EXAMINATION WORK IN BUILDING CONSTRUCTION.

BY

HENRY ADAMS,
M. Inst. C.E., M. Inst. Mech. E., F.S.I., F.R. San. I., M.S.A., etc.;
Examiner in Building Construction to The Board of Education and The Society of Architects.
Late Professor of Engineering at the City of London College.

WITH NUMEROUS ILLUSTRATIONS

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PREFACE.

AS the Council of The Society of Architects have decided not to publish any further examination questions and answers, it occurred to the author that those written by him, and already published at intervals in the Society's Journal, might be useful to students generally if they were collected in one volume and issued at a cheap rate. They will be found applicable to other examinations besides those of The Society of Architects. It should be noted, that to economise space, the diagrams have all been reduced to about half the size required in the examinations. A perusal of the Index will show the very considerable range of the information given by these worked answers.

EXAMINATION, APRIL, 1901.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

Question 1. *The excavation for a basement story is 12 ft. below ground level; show by sketches and description how the earth is supported during the excavation and while the walls are being carried up.*

Answer 1. If possible a trench should be excavated so that the outside may be supported from the inside. The arrangement would then be as Fig. 1, where the timbering could be removed in stages as the wall is built up, the whole length being dealt with at one time. If the excavation had to be made over the whole site at the same time, the outer face would have to be supported by shoring in at least two stages and probably three. Let Fig. 2 be a plan of perpendicular face of excavation, the first stage will be poling boards 4 ft. deep, with walings and struts or shores AA wedged up on footing pieces for which sufficient excavation is made. Then the intermediate earth is removed and another row of poling boards put in below the first series with struts at B B to both walings. Then struts A A are removed and the earth excavated another 4 ft., poling boards and waling inserted, and all three strutted at A A from footing pieces at the lowest level. As the wall is built up the lower struts, waling and poling boards are removed and earth filled in and rammed, and so on until the surface is reached.

Question 2. *It being decided to build a large Warehouse on a concrete raft, on account of bad foundations, state the chief points to keep in view in order to insure stability, and give section through base of 3 brick wall at suitable distance from edge of raft. Scale* $\frac{3}{4}$ *in. to 1 ft.*

Answer 2. The chief points to keep in view are (*a*) The uniformity of the foundation, any specially soft place being filled and rammed. (*b*) The drainage of the site if possible by agricultural pipes. (*c*) The shutting in of the soil if necessary by sheet piling round the site. (*d*) The load to be carried at concentrated points as from stanchions and columns, main walls, party walls, &c. (*e*) The necessity or otherwise of inserting rolled joists, old rails, or other stiffening in the concrete. (*f*) The projection of the concrete all round, so that the main walls shall not fall outwards. See section.

Question 3. *Give vertical section, 1 in. to 1 ft., through a wall 2 ft. thick, built of rubble stone with brick lining; describe the bonding and the advantage of the brick lining. Assuming the building to be a public hall, built on gravel with floor line 6 ft. above ground line, show the lower 9 ft.*

Answer 3. See diagram. The description is as follows: The rubble wall to be built in blue lias mortar, 3 sand to 1 lime. All stones to be laid the largest face downwards, and to break joint as far as possible. At least one good bond stone to be inserted in every square yard on each face, and the rubble to be brought up to a level bed every 3 feet in height. Small stones to be laid in where necessary to level up each course. The largest stones to be selected for the lower part of wall. The plinth course to be of wrought ashlar, 9 in. deep. The brick lining to be half-brick thick, as shown, with all whole headers in every fourth course. The brickwork to be of best pressed bricks, flat jointed in lias mortar. The advantage of the brick lining is to prevent "osmotic" action, or the deposition of moisture on the inner face of stone wall, such as would occur upon the collection of a crowd of persons in the room when the walls are cold, or upon a rise of temperature after cold weather. It also presents a better appearance than the stone for an interior, but the stone might be plastered over or rendered and jointed.

Question 4. *A window opening, 3 ft. 9 in. wide, is surmounted by a gauged brick camber arch. Show the jointing of brickwork on face in full lines, Flemish bond, and dot-in the recessed jamb, lintel and relieving arch. Scale* $1\frac{1}{2}$ *in. to 1 ft.*

Answer 4. See diagram.

Question 5. *A parish room is 36 ft. by 24 ft. The ceiling may be in three planes. Show half plan and section of roof, giving scantlings. Scale* $\frac{1}{4}$ *in. = 1 ft. Show provision for ventilation.*

Answer 5. See diagram, as submitted by one of the candidates.

Question 6. *A stand with seats is required from which to view a procession, upon a site 40 ft. by 10 ft. The front is to be 4 ft. above pavement behind some iron railings. Give section and part plan to a scale of* $\frac{1}{2}$ *in. to 1 ft.*

Answer 6. See diagram.

Question 7. *Draw to a scale of* $\frac{1}{2}$ *in. to a foot, plan, section and elevation of a double hung sash, 4 ft. wide, with jamb linings, in 18 in. wall, and seat formed in recess.*

Answer 7. See diagram.

Question 8. *Two 14 by 6 by 46 lb. and two 10 by 5 by 29 lb. rolled steel joists meet on a 9 by 7 by 58 lb. rolled steel joist as stanchion, which is continued to an upper floor. Show plan and elevation, at junction, to a scale of* $1\frac{1}{2}$ *in. to 1 ft.*

Answer 8. See diagram.

Question 9. *A semi-circular brick arch, 6 ft. span, with 3 half-brick rings, occurs in a 9 in. wall. Assuming a distributed load of 1 ton per horizontal foot run over the arch, show line of thrust. Scale* $\frac{1}{2}$ *in. to 1 ft.*

Answer 9. See diagram.

Question 10. *Show, by elevation of top flange to unequal scales, how the lengths of the plates of a built-up girder are proportioned to the variation of bending moment. Assume the flange to consist of four* $\frac{5}{8}$ *plates, the inner one being in two lengths, and the angle irons equivalent to a* $\frac{3}{8}$ *plate.*

Answer 10. See diagram. A parabola is drawn from centre to centre of bearing surfaces with a height equal to thickness of plates and equivalent thickness of angle iron. The ends of plates are then stopped off half cover distance beyond parabola, the parabola being the curve of bending moments for a girder uniformly loaded. Note the unequal scales as drawn.

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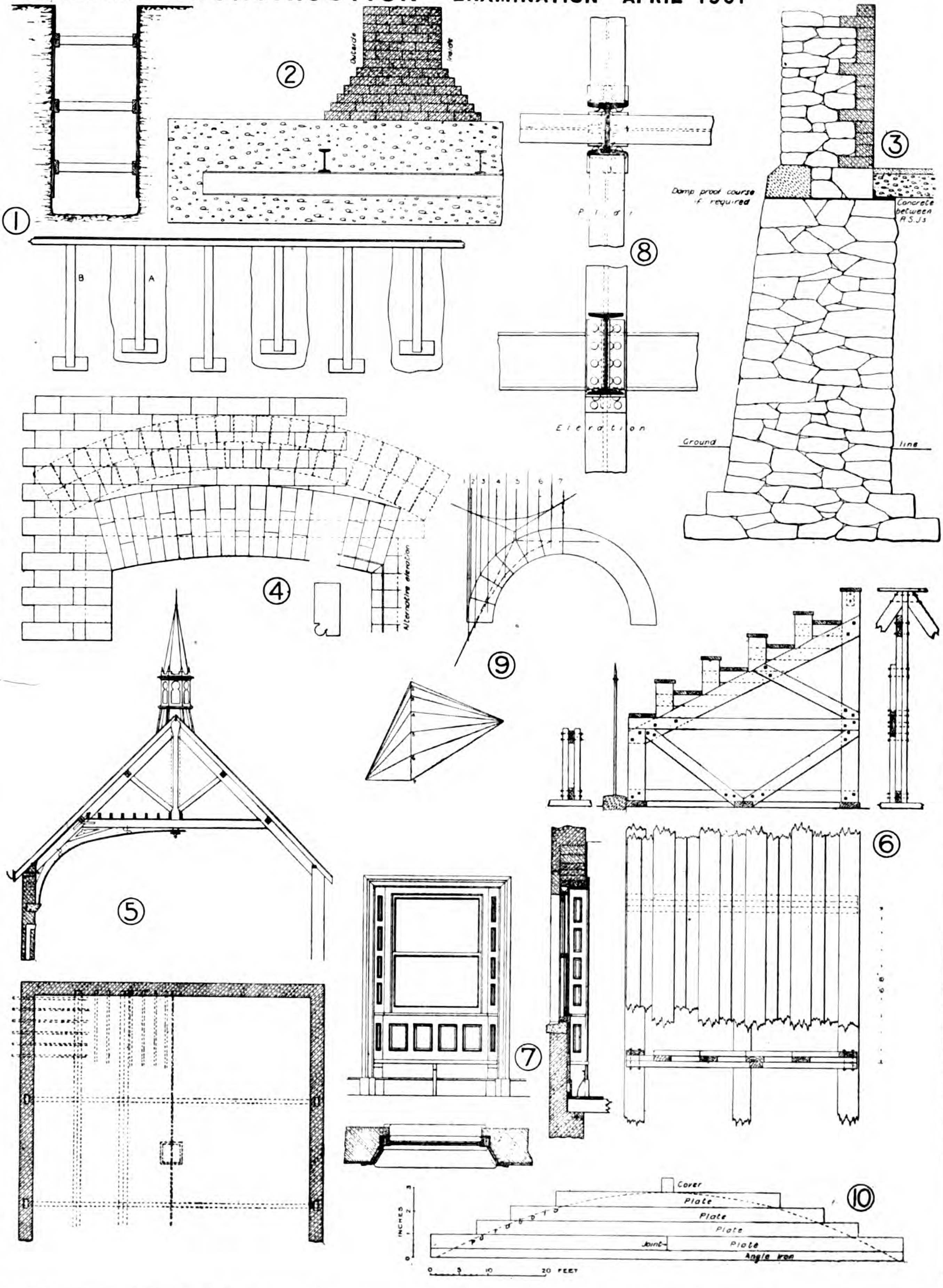


EXAMINATION, OCTOBER, 1901.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

OBLIGATORY.

Question 1. *Describe, with sketches, the operation of timbering and the precautions necessary in timbering and pumping the excavation to trenches in a wet soil.*

Answer 1. There are two chief methods of timbering in wet soils. In fig. 1a, vertical poling boards **A** called runners, bevelled at the bottom, are driven down slightly in advance of the excavation, and held in place by a waling **B** and struts **C.** When the excavation has reached the bottom of the first set, a second set of runners **D** is started, and when they are well entered they are kept in place by a similar waling and struts. As, however, the second set is not driven quite down to the feet of the first set, but left with a slight overlap, the excavation sometimes gets narrower as the depth increases, and allowance must be made for this. The other method is shown in fig. 1b, where horizontal poling boards **E** are used, put in one at the time and held by temporary struts **F.** When three or four of these horizontal boards are in, vertical walings **G** are inserted with larger struts **H,** as in fig. 1c, and the temporary struts **F** removed. If the soil is very sandy, as well as being wet, the joints of the poling boards have to be caulked or stopped with hay or fresh grass to prevent the sand from being carried away. The excavation should be made with a slight fall and a sump-hole made at the lower end for the insertion of the foot of a barge pump for drawing off the water. In larger excavations special appliances may need to be used.

Question 2. *Give section to a scale of $\frac{1}{12}$ through a pile and concrete foundation for an 18 in. brick wall on a peaty subsoil 15 ft. deep overlying clay.*

Answer 2. See diagram 2. The piles would be driven not less than 5 ft. into the clay.

Question 3. *Describe the laying of the bricks and the bonding in a thick wall. Show by sectional plan (scale $\frac{1}{12}$) how the brickwork is arranged in skeleton steel construction with brick filling.*

Answer 3. In a thick wall, whether the facing be in English or Flemish bond, the face bricks are carefully laid to keep the perpends with a true surface, and the interior is laid all headers with through joints on a thick bed of mortar, the mortar being squeezed up between the bricks by pushing them along, called larrying. In common work the bed of mortar is thinner and the interior bricks are laid dry and grouted every third or fourth course, but this does not make such good work. In walls of three bricks thick and upwards raking courses, diagonal or herringbone, are sometimes laid in every fourth course to increase the longitudinal strength. For brickwork in connection with skeleton steel construction see diagram 3.

Question 4. *A Queen Anne gauged brick arch occurs over a three-light window 9 ft. wide, the central bay having a semi-circular elevation. Show the outline of arch with bonding of a little more than one-half to a scale of $\frac{1}{8}$.*

Answer 4. See diagram 4. The bonding of the arch has been inadvertently continued further than asked for in the question.

Question 5. *Give a design (scale $\frac{1}{24}$) for centering suitable for use in the construction of a semi-circular brick arch 20 ft. span in a 3 brick wall. Describe how an invert arch is turned.*

Answer 5. See diagram 5 for centering. The centre is composed of two sets of frames connected by the laggings. In forming an invert arch the bricks below the arch are cut to fit a curved template the shape of the arch just as if they were being cut to fit on the top of an ordinary arch, and the invert arch is laid in half-brick rings from the centre to the skewbacks. The piers are then built up, carefully cut and bedded at the skewbacks to transmit the load to the inverts.

Question 6. *Give outline (scale $\frac{1}{48}$) with the requisite details and scantlings for the most economical roof for covering a shed 40 ft. span.*

Answer 6. See diagram 6, which is from Walmisley's paper on cheap roofs, read before the Surveyors' Institution. The diagram has been inadvertently drawn to half the required scale.

Question 7. *Explain the following kinds of stair:—Dog-legged, newel, geometrical, dancing. What proportion should the treads and risers for a staircase bear to each other?*

Answer 7. See diagram 7, where (*a*) is a dog-legged stair, (*b*) a newel, or open newel, stair, (*c*) a geometrical stair, or continuous handrail stair, and (*d*) the modification of the latter called dancing or balanced, where the fliers nearer the winders are intermediate in shape.

There are several rules for the treads and risers of staircases, viz. :—

1. Tread + rise = 16 to 17.
2. Tread × rise = 60 to 65.
3. Tread + 2 rise = 22 to 25.
4. $\frac{\text{Angle of string} + 42}{12}$ = rise.
5. $\frac{96 - \text{angle of string}}{6}$ = tread.

Question 8. *A roof 30 degrees pitch and 40 ft. long has a parapet wall and discharges into rain-water stack pipes at each end. Show plan of the gutter to a scale of $\frac{1}{48}$, and enlarged sections at a roll and drip.*

Answer 8. See diagram 8. The arris fillet in drip is to prevent the lead being split in dressing into the angle, and the groove on the face is to prevent capillary action between the two sheets of lead, the lower one being dressed into the groove and the upper one laid flat over it.

VOLUNTARY.

Question 9. *In warehouse construction a limit for cubic space is fixed by the Building Act. What is this limit, and how is it overcome in the case of larger buildings? Show by sketches how the communication openings are protected. Scale $\frac{1}{24}$.*

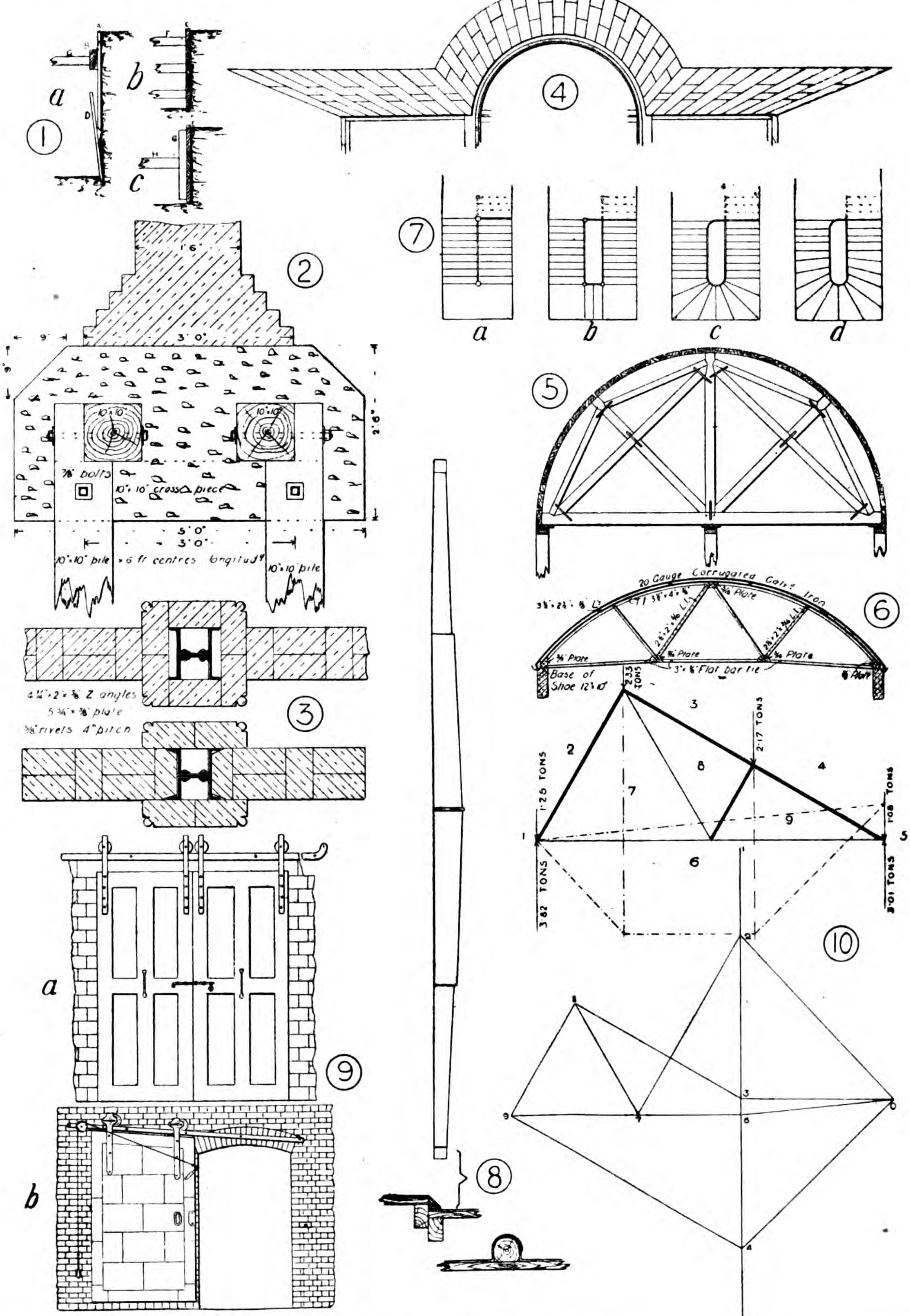
Answer 9. Warehouses were formerly limited to 216,000 cubic feet, equal to the contents of a cube of 60 feet side, but by the L.B. Act, 1894, they may contain 250,000 cubic feet in one block. If a larger warehouse be desired it must be divided up by party walls so that no portion exceeds 250,000 cubic feet, and the openings through the party walls must not be more than 7 ft. wide or 8 ft. high and protected with two wrought-iron doors properly constructed on opposite sides of the wall. Diagram 9 shows at (*a*) the ordinary $\frac{1}{4}$ in. wrought-iron doors and at (*b*) the modern fire-resisting door with thin sheet steel covering every part and automatic closing gear actuated by the melting of a very fusible alloy which forms part of the cord holding the door open.

Question 10. *Draw the elevation of a "north-light" or saw tooth roof truss, 20 ft. span and 10 ft. centre to centre, and show stress diagram for vertical loading. State how the load is made up. Scale $\frac{1}{4}$ in. to 1 ft. and 1 in. to 1 ton.*

Answer 10. See diagram 10. The total vertical load is taken at $\frac{1}{2}$ cwt. = 56 lbs. per ft. sup., made up as follows :—

Countess Slating ..	8	lbs. per square foot.
Slate Boarding ..	$2\frac{1}{2}$	,, ,,
Common Rafters ..	3	,, ,,
Snow	5	,, ,,
Wind, say	30	,, ,,
Purlins and Trusses (iron)	7	,, ,,
	$55\frac{1}{2}$	

BUILDING CONSTRUCTION EXAMINATION OCTOBER 1901



EXAMINATION, APRIL, 1902.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

Question 1. *Describe the various methods available for the removal of the material from a moderately deep excavation in a confined position, such as for a block of City offices.*

Answer 1. In the smallest jobs the material from the excavation would be basketed by manual labour, the baskets being of cane, carried on a man's shoulder, and holding about $1\frac{1}{4}$ cwt. In larger jobs the baskets would be lifted by a rope over a jenny (or gin wheel) or rubbish pulley, hung from scaffolding or shear legs, or by means of a simple whipping winch having a wood barrel 7 in. diameter and 2 ft. 3 in. long, with a handle fixed at each end 15 in. radius, or by an ordinary single purchase crab. Upon the same principle larger jobs would be dealt with by a steam crane lifting iron skips containing from $\frac{1}{3}$ to $\frac{1}{2}$ ton. Another method would be entirely by spade work, lifting the material by stages of 5 to 6 ft., the stages being formed of scaffold boards resting on the struts of the timbering. In all cases provision should be made for standing room for a cart while loading. Ramps are only available for barrows or carts when the site is extensive, and then the last portion of the excavation must be removed by one of the former methods.

Question 2. *Draw to a scale of $\frac{1}{8}$ the plan of a 3-brick wall in double Flemish bond with a 2-brick party wall. Show the joints by single lines, and add the outlines of each course of the footings. Show by separate plan just sufficient of an adjacent course to indicate the bonding at the junction of the walls.*

Answer 2. See drawing No. 2. The bonding of the party wall not being stated, equal credit was given for either English or Flemish.

Question 3. *Show in sectional plan and elevation modern half-timbering with brick backing, as permitted by the London Building Act. Scale $1\frac{1}{2}$ in. to 1 ft. What are the conditions under which this may be used?*

Answer 3. The model bye-laws which apply to urban districts allow of the external walls of buildings being constructed of timber framing provided that the new building is at least 15 ft. distant from any adjoining building not being in the same curtilage. The timber framing must be properly put together with at least $4\frac{1}{2}$ in. of brickwork at the back of every portion of timber, properly bonded with the brickwork filling the spaces between timbers. If the building is part of a block of dwelling houses not exceeding three in number the regulations are as above, with the addition of proper brick party walls between each building, and projecting at least one inch beyond timber framing at each end. In best work good oak only should be used not less than 6 in. by 6 in. for uprights, and other parts proportionately stout, and fixed with oak pins left projecting $\frac{1}{2}$ in. The oak should have an adzed face, and be left as nearly as possible in its natural condition though the ends must be sawn to obtain close joints. Bent pieces are used for braces and brackets. After preparation all the pieces may be well oiled with linseed oil, which will oxidise and form an impervious coating. Barge boards and strings may be carved or ornamented with incised work. The plaster may be flush with face of timber, but is generally recessed $\frac{1}{2}$ in. In addition there must be no timber built in within 18 in. from inside of any flue, nor abutting against brickwork within 6 in. from inside of any flue, and all brickwork must be of the requisite thickness according to length and height irrespective of the timbering. For details of construction see fig. 3.

Question 4. *Show by sketches what is meant by lacing courses in a brick arch. How is the angle of a skewback determined? Where and how is hoop iron bond used?*

Answer 4. Lacing courses are carefully built gauged-brick courses in a common brick arch of two or more rings as in fig. 4. The direction of a skewback is always radial, *i.e.*, drawn from the centre from which the arch is struck and the angle is measured from the horizontal. The angle is only named, however, in the case of a straight arch, where the angle is usually 60 degrees. Hoop-iron bond is used wherever an increased longitudinal strength is required in a brick wall, such as on bad foundations or where the wall is much cut up by openings. It may be laid in single courses, one line to each half-brick thickness, or may be used in two or three adjacent courses, immediately above damp proof course, over arches, under window openings, at the angles of buildings, or where party or cross walls join. Joints in the same line, or at right angles, are made by hooking the two pieces together. The best is Tyerman's patent stabbed hoop iron. The iron should be tarred and sanded before laying, and must not be placed where moisture would reach it.

Question 5. *A tiled roof has a span of 20 ft. and pitch of 60 degrees. Give drawing of truss and mark the scantlings, the trusses being 10 ft. centre to centre. Scale $\frac{1}{48}$.*

Answer 5. For answer see fig. 5.

Question 6. *Sketch and describe the different forms of tenon and mortise joints for indoor and outdoor work.*

Answer 6. Tusk tenons are used when trimming round an opening as for a fireplace, lift-way, staircase, chimney stack, etc. Dovetail and foxtail tenons are used when framing into a timber already fixed. Shouldered, double and twin tenons are used in framing doors. Stump or stub tenons are used for posts and sheds. Plain tenons with wedges are used for common framing. Pinned tenons are used when the framing may require taking to pieces. The joints are put together with glue for indoor work, and with white lead paint for outdoor work. All pin holes are draw-bored. See drawing, fig. 6.

Question 7. *A lantern light over a billiard room has side sashes to open for ventilation, give section through one side, scale $\frac{1}{12}$, showing provision to keep out the weather. Show or describe the mode of opening.*

Answer 7. For answer see fig. 7. The sash is opened by top and bottom cords fixed to a cleat, or patent brass roller and screw.

Question 8. *Show full size a $\frac{3}{4}$ in. rivet, 3 in. long, and a $\frac{3}{4}$ in. bolt, nut and washers, 10 in. wood measure, for carpenters' work.*

Answer 8. For answer see fig. 8.

Question 9. *A cast-iron column, 12 in. diameter, and a mild steel stanchion, 10 in. square over all, are to be encased to render them more fire-resisting. Show by sketches how you would recommend this to be done.*

Answer 9. For answer see fig. 9.

Question 10. *A wood beam, 8 ft. span, has three loads, 2, 4 and 6 cwts. respectively, placed 2 ft. apart. Draw a diagram of the bending moments, and give the section of beam when safe distributed load* $=\frac{bd^2}{L}$

Answer 10. For answer see fig. 10.

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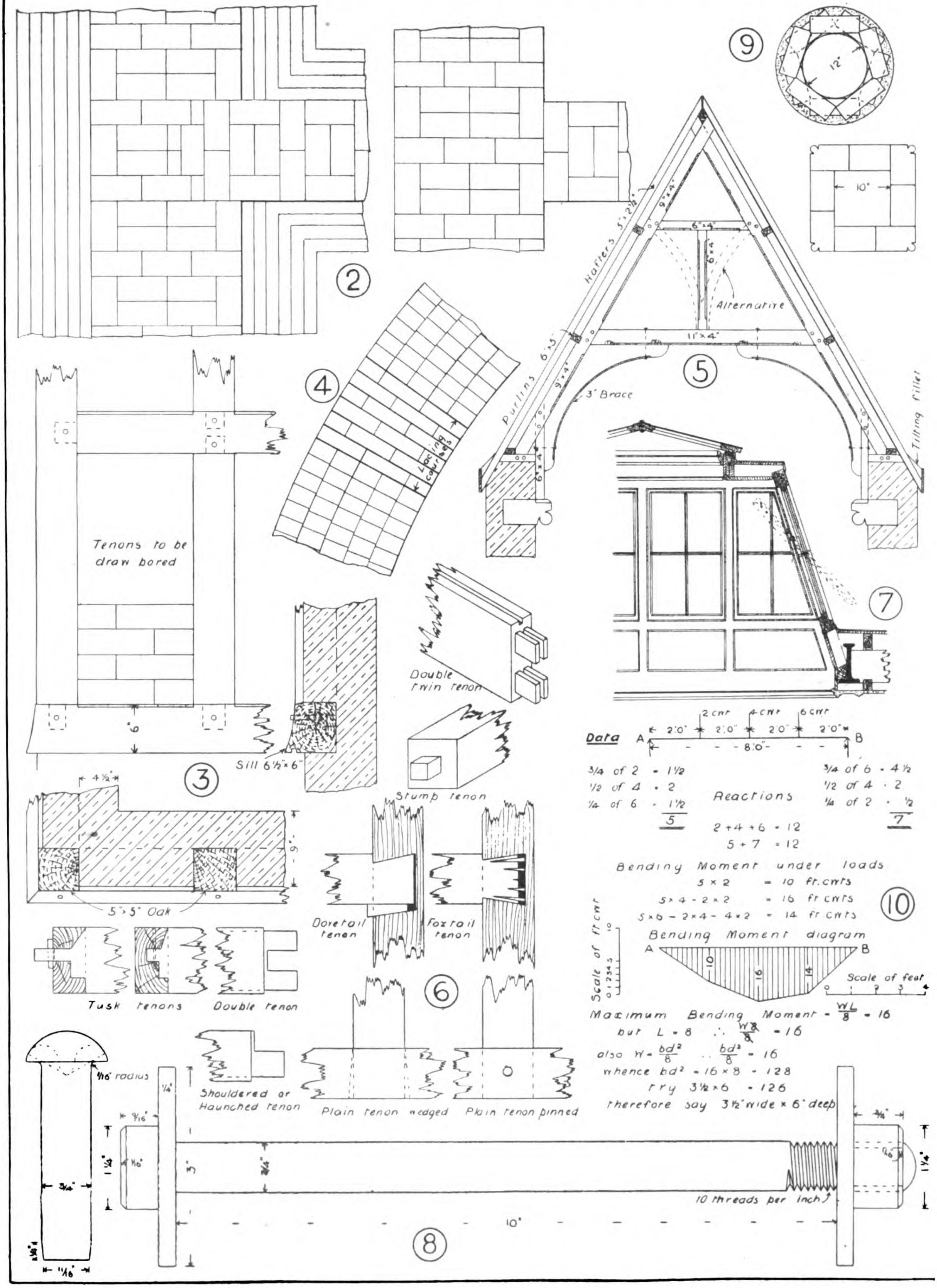


EXAMINATION, OCTOBER, 1902.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

OBLIGATORY.

Question 1. *State what load per foot superficial could be safely placed upon the following soils :*—(a) *made ground ;* (b) *wet sandy gravel ;* (c) *hard compact gravel ;* (d) *loamy clay ;* (e) *deep clay ;* (f) *solid chalk. State whether any special precautions are needed in dealing with either of these cases.*

Answer 1.	(*a*) Made ground ..	$\frac{3}{4}$ ton per ft. sup.
	(*b*) Wet sandy gravel	$1\frac{1}{2}$	,,
	(*c*) Hard compact gravel	3	,,
	(*d*) Loamy clay ..	$1\frac{1}{2}$	,,
	(*e*) Deep clay ..	5	,,
	(*f*) Solid chalk ..	3	,,

Made ground should not be built on for at least three years after deposit and exposure to the weather, and then the footings should be spread wider than usual, the concrete below them reinforced by iron rods, and the site covered with 6 in. of cement concrete.

Wet sandy gravel should be thoroughly drained by field pipes before commencing to build. If it is impossible to drain it thoroughly the site should be surrounded by close sheet piling, the surface at the required depth covered with at least 6 in. of cement concrete, and the loads above it uniformly distributed.

Hard compact gravel is the best foundation to build upon and requires no other preparation besides levelling.

Loamy clay is not generally a bad soil to build on, but requires care. The bottom of footings should be 4 or 5 ft. below the surface, and any springs should be carefully led away from the foundations by field pipes.

