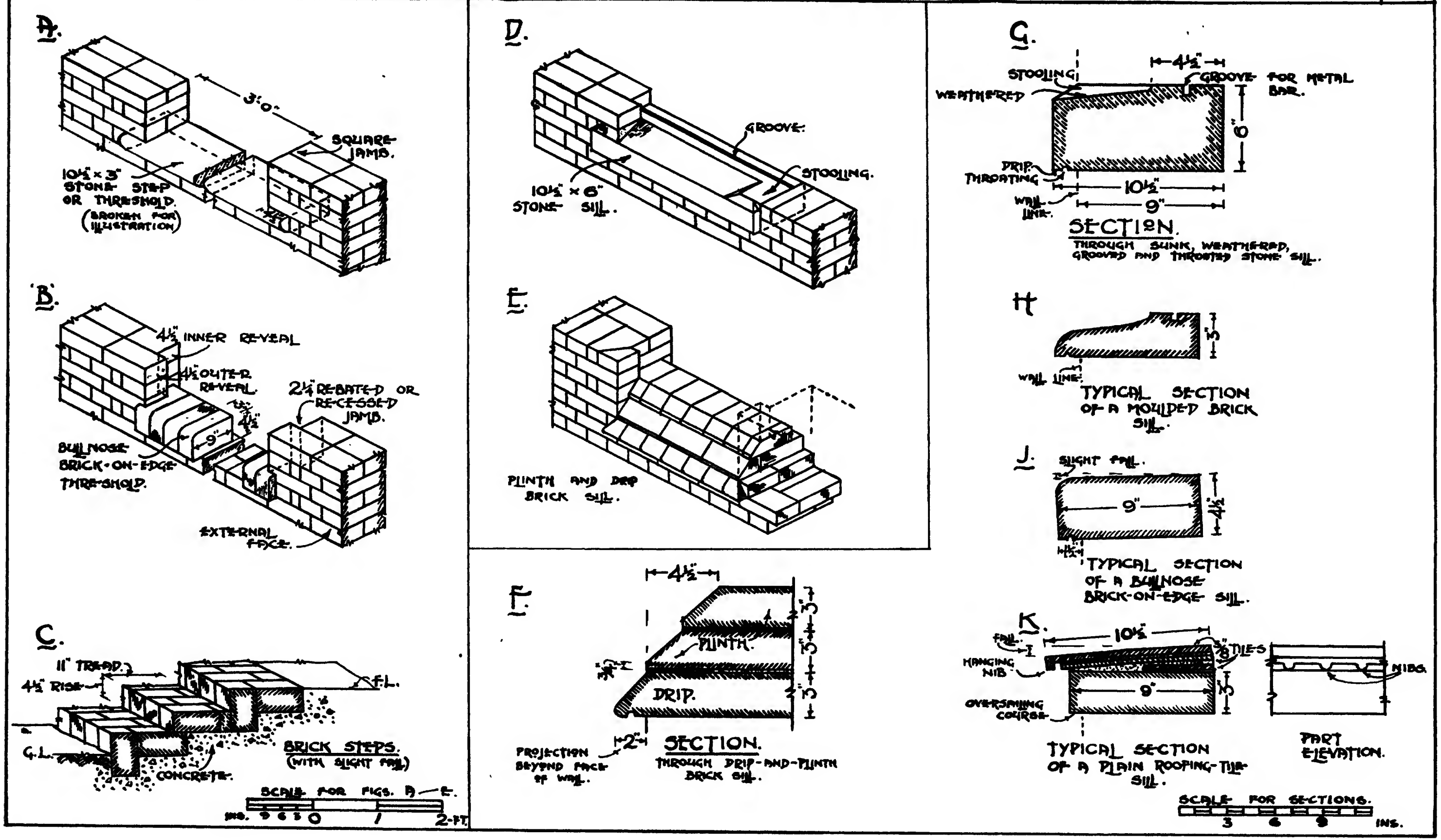
FLEMISH BOND IN A TWO-AND-A-HALF BRICKS THICK WALL



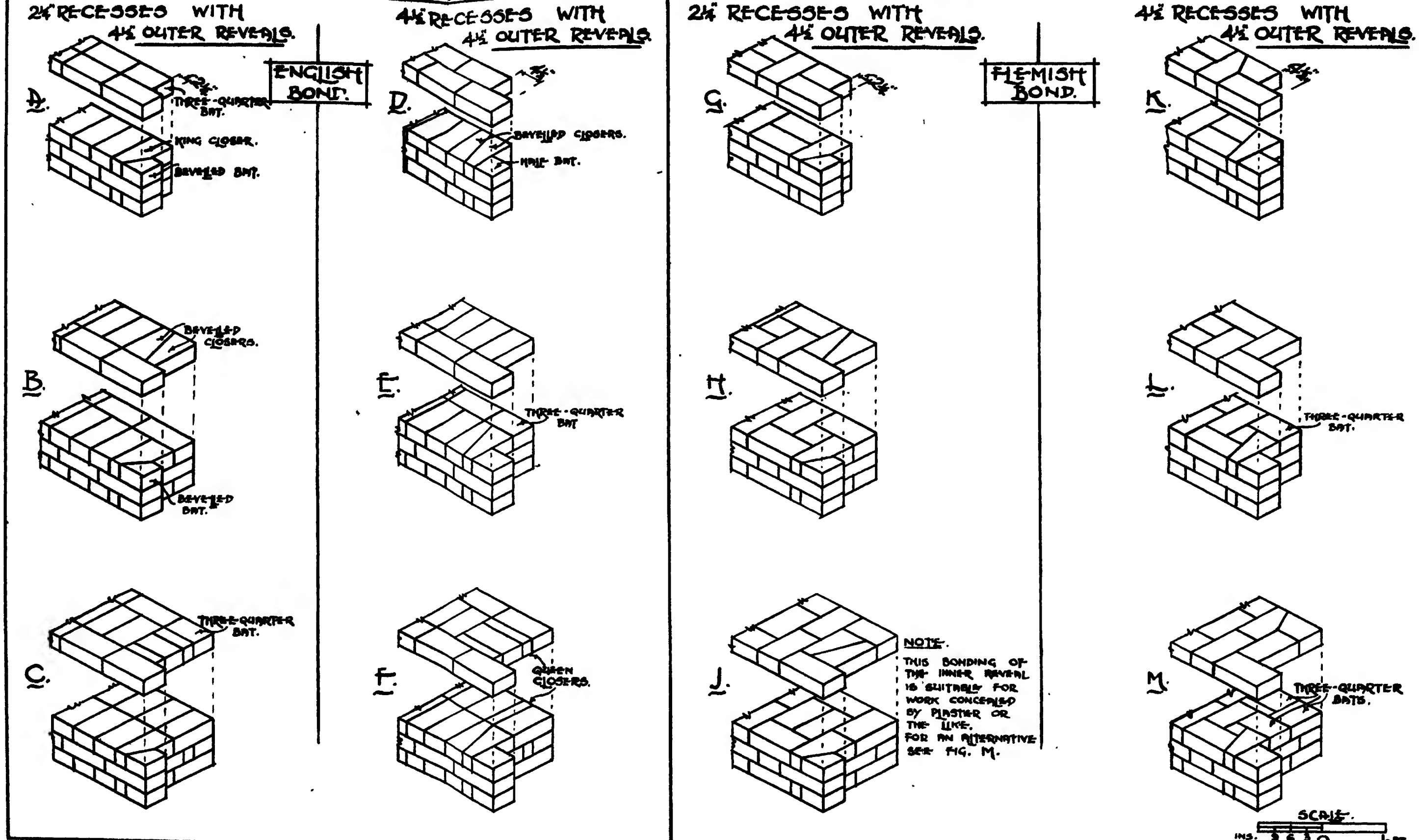
DAMP-PROOF COURSES AND SUPPORT OF GROUND FLOORS.