Deep clay gives a good foundation when it is not intersected by wet horizontal layers. The footings must be at least 10 ft. deep, unless provision be made for alternate expansion and contraction due to variations of moisture contained by the clay. If a concrete raft, reinforced by iron rods, covers the whole site the foundations may be as little as 5 ft. deep, but otherwise the walls will shift and crack.

Solid chalk forms a good foundation and only requires levelling. If on a slope, provision should be made for carrying away surface water by a trench cut on the upper side.

Question 2. *A seaside hotel is proposed to be built on sandy soil containing only thin layers of gravel to a known depth of* 25 *ft. Supposing the site to be* 120 *ft. square, describe with sketches the preparation you would make for the foundation. The surface of the ground has a fall of* 1 *in* 30 *and the average height above high-water mark is* 7 *ft.*

Answer 2. See diagram 2.

Question 3. *Give design for an ornamental brick apron below a window,* 3 *ft.* 9 *in. wide. Show the bonding, and state in what material the bricks are laid. Scale,* 1 *in. to* 1 *ft.*

Answer 3. See diagram 3.

The apron should be of red rubbers, set in (*a*) mastic composed of powdered brick (of the same kind), mixed with boiled linseed oil and litharge ; or (*b*) plasterers' putty composed of pure lime slaked to a cream and run through a sieve ; or (*c*) patent knotting and white lead mixed to a cream paste ; or (*d*) if there is no carving good mortar without lumps and reduced to a cream may be sufficient.

Question 4. *Show elevation and section of part of a boundary wall,* 6 *ft. high, in rubble stone with plinth and coping. Name the kind of rubble work shown. Scale,* $\frac{3}{4}$ *in. to* 1 *ft.*

Answer 4. See diagram 4.

Question 5. *A lathed and plastered partition,* 10 *ft. high, on an upper floor is required to be self-supporting, and to carry a distributed load of* 10 *tons on top over a span of* 16 *ft. There will be a door* 3 *ft. wide,* 2 *ft. from one side. Show the trussing and mark scantlings. Scale* $\frac{1}{2}$ *in. to* 1 *ft.*

Answer 5. See diagram 5.

Question 6. *Show by plan and section how the rafters,* 4 *ins. by* 2 *ins., are trimmed round a half-brick chimney stack containing three flues, each* 14 *in. by* 9 *in., in a roof sloping* 30 *degrees. Scale,* $\frac{3}{4}$ *in. to* 1 *ft.*

Answer 6. See diagram 6.

Question 7. *Show by sketches what is meant by the following terms :—" lying panel," " raised panel," " frieze panels," " diminished style," " bolection moulding," " dovetailed backings to jamb linings."*

Answer 7. See diagram 7.

Question 8. *Give full-size section of an ogee cast-iron rain-water gutter. Describe how it is jointed, how fixed, what fall, how far apart the down pipes, how connected to down pipes.*

Answer 8. For section see diagram 8.

One end of each length is made large enough to take the end of the next length with a flush joint inside. Before putting together the abutting surfaces are coated with red lead putty and bolted together. The guttering is fixed to the gutter board or fascia board by means of wood screws through the back, but brackets or holdfasts underneath the gutters are a desirable addition. The holes being plugged with red lead putty before putting the screws in, the putty squeezes out and prevents leakage past the screws. The fall to the down pipe should be $\frac{1}{2}$ in. to each 6 ft. length. The distance apart of the down pipes should depend upon the size of the roof, one being required for say every 300 ft. sup. The connection between the gutter and the down pipe is made by an outlet cast on the gutter inserted in a hopper head or swan neck at the top of the down pipe.

VOLUNTARY.

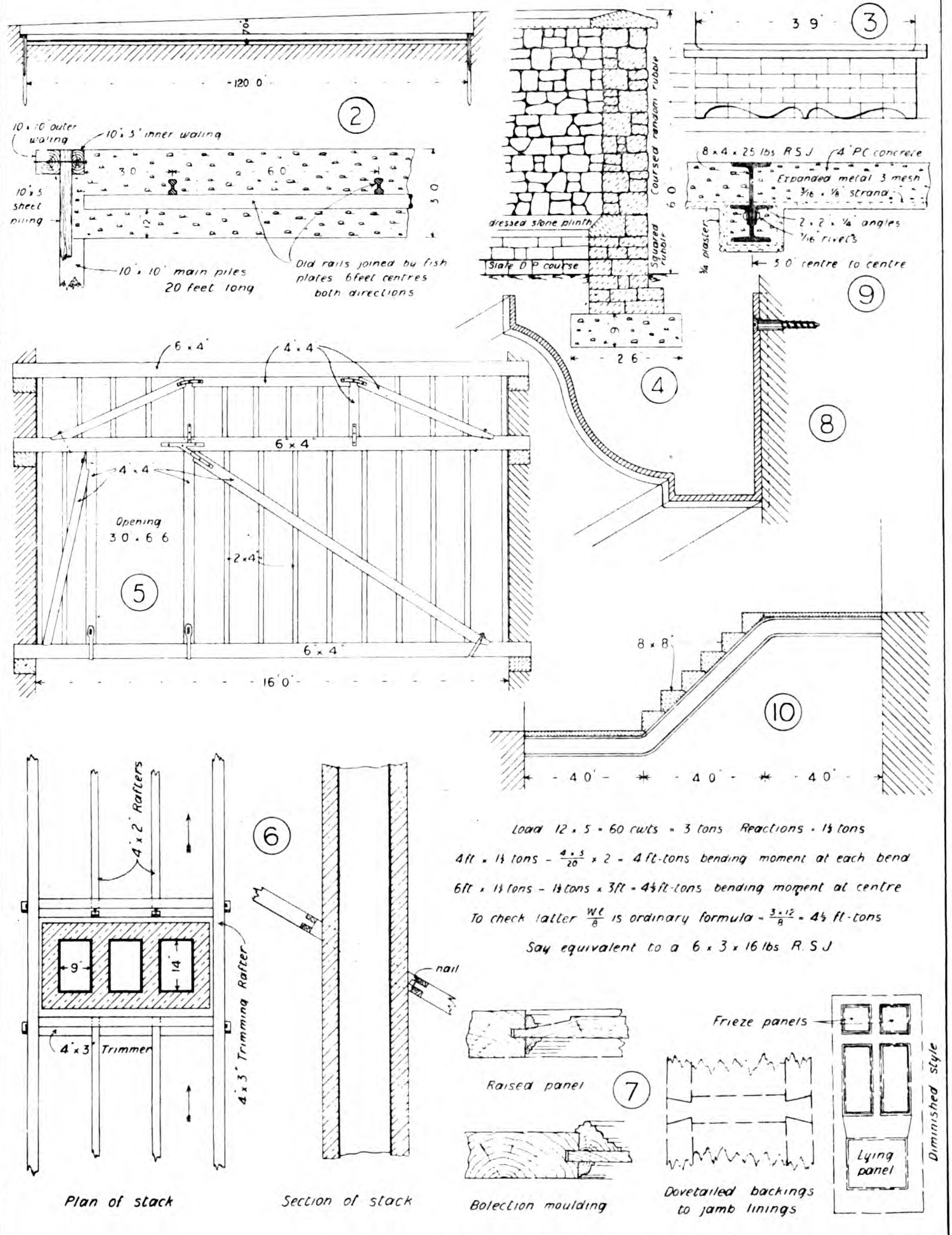
Question 9. *Show by sketches what you consider to be a good fire-resisting floor for a span of* 16 *ft., allowing for an external load of* $1\frac{1}{4}$ *cwt. per foot, superficial.*

Answer 9. See diagram 9.

Question 10. *Two bent rolled joists support short landings and an intermediate flight of six* 8 *in. by* 8 *in. steps, the distances being, say,* 4 *ft. horizontal,* 5 *ft.* $7\frac{1}{2}$ *in. at* 45 *degrees, and* 4 *ft. horizontal. Allowing a load of* 5 *cwt. per foot run horizontal, what will be the bending moment on the joists in the centre and at each bend ?*

Answer 10. See diagram 10.

BUILDING CONSTRUCTION EXAMINATION OCTOBER 1902



EXAMINATION, APRIL, 1903.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

Question 1. *Describe the operation of testing the suitability of a soil for foundations by boring.*

Answer 1. When a heavy structure is to be built upon an unknown subsoil it is necessary to make sure of the foundations by digging trial holes or by boring. The operation of boring will differ slightly according to the material expected, for instance, if the soil contains stone boulders the jumpers for breaking it up for lifting must be + shaped at the end and especially hardened. In ordinary cases various forms of augurs are used, say 3 in. diameter, and rotated by levers, being increased in length by rods screwed on the top as the point recedes from the surface. The most notable form of augur is the *miser*, so called because it "gets all it can and keeps all it gets." It is something like a tin can with the bottom cut and bent to a spiral or nose-bit shape, so that when rotated it cuts into the earth below and when lifted brings up its contents. The contents being laid out on the surface are carefully examined and their nature recorded, the distance below the surface being obtained from the measurement of the rods. A scale section is then made as in fig. 1, *a* and *b*.

Question 2. *The walls at the base of a high brick tower are 3 ft. 9 in. thick. Show to scale of ¾ in. to 1 ft. what footings you would recommend, the thickness of concrete and the distance below the surface.*

Answer 2. The width at bottom of footings would be the same as for an ordinary wall, viz., twice thickness of wall and set-off 2¼ in. in each course. Occasionally double courses are adopted and sometimes double the number of single courses with only 1⅛ in. set-off. The latter method involves cutting the bricks, and generally speaking it will be quite sufficient if the ordinary footings are put in but with the bottom course double. The projection of concrete beyond the brickwork would be at least 6 in., but if the soil were such that the pressure upon it must be reduced below 1½ tons to the square foot, the concrete would need to be further extended. As a wall carrying a load is usually so proportioned that the base immediately above the footings carries 3 tons per ft. sup. the thickness of a wall is a measure of the load upon it. When the concrete is extended beyond the usual 6 in. its thickness must be increased, so that the projecting part acting as a cantilever, pressed upwards from below, shall not break off. This is obtained by carrying a line downwards from outer angle of footings at 60 degrees from the horizontal to cut the side of concrete, when the intersection gives the minimum depth. See fig. 2. If necessary the concrete may be carried deeper than this to reach a good bearing stratum of gravel or hard clay. The distance of bottom of concrete below the surface is partly decided by the nature of the subsoil as above and partly by the surface soil. When the surface soil is clay the foundations of any important structure must be carried down at least 10 ft., in order to get below the shifting due to expansion and contraction from variation of contained moisture, and in ordinary buildings 5 ft. is the minimum depth.

Question 3. *A three-light window with openings 2 ft. and 3 ft. is surmounted by semi-circular gauged brick arches. Show half elevation of two of the arches meeting on the head of a 9 in. pier, with the bonding. Scale. 1 in. to 1 ft.*

Answer 3. When the width of skewback is insufficient to allow full width of both arches the joints are continued as uniformly as possible in the two arches, the junction being formed by alternate vertical centre joints and saddle bricks cut in a mould. See fig. 3.

Question 4. *Give section through a stone cornice and blocking course, the cornice to project 18 in. Describe the direction of the natural bed in each stone. Scale, 1½ in. to 1 ft.*

Answer 4. The natural bed will as a rule be placed perpendicular to the direction of the pressure, being horizontal in a wall and radial in an arch stone. In the case of an undercut cornice it is, however, necessary to place the natural bed vertical and perpendicular to the face in order to prevent portions of the moulding from dropping off. In such a case the weathered top requires protecting with sheet lead to prevent the ingress of moisture between the planes of stratification. See fig. 4.

Question 5. *Show by sketches the difference between a single floor, a double floor, and a framed floor.*

Answer 5. In a single floor there are no ceiling joists. A double floor has common joists resting upon binders. A framed floor consists of common joists, binders and girders into which the binders are framed. See drawing, fig. 5.

Question 6. *Give a little more than half the elevation of a queen post roof truss for a span of 42 ft. Scale $\frac{1}{4}$. Show enlarged sketch of joints at head of queen post.*

Answer 6. For answer see fig. 6.

Question 7. *Give elevation of a double margin oak entrance door, 4 ft. by 8 ft. 6 in., dotting the tenons. Scale, 1 in. to 1 ft.*

Answer 7. For answer see fig. 7.

Question 8. *Show by full size section how glass is fixed in a glazed swing door and a double hung sash.*

Answer 8. For answer see fig. 8.

Question 9. *Give (a) sectional plan and (b) elevation of top 3 ft. of a steel lattice stanchion composed of two 12 by 3½ channel bars. Scale, 1½ in. to 1 ft.*

Answer 9. For answer see fig. 9.

Question 10. *A triangular cantilever bracket is 1 ft. deep and projects 3 ft., it is loaded uniformly along the top with 15 cwt. Show by reciprocal diagram what are the reactions and the stresses in the various parts. Show graphically the bending moment in the top member due to the loading. Scales, 1 in. to 1 ft., 5 cwt. to 1 in., and 10 ft.-cwt. to 1 in.*

Answer 10. For answer see fig. 10.

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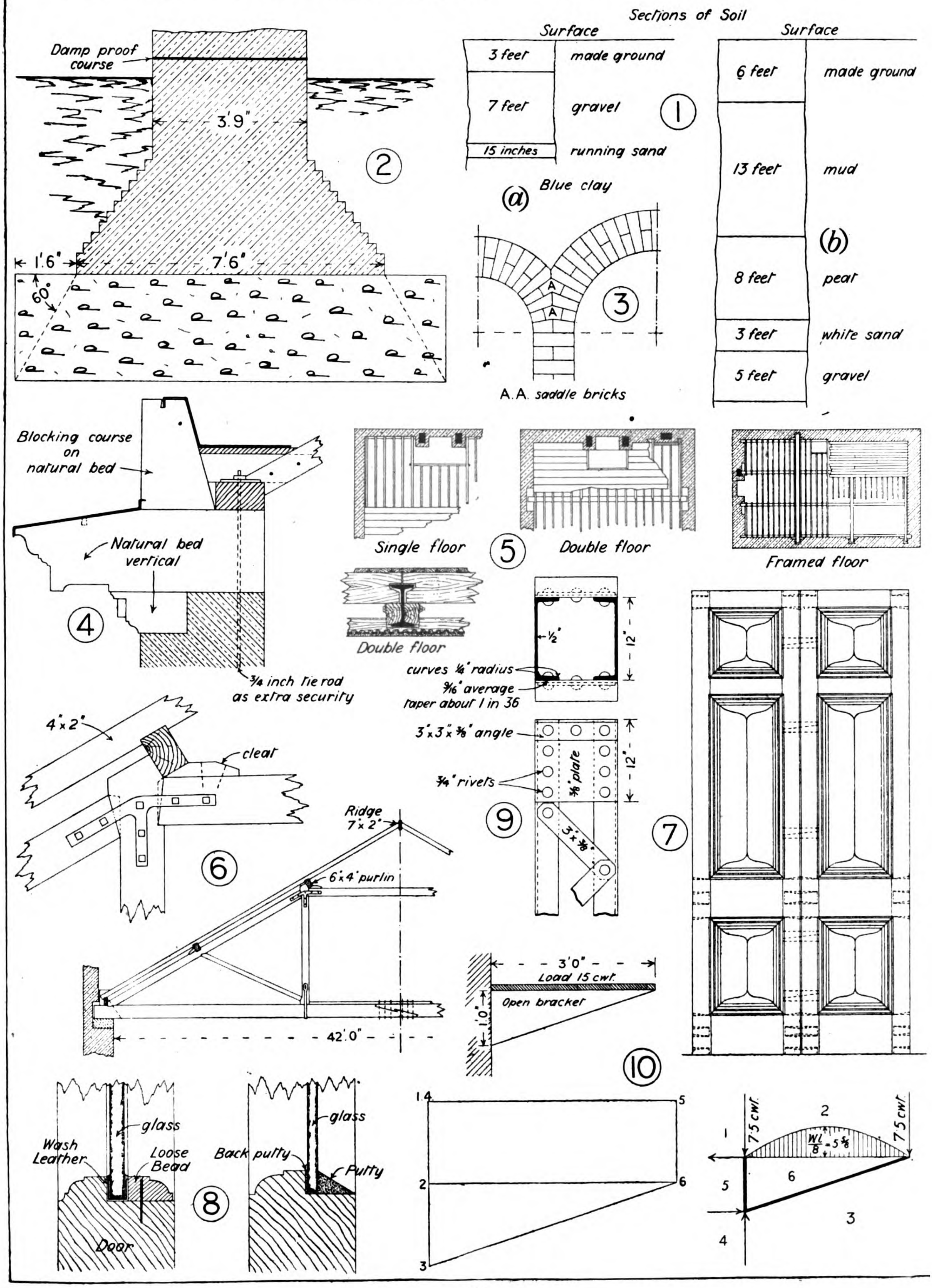

EXAMINATION, OCTOBER, 1903.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

Question 1. *Sketch the timbering for a pier hole 6 ft. by 4 ft. by 6 ft. deep in loose dry ground.*

Answer 1. See diagram.

Question 2. *Show by sketches three methods of preventing moisture in the soil from rising into a brick wall :* (a) *an ordinary* 14 *in. wall,* (b) *a* 16 *in. cavity wall,* (c) *an* 18 *in. basement wall.*

Answer 2. (*a*) See diagram 2 (*a*). The damp proof course may consist of—sheet lead lapped at joints, a double course of slates in cement, Callender's bitumen, asphalte or neat cement, glazed ventilated stoneware tiles. (*b*) See diagram 2 (*b*). (*c*) See diagram 2 (*c*).

Question 3. *Show by sketches what is meant by the terms scheme arch, jack arch, French arch, Welsh arch.*

Answer 3.

A scheme arch is one which, while starting off a level bed, has a less rise than a semicircular arch. See diagram 3 (*a*).

A jack arch is a rough arch turned over a small opening, and either axed or plain. See diagram 3 (*b*).

A French or Dutch arch is a face arch with straight soffit but the bricks not cut to wedge shape. See diagram 3 (*c*). It usually occurs in cheap buildings and is rendered in cement.

A Welsh arch is formed by cutting the bricks over the outlet from a gutter cesspool to a rain-water head, as diagram 3 (*d*).

Question 4. *Draw,* $\frac{1}{4}$ *in.* = 1 *ft., the upper part of gable wall built of rubble stone, brought up to courses, and surmounted by a wrought stone coping with apex stone, kneeler, and footstone.*

Answer 4. See diagram.

Question 5. *A trussed partition,* 25 *ft. span,* 12 *ft. high, placed across the joists at first floor level, has a doorway on each side* 4 *ft. by* 8 *ft. Give elevation of a little more than half and mark the scantlings to enable it to carry its own weight with lath and plaster.*

Answer 5. See diagram.

Question 6. *A floor is composed of* 12 *by* 6 *by* 39 *lb. rolled steel joists,* 9 *by* 3 *fir joists, and* $1\frac{1}{4}$ *in. batten flooring with a lath and plaster ceiling continued round the lower part of steel joists. Show section,* $1\frac{1}{2}$ *in. to* 1 *ft., at one of the steel joists.*

Answer 6. See diagram.

Question 7. *Give horizontal section, half full size, through the side of the frame for* 2 *in. double-hung sashes, name the parts, and indicate position of window opening.*

Answer 7. See diagram.

Question 8. *Give full size section of a plumber's wiped joint in* $1\frac{1}{2}$ *in. lead pipe.*

Answer 8. See diagram.

Question 9. *Sketch the arrangement of two modern varieties of fireproof floors and describe the peculiar advantages of each.*

Answer 9. In Dawnay's solid fireproof tile floor, the tile is made somewhat similar in section to a cast-iron girder, as the resistance of burnt clays is very much like that of cast-iron in tension and compression. Diagram 9 (*a*) shows cross section and longitudinal section of the complete floor. In the Koenen uniform resistance fireproof flooring steel rods are arranged to take the tension while the concrete takes the compression and shearing. The arrangement is shown in diagram 9 (*b*), and is based upon true theoretical principles for obtaining the lightest possible steel-concrete floor.

Question 10. *What is meant by Bending Moment, Moment of Inertia, and Modulus of Elasticity.*

Answer 10.

"Bending Moment" is the moment of the external forces on one side of a transverse section estimated relatively to the section. It is the measure of the effect of the load and its leverage.

"Moment of Inertia" is the summation of the areas of all the individual parts of a section multiplied by the squares of their distances from the neutral axis. It is the resisting value of a section according to the arrangement of its area.

"Modulus of Elasticity" is the ratio of the stress per unit of section to the strain per unit of length. If the strain or elongation proceeded uniformly, it is the load per square inch that would stretch a bar to twice its original length.

EXAMINATION, MARCH, 1904.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

Question 1. *Give cross section one-eighth full size from bottom of excavation through completed subsoil drain under a house. State the distance apart the drains should be laid, and the materials employed.*

Answer 1. See diagram 1. The subsoil drains should be of agricultural pipes, *i.e.*, plain earthenware pipes without sockets, or of socketed stoneware pipes laid dry, *i.e.*, without jointing material, and rubble chalk, gravel, clinker or other open material filled in above the pipe, with a layer of pea gravel, straw, or faggots over that to keep the earth out. The distance apart of these drains would be from once to four times their depth according to circumstances, and they would generally lead into a main drain. If discharging into a sewer or house-drain a disconnecting trap must be inserted at the junction, and this should be accessible for cleansing in the event of silting up.

Question 2. *A brick chimney shaft* 150 *ft. high is* 16 *ft.* $1\frac{1}{2}$ *in. square at the bottom of the footings, and weighs* 400 *tons. Show what foundations you would put in, the surface of concrete being* 7 *ft. below ground level, and the soil underneath consisting of alternate layers of ballast and sandy clay. Scale,* $\frac{1}{4}$ *in.* = 1 *ft.*

Answer 2. See diagram 2. A rough calculation should be made for maximum pressure at outer edge of concrete due to load and effect of wind. Say concrete 24 ft. square, 6 ft. thick. Dead load per square foot $= \frac{400 + (6 \times 24^2 \times \cdot 06)}{24^2}$ = say 1 ton. Bending moment from wind pressure say $\frac{150 \times 7 \times \cdot 6 \times 36 \times 75}{2240}$ = say 750 foot tons, $P = w + \frac{M}{Z} = 1 + \frac{750}{\frac{1}{6} \times 24^3} = 1 \cdot 33$ tons

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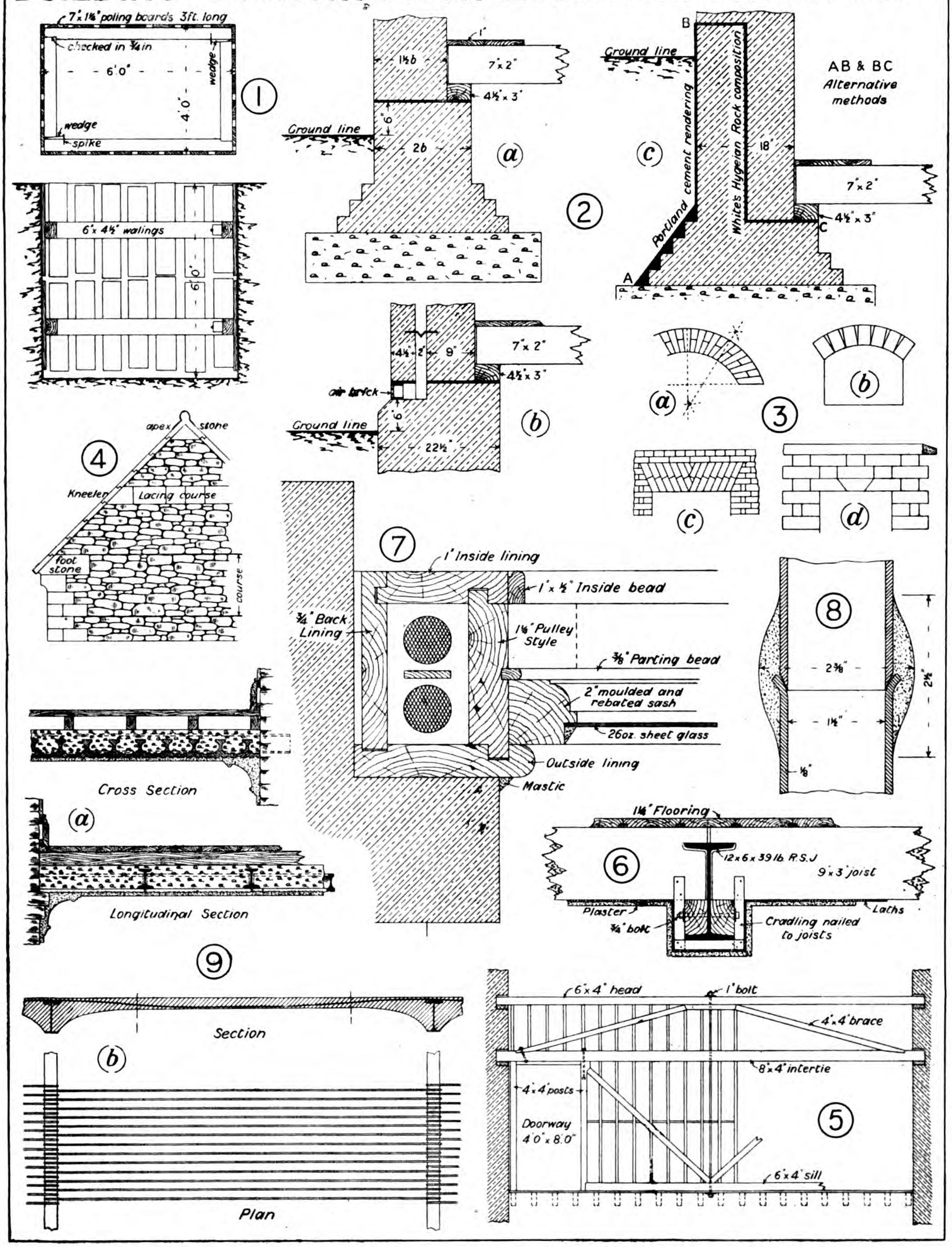

per sq. ft., which will be about right for the soil named. Some of the weight and cost of the concrete may be saved by reinforcing it with steel bars or rolled joists, making it say 3 ft. thick with $3\frac{1}{2} \times 1\frac{1}{2} \times 6$ lb. rolled steel joists, 4 ft. centres in both directions.

Question 3. *An 18 in. wall in English bond has an inverted arch 6 ft. span, 12 in. dip. Draw rather more than half the arch in elevation and section with the usual footings. Scale, $\frac{3}{4}$ in. = 1 ft.*

Answer 3. See diagram 3.

Question 4. *Sketch to a scale of $\frac{1}{2}$ in. = 1 ft. the elevation of a masonry wall in snecked rubble, showing a portion about 8 ft. square. Mark the snecks, jumpers, and bond stones by initial letters.*

Answer 4. See diagram 4.

Question 5. *Draw in elevation a "wing frame" fitted with door and casement window, the overall dimensions being 8 ft. high × 4 ft. 7 in. wide, the height to underside of casement sill 3 ft. The door to be 6 ft. 6 in. × 2 ft. 4 in., upper part glazed, and small fanlight over. Scale, $\frac{1}{2}$ in. to 1 ft.*

Answer 5. See diagram 5.

Question 6. *Draw an isometrical projection of the naked flooring round the trimmer arch for a fireplace opening 3 ft. wide, the joists being at right angles to the fireplace and 14 ft. span. Scale, 1 in. to 1 ft.*

Answer 6. See diagram 6.

Question 7. *Give sketches showing the following details: Hammer-headed key, double-faced skirting, two methods of connecting sash-bars at their junction.*

Answer 7. See diagram 7. (*a*) shows hammer-headed key used in curved door styles, (*b*) shows double-faced skirting, (*c*) shows common method of connecting sash-bars, (*d*) shows the method known as franking.

Question 8. *Give sketch of the plumbers' work for the following connections:—Ground floor, two wash basins; first floor, lavatory basin and bath; second floor, nursery sink; all near external wall. The separate wastes to be trapped and ventilated, and let into a 2 in. main waste, ventilated and discharging over a gulley.*

Answer 8. See diagram 8, but the waste-pipe on first and second floors should have been shown with more fall.

Question 9. *A fire-resisting floor is required over a span of 30 ft. Give approximate size and centre distance of main girders, and state how you would construct the floor between them.*

Answer 9. See diagram 9. The concrete to be composed of 1 part Portland cement to 1 part sharp sand and 4 parts of coke breeze, pumice stone, hard brick, clinker or slag, of varying sizes, but all to pass a 1 in. ring.

Question 10. *Draw stress diagram for a king post truss, 30 ft. span, with the wind on one side. Assume dead load on truss = 60 cwt., and wind 2 cwt. per foot run normal to roof plane. Scale, $\frac{1}{8}$ in. to 1 ft. and 20 cwt. to 1 in.*

Answer 10. See diagram 10.

EXAMINATION, OCTOBER, 1904.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

Question 1. *It is necessary to underpin an 18 in. wall to a depth of 6 ft.; describe with sketches and measurements the mode of doing this.*

Answer 1. If the ground is at all loose or the wall defective, the latter must first be shored up with raking shores to avoid risk of accident. The ground may then be excavated alongside wall to the level of bottom of footings, or concrete, if latter exists, and timbered to support the earth. There are then two alternatives (*a*) to needle the wall and do the whole underpinning at the same time as fig. 1*a*, (b) to excavate alternate spaces in front of and below the foundations, and fill in new work before opening intermediate parts as fig. 1*b*. Where the soil is loose (*a*) will probably be better and (*b*) where it is firm. The underpinning may consist of Portland cement concrete alone when the original concrete is left in, but if the original concrete and footings are removed, the underpinning should consist of hard brickwork in cement with the usual footings and concrete below. The junction is made tight by wedging in slates set in cement, or by grouting in liquid cement with a few inches head. The order of working for alternate excavation might be as numbered in fig. 1*b*. If the wall is sound the width of each portion along the wall may be 4 ft. 6 in. and the distance out say 2 ft. 6 in., but if the wall is in bad condition these dimensions may have to be reversed, both dimensions are shown in section fig. 1*c*.

Question 2. *Draw to a scale of $\frac{3}{4}$ in. = 1 ft. the plan of the foundations for a 14 in. party wall containing chimney breasts on both sides, with 3 ft. 6 in. opening for kitcheners and 9 in. jambs.*

Answer 2. See diagram 2. When an alteration of design is desirable it may be shown by an alternative arrangement as in fig. *b*.

Question 3. *An external door opening is finished with bullnosed blue brick jambs and arch. The arch is 4 ft. span and 4 in. rise. Draw to scale of 1 in. to 1 ft. an elevation of half the arch and part of the jamb in English bond.*

Answer 3. See diagram 3. The round angle must be mitred as shown in order that the curves may be identical at the junction.

Question 4. *Show by sketch the difference between "reticulated" and "vermiculated" in the face-work of masonry. What is "boasting" in masonry?*

Answer 4. See diagram 4. Boasting is a rough tooling with a boaster or broad chisel, making bats or marks 2 in. wide. Capitals to be carved, and deeply undercut cornices, are first roughed out with a boaster.

Question 5. *A common stud partition 9 ft. high runs across the joists; show elevation of naked timbers at the side of a 3 ft. doorway, with detail of the joints. Scale, $\frac{1}{2}$ in. = 1 ft.*

Answer 5. See diagram 5.

Question 6. *Show by plan and section how the common rafters are framed round a dormer in a roof. Scale, $\frac{1}{2}$ in. = 1 ft.*

Answer 6. See diagram 6 for plan and section.

Question 7. *Draw $\frac{3}{4}$ in. = 1 ft. the elevation and section of a good interior 2 in. six-panelled door, 3 ft. 3 in. by 7 ft., with an over-door.*

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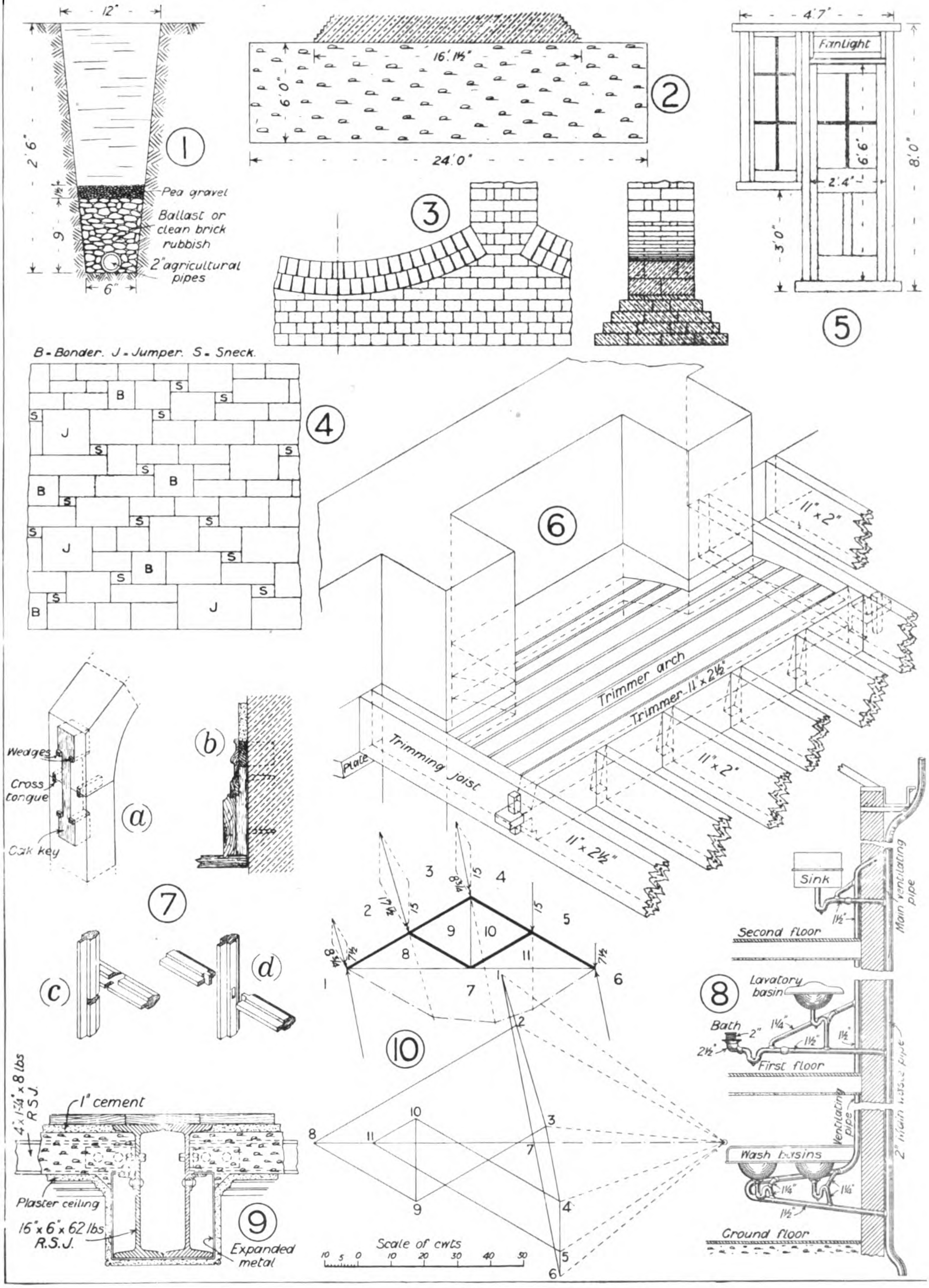

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Answer 7. See diagram 7. This is by one of the candidates and shows how the work should be left, enough being shown to indicate the full construction but not necessarily completed in detail.

Question 8. *Give section 3 in. to 1 ft. through any modern form of dry glazing for roofs, and state how it is finished off at the ends.*

Answer 8. See diagram 8 of Rendle's Invincible Glazing. The glass overlaps the support at the lower end with lead flashing underneath it and an iron or copper clip to prevent sliding ; the capping roll and water bar simply terminate flush with edge of glass ; or the clips may be made in a double casting to pass each side of roll and cover the end, forming a clip at side of each sheet of glass. The cross section only, with description, would have answered the question.

Question 9. *An inside staircase is required to be fire-resisting; describe and sketch the mode in which you would propose to construct it.*

Answer 9. See diagram 9. Stone staircases are not fire-resisting, all that can be said for them is that they are incombustible and not inflammable as wooden staircases are. A good arrangement is a concrete staircase built up in place with tee iron through each step, and at intervals through the landings. The concrete should be formed of Portland cement, sand, and small broken limestone in the proportion of say one cement, one sand and four stone, put in by specialists, such as B. Ward & Co. If preferred the steps can be formed singly and built up as in stone.

Question 10. *Give elevation of a northern-light iron roof-principal, 20 ft. span, and draw a stress diagram for vertical loading. Scale, ¼ in. to 1 ft. and ½ in. to 1 ton.*

Answer 10. See diagram 10. A funicular polygon is required to obtain the proportion of reaction at each abutment on account of the unsymmetrical loading.

Subject b.—MATERIALS.

Question 1. *What varieties of Portland stone are in use and for what purposes are they used?*

Answer 1. Portland stone is a limestone from the upper part of the Oolitic series in the Isle of Portland. There are four principal beds. True Roach, Whitbed, Bastard Roach or Curf, and Basebed or best bed. The True Roach is a mass of fossils cemented by carbonate of lime ; it is full of cavities but is hard and weathers well ; used for heavy engineering works, plinths and steps. The Whitbed is composed of fine Oolitic grains well cemented together with a small amount of shelly matter, the cementing material being hard and crystalline. This bed forms the best building stone as it is easily dressed to a smooth surface and will take a sharp arris. Bastard Roach is very similar to the True Roach with many fossils, but without the "Portland screw fossil" ; it does not weather well and is only used locally. The Basebed stone is very similar to the Whitbed, but softer and does not weather so well ; it is suitable for internal work and carving.

Question 2.

(a) *What is the difference in appearance between a sand-faced hand-made red brick and a machine-pressed red facing brick? Which would you prefer for a country church and town mansion respectively, and why?*

(b) *Name some green slates and describe their characteristics. How would you test the weathering properties of a slate?*

Answer 2.

(*a*) A sand-faced hand-made red brick is usually of a more or less pinky or orange red, with a rough surface and frog on one side only, and although it may be of good shape has not perfectly square arrises or flat faces. A machine-pressed red facing brick is usually darker in colour being more of a crimson or purplish red, has a frog top and bottom, has sharp straight arrises and flat smooth faces slightly glazed. For a country church the hand-made brick would be more sightly and economical, but for a town mansion where the bricks are fouled by soot and dirt the machine-pressed brick would deteriorate less and would be more in keeping with the position and the architecture. The joints would be fine, the faces dense and true, and the maximum stability and endurance would be obtained.

(*b*) Green slates are obtained from Carnarvonshire and Carmarthenshire in Wales, from Westmoreland, Lancashire, and Devonshire in England, also from Kilkenny in Ireland, and from America. The Tilberthwaite slates are the best known for good quality, they are somewhat heavy and thick with rough surface, but hard and sound, and are found in several shades of green which weather well. The Eureka brand is a thin American slate used for cheaper work, and not so permanent in colour.

Inspection and Tests.—Examine colour, note uniformity of colour and absence of patches, marks, pyrites, etc. Note surface, if hard and rough or smooth and greasy. Examine broken edges for grain of slate. Strike with knuckles, good slate will ring. Visit roofs covered with same slates and note condition compared with age. Weigh slate dry, steep for twenty-four hours, wipe water off, and weigh again, difference of weight will be absorption. Stand slate to half its depth in water, which should not rise up the slate more than ⅛ in., if it does it shows bad quality. Breathe on slate, strong clayey odour indicates probability that slate will not weather well. Strike slate on edge of wall and note ease or difficulty of fracture.

Question 3. *Describe the complete operation of painting a new outside door grained in imitation of oak and finished in the best way to withstand the effects of sun and weather.*

Answer 3. The door having been cleaned off to dimensions at the bench and tried up in place, well rubbed down and dusted, and the knots properly "killed," the priming coat is then laid on, composed of white-lead and a little red-lead, mixed with raw linseed oil, and a little litharge ground very fine in turpentine as a drier. After the priming coat to stop suction, there comes the stopping or filling up of the nail-holes, etc., with glazier's putty, or, better, with hard stopping of white-lead mixed with gold-size, and then the door may be hung. The work must then be rubbed smooth again with glasspaper or pumice stone, well dusted, and the second coat put on, consisting of white-lead with a little litharge mixed with boiled linseed oil, and very little, if any, turps, to avoid blistering and sun cracks. A small portion of burnt umber should be added to give the desired colour. The third coat should consist of the same ingredients, except that if the door were not required to be varnished there should be no turps. The previous coat being dry, the graining coat is then to be applied, consisting first of an even ground of light tint composed of white-lead stained with orange chrome, linseed oil, and a little driers, and as soon as this is dry, a graining colour of burnt umber and linseed oil with a little driers is put on, combed for the grain, and worked with pieces of rag or sponge for the flower.

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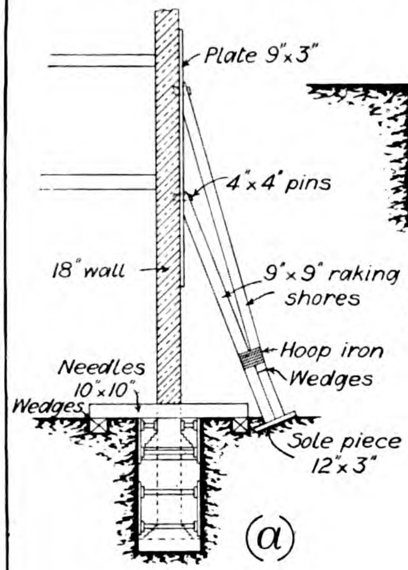

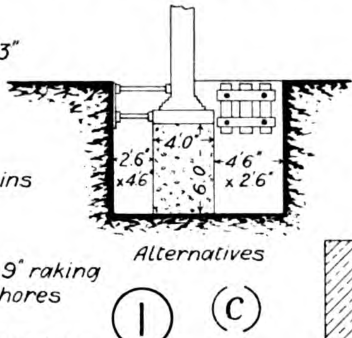

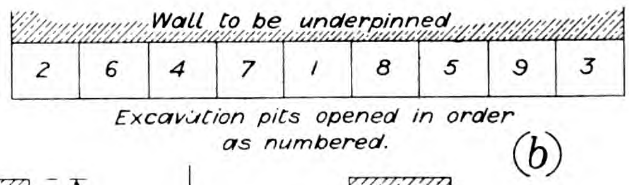

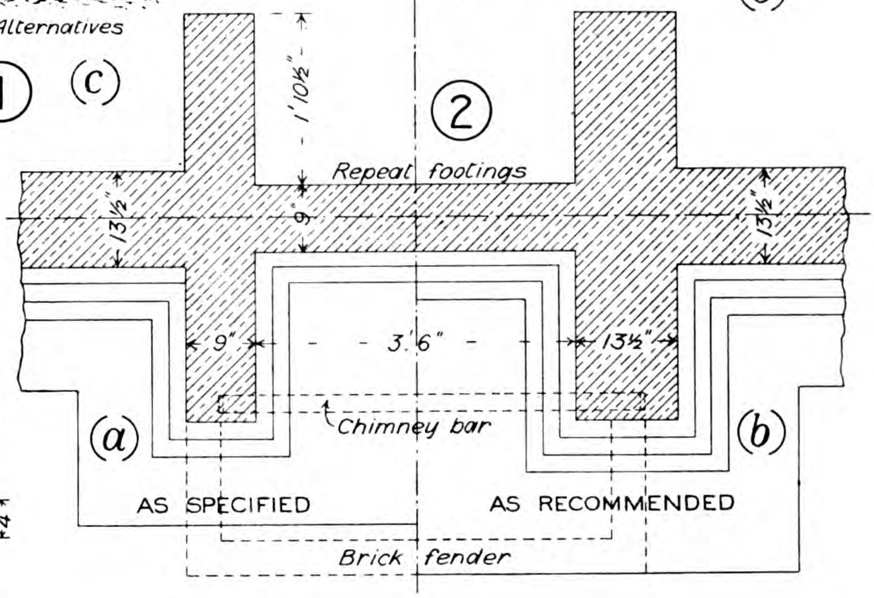

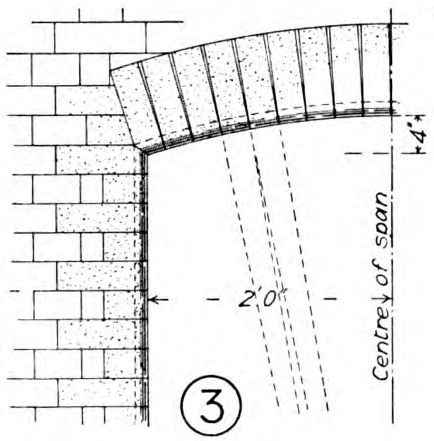

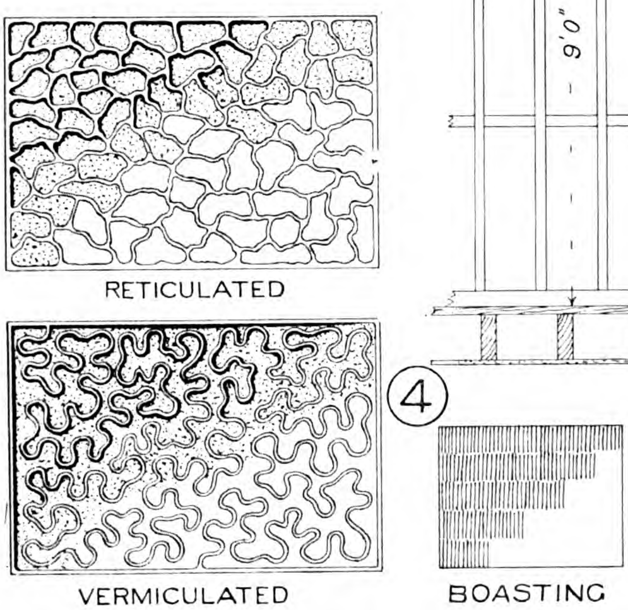

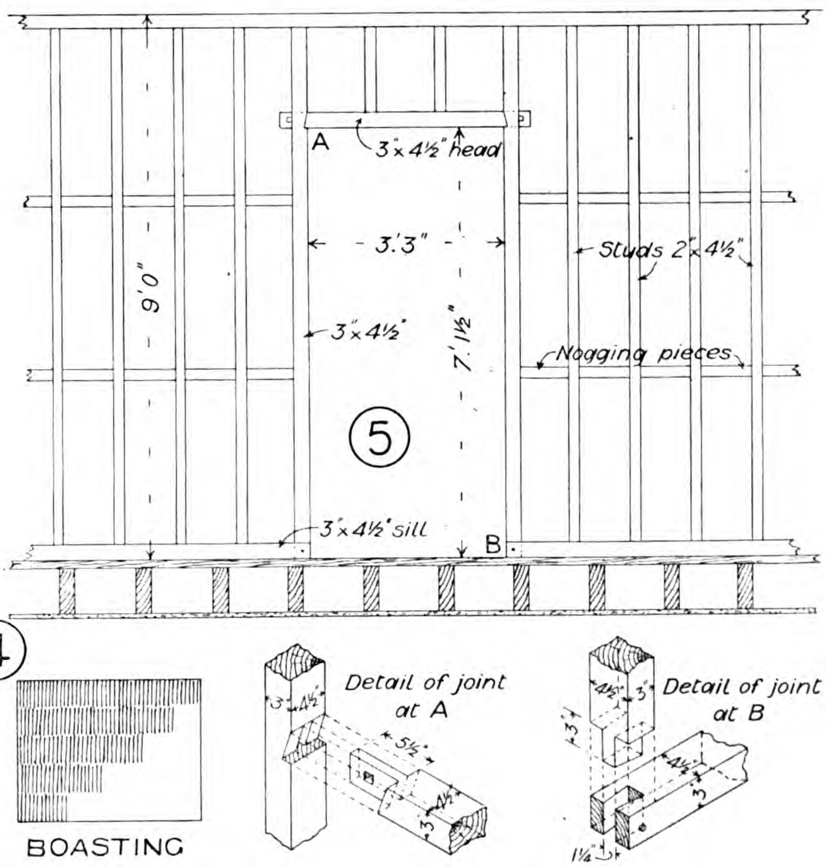

An extra coat of glazing or overgraining may be made with a thin wash of raw umber mixed with small beer and applied with a flat brush drawn over the surface with a wavy motion of the hand. When dry, the door should be varnished with one or two coats of best hard copal body varnish. Care must be taken that none of the painting or varnishing is done while the surface is damp, as in the early morning, or during or immediately after rain, or blistering is sure to take place. Early spring is best time, to allow for hardening before hot sun reaches it.

Question 4.

(a) *Assuming the maximum load on a cube of brickwork to be five tons per square foot, what load might be placed on a pier 2 ft. 3 in. by 1 ft. 6 in., and 18 ft. high?*

(b) *A fir beam is required to carry a load of two tons uniformly distributed over a clear span of 20 ft. What size beam should be used? Show method of calculation.*

Answer 4.

(*a*) When the height of a brick pier exceeds six times its least width the load must be reduced. Let W = safe load in tons per foot super on cube of brickwork, *r* = ratio of height of pier to least thickness, then safe load in tons per square foot on pier $= W\left(\frac{24-r}{18}\right) = 5\left(\frac{24-12}{18}\right) =$ $3\frac{1}{3}$ tons per square foot. Total load $= 2{\cdot}25 \times 1{\cdot}5 \times 3{\cdot}33 = 11{\cdot}25$ tons. Weight of pier itself $= w\ b\ d\ h = 112 \times 2{\cdot}25 \times 1{\cdot}5 \times 18 = 6804$ lbs. = say 3 tons. Net external safe load on pier $11{\cdot}25 - 3 = 8\frac{1}{4}$ tons if built in cement mortar.

(*b*) The safe load on a beam supported at the ends is given by the formula $W = \frac{bd^2}{L}$, where W = safe load cwts. distributed, b = breadth in inches, d = depth in inches, L = span in feet, no constant being needed. In the present case $40 = \frac{bd^2}{20}$, therefore $b\ d^2 = 40 \times 20 = 800$. Assuming 10 in. by 8 in. we should have $8 \times 10^2 = 800$ which is exactly the required value and otherwise suitable.

Question 5. *Discuss the various kinds of concrete as to their suitability for a fire-proof floor in combination with steel beams, and give specification clause.*

Answer 5.

Concrete of Portland cement and ballast breaks up when hot as soon as water comes upon it, and is looked upon as dangerous to firemen unless expanded metal, or small sections of steel not more than 2 ft. 6 in. apart, be embedded in the underside. A concrete composed of plaster-of-Paris and pumice stone resists fire the best, and is lighter than ordinary concrete, but not so strong. Coke breeze concrete is frequently used for theatres and public buildings, partly from its lightness, but also on account of its not cracking under fire and water so readily as ballast concrete.

Specification for Concrete.—The concrete is to be composed of one part by measure of Portland cement as described, to one part of clean sharp coarse sand, and four parts of coke breeze, pumice stone, hard brick, clinker or slag, free from dust, broken in various sizes to pass a 1 in ring as a maximum. The materials to be carefully mixed dry on a wood floor, not more than ½ cubic yard at one time, and again turned over twice while being watered through a rose. Concrete to be used within one hour of mixing and not disturbed afterwards. Flint gravel or broken limestone is not to be used under any circumstances for fire-proof work.

EXAMINATION, APRIL, 1905.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

Question 1. *Brick wells are sometimes sunk through loose soil to form a foundation for a heavy load, as at St. Paul's Cathedral, London; give sketch section of such a well 4 ft. internal diameter in 9 in. work, and describe the method of sinking it upon oak curbs.*

Answer 1. There is more than one method of sinking brick wells for foundations. The simplest is to excavate a circular hollow equal in diameter to the outside of the brickwork and as deep as the ground will stand without falling in. The oak curb, made in two thicknesses each in eight pieces out of 12 in. by 1½ in. breaking joint and well spiked together, is then laid in the bottom and brickwork built up to about 3 ft. above the ground level. The earth in the centre is then excavated deeper and that round the sides removed from below the curb, working at opposite sides simultaneously so that the brickwork may sink evenly with its own weight, more being added on top as fast as the sinking occurs. In a loose, open soil this may go on until sufficient depth is reached, but in a clay soil the expansion of the clay will nip the brickwork. Then the excavation in the centre has to be carried down and props placed as shown in section fig. 1, when another oak curb is laid on the bottom and the steining built up to meet the former curb by a process of underpinning. After brick piers are carried up between the props, the latter are removed and the intermediate spaces built in. The same operations may be repeated as often as necessary, and when the well is complete it may be filled with concrete or covered with thick York landings. A cast-iron curb, bolted together in pieces, with a cutting edge on the outer diameter is better for sinking the brickwork, as the cutting edge keeps in advance of the excavation and makes it more true.

Question 2. *Describe the Hennebique system of reinforced concrete piles and mode of driving. What do you consider to be their advantages?*

Answer 2. These piles of steel rods embedded in concrete, as shown in fig. 2, are constructed in vertical timber moulds supported by frames, the inner section of the mould corresponding to the size and shape of each pile. The working face of the mould is left open, care being first taken to see that everything is perfectly plumb. The steel shoe is then inserted in the bottom of the mould, with its upper ends turned over inwardly to form a key to the concrete. The vertical rods are then placed in position, about an inch below the surface of the concrete, and connected together with distance pieces dropped from the top as required. Concreting is then commenced, and the working face of the moulds is gradually closed with shuttering fixed about every six inches in height by the workman as he proceeds with the punning. After about thirty-eight hours the concrete is sufficiently set for the moulds to be stripped, and the piles are allowed to remain twenty-eight to forty days to dry preparatory to driving. It is sometimes more economical and convenient to make the piles in horizontal moulds, but in that case the greatest care must be observed in obtaining the right consistency of concrete, so that in the punning operation the cement be not worked out too much to the upper surface.

According to the nature of the ground the piles can be driven hydraulically, or by the ordinary pile-driver,

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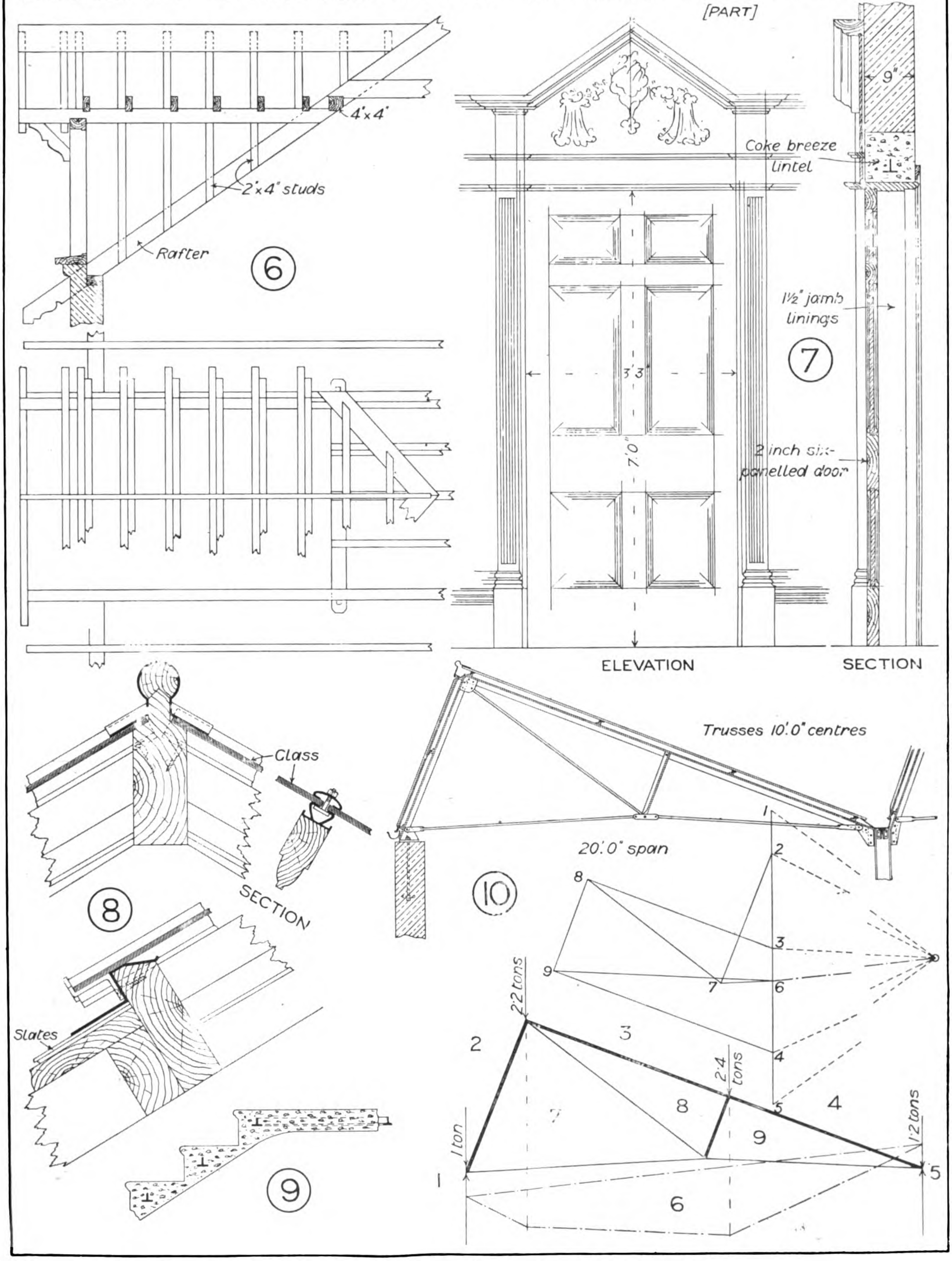
[PART]



or a combination of both, but the Lacour pile-driver, with its quick succession of blows combined with a heavy ram and short drops, gives the best results. Piles 14 in. by 14 in. have stood being driven by a 2 ton ram with a 6 ft. drop, and at Southampton Old Extension Quay, they were driven 22 ft. through a stratum of gravel and hard sand on the combined system, as owing to the presence of clay and fine gravel it was impossible to sink with the water jet alone. The water is conducted from the hydraulic mains down a $\frac{3}{4}$ in. pipe in the centre of the pile, terminating in a $\frac{3}{8}$ in. nozzle at the point of the shoe, and the working pressure is throttled down to about 300 lbs. per square inch, the piles being driven to their required depth in less than an hour.

In driving, the heads of the piles are protected with a steel helmet, the space between the helmet and the head of the pile being filled with sawdust. A tight joint of hemp and clay is made between the lower part of the helmet and the pile to prevent the escape of the sawdust, which becomes so compressed after the driving as to be almost solid. Occasionally, fine sand is substituted for sawdust, and a timber dolly is interposed between the ram and the pile head in the usual way. These piles are especially adapted for foundations of piers, bridges, and locks of docks, saving the heavy cost of cylinders, and in the case of masonry piers the necessary but expensive cofferdams and pumping. These are sometimes moulded hollow and applied to foundations in rocky ground.

Question 3. *A church in London is to be faced with stone upon a brick backing. Give a horizontal section through one jamb of a window or door opening, showing part of the wall, to a scale of $1\frac{1}{2}$ in. to 1 ft., and a vertical section through 2 ft. in height of the wall showing the bonding of the two materials.*

Answer 3. For answer, see fig. 3.

Question 4. *Describe in detail the method of laying the bricks in a thick wall. What are line pins and plumb rules used for?*

Answer 4. In laying bricks the only tool required by the bricklayer is the trowel, which he uses for taking up and spreading the mortar, as well as for roughly cutting bricks to the required shape, as in making closers, etc. The ordinary practice in laying bricks is as follows: In laying the facing bricks the bricklayer takes up some mortar, throws it on the last laid course, and spreads it out with the point of his trowel to form a bed for the next brick; whatever projects on the face of the work he then strikes off and catches on the flat of his trowel scraping it against the vertical angle of the last laid brick and this is often all the mortar applied to the side joints of the facing bricks, instead of their being filled up solid. Having done this, he presses the next face brick into its place, carefully adjusting it with his hand, or by tapping it with the edge of the blade, or the handle of his trowel, a process in which a careless workman will often break from one-sixth to one-fifth of the headers, by giving too hard a blow. The mortar squeezed out of the joint, in pressing the brick into its place, is then struck off, and the joints, after the mortar has stiffened a little, are neatly drawn or struck, by drawing the point of the trowel along them—unless the wall is to be pointed after completion, or to be plastered; in the latter case the mortar is generally left to project, in order to form a key to hold the plaster, whilst in the former case the mortar is scraped out of the front of the joints, leaving a hollow key to receive the pointing. The best way of laying the paving or bricks in the body of a wall, after sufficient facing bricks have been laid, is to lay in between the face bricks a thick bed of larry, or rather liquid mortar, and then slide each brick along in it into its place; in doing which the mortar rises to the top of the joints, the process being called larrying. Lines and pins consist of two iron pins like small chisels with button heads, with about 60 ft. of fine cord attached to and wound round them. To prevent constant recourse to the plumb-rule and level, the bricklayer, on clearing the footings of the wall, will build up bits of six or eight courses in height, called perpends, at the quoins or external angles, and at intervals along the wall carefully plumbing and levelling them across from one to the other; these form gauges, to which he works the intervening parts of the courses, by means of the line tightly strained between the perpends, the pins being stuck into the joints at the upper and outer angles of the gauge bricks in the next course to be laid. To prevent sagging, if the line be long, it must be carefully propped at intervals, the bricks used for this purpose being called tingles.

After carrying up three or four courses with the line the work should be proved with the level and plumb-rule. A smart tap with the handle of the trowel will generally adjust any brick that may be out, without injuring the work while it is so green. The plumb-rule is a thin wooden rule, 4 to 7 in. wide, with a line and plummet fixed at one end, and swinging down its centre; used to insure the perpendicularity of the walls, and the joints being kept one over the other. For further information see Seddon's *Builders' Work*.

Question 5. *Give section through a 9 in. parapet wall and part of a flat timber roof, covered with concrete and asphalted. Joists 3 × 9. Scale, $\frac{1}{12}$. What precautions must be taken if the addition of a ceiling is required?*

Answer 5. See fig. 5. The precautions necessary when a ceiling is required are to secure efficient ventilation of the space between ceiling and roof, either by a continuous perforated course of glazed stoneware in the wall, by brandering as shown, or by ceiling joists, leaving space below joists and with air bricks at each side of roof so that a current may blow through.