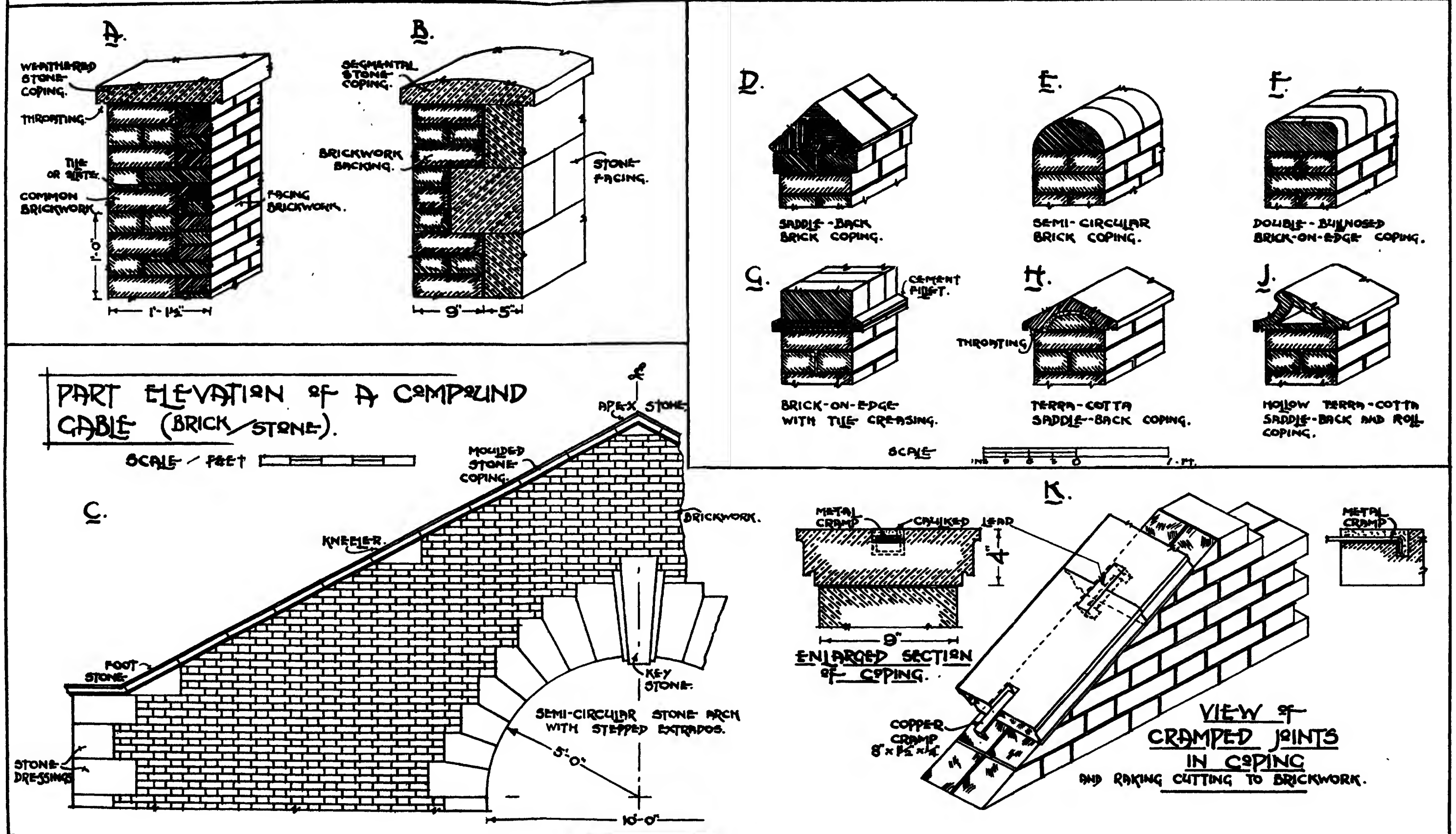
THRESHOLDS AND SILLS.

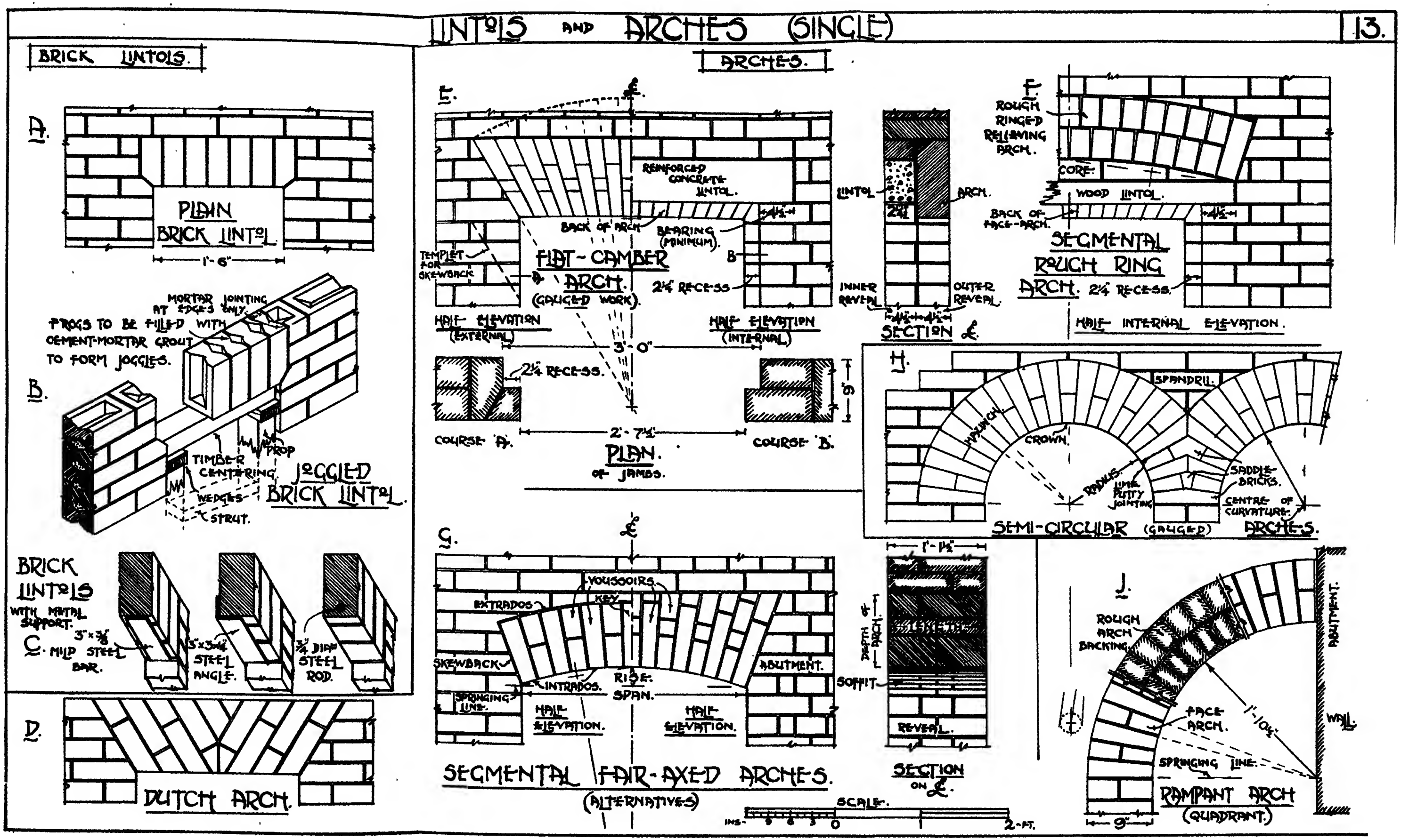


BONDING OF RECESSED REVEALS.