Question 6. *Show elevation and section of suitable centering for a semi-circular arch 7 ft. 6 in. span in an 18 in. brick wall. Scale $\frac{1}{2}$ in. to 1 ft.*

Answer 6. For answer see fig. 6.

Question 7. *Give section, half full size, through the bottom rail and sill of a $2\frac{1}{4}$ in. casement window opening outwards.*

Answer 7. For answer see fig. 7.

Question 8. *Show by neat sketches what you understand by* (a) *town clout nail;* (b) *cut clasp nail;* (c) *French nail;* (d) *coach screw.*

Answer 8. For answer see fig. 8.

VOLUNTARY.

Question 9. *A built-up steel stanchion is composed of two $5 \times 4\frac{1}{2} \times 22$ lb. rolled steel joists rivetted on to the sides of the web of a $10 \times 5 \times 35$ lb. rolled steel joist. Draw the section one quarter full size, and show how you would protect it against fire.*

Answer 9. For answer see fig. 9, where two half plans are given showing alternative methods of finishing. When finished circular the lower portion is sometimes cased in thin sheet iron for protection against rough usage.

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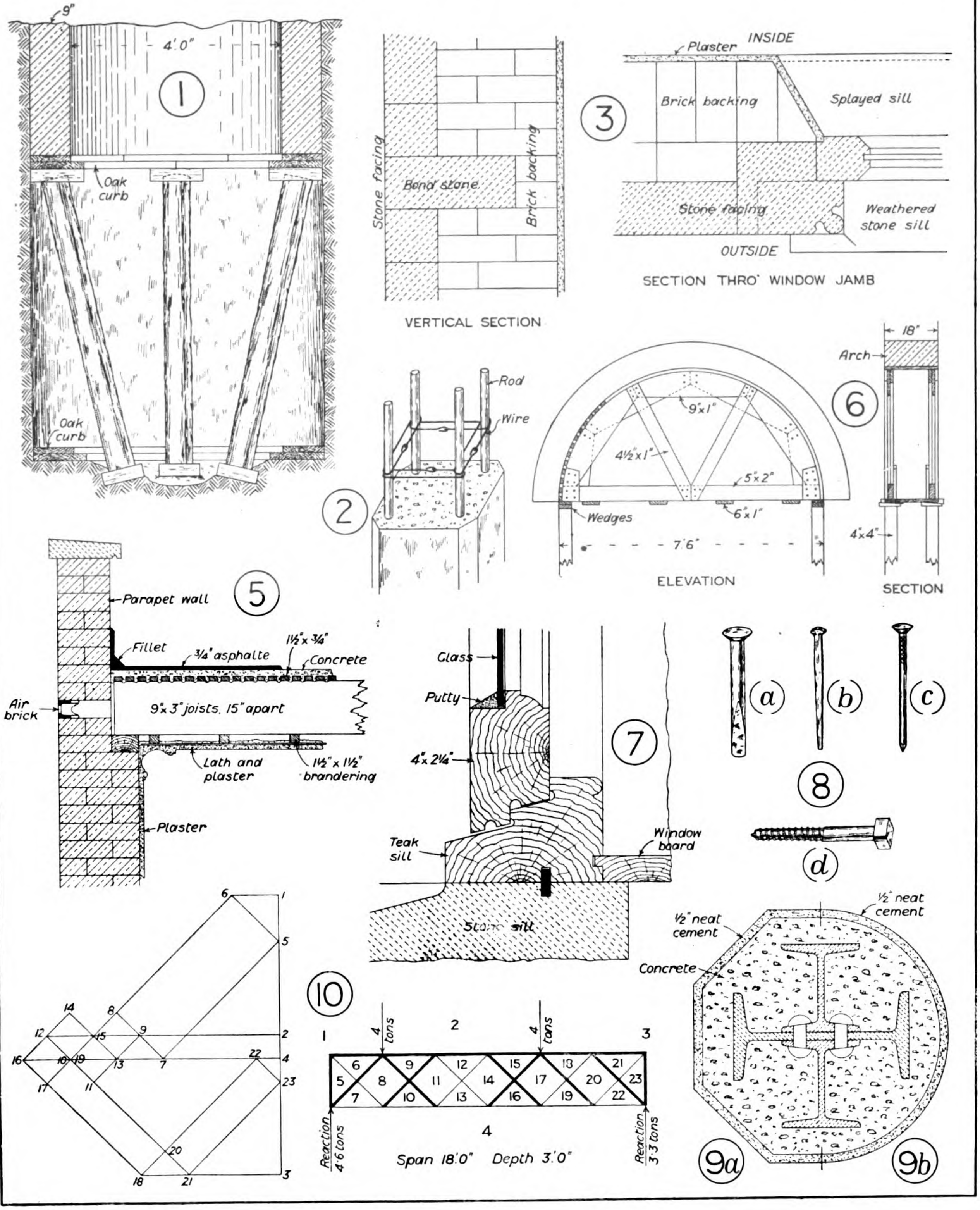


Question 10. *A lattice girder, 18 ft. span and 3 ft. deep, with bars at 45 degrees, carries loads of 4 tons on the top flange at 3 ft. and 12 ft. from the left-hand side. Draw complete stress diagram. Scales, $\frac{1}{4}$ in. to 1 ft., and $\frac{1}{2}$ in. to 1 ton.*

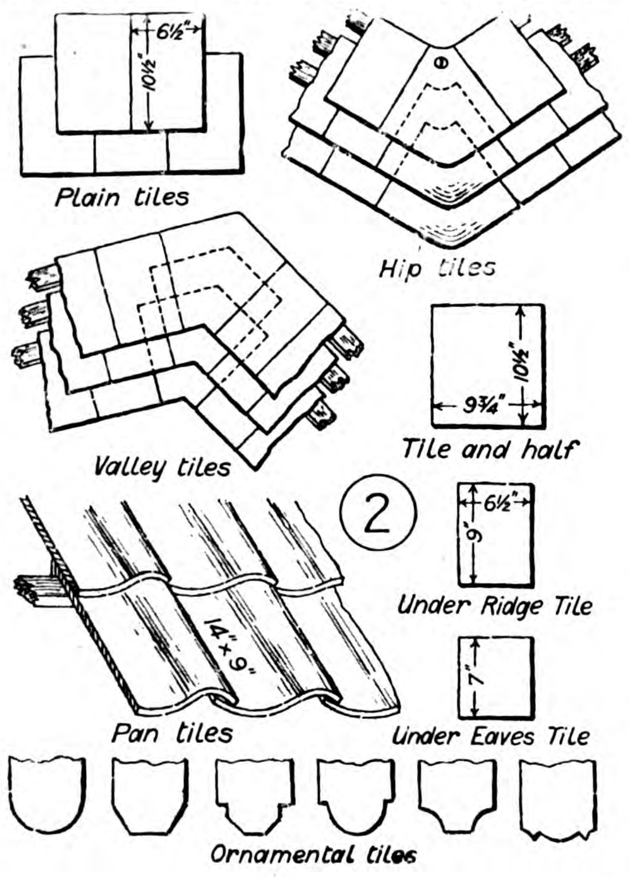
Answer 10. For answer see fig. 10.

Subject b.—MATERIALS.

Question 1. *Give clauses for the specification of Portland cement and concrete in important fire-resisting floors.*

Answer 1. The Portland cement to be of British manufacture from an approved maker. To be air-slaked for one month under shelter, in bulk, with a depth of not less than 1 nor more than 2 feet, and to be turned over twice in that time. The cement is to weigh not less than 112 lbs. per imperial striked bushel, and to pass through a No. 35 S.W.G. sieve of 2,500 meshes to the square inch, leaving a residue not exceeding 1 per cent. Briquettes for testing to have a minimum section of $1\frac{1}{2}$ in. by $1\frac{1}{2}$ in. ($=2\frac{1}{4}$ square inches), and to be gauged with pure water at 60° Fahrenheit. Every three consecutive briquettes to break at end of 7 days (6 in water), with an average tension of at least 850 lbs. and a minimum of 750 lbs., and at 28 days 1,000 lbs. and 900 lbs. respectively. When gauged in a thin glass tube the cement must not swell so as to crack the tube or shrink so as to become loose.

The concrete is to be composed of one part by measure of Portland cement as described, to one part of clean sharp coarse sand, and four parts of coke breeze, pumice stone, hard brick, clinker or slag, free from dust, broken in various sizes to pass a one inch ring as a maximum. The materials to be carefully mixed dry on a wood floor, not more than $\frac{1}{2}$ cubic yard at one time, and again turned over twice while being watered through a rose. All concrete to be used within one hour of mixing and not disturbed afterwards. Flint, gravel or broken limestone is not to be used under any circumstances for fire-proof work.



Question 2. ***Sketch the varieties of roofing tiles in common use with their dimensions, and state how you would test them.***

Answer 2. See accompanying diagram. The plain tiles should be examined carefully for absence of cracks, distortions, or lumps of lime, tested by straightedge for requisite hollowness on underside, struck together for metallic ring showing soundness, and stood on edge in water to test absorption which should not exceed one inch rise. Pan tiles are only used for rough work, they should, however, be hard and non-porous.

Question 3. *How is sheet lead made, what are the sizes, and how are they cut up for use?*

Answer 3. According to Middleton's *Building Materials*, "Sheet lead is generally made by casting a plate of lead about 5 in. thick, weighing about 7 tons, and then passing this under metal rollers until it is squeezed down to the required thickness. Such sheets are known as 'milled lead,' and can be gauged very accurately, the various thicknesses being known by the weight in pounds per foot super. Such sheets are commonly made in lengths up to 35 ft., and in widths which vary from 5 ft. 6 in. to 8 ft., but greater lengths and widths can be obtained if desired.

"Sheets can also be made by pouring the molten metal on to a carefully levelled bed of sand on a wooden bench, and then passing a 'strike' over the surface to sweep away any surplus beyond the desired thickness. Such sheets are known as 'cast lead,' and they are generally thicker than the milled sheets and smaller in size."

According to Leaning's *Quantity Surveying*, "A sheet of lead is ostensibly 7 ft. by 30 ft., usually about 6 ft. 10 in. wide, and of length varying from 25 ft. to 30 ft. The lead for gutters and flats is cut lengthwise of the sheet, that for flashings, hips, ridges, etc., across the sheet."

The actual cutting is done by a drawing knife or shears.

Question 4. ***Fir joists, 9 in. by 3 in., are placed 12 in. centre to centre over a span of 16 ft.; what total load per foot super. should they carry with a factor of safety of 7?***

Answer 4. A fir joist with a factor of safety of 7 will carry $\frac{b\,d^2}{L}$ cwts. distributed, $=\frac{3 \times 9^2}{16}=$ say 15·2 cwts. As these joists are 12 in. centre to centre the cwts. per ft. run will be also cwts. per ft. super. $\frac{15{\cdot}2}{16}={\cdot}95$, say 1 cwt. per ft. super., safe load. Or by ordinary book formula B.W. cwts. centre $=\frac{c\,b\,d^2}{L}=\frac{35 \times 3 \times 9^2}{16}=53{\cdot}1$. Safe load distrib. $=53{\cdot}1 \times \frac{2}{7}=15{\cdot}2$. Safe load per ft. super. $=\frac{15{\cdot}2}{16}={\cdot}95$ say 1 cwt. as before.

Question 5. *Name three good fire-resisting materials (not metals) and three good damp-resisting materials, and any that you know of capable of resisting both fire and damp.*

Answer 5. Fire-resisting:—Brickwork, pumice stone, uralite. Damp-resisting:—Bitumen, hard slate, Hygiean rock composition. Fire and damp-resisting:—Silicate cotton and asbestos cloth, slag wool, terra cotta, Staffordshire blue bricks.

EXAMINATION, OCTOBER, 1905.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

OBLIGATORY.

Question 1. *Sheet piling is required round the foundations of a warehouse to hold in the soil, which is of a loose sandy nature. Give neat sketches showing how this would be carried out.*

Answer 1. See diagram (1). The scantlings would depend upon the depth the piles were required to be driven. Approximately, say, guide piles 1 in. side for each 18 in. depth; sheet piling one-third thickness of guide piles; walings half thickness of guide piles. One double row of walings bolted through guide piles $1\frac{1}{2}$ ft. to 2 ft. below surface of ground, or two double rows about 3 ft. apart, top row 1 ft. below surface. Sheet piling to be birdsmouthed and bevelled at edges and raking at foot.

Question 2. *Sketch and describe how the width and thickness of concrete under footings is determined.*

Answer 2. See diagram (2). The width of concrete is determined by allowing 6 in. projection beyond each side of lowest course of footings, or such extra width as may be necessary to provide sufficient bearing area upon the soil. There are various ways of determining the thickness of the concrete. Fig. 2*b* shows all that is necessary, the depth being made sufficient to prevent the projecting part shearing through at line of brickwork, or breaking off as a cantilever. Fig. 2*a* shows what is recommended in Mitchell's *Building Construction*, but this is wasteful of material, as the stability is not increased by adding to the depth, and the thickness is in no way dependent upon the soil. Fig. 2*c* shows a thickness intermediate between (*a*) and (*b*) which has been suggested, but this has the defect of not varying with the projection.

Question 3. *Draw a section to a scale of $\frac{3}{4}$ in. to 1 ft. through the wall of a swimming bath, 6 ft. deep. The selection of the materials is left to the candidate, but they must be fully described.*

Answer 3. See diagram (3). The materials are described on the section. The concrete might be one Portland cement, one sand, five washed ballast.

Question 4. *Give section and part elevation, to a scale of 1 in. to 1 ft. of a rubble stone boundary wall, 6 ft. high, with hammer-dressed plinth and wrought coping.*

Answer 4. See diagram (4).

Question 5. *Draw to a scale of $\frac{1}{24}$, a simple collar beam roof truss of maximum span, figure the span and give the scantlings. State what are the chief objections to this kind of truss.*

Answer 5. See diagram (5). The weight of the roof causes the feet of the rafters to spread and put a considerable cross strain upon them where the collar is connected, and the collar is in tension. When the walls are sufficiently thick, or buttressed to prevent the rafters spreading, the collar will be in compression and the roof stronger, but this seldom happens. The collar is often placed half way up the rafters, it should not be more than about one-third of the way up to reduce the leverage.

Question 6. *Draw one-eighth full size, a scarf joint suitable for a tie-beam, 12 in. by 6 in. Add all necessary ironwork, wedges, bolts, washers, etc., that you may consider necessary.*

Answer 6. See diagram (6).

Question. 7. *Draw to a scale of $1\frac{1}{2}$ in. to 1 ft. the vertical section through a sash hung on centres in a 9 in. wall. The clear height from top of stone sill to soffit of gauged arch is 2 ft. 6 in.*

Answer 7. See diagram (7). It is important to note, by the dotted lines of the open sash, which parts of the inside and outside beads are fixed to it.

Question 8. *Show by neat sketches (a) how a lead soil pipe is fixed to the wall, (b) how the joint at foot of soil pipe is made with stoneware drain.*

Answer 8. See diagram (8*a*) for lead soil pipe fixed to wall, in plan and elevation. Also (8*b*) for joint at foot of soil pipe with stoneware drain.

VOLUNTARY.

Question 9. *Draw, or sketch neatly, to a scale of 2 in. to 1 ft., the section through a pair of 12 by 6 by 54 lb. rolled steel joists connected by bolts and cast-iron separators. Figure as near as you can the thickness of web, and mean thickness of flange.*

Answer 9. See diagram (9).

Question 10. *Show how to find the moment of inertia of a tee section. What use is made of the moment of inertia in finding the strength?*

Answer 10. Let B = breadth of flange of tee, and D=total depth of tee, *b* breadth of flange minus thickness of web, and *d*=depth of web exclusive of flange. Then the moment of inertia

$$I = \frac{(BD^2 - bd^2) - 4BDbd\,(D - d)^2}{12\,(BD - bd)}.$$

The moment of inertia is used in finding the strength of a beam as follows:—

Effort = Resistance.

Bending moment = moment of resistance.

$$M = R$$

$$\frac{Wl}{k} = ZC$$

$$\frac{Wl}{k} = \frac{I}{y}C$$

$$\therefore W = \frac{I}{y} \times C \times \frac{k}{l}$$

In the above equations:—

M = bending moment.

W = load in tons.

l = span in inches.

k = co-efficient of reaction = 4 for central concentrated load, 8 for uniformly distributed load, beam supported at both ends.

R = moment of resistance.

Z = modulus of section in inch units.

C = modulus of transverse rupture, commonly called extreme fibre stress.

I = moment of inertia in inch units.

y = distance from neutral axis to extreme edge of section in inches.

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Section II.—BUILDING CONSTRUCTION AND MATERIALS.

Subject b.—MATERIALS.

OBLIGATORY.

Question 1. *Name the various materials used, and the proportions of each, for different kinds of mortar.*

Answer 1. Lime mortar :—

(*a*) 1 part grey stone lime to 2 or 3 parts clean sharp pit sand.
(*b*) 1 part ground blue lias lime to 3 parts sand.

Cement mortar :—

(*a*) 1 part Portland cement and 3 to 5 parts sand.
(*b*) 1 part Roman cement to 1 part sand.

Mill mortar :—

1 part blue lias lime to 3 parts clean hard brick rubbish or furnace clinker ground together in a mortar mill, with or without 1 part sand additional.

Selenitic mortar :—

1 part of selenitic lime mixed to a paste and 4 to 5 parts sand ground with it in a mortar mill.

Plasterers' coarse stuff :—

1 part of chalk lime, 1½ sand, and 1lb. ox hair to 2 cubic feet of stuff.

Question 2. *Name the principal fire-bricks in use, placing them in the order of their fire-resisting qualities. What are the peculiarities of the Dinas fire-brick ?*

Answer 2. Dinas (Glamorganshire), Lee Moor (Devonshire), Newcastle (Northumberland), Stourbridge (Worcestershire), Dowlais (Glamorganshire), Poole (Dorsetshire).

The Dinas fire-brick contains nearly 98 per cent. of silica in the form of sand, to which about 1 per cent. of lime has to be added in order to secure cohesion. It has a coarse fracture, but is the most refractory fire-brick known.

Question 3. *State what you know of asphalte and its uses.*

Answer 3. Asphalte may be natural or artificial. Natural or rock asphalte is a natural limestone impregnated with bitumen, averaging 10 per cent. of bitumen to 90 per cent. of limestone. The three best known are the Seyssel, the Val de Travers, and the Limmer. Two varieties are used, the " compressed," in form of powder spread hot and rammed with heated beaters, and the " mastic," which is melted, mixed with sharp grit, and spread with a wooden float. Artificial asphalte is made by mixing Trinidad bitumen with broken stone, chalk, and other mineral matter. They are used for road surfaces, foot pavements, and roofs ; and the mastic only, for damp-proof courses and reservoir linings.

Question 4. *Give the common rule for the size of fir joists, and prove its sufficiency.*

Answer 4. The common rule is half span in feet + 2 = depth in inches, and one-third of depth = thickness. Thus 14 ft. span, $\frac{14}{2} + 2 = 9$ in. deep, and $\frac{9}{3} =$ 3 in. thick. A simple formula for the strength of a fir beam, allowing a factor of safety of 7 is $W = \frac{bd^2}{L}$, where W = safe load cwts. distributed, b = breadth in inches, d = depth in inches, L = span in feet. Then 9 in. by 3 in. joist over 14 ft. span $= \frac{bd^2}{L} = \frac{3 \times 9^2}{14} = 17{\cdot}3$ cwt. distributed. Assuming the joists to be 12 in. apart or 15 in. centre to centre, this will give a safe load of $\frac{14 \times \frac{15}{12}}{17{\cdot}3} =$ say, 1 cwt. per foot super.

Another rule is :—

$\frac{6}{10}$ span ft. = depth inches. $\frac{1}{6}$ span ft. = thickness inches.

Example 14 ft. span.

$14 \times \frac{6}{10} = 8{\cdot}4$ in. deep. $14 \times \frac{1}{6} = 2\frac{1}{3}$ in. thick.

Another rule is :—

$\frac{1}{2}$ in. deep for every foot span, thickness $= \frac{1}{3}$ depth.
$\frac{1}{2} \times 14 = 7$ in. deep. $\frac{1}{3} \times 7 = 2\frac{1}{3}$ in. thick.

but this is too light for ordinary use.

VOLUNTARY.

Question 5. *What fire-proofing preparations can be used for protecting timber, and what independent coverings may be applied for the same purpose ?*

Answer 5. The fire-proofing preparations are mostly trade secrets, such as that of the Non-Flamable Wood Company, Cyanite, etc. The surface may be painted with alternate coats of silicate of soda and limewash, or with asbestos paint. Or the wood may be soaked in tungstate of soda or in alum. Or it may be Powellised, which consists of boiling in a saccharine solution in which certain chemicals have been placed, and afterwards drying in a kiln.

For independent coverings :—Thin sheet steel is highly approved for wooden doors in a warehouse, they are considered to be better than the well-known iron doors. Uralite may be applied in thin sheets. For ceilings metallic lathing may be used to protect the joists, say Crittall's expanded cup lathing for preference, plastered over with Robinson's cement, or a fire-proof cement composed of gypsum and asbestos fibre.

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BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

OBLIGATORY.

Question 1. *Describe, with sketches, the method of setting out the foundations for the four walls of a rectangular building.*

Answer 1. See diagram 1. The building may be assumed to be detached. The " building line " AB will be the first to set out on the ground by means of fine twine, and this will either be at a given distance back from the " frontage line," or in line with buildings already erected ; then the points C and D must be marked by temporary pegs where the front wall terminates. Then line CE representing the face of flank wall must be set true by a 6 or 10 ft. framed setting-out square. Similarly DF will be set out at right angles

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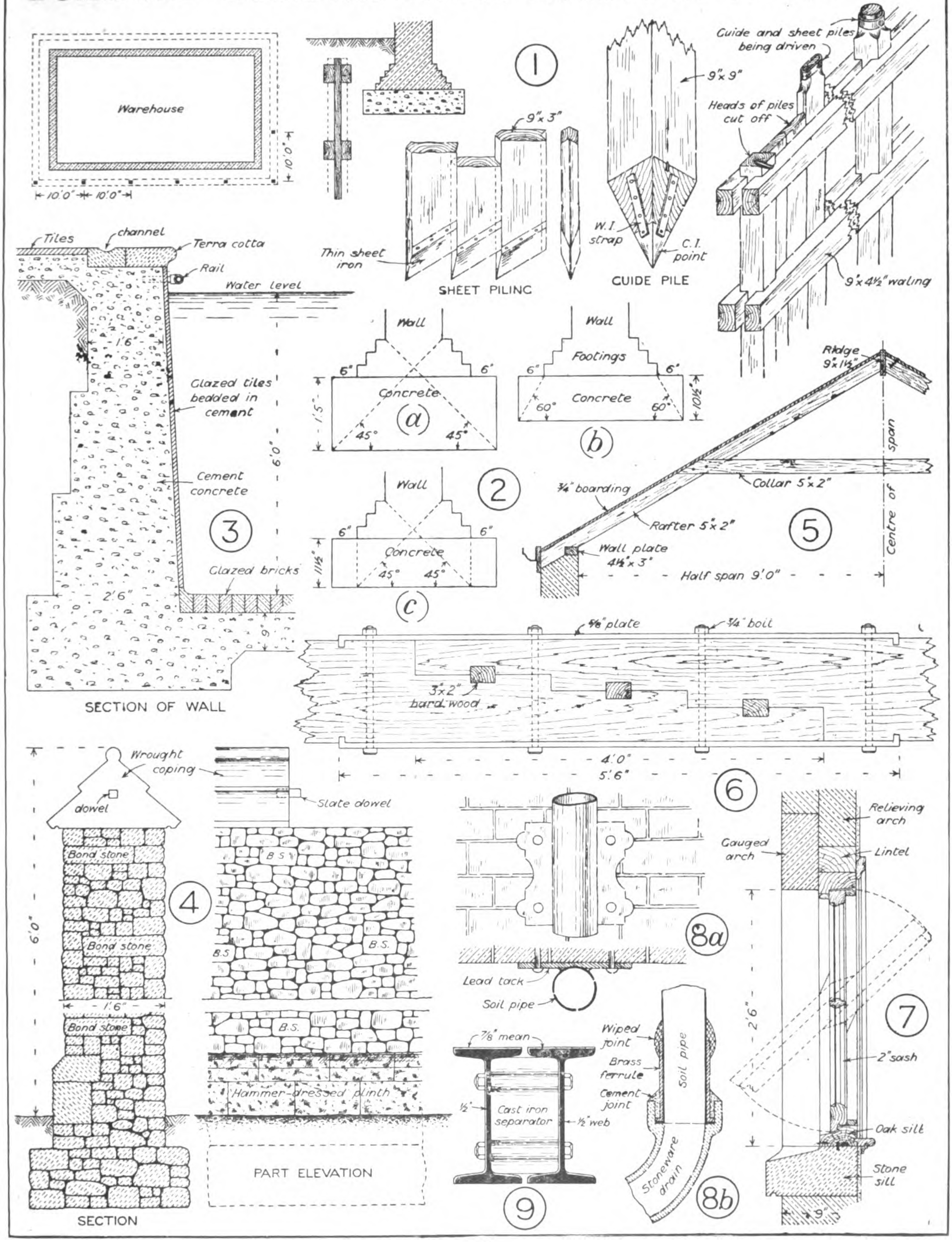


to AB. Then the length of building CE and DF will be marked, the length EF compared with CD, and the diagonal ED compared with the diagonal CF. Then the lines of the four walls should be marked by pegs at each end clear of the trench, with saw cuts in the top so that a line may be strained through at any time for testing the work. The dotted lines representing the trench will be marked by lines measured off from the four main lines, and strained round temporary pegs clear of the trenches. It must be understood that " lines " on the ground are all twine or cord strained through to correspond with lines on the sketch. In setting out very large buildings a theodolite and steel tape are required to give the angles and lengths. An ordinary tape cannot be relied on within 3 inches. The levels would be taken from some given bench mark, and fixed on the site by level pegs.

Question 2. *Assuming a warehouse wall to be 50 ft. high and 50 ft. long, the thickness at top 13½ in., and at base 2 ft. 3 in., show by diagram how the intermediate thicknesses are obtained. What is the greatest allowable height for any storey of a given thickness?*

Answer 2. See diagram 2. Whatever number of floors or wherever the change of thickness may take place, the dotted line from A to B must not be cut into. The maximum height of wall for any storey is fourteen times its thickness, but if this height is exceeded the extra thickness required may be made up by piers.

Question 3. *Draw a piece 4 ft. square of a random rubble wall brought up to 2 ft. courses. (Scale 1/12).*

Answer 3. See alternative diagrams **3a** and **3b**. Rankine says one-fourth part of the face work should consist of bond stones or headers, but rubble walls are sometimes found with as low a proportion as one through bond stone per square yard of face.

Question 4. *Draw to a scale of 1½ in. to 1 ft. a countess slate holed for centre nailing, and a section showing three complete slates in position, with the dimensions marked for gauge and lap.*

Answer 4. See diagram 4.

Question 5. *Draw a vertical section on face of trimmer through a trimming joist 9 in. by 4 in., showing detail of joint. Scale, 3 in. to 1 ft.*

Answer 5. See diagram 5.

Question 6. *Draw the elevation of a 3 ft. by 7 ft. by 2 in. sash door glazed with 4½ in. margins, and a horizontal section 5 ft. from ground. Scale, 1 in. to 1 ft.*

Answer 6. See diagram 6.

Question 7. *Draw a cross section through a parapet gutter, 1 ft. wide, showing leadwork complete, and part of slated roof. Scale, 1½ in. to 1 ft.*

Answer 7. See diagram 7.

Question 8. *Draw a section through a bracketed ceiling cornice in plaster, 2 ft. girth, showing all details. Scale, 2 in. to 1 ft.*

Answer 8. See diagram 8.

VOLUNTARY.

Question 9. *An 8 in. by 5 in. by 30 lb. rolled steel joist as girder is to be attached to the web of an 8 in. by 6 in. by 35 lb. rolled steel joist as stanchion. Show all details of the connection assuming the girder to carry a distributed load of 12 tons. Scale, 3 in. to 1 ft.*

Answer 9. See diagram 9.

Question 10. *A trussed fir beam, 24 ft. span, has a mean depth of 3 ft., and is divided into three bays. Draw a stress diagram for a distributed load of 2½ cwt. per foot run. Scales, ¼ in. to 1 ft., 1 ton to 1 in., and 2 ton-ft. to 1 in.*

Answer 10. See diagram 10. It should be observed that the top member, being in the condition of a continuous beam over three spans, will properly have the load of 3 tons divided over the supports in the proportion of ·4, 1·1, 1·1, ·4, instead of the usual assumption of ·5, 1, 1, ·5.

Subject b.—MATERIALS.

OBLIGATORY.

Question 1. *Name and describe briefly the characteristics of three varieties of limestone and three of sandstone.*

Answer 1.

(*a*) LIMESTONES.

Portland stone is the most important of the limestones. The true roach bed is the hardest and best for exposure to the weather, it is a grey stone, very tough and recognized by the Portland screw fossil contained in it. The Whitbed is a creamy colour, very close grained and good for interior work.

Bath stone consists of several varieties, the box-ground is one of the best for exposure to the weather, as in sills and string courses. It has a light creamy-brown colour, is soft when first quarried, but hardens by exposure.

Kentish Rag is a very tough stone which can only be dressed with a hammer. It is a bluish-grey and is used for facings.

(*b*) SANDSTONES.

Craigleith is the most durable sandstone, with a creamy-white crystalline fracture, consisting of 98 per cent. of silica and a little carbonate of lime, oxide of iron and alumina.

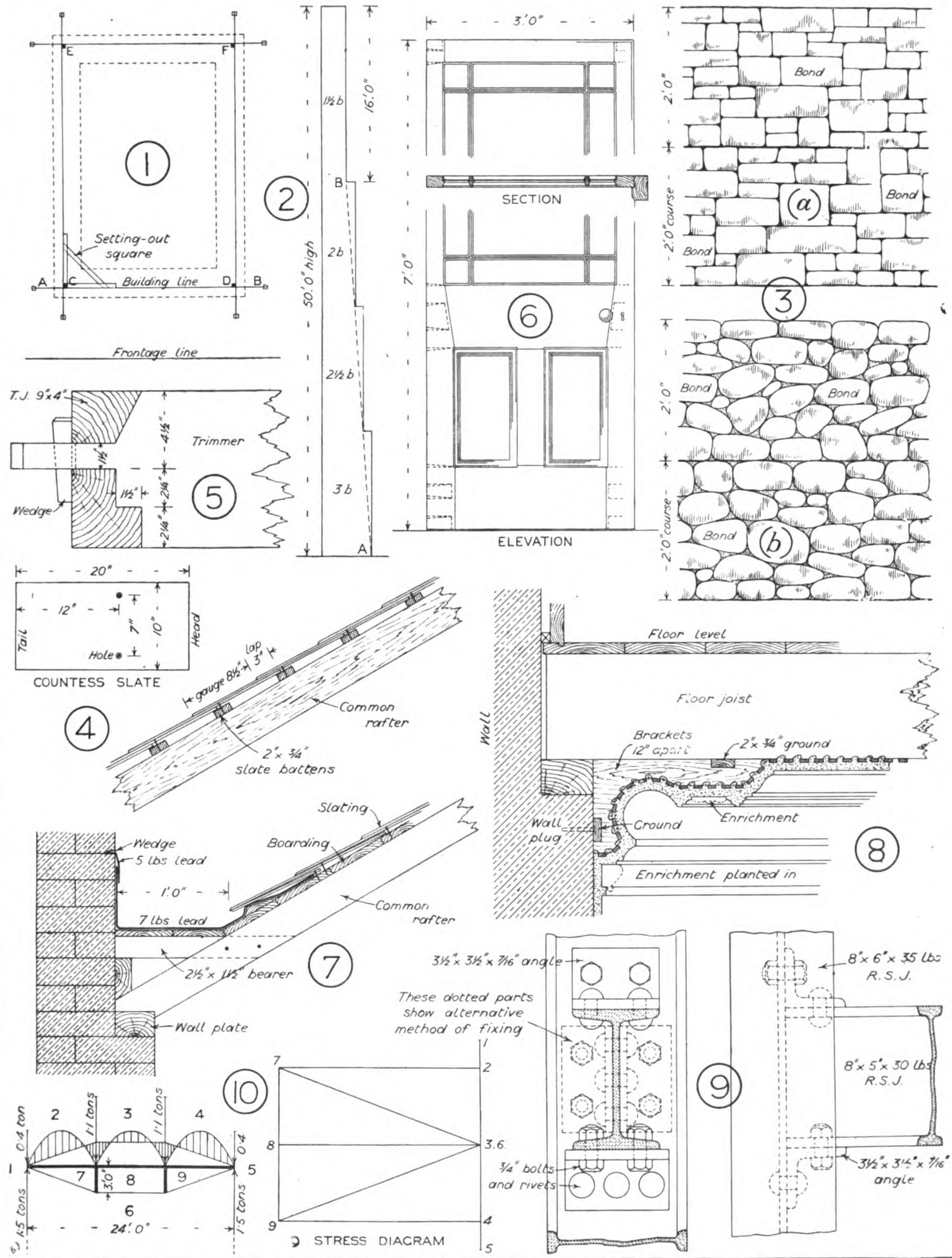
York stone is a hard brownish-yellow stone quarried in Yorkshire. The best was from the original Bramley Fall Quarries, which are now worked out, but a very similar stone is found in the neighbourhood. It is much used for ashlar work in foundations for columns, and for steps and sills. The laminated varieties are used for landings and pavings.

Blue Pennant, from Bristol, is a deep blue-grey colour, obtainable in large slabs and blocks. It is hard and strong, but difficult to work; it is a good weathering stone, and takes a fine surface. The expense of working it is its principal drawback.

Question 2. *What do you understand by the term red deal? How would you distinguish oak from chestnut, and pitch-pine from larch?*

Answer 2. *Red deal* is from the same botanical source as yellow deal, viz., the *Pinus sylvestris.* Memel fir is sometimes called red wood or red deal from its deeper colour than other varieties, but in certain districts any log timber cut up into scantlings is so called. In London the term red deal is applied to a clean straight grained variety of joiner's wood that takes a pinkish tint after finishing, the source is not known to the writer. *Oak* may be distinguished from chestnut by the medullary rays which are absent from chestnut. The grain is slightly more open, but the annual rings are closer. Oak is also heavier and harder than chestnut. The colour is very similar, but chestnut has rather more of a cinnamon cast, which makes the contrast with the sapwood rather more pronounced. Chestnut is more liable to split in

BUILDING CONSTRUCTION EXAMINATION APRIL 1906



nailing, and the nails do not blacken it. In *pitch-pine* the annual rings are more regular, and the wood is harder and heavier, but otherwise it is very similar to larch in colour and general appearance.

Question 3. *Give the approximate composition of white lead, red lead, and blue lead. Why is white lead used in paint?*

Answer 3. White lead is chiefly a basic carbonate of lead, it consists usually of a mixture of 25 per cent. of hydrated oxide and 75 per cent. of carbonate.

Red lead is a per-oxide of lead produced by heating litharge with access of air.

Blue lead is metallic lead.

White lead ground to a fine powder and mixed with 10 per cent. of linseed oil is used to give the body in ordinary paint, the colour being given by the addition of certain pigments in powder, and the drying properties by the additions of driers.

Question 4. *A cube of brickwork, 2 ft. 3 in. side, will safely carry a load of 4 tons per foot super, what total load will an 18 in. by 18 in. pier of similar brickwork carry when its height is 12 ft.?*

Answer 4. One rule for the safe load on a brick pier is that if the height exceeds six times the least width the normal strength is reduced to two-thirds. In this case the pier exceeds six times its least width, therefore the 4 tons per ft. super will be reduced to $4 \times \frac{2}{3} = 2\frac{2}{3}$ tons per ft. super; 18 in. = 1·5 ft., $1{\cdot}5 \times 1{\cdot}5 = 2{\cdot}25$ square ft.; $2{\cdot}25 \times 2\frac{2}{3} = 6$ tons. . . . . (1).

Another rule is, if W = normal load and r = ratio of height to least width, the load on a pier should be reduced to $\frac{24\,W - Wr}{18}$; in this case $r = \frac{12}{1{\cdot}5} = 8$, therefore $\frac{24\,W - Wr}{18} = \frac{24 \times 4 - 4 \times 8}{18} = 3{\cdot}5$, and $2{\cdot}25 \times 3{\cdot}5 = 8$ tons safe load. Strictly the weight of the brickwork should be deducted $2{\cdot}25 \times 12 \times 120$ lbs. = 1·45 tons, therefore net safe load = 8—1.45 = 6.55 tons . . . . (2).

By Gordon's formula, treating the pier as an independent structure $W = \frac{FS}{1 + \frac{1}{600}\left(\frac{l}{d}\right)^2} = \frac{4 \times 2{\cdot}25}{1 + \frac{1}{600}\left(\frac{12}{1{\cdot}5}\right)^2} = \frac{9}{1 + \frac{64}{600}} = \frac{9}{1{\cdot}128} = 7{\cdot}97$ tons, 7·97—1·45 = 6·52 tons net . . . . (3).
Showing a fair agreement by all available methods.

Voluntary.

Question 5. *What is uralite, and for what purposes is it useful.*

Answer 5. The main ingredient of uralite is asbestos mixed with water and chalk into a pulp like paper pulp. This is rolled into sheets and a small quantity of silicate of soda is added to give it stability. These sheets are cut into sizes, pressed and dried. They are then steeped in a solution of silicate of soda which is afterwards decomposed by bicarbonate of soda, causing a deposition of colloid silica over the fibres of the asbestos. It may be used for roof covering, ceilings, floors and partitions, and can be veneered, varnished, painted, and worked with carpenters' tools like ordinary timber. It will withstand a temperature of 2,000° Fahr. without destruction.

EXAMINATION, OCTOBER, 1906.

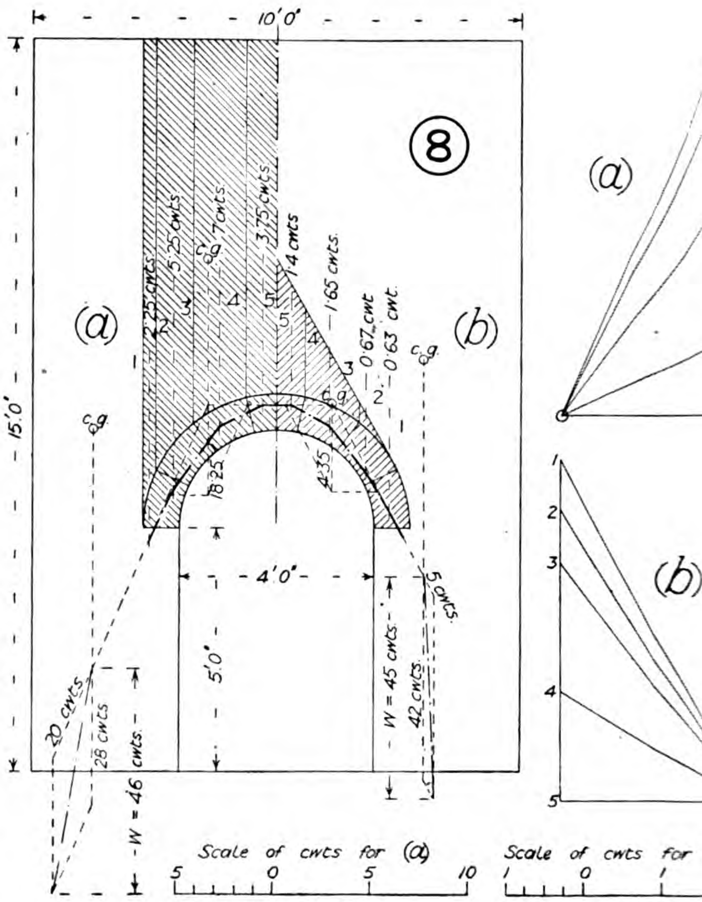
BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—Construction.

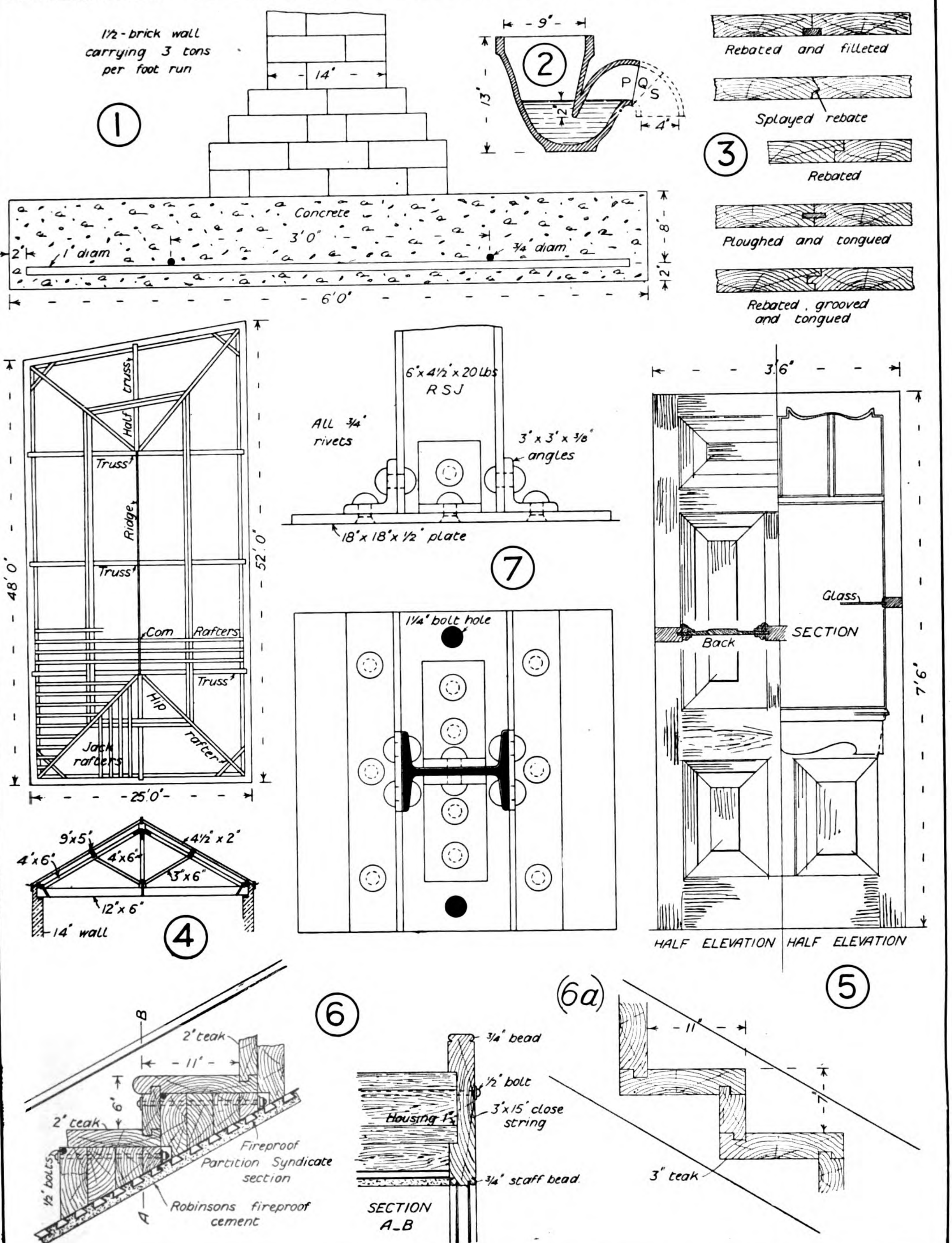
Question 1. *A 14 in. wall, carrying a load of 3 tons per foot run, is required to be built on made ground capable of carrying safely a load of ½ ton per foot super. Draw section at base of wall, showing the foundations you would put in. Scale, 1½ in. to 1 ft.*

Answer 1. See diagram 1. As the load is 3 tons per foot run and the ground is capable of carrying only ½ ton per foot super, the width of concrete will require to be 6 ft. With the ordinary brick footings to a 14 in. wall, the projection on each side of bottom course would be $\frac{6 - 2{\cdot}15}{2} = 1{\cdot}875$ ft., and the depth being 1½ times the projection it would have to be $1{\cdot}875 \times 1{\cdot}5 = 2{\cdot}8125$ ft., say 2 ft. 10 in. thick. To avoid this great mass of concrete the number of courses of footings might be increased to, say, six. Then the thickness of concrete would be reduced to $\frac{6 - 3{\cdot}375}{2} \times 1{\cdot}5 = 1{\cdot}97$, say 2 ft. This would be better, but a still greater saving in concrete and excavation may be made by using reinforced concrete.

Note.—The time available at the examination would not permit of full calculation and the design is necessarily approximate, but some candidates showed complete inattention to the conditions.



BUILDING CONSTRUCTION EXAMINATION OCTOBER 1906.



Question 2. *Make a neat sectional sketch, one-eighth full size, of a 4 in. yard gulley, with 9 in. square inlet. Indicate by dotted lines the difference between P, Q, and S outlets.*

Answer 2. See diagram 2. Showing Broad & Co.'s yard gulley with detached cover stone.

Question 3. *Show, by cross sections, to a scale of quarter full size, three methods by which dust and draught may be prevented from passing through the joints of floorboards.*

Answer 3. See diagram 3 for several methods. It should be noted that the heart side should always be downwards.

Question 4. *A warehouse, 25 ft. frontage, extends backwards at right angles for a depth of 48 ft. on one side and 52 ft. on the other. Draw a roof plan with hipped ends, showing position of trusses, and an elevation of one timber truss with scantlings marked on. Scale, ⅛ in. to 1 ft.*

Answer 4. See diagram 4.

Question 5. *Draw the elevation of a 3 ft. 6 in. by 7 ft. 6 in. internal door in hard wood, and a horizontal section half-way up. Scale, 1 in. to 1 ft.*

Answer 5. See diagram 5.

NOTE.—This is copied directly from the answer of one of the candidates, showing the style of execution that is acceptable in examination work, as distinguished from a carefully finished, weak, thin line, engraving style.

Question 6. *Draw a section through two steps of a wooden fire-resisting staircase. Also a section of the close outer string, showing the housing. Name the wood you would use. Scale, 1½ in. to 1 ft.*

Answer 6. See diagram 6. Teak should be used for the treads, risers and strings, and fir may be used for the solid backing. Diagram 6a shows an alternative simple section in 3 in. teak.

Question 7. *A 6 in. by 4½ in. by 20 lb. rolled steel joist is to be used as a stanchion to carry 22½ tons. Draw the base of stanchion showing suitable base plate, assuming that the material it stands on will carry 10 tons per square foot. Scale, 3 in. to 1 ft.*

Answer 7. See diagram 7.

NOTE.—All the answers to this question were very weak and showed an insufficient acquaintance with the subject.

Question 8. *A semi-circular brick arch, 4 ft. span, 9 in. on face, 5 ft. from ground line to springing, is proposed to be formed in the centre of a 9 in. wall, 15 ft. high and 10 ft. long. Draw the elevation to a scale of ½ in. to 1 ft., and show, by sketches and description, how you would proceed to ascertain the stability.*

Answer 8. See diagram 8, page 30.

NOTE.—At the examination, time only permitted the general principles of this answer to be sketched out, but no candidate showed any real knowledge of the subject. It is here worked fully, for general information. On the left hand side the maximum load is taken and the right hand side minimum load. The actual load in practice would depend upon the workmanship, and the strength of the mortar. The calculations of maximum stress are as follows. Left side

Arch

$$\frac{2}{3}\frac{W}{d} = \frac{2 \times 13{\cdot}5}{3 \times \frac{1}{6}}$$
$$= 54 \text{ cwt.} = 2{\cdot}7 \text{ tons per sq. ft.}$$

Abutment

$$\frac{2}{3}\frac{W}{d} = \frac{2 \times 46}{3 \times \frac{7}{8}}$$
$$= 35 \text{ cwt., or } 1{\cdot}75 \text{ tons per sq. ft.}$$

Right side.

Arch

$$\frac{2}{3}\frac{W}{d} = \frac{2 \times 4}{3 \times 0{\cdot}15} = \frac{8}{0{\cdot}45}$$
$$= 18 \text{ cwt.} = 0{\cdot}9 \text{ tons per sq. ft.}$$

Abutment

$$\frac{W}{A} + \frac{M}{Z} = \frac{45}{2{\cdot}25} + \frac{45 \times 0{\cdot}3}{1{\cdot}125}$$
$$= 20 + 12$$
$$= 32 \text{ cwt.} = 1{\cdot}6 \text{ tons per sq. ft.}$$

Subject b.—MATERIALS.

Question 1.

(*a*). *What precautions have to be adopted as regards the size, position and shape of stonework in a building?*

(*b*). *Describe Portland stone from the "true roach" bed, and state how you would recognize it.*

Answer 1.

(*a*). *Size.* The size should be within the limits obtainable from the particular quarry or bed specified, but not larger than the work absolutely requires. The area on the natural bed should be greater than upon the other faces. When bonded with brickwork as quoins or dressings to openings each stone should be a given number of courses high less the thickness of one joint. When carrying a special load the area must be proportioned to the load so that the safe intensity of pressure is not exceeded.

Position. All stones should be set with the natural bed perpendicular to the pressure, except overhanging undercut cornices, when the natural bed should be vertical and run from front to back. In mullions this is often neglected, with the result of an unsightly appearance as soon as the stone begins to weather. In walling, the largest blocks should be placed at the bottom and the longest should be kept for through bonds. When used as a lintel the superincumbent pressure should be taken by a relieving arch.

Shape. The beds should be worked square to the face and not hollow or tapered in thickness, which might cause "spalling." All mitres should be contained in a solid block instead of at joints.

(*b*). Portland stone from the "true roach" bed is a light bluish-grey limestone (brownish when first quarried) of hard and tough texture, weathering well in a town atmosphere, but not sufficiently uniform or close grained to allow mouldings to be worked upon it. It is full of fossils and shells cemented together by carbonate of lime. It is recognized by the "Portland screw fossil."

Question 2.

(*a*). *Name and describe three of the principal varieties of bricks in use. How would you test them, and for what purposes would you use them?*

(*b*). *What are the advantages and disadvantages of pressed tiles?*

Answer 2.

(*a*). *Stock Bricks* are the bricks commonly manufactured in any district. They may be slop or sand moulded, or wire cut, or machine pressed; hack or kiln dried; and clamp or kiln burnt. They are fairly hard and non-absorbent, may be picked of a uniform colour, and are used for general building purposes. *Blue Staffordshire Bricks* are very hard and dense, burnt almost to vitrification, very impervious to moisture, of a dark blue colour, very heavy, and used for plinths, quoins, sewer inverts, paving, etc. *Fire Bricks* are made from refractory clays that will bear a great heat without melting. They are open in texture and generally of a yellowish colour with a granular appearance. The Dinas bricks are the best as they contain 98 per cent. of silica. Used for building furnace bridges, flues, and inner lining of tall chimneys.

Tests. The test will vary with the use for which they are required and the opportunities for making the test. Generally bricks are inspected for colour, shape, texture and hardness. Two knocked together should ring clearly, when broken across they should appear uniform in texture, if for structural work they should not score with a knife, if for cutting or rubbing they should not score with the thumb nail. They should not absorb more than 15 per cent. of water, blue Staffords $2\frac{1}{2}$ per cent. There should be no lumps of free lime in them.

(*b*). The advantages of pressed tiles are density and non-absorption of moisture, and hence better weathering properties and longer life. Not so readily affected by frost. More regular in appearance. They lie evenly and are less likely to let a driving rain get underneath. The disadvantages are that they have too regular an appearance to please some architects, and being non-absorptive do not so readily change colour by the weather or by the growth of lichens. When wire-cut the nibs are planted on separately and very liable to come off. Face sometimes scales off. Heavier for same thickness.

Question 3.

(*a*). *Describe two varieties of metal lathing for ceilings.*

(*b*). *How are fir laths made?*

Answer 3.

(*a*). Expanded metal lathing is made by cutting through sheet metal in alternate lines of short length and pulling out into lozenge-shaped openings. Cup lathing is a modification of this, with corrugations running across the openings so that the metal stands off a flat surface better to allow of a key being formed. Wire wove lathing consists of wires crossed at right angles, and requires counterlathing when used against flat surfaces.

(*b*). Fir laths are riven or split by hand from Baltic fir logs about 4 ft. long to ensure the grain being continuous. They should be free from knots and not twist in the length. Sawn laths should never be used.

Question 4. *What safe load distributed may be carried on a 12 in. by 6 in. Memel beam supported at the ends over a span of 10 ft.? Show details of your calculations.*

Answer 4. $W = \frac{bd^2}{L} = \frac{6 \times 12^2}{10} = 86{\cdot}4$ cwts. This allows a factor of safety of 7.

EXAMINATION, MARCH, 1907.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

Question 1. *Sketch and describe the construction of a ferro-concrete foundation for a stanchion carrying* 50 *tons.*

Answer 1. See diagram 1. The object of using a ferro-concrete foundation in this case is to reduce the depth and economise both excavation and concrete. At the examination only an approximate section could be given owing to want of time, but the following notes show how the full calculation would be made. Say 12 tons per ft. sup. on cement concrete (max.), area base plate $= \frac{50}{12} = 4{\cdot}16$ say 4 sq. ft., or 2 ft. by 2 ft. Safe load on soil say 1 ton per foot super. Total load $= 50 +$ say 1 for stanchion $+$ say 5 for concrete $= 56$ tons, requiring $\sqrt{56} = 7{\cdot}483 =$ say 7 ft. 6 in. width of side of concrete. Projection of concrete below base of stanchion $\frac{7{\cdot}5 - 2}{2} = 2{\cdot}75$ ft. Bending moment for 1 ft. run $= 2{\cdot}75 \times \frac{2{\cdot}75}{2} = 3{\cdot}78$ ton-ft. Using the writer's formula for ferro-concrete beams, $W = ({\cdot}37p + {\cdot}214)\frac{bd^2}{L}$, where W = safe load tons distributed, ends supported, p = percentage of reinforcement, bd = breadth and depth in inches, L = span ft. Then $\frac{WL}{8} = \frac{{\cdot}37p + {\cdot}214}{8}bd^2$, and safe moment of resistance ZC (ton-ft.) $= ({\cdot}046p + {\cdot}027)\,bd^2$. Allow $1\frac{1}{2}$ per cent. reinforcement, then $({\cdot}046 \times 1{\cdot}5 + {\cdot}027)\,bd^2 = 3{\cdot}78$, ${\cdot}096bd^2 = 3{\cdot}78$, $bd^2 = 39{\cdot}4$ say 40; but b = 1 ft., therefore $d = \sqrt{40} = 6{\cdot}32$, say $6\frac{1}{2}$ in., depth of concrete above centre of reinforcement, $6{\cdot}5 \times 12 = 78$ sq. ins.; $1\frac{1}{2}$ per cent. of $78 = \frac{1{\cdot}5}{100} \times 78 = 1{\cdot}17$ sq. in. reinforcement per ft. run. Say $\frac{3}{4}$ in. rods, 4 in. centre to centre $= {\cdot}44 \times 3 = 1{\cdot}32$ sq. in. and section as in diagram 1. (NOTE.—The work of the candidates on this question shows a very poor knowledge of the subject, and some of the answers were ludicrous.)

Question 2. *A plain semi-circular arch of* 3 *ft. span is formed of two half-brick rings. Draw to a scale of* $1\frac{1}{2}$ *in. to* 1 *ft., and show the joints in half the arch.*

Answer 2. See diagram 2. (NOTE.—None of the candidates seemed to appreciate the necessity for symmetry in the joints, and all omitted a centre line to guide them in the jointing.)

Question 3. *Draw the section through two feather-edged stone steps fitted with non-slipping treads suitable for an office building (scale* 3 *in. to* 1 *ft.), and a section full size of a part of the added fitting.*

Answer 3. See diagram 3. (NOTE.—The non-slipping tread seemed to be generally understood, but the joint between the steps was in most cases very badly designed.)

Question 4. *Sketch and describe an armoured sliding door for a warehouse, fitted with attachments for self-closing in case of fire.*

Answer 4. See diagram 4. This form of door, by Messrs. Mather & Platt, Ltd., is constructed of three or four thicknesses (according to the area of opening) of well-seasoned pine boards, planed, tongued and grooved, and nailed together with wrought-iron nails driven flush and clenched on the other side. They are completely covered with tinned-steel sheets, put on in such a manner that, whilst free to expand, they exclude the air and cannot become detached. By excluding the atmosphere from the wood, combustion is prevented; an exposure of several hours to the flames only resulting in the timber becoming carbonized to the depth of a fraction of an inch. These doors are usually fitted with an automatic apparatus for self-closing in case of fire.

A connecting part, of a combustible or fusible character, sustains the attachment of the balance weight to the door until acted upon by fire, when the weight is released and the door closes.

Question 5. *Draw a part elevation of a panelled dado in oak, 4 ft. 6 in. high (scale, 1 in. to 1 ft.), and show half size section through one stile and panel.*

Answer 5. See diagram 5. (NOTE.—This was the only question candidates appeared to understand.)

Question 6. *Give a section (scale, $1\frac{1}{2}$ in. to 1 ft.) through the eaves of a tiled roof, 45° pitch on a 14 in. wall. Show all details, including laths, sprockets and guttering.*

Answer 6. See diagram 6. (NOTE.—Although fairly correct work was shown in the answers to this question, they nearly all had some serious defects.)

Question 7. *Draw to a scale of $1\frac{1}{2}$ in. to 1 ft. the connection of a 12 in. by 6 in. by 54 lb. R.S.J. as a girder carrying 16 tons, to a similar R.S.J. as a stanchion. What are the advantages and disadvantages of a flange connection as against a web connection?*

Answer 7. See diagram 7. A flange connection has the advantage of applying the load at the strongest part and in the direction of the greatest radius of gyration, with the disadvantage of being further away from the neutral axis and producing a greater bending moment. A web connection has the advantage of being so near the neutral axis that little bending moment is caused, but such as there is occurs in the direction of the least radius of gyration and therefore produces considerable stress. (NOTE.—Structural steel work, which is an important branch of modern construction, seems intended to be left to the contractor, if one may judge by the want of knowledge shown in the answers.)

Question 8. *The earth in front of a semi-basement to a house has to be supported for a depth of 6 ft.; show to a scale of 1 in. to 1 ft., the section of a suitable retaining wall, and prove its stability by graphic diagram.*

Answer 8. See diagram 8 for the section proposed. (NOTE.—The diagram 8 (*a*) shows the graphic diagram for stability, for which time would not permit at the examination, but it is added for the benefit of those who failed to draw a reasonable section.)

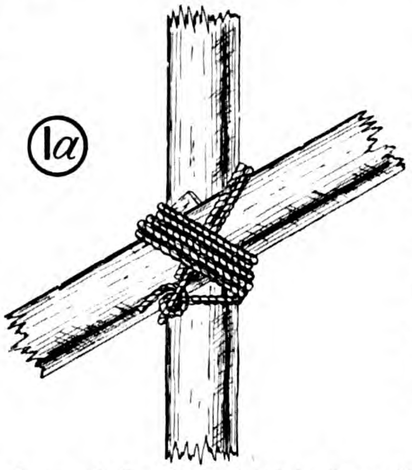
SPECIAL NOTE BY THE EXAMINER.—Only one candidate out of the seven who sat for this subject succeeded in obtaining half marks. The questions cannot be considered too difficult for anyone applying for a certificate of qualification as a full member, and in judging of the answers every allowance is made for the variation of practice in different districts.

Subject b.—MATERIALS.

Question 1.

(*a*) *Sketch the lashing of a brace with a scaffold pole in a bricklayer's scaffold.*

(*b*) *Give the usual sizes of scaffold cords and scaffold boards.*



Answer 1.

(*a*) See diagram 1a.

(*b*) Scaffold cords are of tarred hemp or jute, or white Manilla, usually 2 to $2\frac{1}{4}$ in. circumference, say $\frac{5}{8}$ in. to $\frac{3}{4}$ in. diameter, and 15 to 18 ft. long. Scaffold boards are usually 7 to 9 in. wide, $1\frac{1}{4}$ to 2 in. thick, and 12 to to 14 ft. long.

Question 2.

(*a*) *State what you know of the sizes of bricks from different districts.*

(*b*) *How are slates obtained from the quarry?*

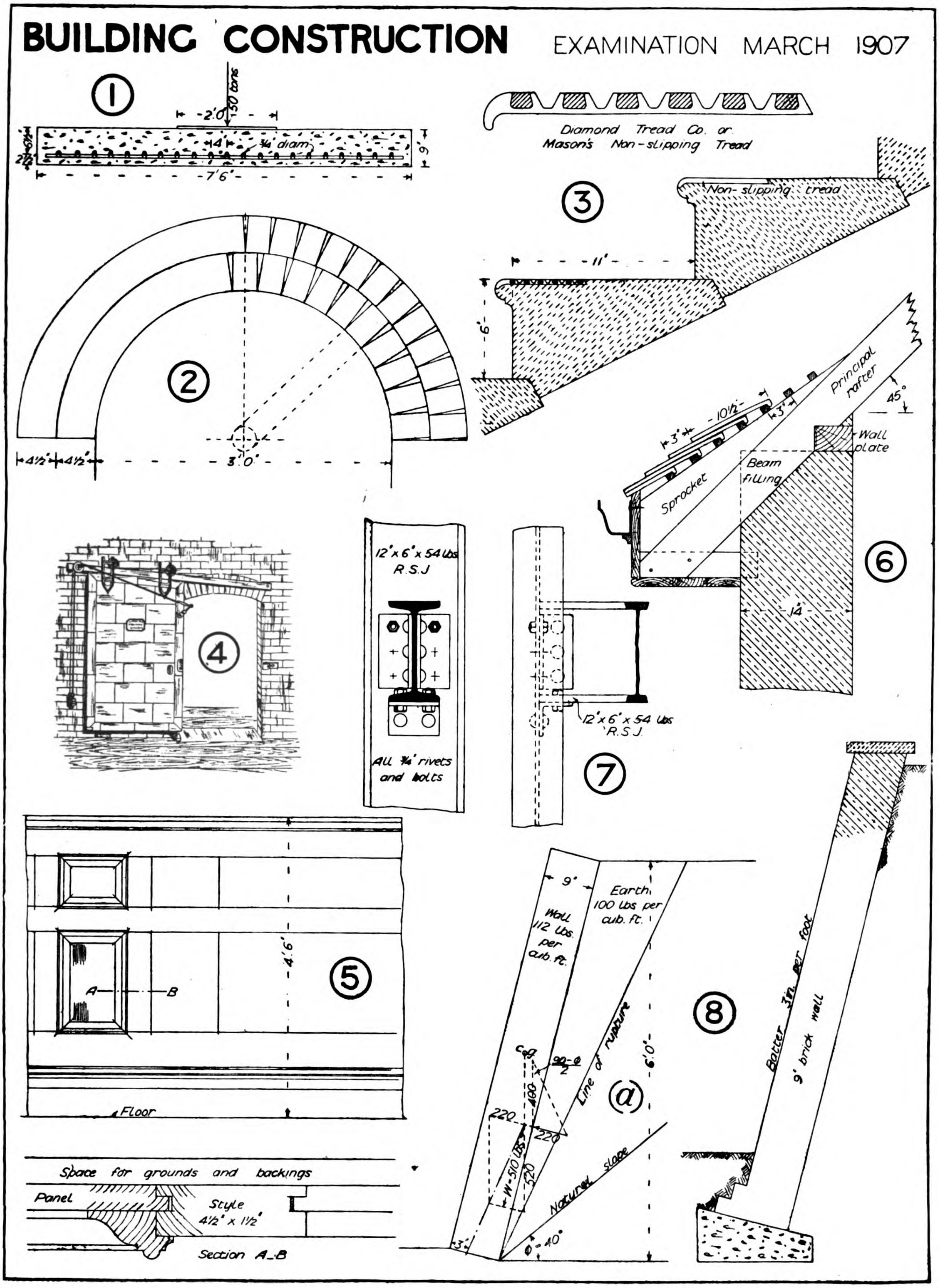
Answer 2.