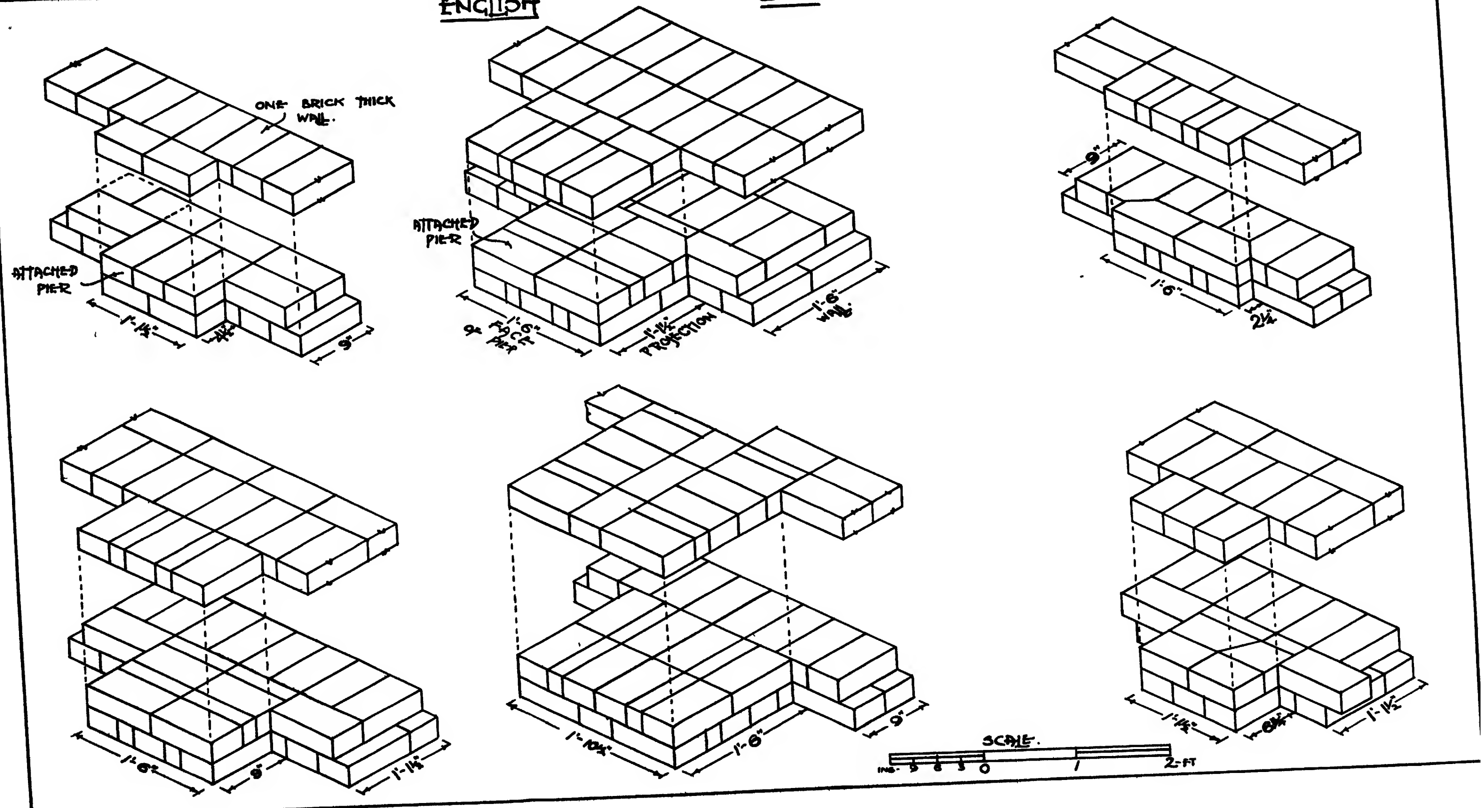
COMPOUND WALLS AND COPINGS.




LINTOLS AND ARCHES (SINGLE)
13.
BRICK LINTOLS.
A.
PLAIN BRICK LINTOL.
1'-6"
B.
FROGS TO BE FILLED WITH CEMENT-MORTAR GROUT TO FORM JOGGLES.
MORTAR JOINTING AT EDGES ONLY.
TIMBER CENTERING.
PROP
WEDGES
STRUT.
JOGGLED BRICK LINTOL.
BRICK LINTOLS WITH METAL SUPPORT.
C.
3"x3/8" MILD STEEL BAR.
3"x3¼" STEEL ANGLE.
¾" DIAM STEEL ROD.
D.
DUTCH ARCH.
ARCHES.
E.
TEMPLET FOR SKEWBACK
REINFORCED CONCRETE LINTOL.
BACK OF ARCH
BEARING (MINIMUM).
B
FLAT-CAMBER ARCH. (GAUGED WORK).
2¼" RECESS
HALF ELEVATION (EXTERNAL)
HALF ELEVATION (INTERNAL)
3'-0"
2¼" RECESS.
9"
COURSE 'A'.
2'-7½"
COURSE 'B'.
PLAN. OF JAMBS.
LINTOL
ARCH.
2¼"
INNER REVEAL
OUTER REVEAL
4½" 4½"
SECTION ℄.
F.
ROUGH RINGED RELIEVING ARCH.
CORE.
WOOD LINTOL.
BACK OF FACE-ARCH.
4½"
SEGMENTAL ROUGH RING ARCH. 2¼" RECESS.
HALF INTERNAL ELEVATION.
H.
SPANDRIL.
HAUNCH.
CROWN.
RADIUS.
LIME PUTTY JOINTING
SADDLE-BRICKS.
CENTRE OF CURVATURE.
SEMI-CIRCULAR (GAUGED) ARCHES.
G.
℄
EXTRADOS
VOUSSOIRS.
KEY
SKEWBACK
ABUTMENT.
RISE.
SPAN.
SPRINGING LINE.
INTRADOS.
HALF ELEVATION.
HALF ELEVATION.
SEGMENTAL FAIR-AXED ARCHES. (ALTERNATIVES)
1'-1½"
DEPTH OF ARCH.
SOFFIT.
REVEAL.
SECTION ON ℄.
SCALE.
INS. 9 6 3 0 1 2-FT.
J.
ROUGH ARCH BACKING.
ABUTMENT.
WALL.
FACE ARCH.
1'-10½"
SPRINGING LINE.
9"
RAMPANT ARCH (QUADRANT).

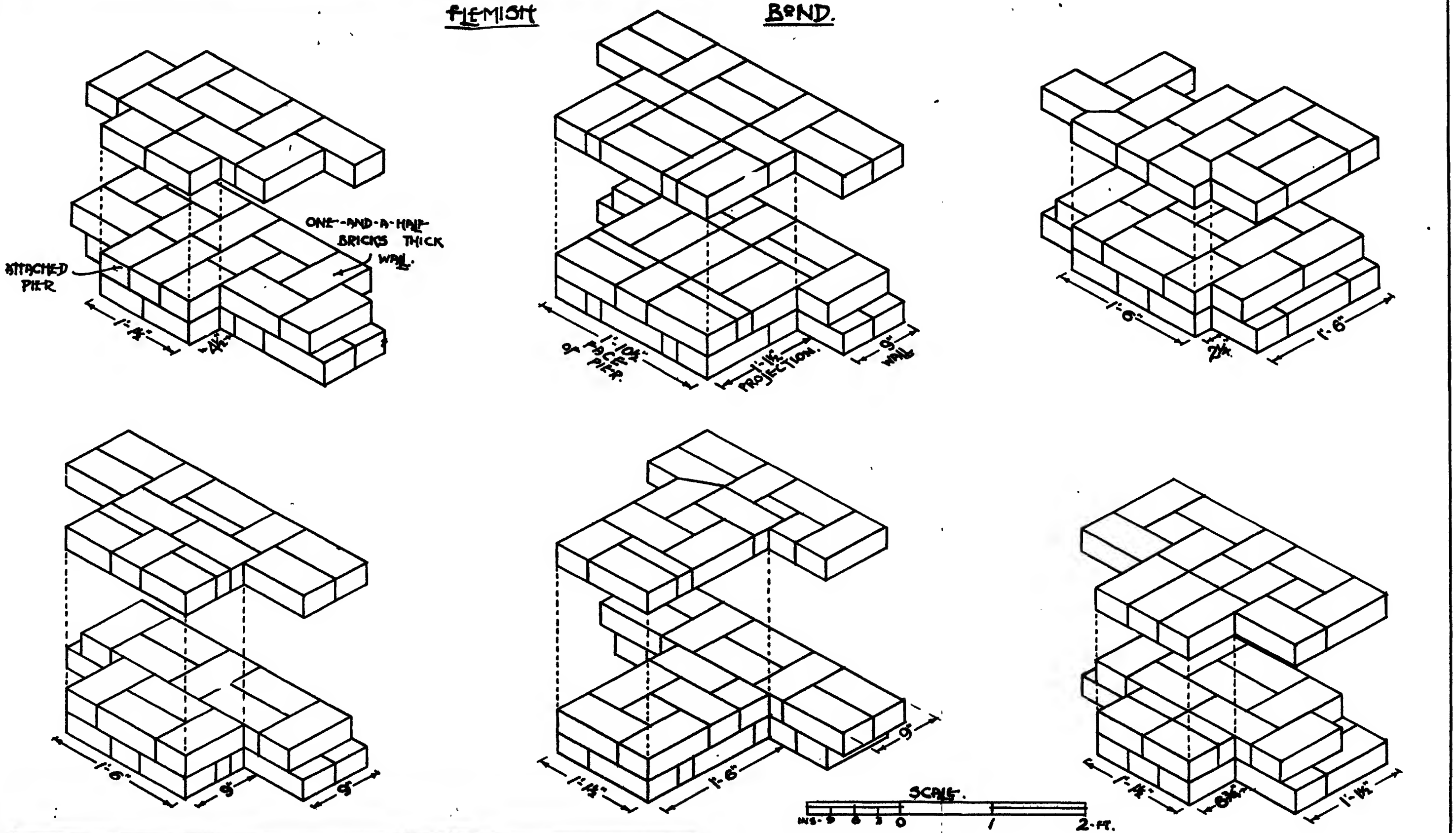
BONDING OF ATTACHED PIERS.

ENGLISH BOND.

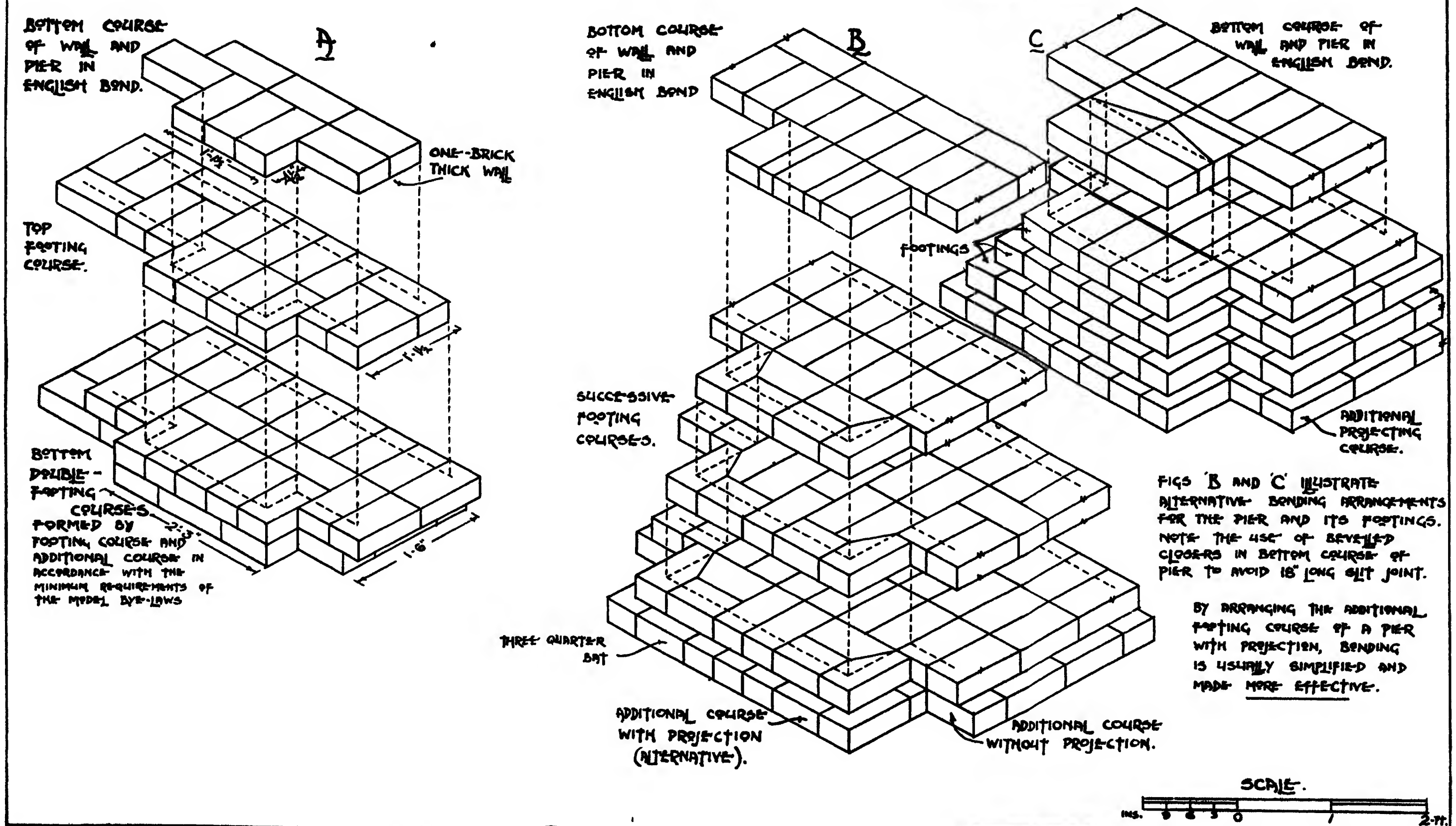


BONDING OF ATTACHED PIERS.

FLEMISH BOND.