(*a*) The size of London stock bricks averages $8\frac{7}{8}$ in. by $4\frac{1}{4}$ in. by $2\frac{3}{4}$ in., Fareham red rubbers, 10·9 in. by 4·8 in. by 2·9 in., and Dutch clinkers, $6\frac{1}{4}$ in. by 3 in. by $1\frac{1}{2}$ in. In the Midlands the average size is 9 in. by $4\frac{1}{2}$ in. by 3 in. The R.I.B.A. standard size comes out at 9 in. by $4\frac{3}{8}$ in. by $2\frac{11}{16}$ in. The length should be equal to twice the width plus one joint.

(*b*) There are two chief methods of obtaining slates from the quarry, viz., open quarrying and mining, but in both cases blasting is used. In the open quarrying method, which is more usual, a quarryface is exposed and then a vertical channel about 3 ft. square is made throughout its height. A horizontal hole called a "split hole" is then made along the cleavage, and if possible in a natural joint, and a blast exploded in this, just enough to lift the rock. A "pillar hole" is next driven at right angles to the cleavage and down to the "split," bursting the stone out at the split towards the already exposed channel along a cleavage which is known as the "pillaring line," which always runs north and south. The blocks are then split along the cleavage by wedges, or plug and feathers, into slabs about 13 in. thick, and taken to the workshop, where they are cut to the required lengths by circular machine saws. These slabs are then split along the cleavage to about 3 in. thick, and "pillared," or split across the cleavage by means of a "pillaring chisel." The slabs are thus roughly reduced to size, and the splitter takes them between his knees and, gauging the thickness by eye, splits them off with a "splitting chisel." The slates are then trimmed to market sizes by a "dressing knife" acting against a "travel," the sizes being scratched on the slate by a nail in a notched "measuring stick." In many quarries the trimming is now done by machinery.

Question 3.

(*a*) *Describe how limewhite, or outside whitewash, is made and used. What is the general object in view?*


BUILDING CONSTRUCTION EXAMINATION MARCH 1907
1
2'0"
50 tons
4"
3/4" diam
9"
7'6"
Diamond Tread Co. or Mason's Non-slipping Tread
3
Non-slipping tread
11"
6"
2
4 1/2"
4 1/2"
3'0"
Principal rafter
45°
10 1/2"
3"
Wall plate
Beam filling
Sprocket
6
14"
4
12" x 6" x 54 Lbs R.S.J
All 3/4" rivets and bolts
12" x 6" x 54 Lbs R.S.J.
7
5
4'6"
A
B
Floor
Space for grounds and backings
Panel
Style 4 1/2" x 1 1/2"
Section A_B
9"
Earth 100 Lbs per cub. ft.
Wall 112 Lbs. per cub. ft.
Line of rupture
6'0"
(a)
220
220
W=510 Lbs.
520
Natural slope
3"
Φ=40°
8
Batter 3in. per foot
9" brick wall

(*b*) *What is size, and how can its objectionable smell be prevented?*

Answer 3.

(*a*) The chief requisite for an effective limewash is a good rich quicklime, recently burnt, and free from earthy matter, which will produce, when slaked, a white and abundant powder. Hydraulic lime should never be used for limewash. Take a wooden receptable of about 20 gallons capacity and place in it 40 lbs. of the lime in lumps. Then sprinkle hot water on to it, so that the water is just absorbed easily, and the lime will then crack and break giving off a quantity of steam The water is sprinkled on in a gradually increasing quantity as the lime swells and absorbs more, and about 6 to 7 gallons of water may thus be poured over the 40 lbs. of lime, the slaked lime being then allowed to cool. A little more water should then be added, and if there are any particles of quicklime remaining heating will take place, and the additional water will probably be sufficient to slake the remaining quicklime. The slaked lime has then 11 to 13 gallons of water added and it is allowed to stand for a few hours, being stirred occasionally. This milk of lime is next passed through a large sieve, with meshes of $\frac{1}{25}$ of an inch, into a vessel holding about 30 to 35 gallons. Any solid particles should be crushed so that all may be carried through, and the operation is finished by passing water through the sieve to make up about 25 gallons of limewash, which is put on by a large brush or a spraying machine. It is used for distempering the walls of houses, workshops, etc., as a disinfectant, wall cleanser and light reflector. If the limewhite is to be secure from rubbing off, about 8 lbs. alum or 5 lbs. cooking salt should be dissolved in $1\frac{1}{2}$ to 2 gallons of water and added to the above.

(*b*) Size consists of weak glue, the glue being melted in hot water and more water added until it is thin enough for use. A pound of glue will make about a gallon of size. The objectionable smell may be removed by adding a little carbolic acid.

Question 4. *A stable loft has a cat-head of timber projecting 3 ft. to support a gin-wheel for hoisting sacks. Assuming a full sack to weigh 2 cwt., what size should the cat-head beam be made? Show details of working.*

Answer 4. 2 cwt. = 224 lbs. The wheel will have to support the pull in the rope and the weight in the sack = 224 + 224 = 448 lbs. An addition of 50 per cent. must be made to allow for a sudden lift, 448 + $\frac{50}{100} \times 448$ = 672 lbs. effective load. 3 ft. = 36 ins. Bending moment = 672×36 = 24192 lbs.-ins. Section modulus for rectangular beam $Z = \frac{bd^2}{6}$. Modulus of rupture for fir C = say 8,000 lbs. per sq. in. Factor of safety say 8. Working modulus = $\frac{8000}{8}$ = 1,000 lb.

Then:

$$\text{Effort} = \text{Resistance}$$
$$M = R$$
$$WL = ZC$$
$$24192 = \frac{bd^2}{6} \times 1000$$
$$bd^2 = \frac{24192 \times 6}{1000} = 145{\cdot}152$$
$$\text{say } d = 6 \text{ ins., then } b = \frac{145}{6 \times 6} = 4.$$

Size of beam say 6 in. by 4 in.

EXAMINATION, OCTOBER, 1907.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

Question 1. *Show by sketch of brick wall with footings and concrete what is meant by benched foundations, and describe when they are required.*

Answer 1. See diagram 1. Stepped footings and benched foundations are required when a wall is built on sloping ground, in order to prevent any tendency to slip.

Question 2. *A square bay in 9 in. brickwork has a projection of 2 ft. $0\frac{3}{4}$ in. from a 9 in. wall. Show two courses of the bonding at one end in English bond.* (*Scale, 1 in. to 1 ft.*).

Answer 2. See diagram 2, (*a*) and (*b*) show each two adjacent courses of alternative bonding.

Question 3. *Give a neat sketch of the exterior of a pointed arch window with plate tracery, and mark distinctly the jointing of the stones.*

Answer 3. See diagram 3.

Question 4. *Draw the elevation of a scarf joint for a tie beam, 9 in. by 6 in., showing all details.* (*Scale, 3 in. to 1 ft.*).

Answer 4. A tie beam should not have a scarf joint if it can be avoided. The usual joint when a scarf is made is shown in diagram 3, but it is not the best form of joint for combined tension and cross strain, such as a tie beam undergoes.

Question 5. *Show by sketches how you would roof a Pier Concert room 60 ft. by 40 ft. If desired, there may be two columns 20 ft. apart below each truss.*

Answer 5. See diagram 5.

Question 6. *Draw sections through the bottom rail and sill of a $1\frac{1}{2}$ in. casement window (a) opening inwards; (b) opening outwards.* (*Scale, full size*).

Answer 6. See diagram 6 (*a*) shows section for casement opening inwards and (*b*) for casement opening outwards.

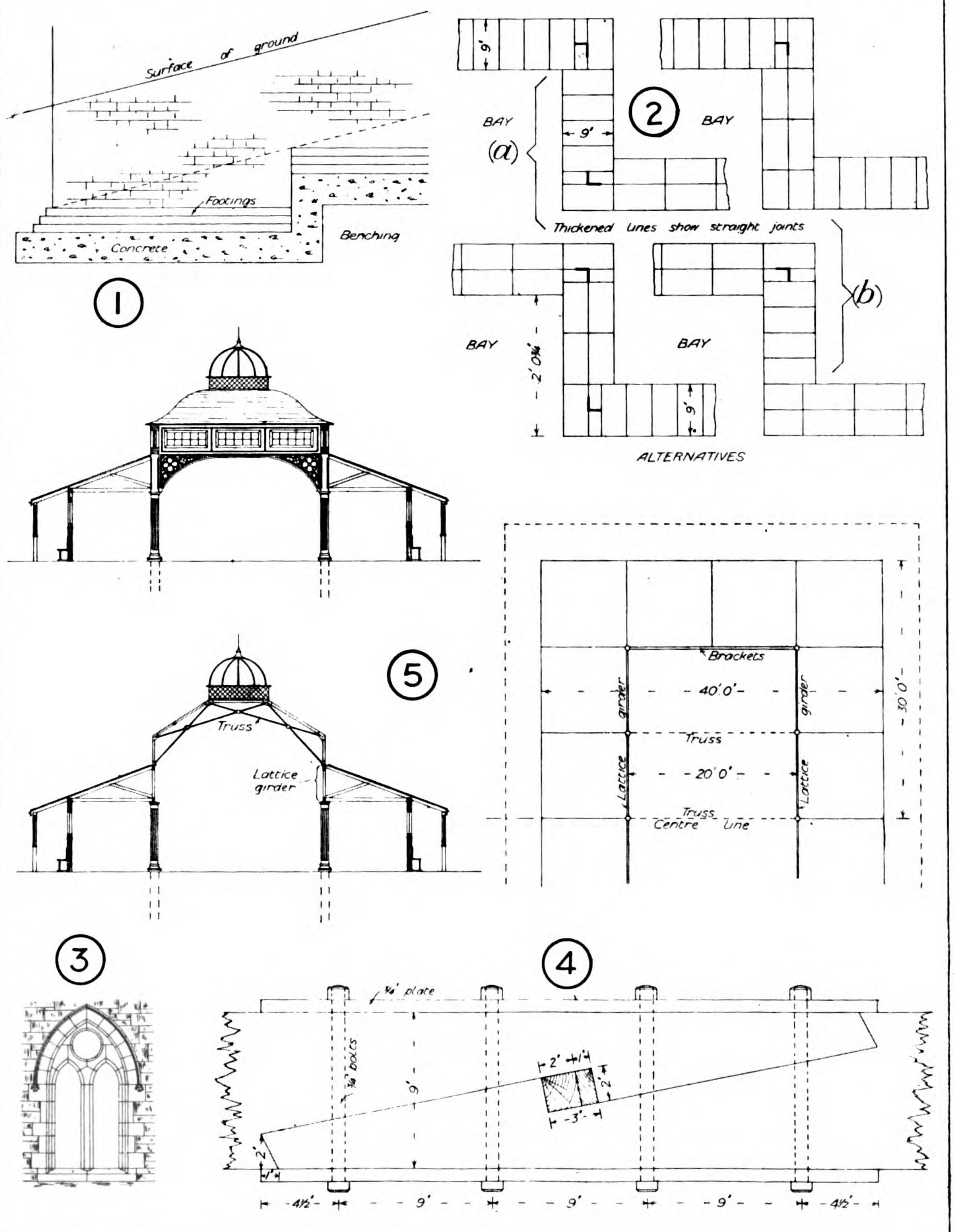
Question 7. *Sketch and describe the construction of two varieties of fire-resisting partitions.*

Answer 7. See diagram 7. (*a*) Shows Turner's Partition Wall built with "Insulation Brick Blocks," with hoop iron bond and keyed for plaster. (*b*) Shows the "Fireproof Construction Co.'s Hygienic Fireproof Block Partition." 2 inches thick, composed of plaster slabs with dowels and metal clamps.

Question 8. *A rolled joist lintel, 6 in. deep and 6 ft. span, is to be built in at each end so as to carry a maximum load. Draw the elevation to a scale of 1 in. to 1 ft. and shade the parts in compression. State how much more the joist will carry than if it had been merely supported at the ends.*

Answer 8. See diagram 8. When the joist is built in $\frac{1}{4}$ span at each end, it will carry 50 per cent. increase of load, or half as much again as when merely supported at the ends.

BUILDING CONSTRUCTION EXAMINATION OCTOBER 1907



Subject b.—MATERIALS.

Question 1.

(*a*) *Of what does plaster of Paris consist, and for what is it used in building constructon?*

(*b*) *What variety of lime is used in plastering, and why?*

Answer 1.

(*a*) Plaster of Paris consists of partly calcined gypsum (hydrous sulphate of lime). It is mostly used in building construction for enrichments to plaster cornices, etc., as it is capable of taking very sharp impressions. It is also used to "gauge" or stiffen the finishing coat of wall plaster.

(*b*) The lime used in plastering is "pure" or non-hydraulic. The reason is that it slakes freely and is less likely to contain unslaked particles, which might "blow," while it will adhere to rough surfaces and can be brought to a smooth and level face. Another reason for its use is that it is porous and therefore absorbs the moisture which would otherwise collect on the plaster and run down.

Question 2.

(*a*) *How is sheet lead made?*

(*b*) *Name some of its uses, giving the thickness in each case.*

Answer 2.

(*a*) Sheet lead is made by first casting a plate of lead say 5 to 6 in. thick, and then passing it under steel rollers which gradually squeeze it down to the required thickness. These sheets are known as "milled lead." Another method is to pour the molten lead on to a levelled bed of sand on a wooden bench. A "strike" is then passed over at the required thickness to sweep away the surplus. These sheets are known as "cast lead."

(*b*) Sheet lead is used generally for making water-tight joints in roofs, and for lining sinks and cisterns. The thickness of lead is usually denoted by its weight per ft. sup. and the following are the weights usually adopted in good work. Flashings to roofs 5 lbs.; hips, ridges, small gutters and the sides of sinks 6 lbs.; cisterns, rainwater pipes, 7 lbs.; roofs, flats, main gutters, and sink bottoms, 8 lbs. lead.

Question 3.

(*a*) *Describe the manufacture of some well-known variety of artificial stone.*

(*b*) *What are the advantages or disadvantages compared with natural stone?*

Answer 3.

(*a*) Victoria stone is made by mixing three parts of well-washed Leicestershire granite, finely crushed, with one part of selected Portland cement in a dry state, by machinery. Water is then carefully added so as not to wash any fine particles away, and the moulds are at once filled before any initial set of the concrete takes place. The moulds are allowed to stand on benches until sufficiently set and when the slabs are dry they are taken out of the moulds and placed side by side in a tank and covered with a solution of silicate of soda. They are kept in the tank for about 14 days when they are taken out and stacked in the stoneyard to season.

(*b*) The advantages of this stone are that for paving it wears evenly and slowly, is practically non-absorbent, and has a great resistance to crushing. For moulded blocks it can be brought to finished proportions direct. The disadvantages are, its appearance, and the difficulty of dressing it if occasion should arise.

Question 4.—*Calculate the safe load that may be put upon a 6 in. by 6 in. fir post, 12 ft. high, with flat ends.*

Answer 4. The approximate safe load on a fir post being 4 cwt. per sq. in., a 6 in. by 6 in. post would carry $6 \times 6 \times 4 = 144$ cwt. $= 7 \cdot 2$ tons. More accurately, by the Gordon formula, $W = \dfrac{FS}{1 + \dfrac{l^2}{250d^2}} = \dfrac{2 \cdot 5 \times 36}{1 + \dfrac{(12 \times 12^2)}{250 \times 6^2}} = 27 \cdot 3$ tons breaking weight. Allow factor of safety of 4, then safe maximum load $= \dfrac{27 \cdot 3}{4} = 6 \cdot 825$ tons, but the ordinary working load $= \dfrac{27 \cdot 3}{6} = 4 \cdot 55$ tons.

EXAMINATION, APRIL, 1908.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

Question 1. *A trench is to be sunk 10 ft. deep and 3 ft. wide in a wet clay soil. Show by dimensioned sketches what timbering should be used, and state what other provisions would be necessary to enable the men to work in the trench.*

Answer 1. See diagram 1. A sump hole would be required at intervals, so that a galvanized iron barge pump can be let down to keep the trench clear of water.

Question 2. *Show to a scale of 1½ in. to 1 ft. plans of two courses of a 1½-b. wall having Flemish facing and English backing.*

Answer 2. See diagram 2.

Question 3. *Draw one quarter full size the elevation of about 2¼ sq. ft. of each of three kinds of rubble walling, and state under what circumstances you would use them.*

Answer 3. See diagram 3. The circumstances under which they should be used are :—

(*a*) For the commonest class of work as fence walls between fields.

(*b*) For better class work as boundary walls to estates.

(*c*) For basement work to buildings with brick superstructure, for engineering work generally, for good boundary walls.

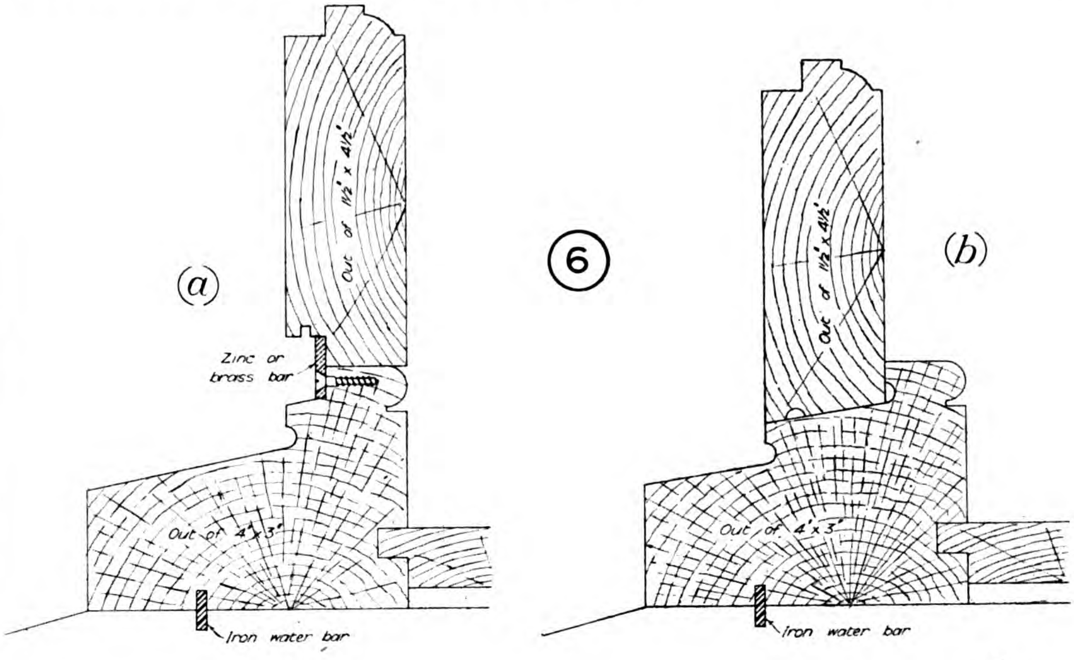
Question 4. *Draw to a scale of 3 in. to 1 ft. the section and plan of three lead soakers with stepped cover flashing at the brick gable of a roof covered with duchess slates on close boarding.*

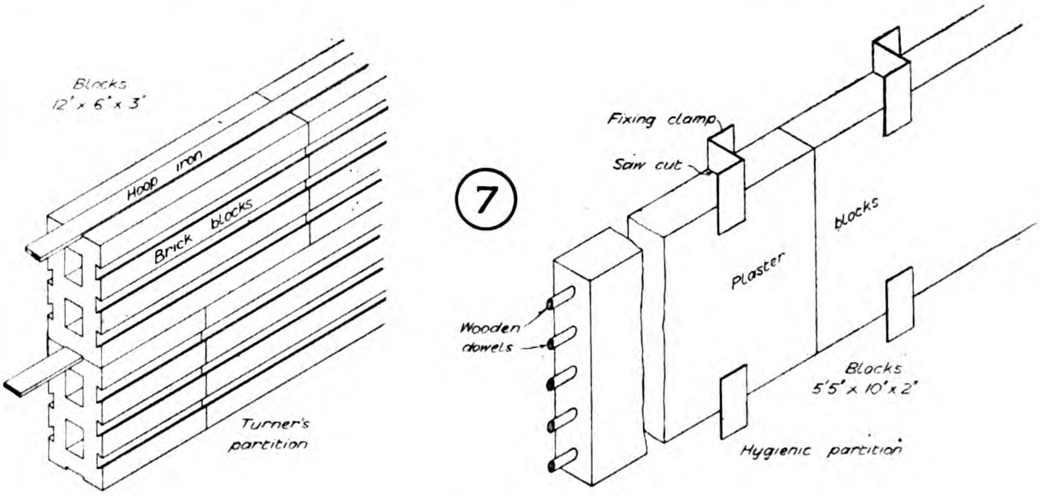
Answer 4. See diagram 4.

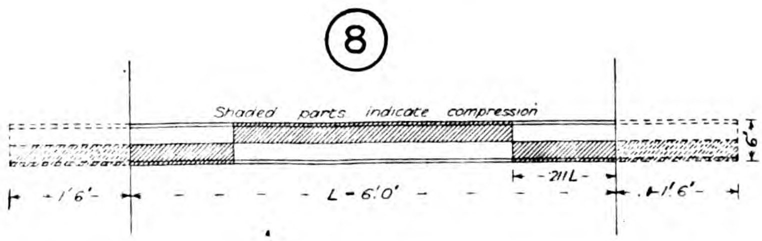
Question 5. *Draw a section half full size through a head and sill of a swivel folding partition for a school. Also a sketch plan to a scale of ½ in. to 1 ft.*

Answer 5. See diagram 5.

BUILDING CONSTRUCTION EXAMINATION OCTOBER ·1907







Question 6. *Sketch neatly a fanlight ventilator hinged at the bottom and opening inwards. Indicate clearly how the opening and closing are effected.*

Answer 6. See diagram 6.

Question 7. *Sketch the section and part elevation of a fire-proof cubicle partition, and describe the construction.*

Answer 7. See diagram 7 showing the partition made by The Fireproof Co., Ltd., York Buildings, Adelphi. For the erection of a cubicle partition, a channel section is fixed to H section uprights, channel section shoes about 4 in. long are placed under each upright. The uprights, $1\frac{1}{4}$ in. by $1\frac{1}{4}$ in. by $\frac{1}{8}$ in., or $1\frac{3}{8}$ in. by $1\frac{1}{4}$ in. by $\frac{1}{8}$ in., are cleated to the channel head and are spaced according to the width of the sheeting used. Between the flanges of the uprights are placed the dovetail corrugated sheets with butt joints and clips where necessary. To tie the partition together, hoop-iron bands are employed from upright to upright alternately on either side of the partition, with the ends bent round the flanges of the uprights. The finished thickness when plastered, and suggested capping in dotted lines are indicated in the section.

Question 8. *Sketch the arrangement you would adopt for a light iron roof truss 20 ft. span, and give details of two of the joints.*

Answer 8. See diagram 8.

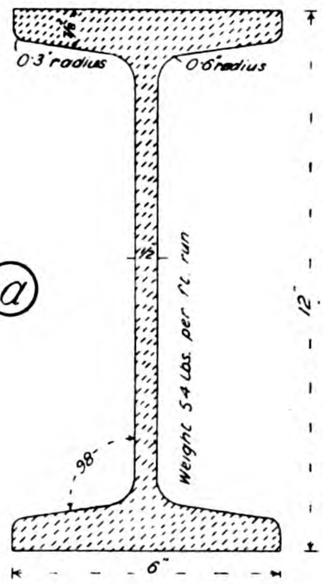
Subject b.—MATERIALS.

Question 1.

(*a*) *Sketch half full size the section of a 12 in. by 6 in. by 54 lb. rolled steel joist, with a mean flange thickness of $\frac{7}{8}$ in. and $\frac{1}{2}$ in. web.*

(*b*) *Name three things for which you would use wrought-iron and three for cast-iron.*

(1a)



Answer 1.

(*a*) See diagram 1a.

(*b*) Wrought-iron is used chiefly for :—

(1) Tie-rods, bolts, straps, etc.

(2) Light ornamental work, such as brackets, gates, railings, etc.

(3) Tanks and boilers.

Cast-iron is used chiefly for :—

(1) Columns, stanchions, etc.
(2) Drain and rain-water pipes.
(3) Grates and mantels, kitcheners, etc.

Question 2.

(*a*) *Describe the manufacture of bricks by hand.*

(*b*) *What are the advantages and disadvantages of hand-made bricks?*

Answer 2.

(*a*) The moulds used in hand-moulding bricks are about 10 in. by 5 in. by 3 in. to allow for the contraction of the clay in burning. In some cases the mould rests upon the plain table, in which case the bottom of the brick is flat or it rests on the " stock board," upon which is a raised projection to form the " frog " of the brick. A clot of clay is taken and dashed into the mould and thoroughly rammed into every corner, and then the superfluous clay is scraped off with a strike or straight-edge of wood or steel. When the mould is dipped in water to prevent the bricks sticking, the process is called " Slop-moulding," and if fine sand is used for the same purpose the process is called " Sand-moulding." The bricks are then carried off on a " hack-barrow " to the hack to dry.

If the bricks are to be clamp burnt, they must be thoroughly dried and that process takes from three to six weeks. After that the clamp is built and the raw bricks burnt.

If the bricks are to be kiln burnt they are " scintled," that is stacked diagonally at a little distance apart so that the wind may pass between them, and this operation takes about ten days. They are then placed in the kiln and burnt.

(*b*) The advantages of hand-made bricks are that they can be rubbed better, as in the case of arches, etc., and they are also considered to have a better architectural effect.

The disadvantages are that the bricks are not solidly pressed and are therefore lighter and more porous than machine-made bricks. They may be irregular in shape and the arrises are not so well defined, and they are also more liable to crack in burning.

Question 3.

(*a*) *State what you know of the manufacture of " slag wool."*

(*b*) *Describe some of its uses in building construction.*

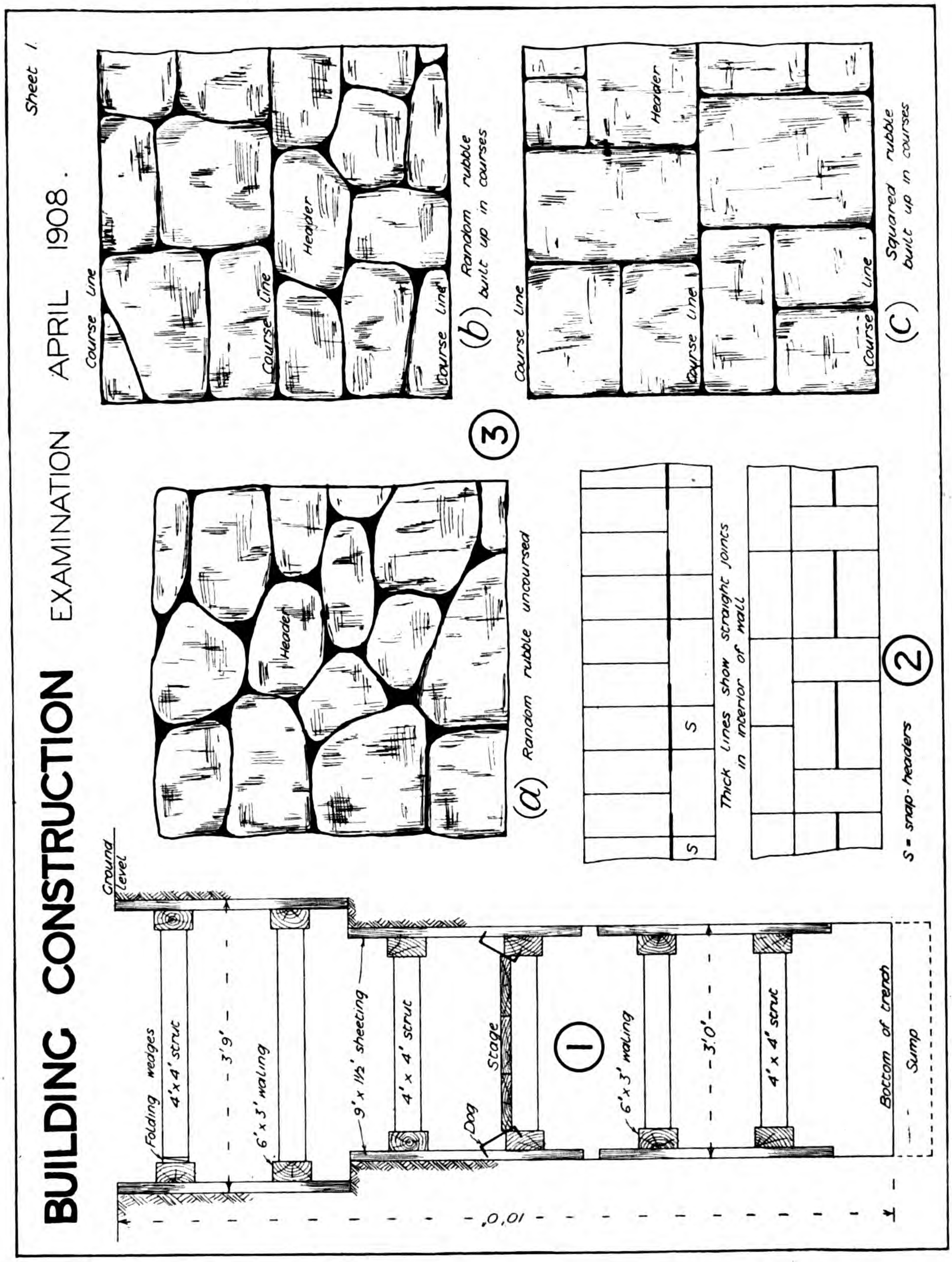
Answer 3.

(*a*) Slag wool is made by forcing a blast of steam through falling molten slag, which blows the slag into a light open substance like cotton-wool.