BONDING OF FOOTINGS FOR ATTACHED PIERS. 17.

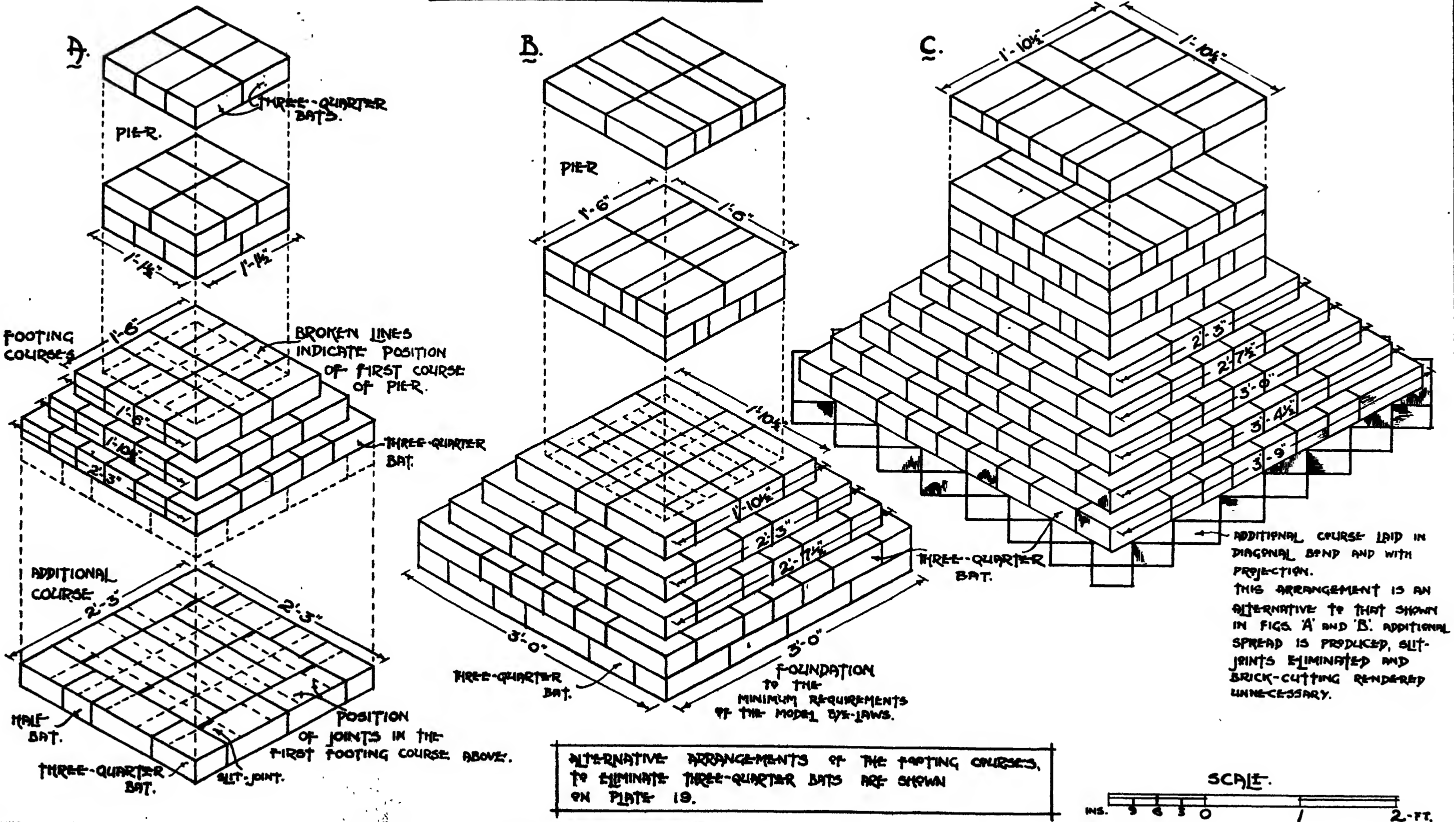


FIGS 'B' AND 'C' ILLUSTRATE ALTERNATIVE BONDING ARRANGEMENTS FOR THE PIER AND ITS FOOTINGS. NOTE THE USE OF BEVELLED CLOSERS IN BOTTOM COURSE OF PIER TO AVOID 18" LONG SLIT JOINT.

BY ARRANGING THE ADDITIONAL FOOTING COURSE OF A PIER WITH PROJECTION, BONDING IS USUALLY SIMPLIFIED AND MADE MORE EFFECTIVE.

BONDING OF ISOLATED PIERS WITH FOOTINGS.

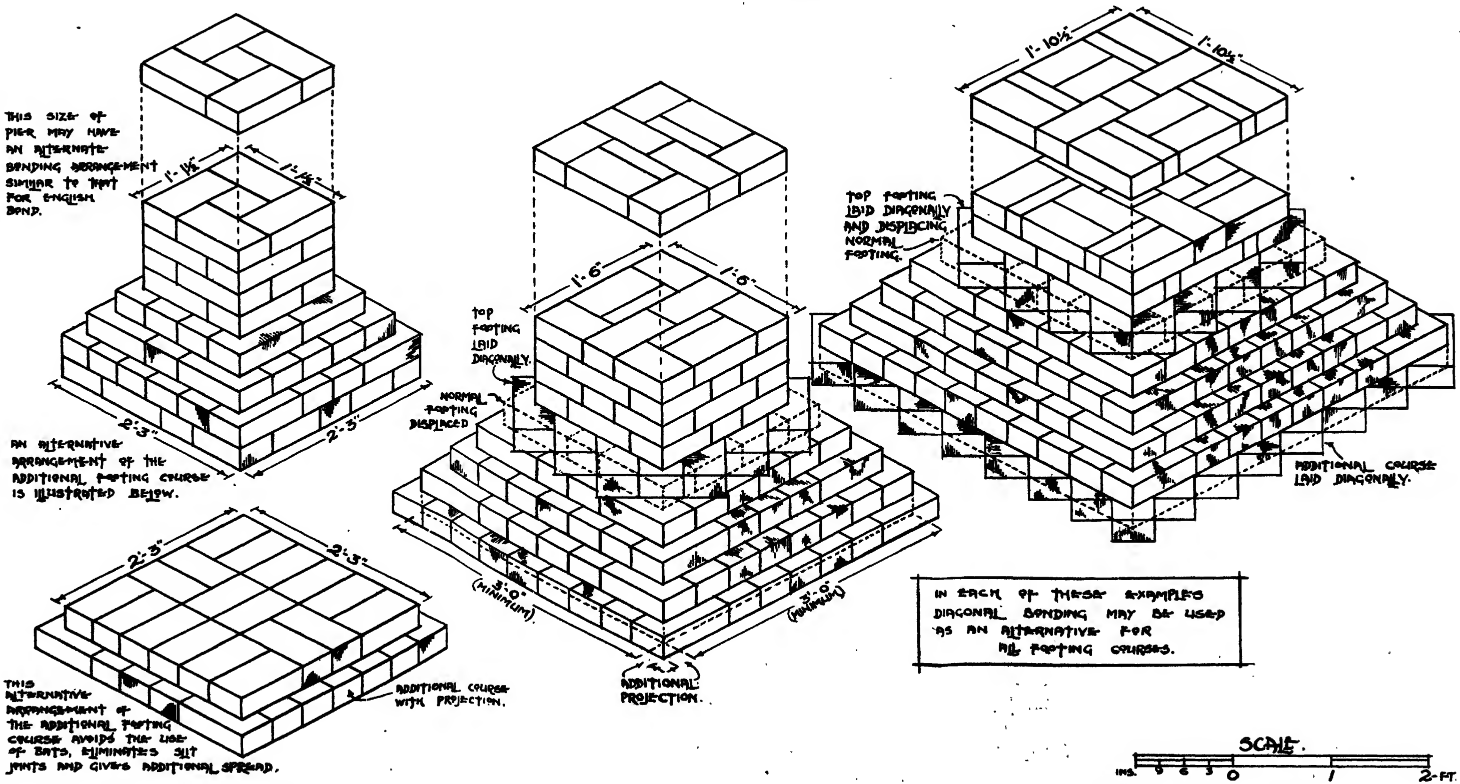
PIERS IN ENGLISH BOND.



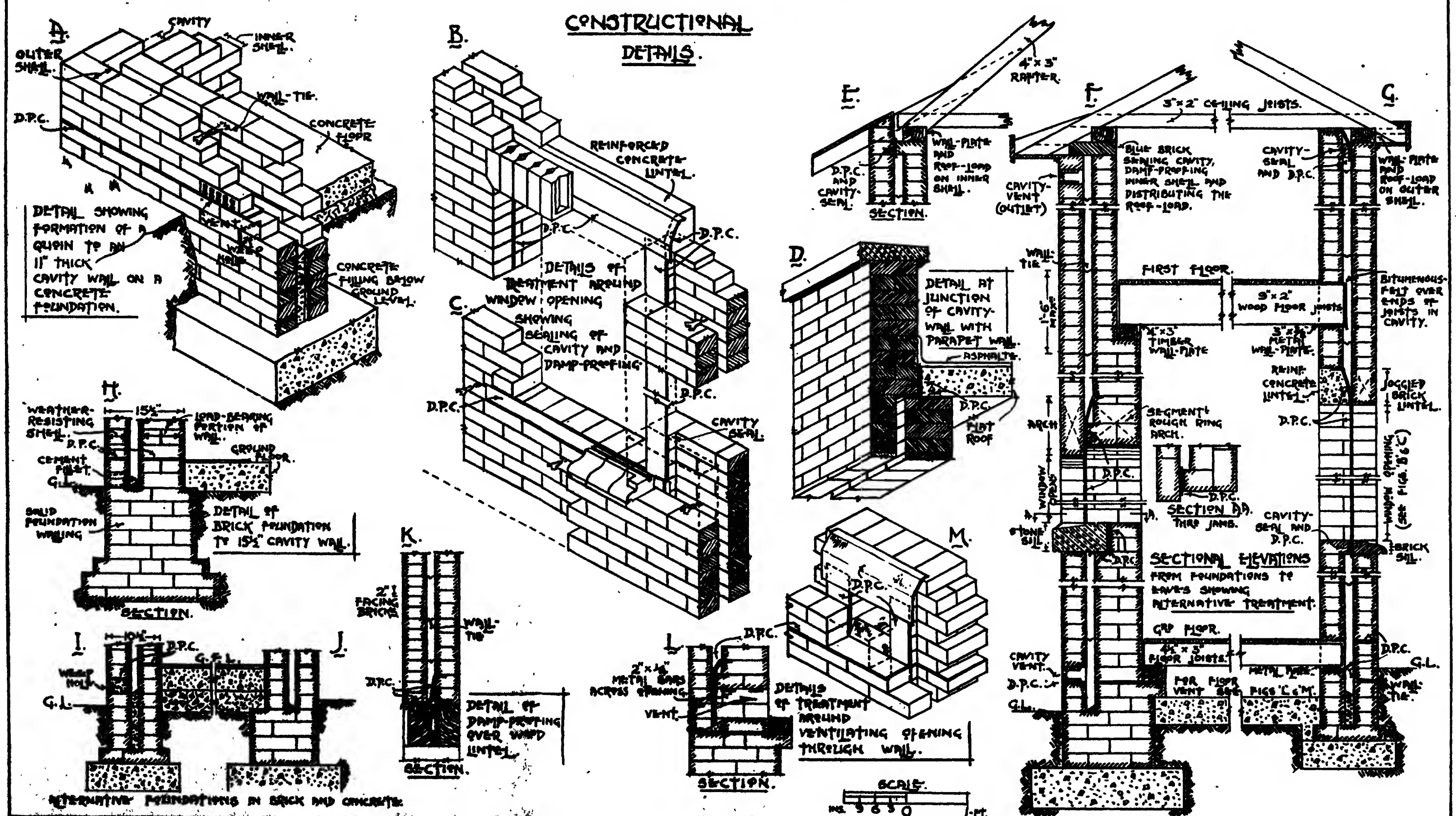
ALTERNATIVE ARRANGEMENTS OF THE FOOTING COURSES, TO ELIMINATE THREE-QUARTER BATS ARE SHOWN ON PLATE 19.

BONDING OF ISOLATED PIERS WITH FOOTINGS.

PIERS IN FLEMISH BOND.



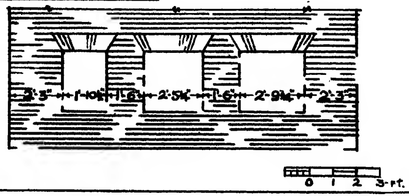
CAVITY WALLS.



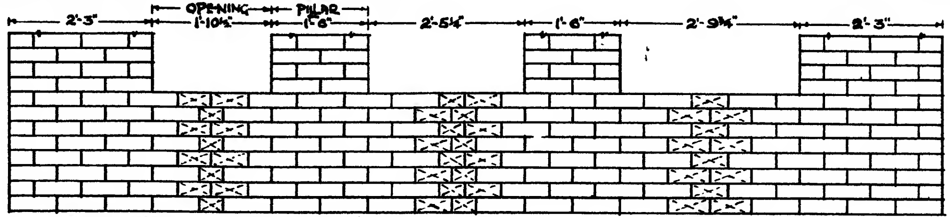
BROKEN BONDING.

KEY ELEVATION.

A.



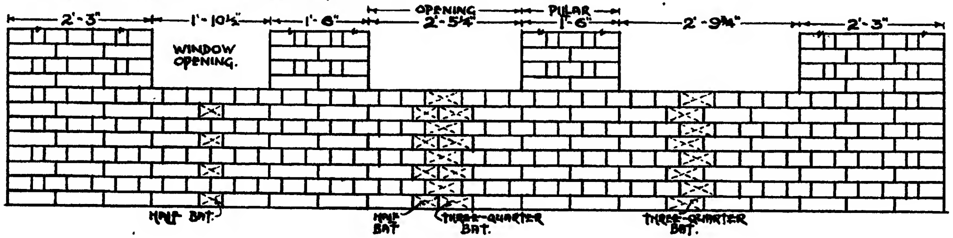
B.



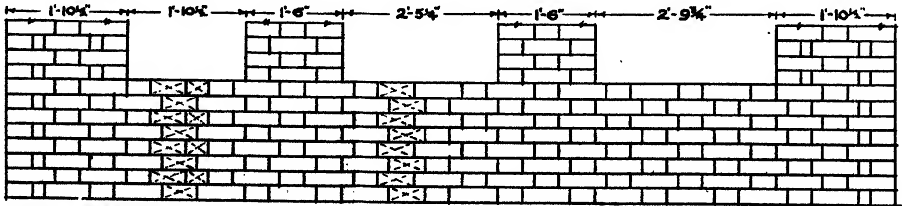
FACE APPEARANCE OF BROKEN STRETCHING BOND ARRANGED UNDER WINDOW OPENINGS.