(*b*) It is used for pugging to make floors and partitions sound-proof, and also as a basis to some of the fire-resisting plasters. It is also used for insulating walls of cold storage rooms, and for packing round pipes.

Question 4. *Fir joists, 8 in. by 2 in., are used 12 in. apart over a span of 14 ft.; calculate the safe external load per foot super, allowing a factor of safety of 7.*

Answer 4. The formula to use in this case will be $W = \frac{bd^2}{L}$ where W = safe load is cwts. distributed, allowing a factor of safety of 7, b = breadth in inches, d = depth in inches, L = span in feet. Then $\frac{bd^2}{L} = \frac{2 \times 8^2}{14} = 9{\cdot}143$ cwt. distributed over $14 \times \frac{14}{12} = 16{\cdot}3$ sq. ft. $= \frac{9{\cdot}143}{16{\cdot}3} =$ 0·56 cwt., or 63 lbs. per ft. super.


BUILDING CONSTRUCTION EXAMINATION APRIL 1908.
Sheet 1.
Ground level
Folding wedges
4" x 4" strut
3'9"
6" x 3" waling
9" x 1½" sheeting
4" x 4" strut
Dog
Stage
1
6" x 3" waling
3'0"
4" x 4" strut
Bottom of trench
Sump
10'0"
(a) Random rubble uncoursed
Header
Thick lines show straight joints in interior of wall
S
S
S - snap-headers
2
3
(b) Random rubble built up in courses
Course line
Course line
Course line
Header
(c) Squared rubble built up in courses
Course line
Course line
Course line
Header

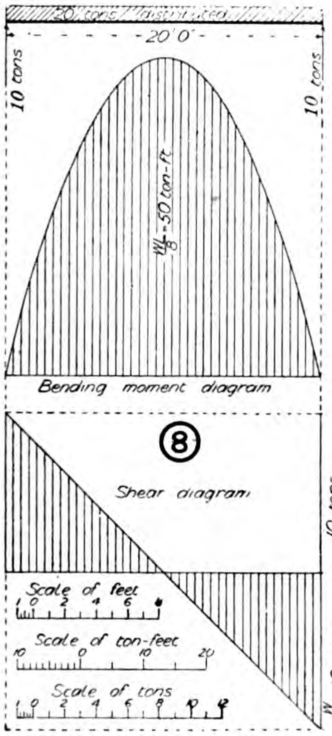
EXAMINATION, OCTOBER, 1908.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

Question 1. *Show in plan and section (¾ in. to 1 ft.) the timbering for a pier-hole 4 ft. square and 6 ft. deep in ordinary soil. Mark the scantlings.*

Answer 1. See diagram 1.



Question 2. *Draw the elevation of 30 ft. run of a 9 in. brick fence wall, 6 ft. mean height, on a slope of 1 in 10. Dot in the footings and concrete. Scale 4 ft. to 1 in.*

Answer 2. See diagram 2.

Question 3. *A plain masonry arch in an ashlar wall has a span of 6 ft. and rise of 1 ft. Draw the voussoirs, keystone, and imposts to a scale of 1 in. to 1 ft., and indicate the direction of the natural quarry-bed in one stone of each kind.*

Answer 3. See diagram 3.

Question 4. *Draw to a scale of ⅛ in. to 1 ft. the elevation of a queen-post roof truss 34 ft. span, mark the scantlings, and state how far apart the trusses should be placed.*

Answer 4. See diagram 4.

Question 5. *Give a section through a wooden entablature for a shop front, showing bressummer girder carrying 14 in. wall. Sun-blind roller to be provided for. Scale ¾ in. to 1 ft.*

Answer 5. See diagram 5.

Question 6. *Draw full-size section through the metal bar of any system of dry roof-glazing, showing the glass in position.*

Answer 6. See diagram 6.

Question 7. *An 8 in. by 6 in. by 35 lb. rolled steel joist used as a stanchion carries a load of 30 tons. Draw the lower end in plan and elevation, showing a suitable base-plate for resting upon cement concrete. Scale, 1 in. to 1 ft.*

Answer 7. See diagram 7.

Question 8. *Draw the bending moment and shear diagrams for a girder 20 ft. span carrying a distributed load of 20 tons. Scales 4 ft. to 1 in., 4 tons to 1 in., 10 ton-ft. to 1 in.*

Answer 8. See diagram 8.

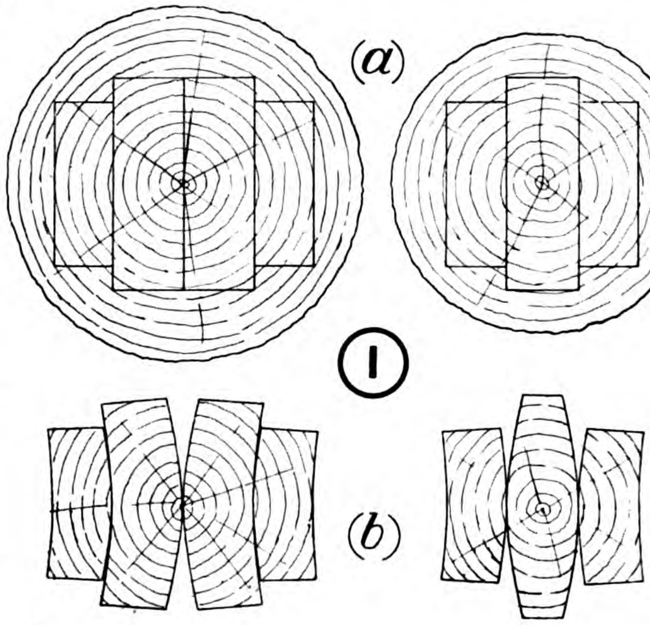
Subject b.—MATERIALS.

Question 1.

(*a*) *Sketch the cross section of a tree trunk and mark upon it the mode of conversion into deals or battens.*

(*b*) *In a separate sketch of the ends of the boards, show how they would alter their shape in seasoning.*

Answer 1. (*a*) See diagram 1a and 1b. Two methods of conversion are shown according to the size of the tree. The shrinking of the boards is exaggerated to show the effect more clearly.



Question 2.

(*a*) *How is pig-iron obtained, and how is it converted into wrought-iron?*

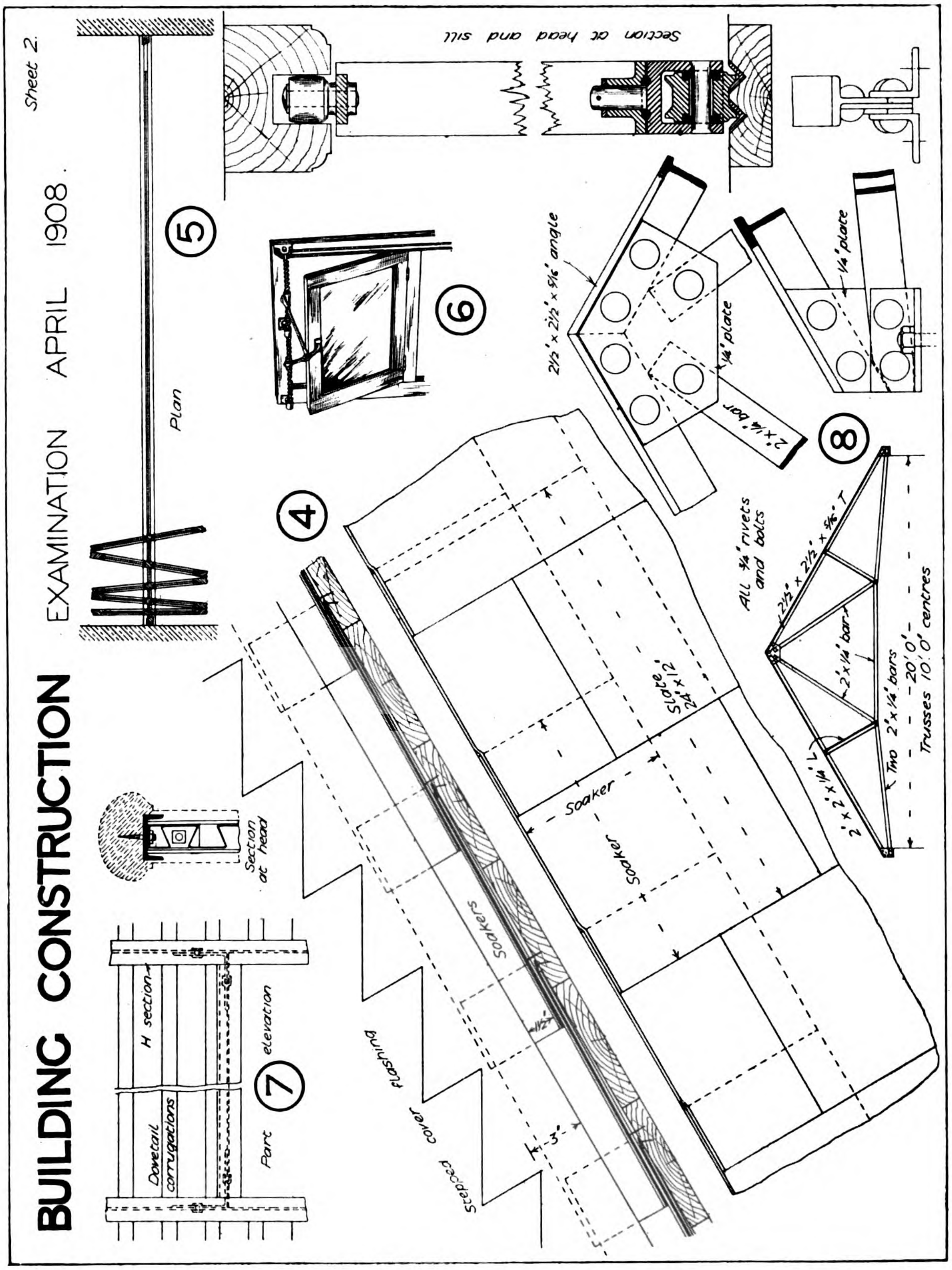
(*b*) *Describe the operation of welding.*

Answer 2.

(*a*) The ore is first broken into pieces, mixed with coal in large heaps and roasted to drive off the water, carbonic acid gas and sulphur. The roasted ore is then mixed with earthy matters to form a flux and smelted in a blast furnace to obtain the metal from the ore. The molten metal is run off into channels in sand, long lines called "sows" and branches 3 or 4 ft. long called "pigs," thus giving the name "pig-iron."

To convert to wrought-iron, the pig-iron is melted in a reverberatory furnace and when molten, is stirred to bring the lower portions into contact with the air, and as the oxygen combines with and extracts the carbon, the metal becomes a pasty mass which then collects in lumps. These lumps are drawn together, worked through a side door, and withdrawn from the furnace in balls or blooms of metal weighing about 60 lbs. These are then hammered or squeezed, and rolled to consolidate them, the result being to produce what is known as "puddled bar." This is cut into short lengths and reheated again in the reverberatory furnace, hammered and rolled, the result being "merchant bar." Repetitions of the process result in "single," "double," and "treble" best iron.

(*b*) To weld iron, the pieces must be first suitably shaped to allow for hammering, brought to a white heat, and the scale swept off before they are put together. They are then brought into contact and well hammered, by which they are reduced to their original dimensions and form one solid piece.


BUILDING CONSTRUCTION
EXAMINATION APRIL 1908.
Sheet 2.
5
Plan
Section at head and sill
6
4
Stepped cover flashing
Soakers
Soaker
Soaker
Slate 24"x12"
3"
1½"
7
Part elevation
Dovetail corrugations
H section
Section at head
8
2½" x 2½" x 5/16" angle
¼" plate
¼" plate
2"x¼" bar
All ¾" rivets and bolts
2½" x 2½" x 5/16" T
2"x¼" bar
2"x¼" bars
Two 2"x¼" bars
2"x2"x¼" L
20'0"
Trusses 10'0" centres

Question 3.

(*a*) *What are encaustic tiles and how are they made.*

(*b*) *What does "mill mortar" consist of, how is it made, and what are its advantages?*

Answer 3.

(*a*) The following is an extract from Rivington's Vol. III. p. 141. "Encaustic tiles are those in which the colours are produced by substances mixed in with the clay, not printed on after the tile is made. Such tiles may be made from ordinary clays and marls carefully prepared, sometimes mixed with finer clays, and also with different colouring substances, such as manganese for black, cobalt for blue. Those tiles which are ornamented by inlaid patterns of different colours are made in the following manner :—The clay used is first very carefully prepared, mixed with the colouring matter, and *slipped*, that is, passed through fine muslin or silk sieves ; boiled in the *slip-kiln* until it becomes plastic, *wedged*, that is, cut up into pieces, which are dashed against one another to drive out the air and consolidate them ; and *aged*, that is, kept for several months, during which fermentation goes on and organic matters disappear. During this time the wedging should be repeated at intervals. After this the clay is *slapped*, that is, cut up by means of a wire into long pieces, which are kept always in the same direction. This consolidates the mass and preserves the grain. Each tile generally consists of three layers :—The face, which is a slab of very pure clay of the colour required for the ground of the pattern ; the body, which is of coarser clay ; and the back, to prevent warping, which is formed with a thin layer of clay different from the body. The clay for the face is cut into a pat about $\frac{1}{4}$ in. thick, and as much larger in area as will allow for contraction in burning. It is then placed upon a plaster-of-Paris slab, upon which the form of the inlaid pattern is left in relief. The face clay pressing upon this receives an indentation corresponding to the form of the pattern required. It is then backed up with the body of coarser clay, and the thin layer to form the back. At this stage the maker's name is stamped on the back, and also a few holes to make the cement adhere to the tile when it is set. Slip clay of the different colours required, according to the design, is then poured into the different parts of the indented pattern on the face. After this has become hard, the superfluous clay is carefully scraped off, leaving it only in the parts originally indented so as to form the pattern. The raw clay tiles are then trimmed, carefully dried, baked in ovens protected from smoke, etc., by being arranged in large fire-clay jars called seggars. The burnt tiles may then, if required, be glazed by dipping them into a mixture of powdered glass and water, and reheating.

(*b*) Mill mortar consists of either lump or ground hydraulic lime and sand in the proportion of 1 of lias lime to 3 or 4 of clean sharp sand or well-burnt ballast, cinders or slag. The mill should be set in motion and water added at intervals, the mortar being left in the mill until thoroughly incorporated.

Question 4. *A fir post is 4 in. by 4 in. and 8 ft. high, with flat ends, what safe dead load will it carry? (N.B.—No credit will be given unless the mode of working is shown.)*

Answer 4. By the Rankine-Gordon formula $W = \dfrac{fA}{1+\frac{l^2}{acr^2}} = \dfrac{3500\times16}{1+\frac{96^2}{4\times750\times1\frac{1}{3}}} = 16{,}970$ lbs. or 7·57 tons. breaking weight. Allowing a factor of safety of 5 the safe load will be $\frac{7\cdot57}{5\cdot0} = 1\cdot51$ tons.

EXAMINATION, APRIL, 1909.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

Question 1. *A ferro-concrete foundation 7 ft. square, on light soil, is required to carry a load of 25 tons from a stanchion with a base 2 ft. 3 in. square. Draw plan and section of what you propose. Scale 1 in. to 1 ft.*

Answer 1. See diagram 1.

Question 2. *Draw to a scale of $1\frac{1}{2}$ in. to 1 ft. the bonding of two adjacent courses of a window jamb in a $1\frac{1}{2}$ b. wall, with $4\frac{1}{2}$ in. reveal and square recess for window frame.*

Answer 2. See diagram 2.

Question 3. *Sketch a small two-light Gothic window and mark the jointing of the stonework.*

Answer 3. See diagram 3.

Question 4. *Show by neat sketches the following joints :—tusk tenon, foxtail tenon, cogged, double notched, housed.*

Answer 4. See diagram 4.

Question 5. *A flat roof is to be constructed to serve as a water tank for fire extinguishing purposes with 1 ft. depth of water. Sketch out a suitable arrangement by a section through one side.*

Answer 5. See diagram 5.

Question 6. *Draw to a scale of $1\frac{1}{2}$ in. to 1 ft. a cross section through the head and sill of a window with 2 in. double hung sashes.*

Answer 6. See diagram 6.

Question 7. *Draw ($\frac{1}{4}$ in. to 1 ft.) the skeleton outline of a suitable steel roof truss for a span of 20 ft. to be covered with Countess slates, and sketch (one-quarter full size) three of the joints in detail.*

Answer 7. See diagram 7.

Question 8. *A girder 20 ft. span is required to carry a load of 10 tons at 5 ft. from one end, draw bending moment and shear stress diagrams and state the value of the stresses at centre of span. Scales $\frac{1}{4}$ in. to 1 ft., 10 ton-ft. to 1 in., and $\frac{1}{4}$ in. to 1 ton.*

Answer 8. See diagram 8.

Subject b.—MATERIALS.

Question 1.

(a) *Sketch the cross section of an oak tree and show the different modes of conversion.*

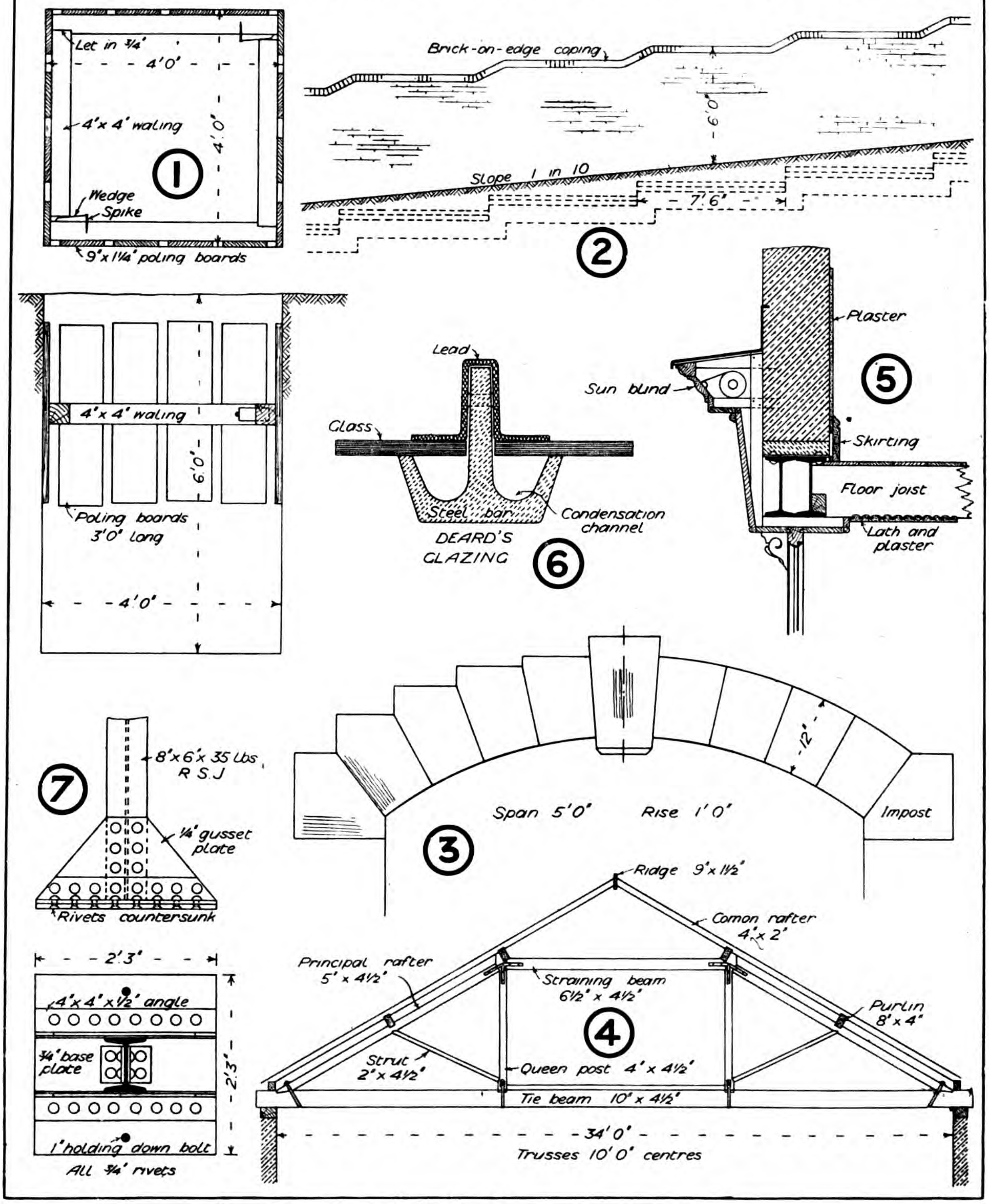
(b) *How does oak compare with elm for use inside or outside a building.*

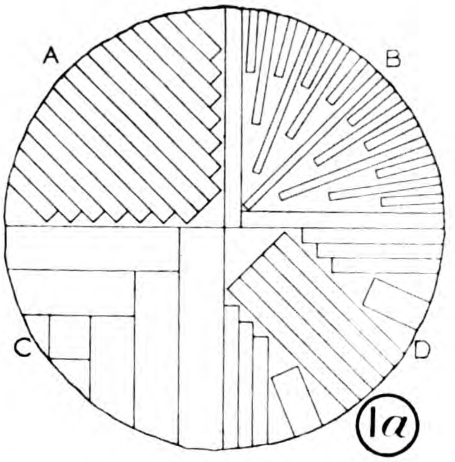
Answer 1.

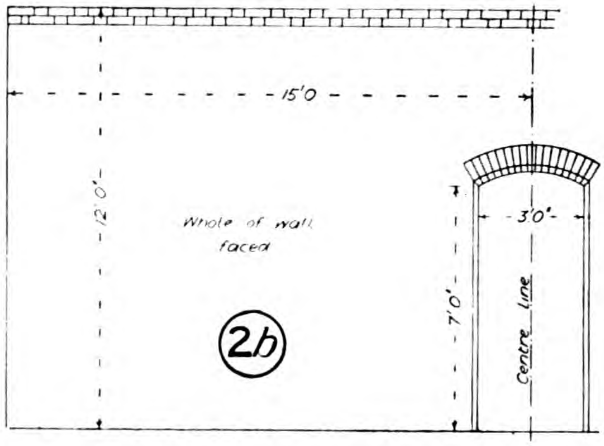
(*a*) See diagram 1a. Method A gives a large number of boards of varying width but irregular in the direction of the grain in cross section and therefore shrinking irregularly.

Method B gives all boards with uniform grain and maximum amount of figure or "flower." There is no waste as the triangular portions form feather-edged laths for tiling and other purposes.

BUILDING CONSTRUCTION EXAMINATION OCTOBER 1908







Method C is the most economical way to convert the log when thick stuff is required.

Method D is the next in economy, giving mixed scantlings.

(*b*) Oak may be used for both external and internal work as it is hard, close-grained and of good appearance.

Elm is not very much used in building construction as it only wears well when subjected to all wet or all dry conditions, and quickly decays when subject to alternate wet and dry. It is suitable for stair treads, mangers, wheel-barrows, etc.

Question 2.

(a) *How are white glazed bricks made.*

(b) *Write an order for the required number and description of white glazed bricks for facing a wall 30 ft. by 12 ft., to be built with an arched opening 7 ft. by 3 ft. with rounded jambs.*

Answer 2.

(*a*) White glazed bricks are made by "dipping" the brick, either before burning or when half burnt, into a "slip" of specially prepared clay so that a smooth face similar to china is produced. Great care must be taken in the preparation of the "slip," dipping and burning, or the glaze may crack and discoloration may also take place.

(*b*) See diagram 2b. Average $\frac{30 \times 2}{1 \cdot 125} = 53\frac{1}{3}$, say 54 facing bricks in each course of Flemish bond, height 12 ft. of four courses to the foot, total number of bricks $12 \times 4 \times 54 - 7 \times 4 \times 5\frac{1}{3} = 2592 - 149 = 2433$, say 2500 half headers and half stretchers. For arch say $\frac{3 \times 12}{2} = 18$ bricks. For jambs $7 \times 4 \times 2 = 56$ bricks.

Order :—Best white glazed slip dipped facing bricks as under :—

1,250 stretchers
1,250 headers
20 bull nosed arch bricks
30 bull nosed quoin stretchers
30 bull nosed headers

NOTE.—The quantities given allow a fair proportion for waste.)

Question 3.

(a) *Name the beds of Portland stone in order of succession from the surface.*

(b) *Which variety of Portland stone would you use for exterior carved work. Describe its characteristics.*

Answer 3.

(*a*) The beds of Portland stone in order of succession from the surface are True Roach, Whitbed, Bastard Roach or Curf, and Basebed.

(*b*) The best variety of Portland stone for exterior carving is the Whitbed. Good Whitbed weathers well, is easily dressed to a smooth surface and will take a very fine arris, and some blocks are fit for the most intricate carving. The stone consists of fine oolitic grains, well cemented, and interspersed with a small amount of shelly matter. The colour is as a rule nearly white, but some of the best stone has a brown tint.

Question 4.

(a) *What size fir joists would you use over a span of 16 ft. for a dining room. Show how you arrive at the size.*

(b) *What do you understand by the Modulus of Elasticity.*

Answer 4.

(*a*) The rule for size of floor joists for ordinary purposes is depth in inches $= \frac{1}{2}$ span in feet $+ 2$, and breadth $= \frac{1}{3}$ depth. In the given case the size would be $\frac{16}{2} + 2 = 10$ in. by $\frac{10}{3} =$ say $3\frac{1}{2}$ in., but the size adopted would probably be 11 in. by 3 in.

(*b*) The modulus of elasticity is a number representing the ratio of the intensity of stress to the intensity of strain produced by that stress, so long as the elastic limit is not passed.

$$E = \frac{\textit{stress}}{\textit{strain}} = \frac{\textit{tension or compression} \times \textit{length}}{\textit{area} \times \textit{elongation}}$$

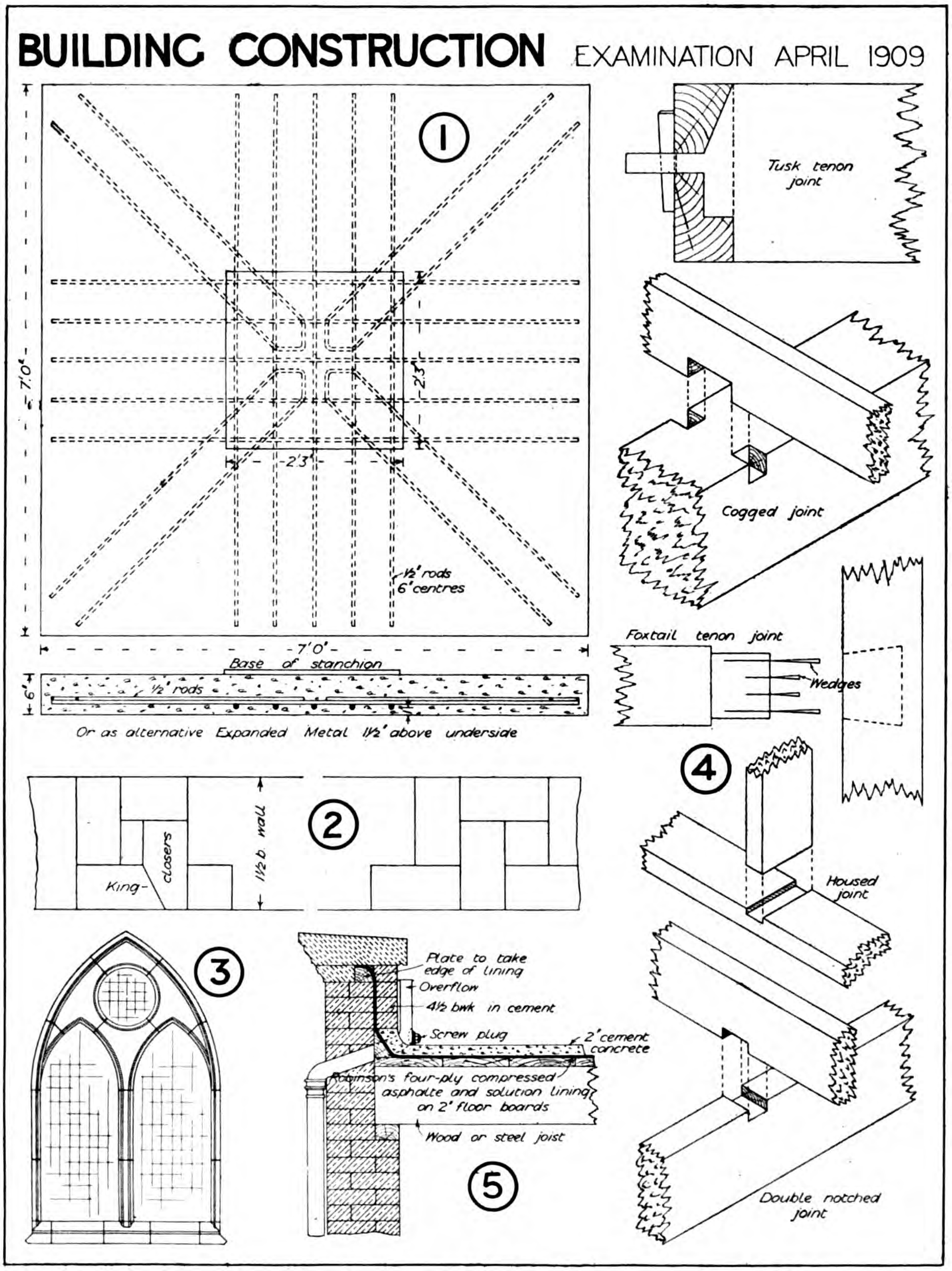
EXAMINATION, OCTOBER, 1909.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

Question 1. *Draw a cross section of the footings and concrete you would give to a $1\frac{1}{2}$ b. wall for a house without basement upon a clay soil, and by dotted lines upon the same diagram any alteration you would make if the soil were good gravel. Scale 1 in. to 1 ft.*

Answer 1. See diagram 1.


BUILDING CONSTRUCTION EXAMINATION APRIL 1909
1
2'3"
2'3"
7'0"
7'0"
½" rods 6" centres
Base of stanchion
6"
½" rods
Or as alternative Expanded Metal 1½" above underside
Tusk tenon joint
Cogged joint
Foxtail tenon joint
Wedges
4
Housed joint
Double notched joint
2
1½ b. wall
closers
King-
3
Plate to take edge of lining
Overflow
4½ bwk in cement
Screw plug
2" cement concrete
Robinson's four-ply compressed asphalte and solution lining on 2" floor boards
Wood or steel joist
5

Question 2. *Give detailed drawing showing the full construction of a ferro-concrete lintel for a window opening 4 ft. wide in a $1\frac{1}{2}$ b. wall. Scale 1 in. to 1 ft.*

Answer 2. See diagram 2.

Question 3. *Draw a cross section through a projecting stone cornice with saddled joints and blocking course on an 18 in. wall. Scale 1 in. to 1 ft.*

Answer 3. See diagram 3.

Question 4. *Draw to a scale of $\frac{1}{4}$ in. to 1 ft. the elevation of a King post truss, 30° pitch, 24 ft. span, mark all the scantlings, and give $\frac{1}{8}$ full-size detailed elevation and section of the joints at foot of King post with ironwork complete.*

Answer 4. See diagram 4.