FACE APPEARANCE OF BROKEN ENGLISH BOND ARRANGED UNDER WINDOW OPENINGS.

C.

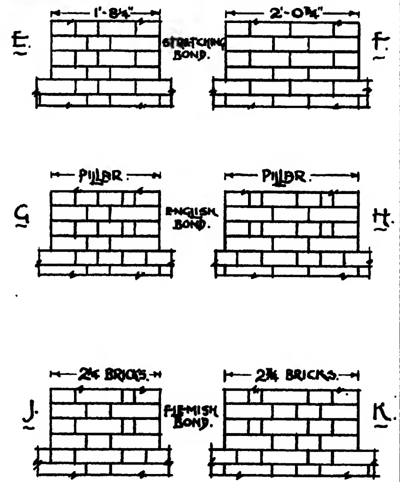


D.

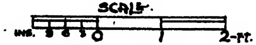


FACE APPEARANCE OF BROKEN FLEMISH BOND ARRANGED UNDER WINDOW OPENINGS.

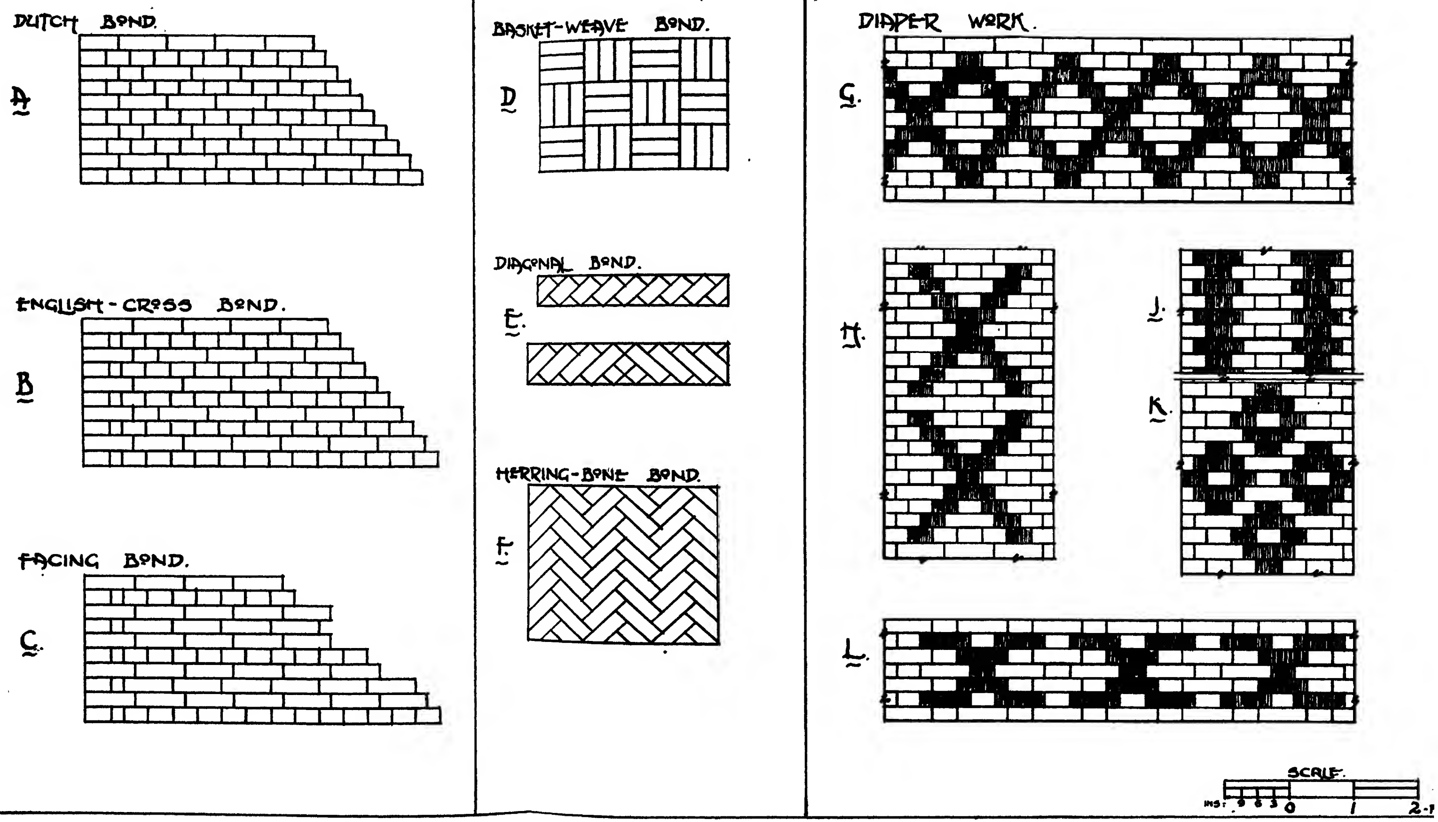
BROKEN BONDING IN PILLARS.

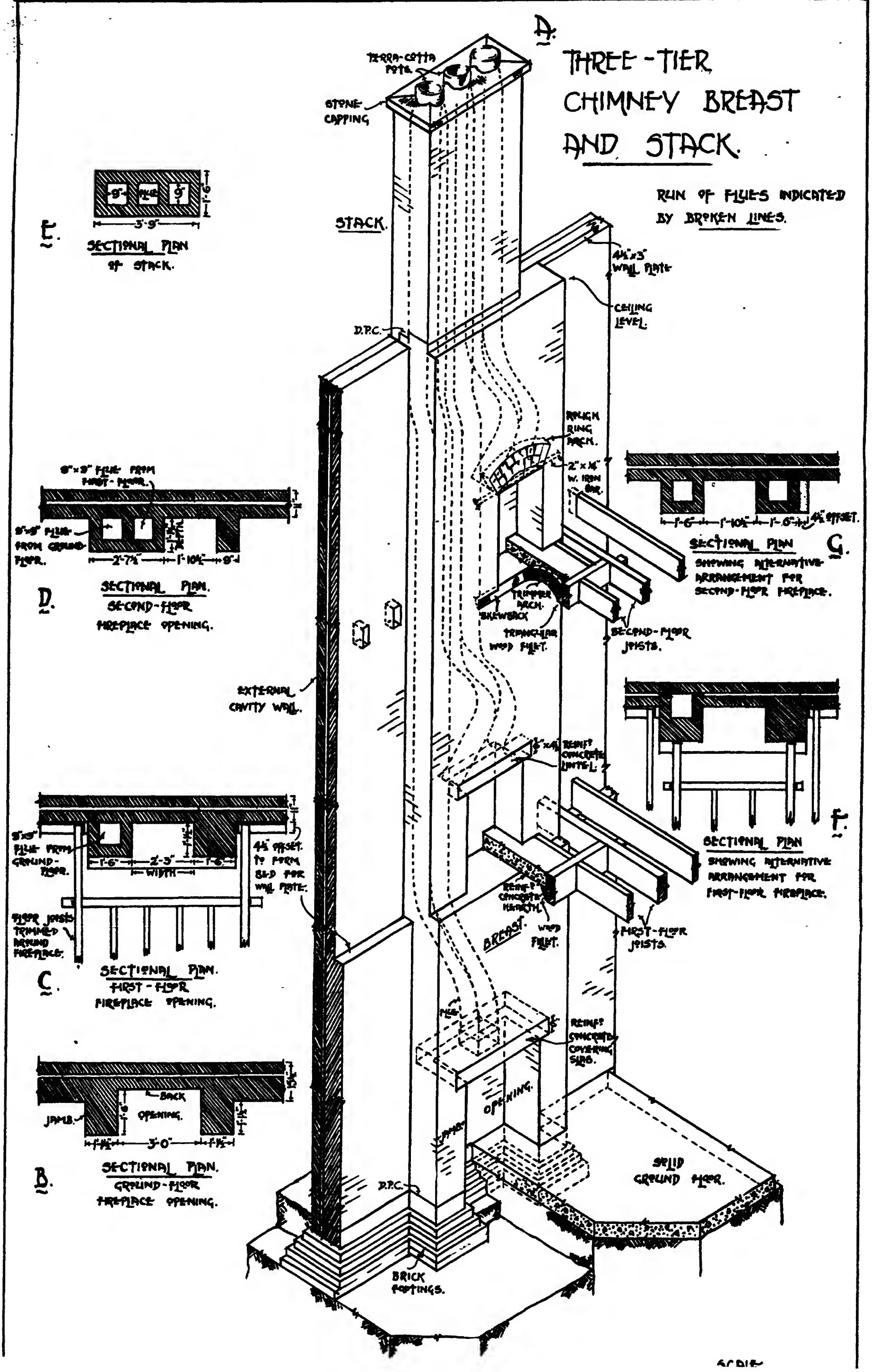


SCALE.

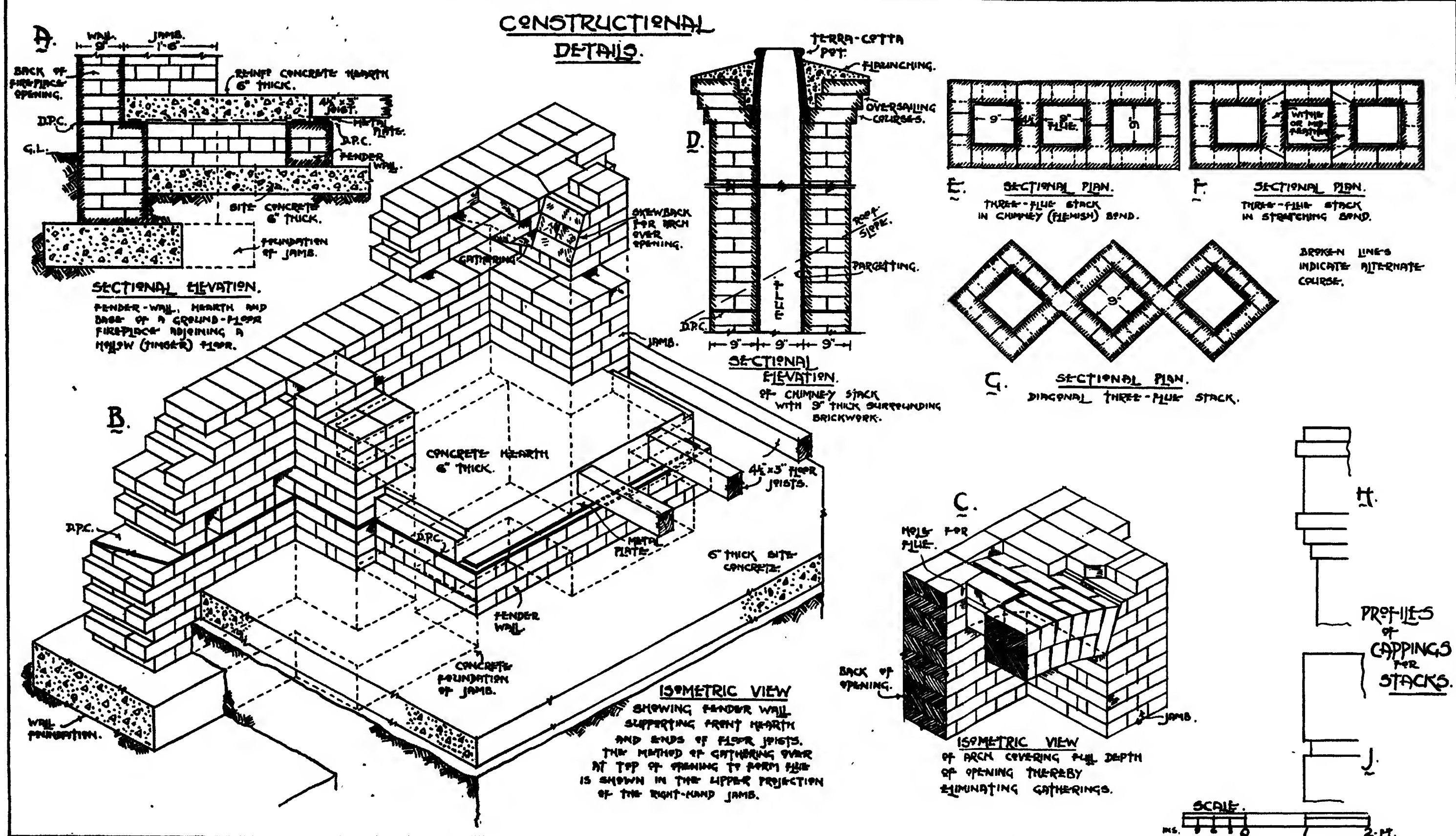


UNCOMMON AND DECORATIVE BONDS.




A.
THREE-TIER CHIMNEY BREAST AND STACK.
RUN OF FLUES INDICATED BY BROKEN LINES.
TERRA-COTTA POTS.
STONE CAPPING
STACK.
4½"x3" WALL PLATE
CEILING LEVEL.
D.P.C.
ROUGH RING ARCH.
2"x½" W. IRON BAR.
TRIMMER ARCH.
SKEWBACK
TRIANGULAR WOOD FILLET.
SECOND-FLOOR JOISTS.
EXTERNAL CAVITY WALL.
REINFD CONCRETE LINTEL.
REINFD CONCRETE HEARTH.
WOOD FILLET.
BREAST.
FIRST-FLOOR JOISTS.
FLUE.
REINFD CONCRETE COVERING SLAB.
OPENING.
JAMB.
SOLID GROUND FLOOR.
D.P.C.
BRICK FOOTINGS.
E.
SECTIONAL PLAN OF STACK.
9" FLUE 9"
3'-9"
D.
9"x9" FLUE FROM FIRST-FLOOR.
9"x9" FLUE FROM GROUND-FLOOR.
2'-7½"
1'-10½"
9"
SECTIONAL PLAN. SECOND-FLOOR FIREPLACE OPENING.
C.
9"x9" FLUE FROM GROUND-FLOOR.
1'-6"
2'-3"
WIDTH
4½" OFFSET TO FORM BED FOR WALL PLATE.
FLOOR JOISTS TRIMMED AROUND FIREPLACE.
SECTIONAL PLAN. FIRST-FLOOR FIREPLACE OPENING.
B.
BACK
OPENING.
JAMB.
1'-1½"
3'-0"
SECTIONAL PLAN. GROUND-FLOOR FIREPLACE OPENING.
G.
1'-6"
1'-10½"
4½" OFFSET.
SECTIONAL PLAN SHOWING ALTERNATIVE ARRANGEMENT FOR SECOND-FLOOR FIREPLACE.
F.
SECTIONAL PLAN SHOWING ALTERNATIVE ARRANGEMENT FOR FIRST-FLOOR FIREPLACE.
SCALE

FIREPLACES AND FLUES.



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