Question 5. *Show by neat sketches, about $\frac{1}{2}$ in. to 1 ft., the construction of a good form of fire-resisting floor.*

Answer 5. See diagram 5.

Question 6. *Draw to a scale of $1\frac{1}{2}$ in. to 1 ft. the horizontal section through one side of a $1\frac{3}{4}$ in. four panel door in a lath and plastered stud partition.*

Answer 6. See diagram 6.

Question 7. *Draw the frame and stress diagram for the truss in Question 4, assuming a total vertical load of 64 cwts., and a total wind pressure normal to one side of 40 cwts. Scales, 8 ft. to 1 in. and 16 cwt. to 1 in.*

Answer 7. See diagram 7.

Question 8. *A 9 in. by 7 in. by 58 lb. rolled steel stanchion carries a load of 50 tons and stands upon cement concrete that will carry 10 tons per sq. ft.; design a riveted base for the stanchion, and show plan and elevation to a scale of $1\frac{1}{2}$ in. to 1 ft.*

Answer 8. See diagram 8.

Subject b.—MATERIALS.

Question 1.

(a) *Describe shortly how clamp-burnt bricks are made and fired.*

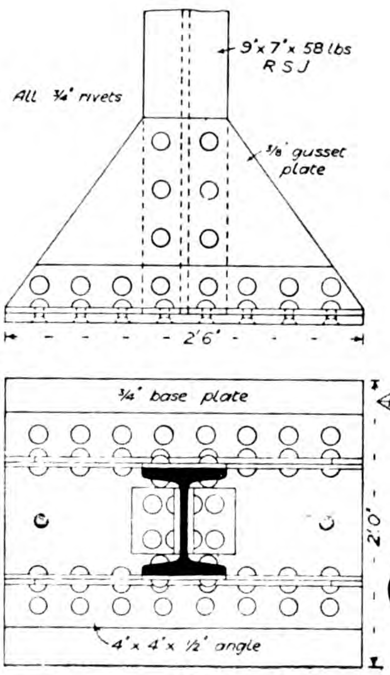
(b) *What points would you look to in inspecting a delivery of terra-cotta facings?*

Answer 1.

(a) In making clamp-burnt bricks the turf and vegetable earth are first removed. The clay is next dug and made into heaps together with ashes or coke breeze and left to weather through the winter. After the frosts, the mixture is passed through a pug mill and then taken to a moulder. The moulder has a box about 10 in. by 5 in., which he places on a board with a raised centre to form the frog. The box is sprinkled with sand, and then the clay after being kneaded is dropped into the mould so as to fill it perfectly. A wire is then passed over the top of the box to cut off any superfluous material. These "green" bricks are then wheeled to a shed and piled in hacks to dry. The site for the clamp is raised above the surrounding ground so that the damp will drain off. A paving, generally of badly burnt bricks, is then made and horizontal flues are formed and filled with faggots. Two layers of bricks on edge laid diagonally are then placed over these flues and the interstices filled with breeze, and then a layer of bricks close together. Breeze is then spread over the whole to a depth of about 7 in., then a course of bricks, and breeze about 4 in. deep. Another course of bricks is then laid; and on top, a layer of breeze about 2 in. deep, and the raw bricks are stacked up to a height of say 14 ft. and the faggots fired.

(b) In examining terra-cotta facings the following points should be noted:—

(1) The moulded portions should agree with the drawings, and the enriched work should be clean and well undercut.



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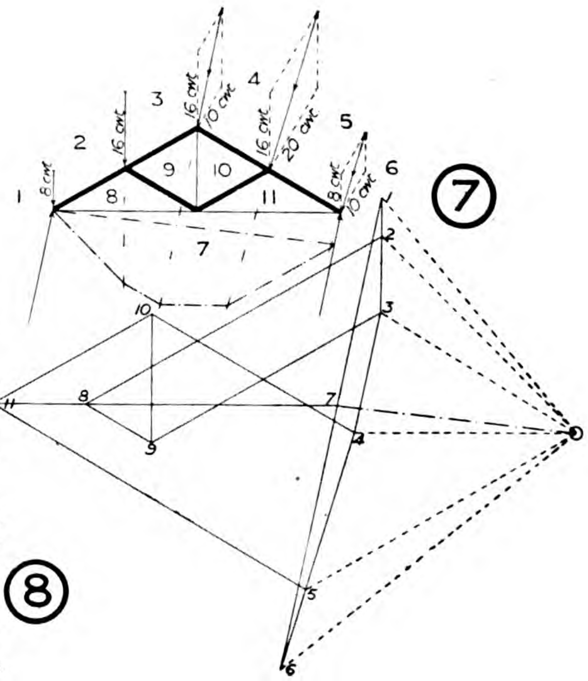

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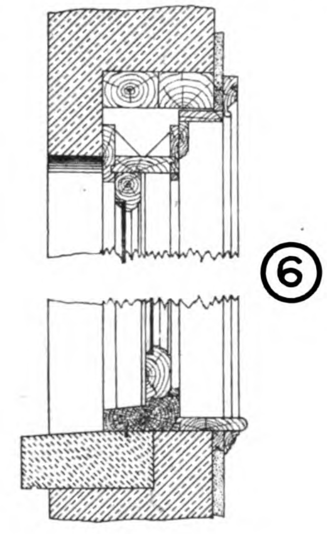
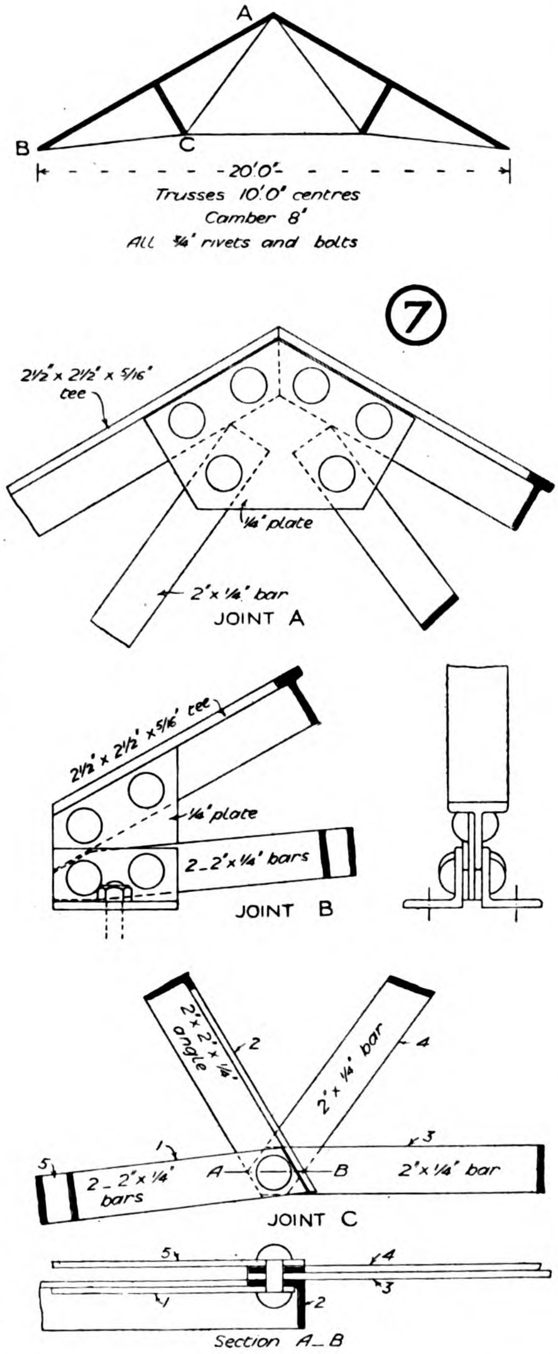
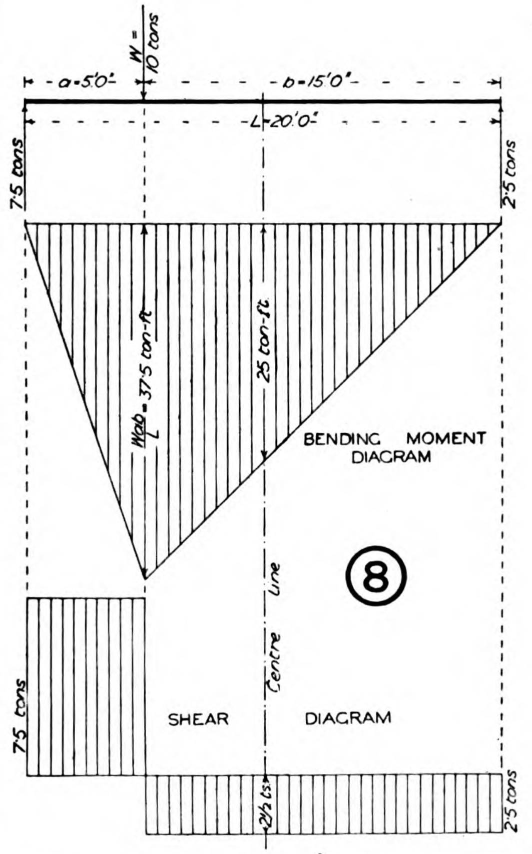






(2) The colour should be practically uniform.

(3) The arrises should be sharp and true and there should be no cracked or twisted pieces.

(4) There should be no cutting, rubbing, filing or chipping.

(5) No stopping or colouring matter should have been applied.

Question 2.

(a) *Describe the composition and mode of laying asphalte, specifying the object for which you are using it.*

(b) *Describe the manufacture of artificial stone and compare its use with that of natural stone.*

Answer 2.

(a) For pavement work the composition of the asphalte should be about 12 blocks of mastic, say 640 lbs., refined bitumen 39 lbs., and sharp grit free from loam, 335 lbs., these proportions being varied according to the amount of sunshine that comes on to the street. These materials are cooked in a " street pot," the time taken being from 4 to 6 hours. The mastic is then ready for laying and is taken out of the pot and put into a wooden pail which is handed to the " spreader " who empties the pail with a sweeping motion. The material is then spread to the required thickness by means of a wooden float. Care should be taken that the second pailful of mastic should overlap the first whilst hot and so on with each pailful.

(b) Victoria stone is a typical artificial stone and consists of 3 parts of finely-crushed Leicestershire granite to 1 of tested Portland cement. Water is carefully added, and before any initial set can take place the mixture is put into the moulds and well worked, so as to fill up the angles and sides. When sufficiently dry the slabs are removed to the silicating yard, where they are placed side by side in a tank and covered with a solution of silicate of soda. The slabs are allowed to remain in the tank for about 14 days and are then stacked in the storeyard to season. Artificial stone is used chiefly for paving, but it is also cast into copings, steps, etc.

Question 3.

(a) *Give specification clauses for the wood to be used for the carpentry and joinery in a building.*

(b) *Describe with sketches six defects in baulk timber.*

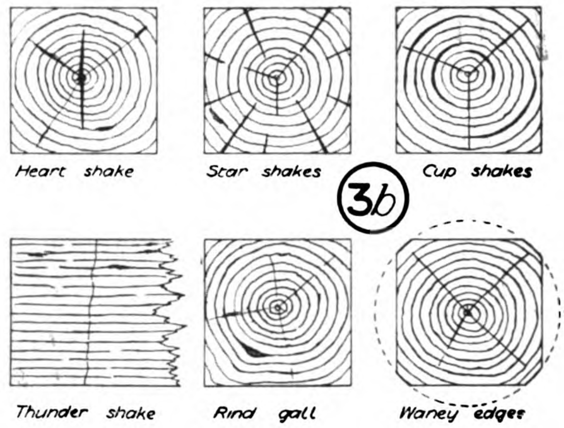
Answer 3.

(a) Wood for carpentry shall be sawn out of sound, bright, square-edged Baltic or White Sea planks, deals, and battens, or Danzig Fir, Pitch, Oregon, or British Columbian Pine of similar quality.

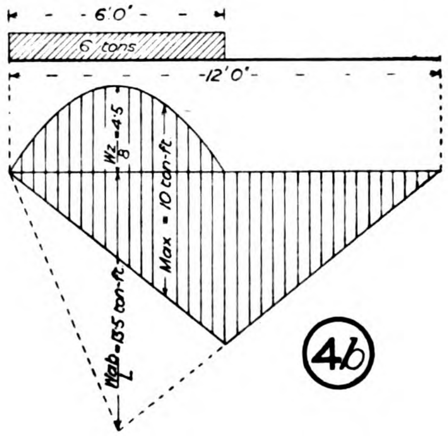
The wood for joinery to be Baltic or White Sea yellow, equal in quality to the best Russian or Swedish shipments.

All to be free from injurious open shakes, large loose or dead knots, or more than a small proportion of perfectly bright sap, and thoroughly seasoned.

(b) See diagram 3b. Heart shake is a split or cleft occurring in the centre of the log, in the direction of the medullary rays and across the rings. Heart shakes are common in nearly every variety of timber, and are very serious when they twist in the length, as they interfere with the conversion into boards or scantlings. They sometimes divide the log in two for a few feet from the end. Star shake is a series of cracks extending to the outside of the tree where they are widest. (NOTE.—By some writers these are called wind cracks, and shakes radiating from the centre at the heart are called star shakes). Cup shake is a crack extending circum-



ferentially, separating two of the annual rings, supposed to be caused by gales. A thunder shake is a fracture across the grain occurring in brittle woods, such as mahogany, supposed by some to be due to lightning, but possibly the reverse of an upset, occurring on the tension side. Rind gall is a curved swelling on a tree caused by the growth of new layers over a part damaged by insects, or by the tearing off, or imperfect lopping, of a branch. It is shown in the log by the grain being irregular and vacuous, with dead bark shut in. Waney edge is caused



when the diameter of the tree at the small end is not sufficient to allow of the log being squared up to the edges.

Question 4.

(a) *What do you understand by the term " bending moment " ?*

(b) *A load of 6 tons is distributed over half the length of a fir beam from one support, the span being 12 ft. What size beam should be used? (NOTE.—No credit will be given for a mere statement of dimensions without showing clearly the mode of arriving at them.)*

Answer 4.

(a) Bending moment, or moment of flexure, and called by some writers " Moment of Rupture," is the moment of the external forces on one side of a transverse section estimated relatively to the section. It is the effective measure of the mode of loading and supporting a beam.

(b) See diagram 4b. Maximum bending moment $= 10$ ton-ft. $= 10 \times 20 \times 12 = 2400$ cwt.-in. Then allowing 6 cwt. per sq. in. for C, the section modulus $= \frac{2400}{6} = 400$, or $\frac{1}{6}\, b\, d^2 = 400$ whence $b\, d^2 = 2400$, which will be given by a beam say 14 in. by 12 in.

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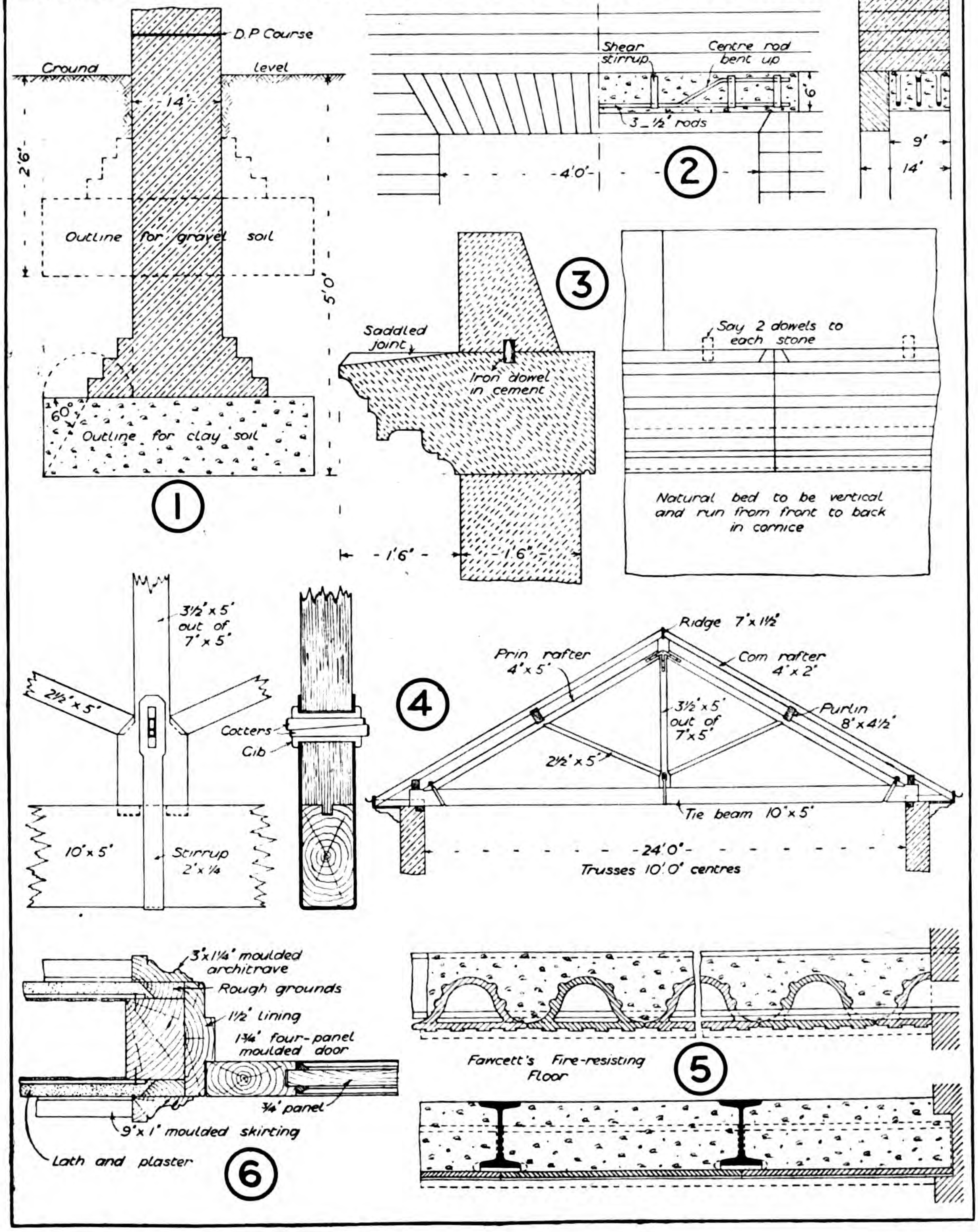


EXAMINATION, MARCH, 1910.

BUILDING CONSTRUCTION AND MATERIALS.

Subject a.—CONSTRUCTION.

Question 1. *Draw to a scale of ½ in. to 1 ft. in section and elevation, the base of a three-brick wall upon ferro-concrete foundation and piling.*

Answer 1. See diagram 1.

Question 2. *When is diagonal or raking bond used in brick walls? Draw to a scale of 1 in. to 1 ft. the plan of two courses of a three-brick wall in raking bond, and state at what intervals you would put a heading course.*

Answer 2. See diagram 2. Diagonal bond is often used to fill in the interior of a thick wall in order to tie the heading courses and increase their longitudinal strength, although it is doubtful whether there is any advantage in it. Each alternate course would be a heading course, and the other courses would rake alternately each way. The method of laying out the bricks to avoid cutting is as follows: Draw the facing bricks first, then take the diagonal length of three bricks A to B, and strike the arc B D. From D with half-brick radius strike an arc, and from C with three-brick radius strike an arc cutting the other in E; join E A and from E draw the horizontal line E F. Then the courses may be started from F, drawing the diagonal joints parallel with E A. If the wall is required to be filled in solid the diagonal joints would be laid at 45 degrees and the bricks cut to fit.

Question 3. *Show by sketch the method of forming the chimney throat in a fire-place opening.*

Answer 3. For alternative answers see diagram **3a** and *b*. Method *a* is used in the south of England and *b* often in the north.

Question 4. *Draw a section through the hanging tiles and lath and plastered coving at the overhang of first floor of a cottage, the lower storey of which is of brickwork finished in rough cast. Scale 1 in. to 1 ft. Overhang 12 in.*

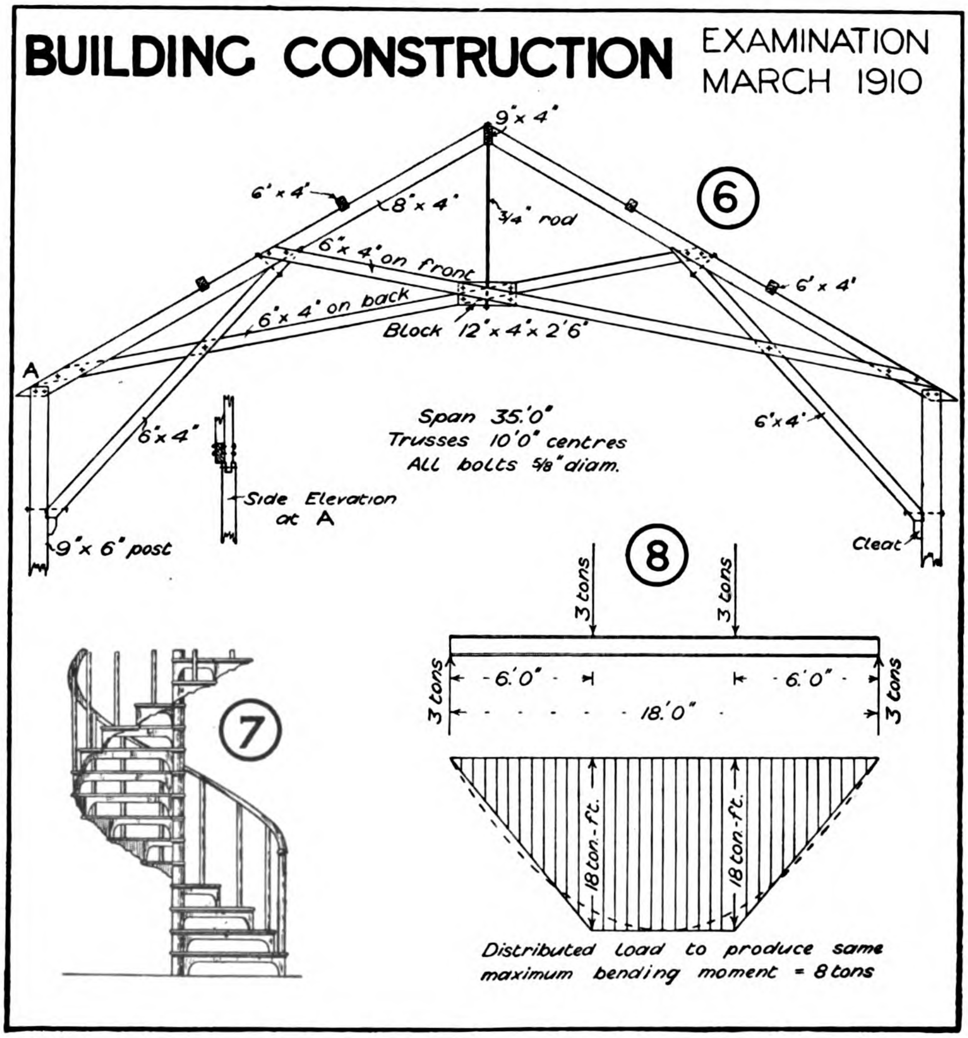
Answer 4. See diagram 4.

Question 5. *Show by sections of a stud partition and a fir joisted floor the application of slag wool as a non-conductor of sound.*

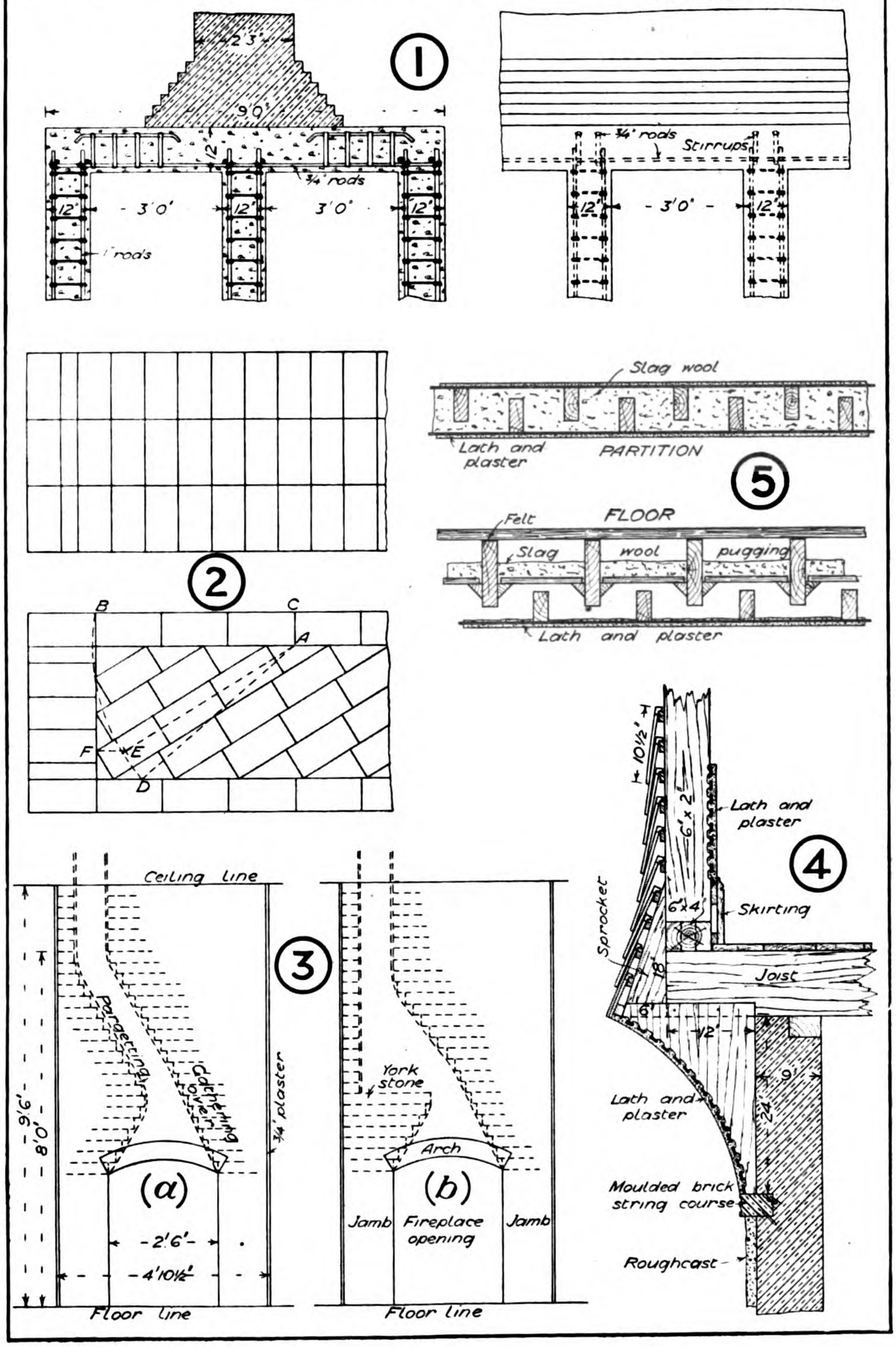
Answer 5. See diagram 5.

Question 6. *Give a design for an open timber roof 35 ft. span, suitable for a temporary structure, such as a skating rink. Mark the scantlings. Scale ¼ in. to 1 ft.*

Answer 6. See diagram 6.



BUILDING CONSTRUCTION EXAMINATION MARCH 1910



Question 7. *Sketch a spiral staircase in iron, and state when and where such stairs are used.*

Answer 7. See diagram 7. Iron spiral staircases are used chiefly in shops, warehouses and libraries, to communicate from one floor to another without occupying much space.

Question 8. *A* 10 *in. by* 5 *in. by* 30 *lb. rolled steel joist,* 18 *ft. span, carries two symmetrically placed concentrated loads of* 3 *tons,* 6 *ft. apart ; what uniformly distributed load could have been placed upon the joist to produce the same maximum bending moment? Illustrate your answer by graphic diagrams.*

Answer 8. See diagram 8. Maximum bending moment from the concentrated loads $= 3 \times 6 = 18$ ton-ft. Distributed load for same maximum bending moment $\frac{WL}{8} = 18$ ton-ft., $W = \frac{8 \times 18}{18} = 8$ tons.

Subject b.—MATERIALS.

Question 1.

(a) *A very sandy river ballast is proposed to be used for concrete in foundations, what objections would there be to its use, and what directions would you give?*

(b) *What proportions of material of each kind would you permit in the formation of the concrete?*

Answer 1.

(a) The extra sand in the ballast would make the proportions incorrect and at the same time reduce the strength of the concrete. To remove this defect the ballast should be well screened before being used to remove as much of the sand as possible and then the correct amount added.

(b) The usual proportions are 1 : 3 : 6, that is 1 part of Portland cement to 3 parts sand and 6 parts broken brick, stone, etc.

Question 2.

(a) *Describe the method of forging, and state to what metals it applies.*

(b) *How is cast-iron melted in the foundry, and how is it transferred to the moulds?*

Answer 2.

(a) In forging, the metal to be forged is placed in a cinder fire and raised to the necessary temperature by the forge blast and then quickly withdrawn and hammered to the required shape on an anvil. Double and treble best Staffordshire and ordinary Yorkshire wrought-iron are suitable for forgings. Steel may be forged gradually at a low red heat, reheating when necessary to avoid working at a blue heat which would damage the material.

(b) For foundry purposes pig-iron is remelted in a cupola, which is a small vertical blast furnace worked intermittently with a cold blast. By means of a gallery the cupola is fed with metal and coke from an upper door, and the iron being melted in the furnace, is run through a shoot into ladles which are carried by men to the moulds and poured.

Question 3.

(a) *What are the best materials for the following floors: stable, skating rink, hospital, railway station, upper floors in a dwelling house?*

(b) *Describe minutely the appearance of Teak and Jarrah woods, and state their chief uses.*

Answer 3.

(a) The best materials for the various floors are: *Stable.*—Blue Staffordshire grooved stable bricks on concrete. *Skating rink.*—Narrow strips of maple laid on felt and concrete. *Hospital.*—Wood blocks laid on mastic. *Railway Station.*—Patent Victoria Stone, or asphalte with stone coping. *Upper floors of dwelling house.*—Christiana white deal battens.

(b) *Teak* is hard and heavy but somewhat open grained, it varies in colour from brownish-yellow to dark brown, has a fine straight grain, and the annual rings are very narrow and regular, but there are no visible medullary rays. It is used chiefly for shipbuilding, treads of stairs, railway carriages, etc.

Jarrah is very hard, heavy, and tough. It is of a red colour and the grain is close and wavy, something like Spanish mahogany. It is used in blocks for paving carriageways, and also in planks for piers, jetties, etc.

Question 4.

(a) *Explain the terms bending moment and section modulus.*

(b) *What is the maximum vertical shear stress upon a* 9 *in. by* 6 *in. fir beam carrying four tons uniformly distributed, and where does it occur?*

Answer 4.

(a) Bending moment is the moment of the external forces on one side of a transverse section estimated relatively to that section, *i.e.*, it is the algebraical sum of all the forces multiplied by their leverages.

The section modulus is a function of the dimensions proportional to the moment of inertia of the section. It is the moment of inertia divided by the distance from the neutral axis to the furthest part on the extended or compressed side.

(b) The total maximum vertical shear stress will be $\frac{W}{2} = \frac{4}{2} = 2$ tons occurring at the edge of each support.

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