CHAPTER NO. 22

WELLS AND CAISSONS

SPECIFICATION NO. 22 1—Open Wells

Wells.

1. (1) **Scope.**—This specification deals with open wells and the methods of their construction.

(2) **Open Wells.**—Open wells may be used for water supply or for carrying foundations of structures to suitable strata. Wells for foundations are akin to open caissons, gow caissons, etc.

(3) **Method of construction.**—Wells may be either dug, bored drilled, or driven. Large size open wells which have to be lowered to shallow depths through comparatively soft soils are usually dug by manual labour or semi-mechanical means, such as 'orange peel' or 'clam shell' buckets attached to the boom of a convertible crane. Bored wells are those where the excavation is made by the use of either hand or power augers. Drilled wells are those where the excavation is made by either percussion or rotary drills and the excavated material is brought to surface by means of bailer, and pump, suction bucket, hollow drill tools, or by hydraulic pressure. Driven wells are those constructed by driving a casing at the lower end of which there is a drive point.

(4) **Well finishing.**—Open wells for water supply and irrigation may be divided into the following types from the stand point of finishing :—

(*a*) **Unlined or *kutcha* wells.**—Such wells are shallow pits 10 to 12 feet (3 to 3.5 metres) deep, dug in stable previous soils where the ground water table can be tapped within this depth.

(*b*) **Previous lined wells.**—Such wells have dry bricks or stone lining or steining with open joints, resting on a curb. Such wells are also used for shallow depths. To avoid flow of sand surrounding the lining, the space behind the lining should be packed with brick ballast of size $\frac{3}{4}$ inch to 1 inch (20 mm. to 25 mm.)

(*c*) **Impervious lined wells :**—Such wells have a comparatively impervious lining of brickwork or stone masonry in cement or lime mortar, plain or reinforced concrete, or precast concrete blocks or sections. Such wells are sunk to depths ranging between 15 and 80 feet (5 and 25 metres) specially where water-bearing strata are available in this range. Water seeps into the well either

through the open bottom or through a pipe sunk to a greater depth.

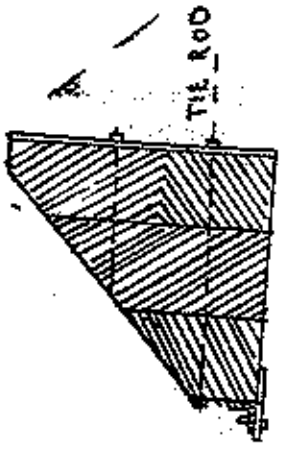
Well-steining and curbs.

2. (1) General.—These specifications shall apply to open wells used for water supply, irrigation or foundations. Such wells consist of a curb and the well lining, wall or steining. Curves for large size wells or where the nature of soil demands are also provided with a suitable cutting edge.

Unless otherwise indicated, shape of wells shall be circular.

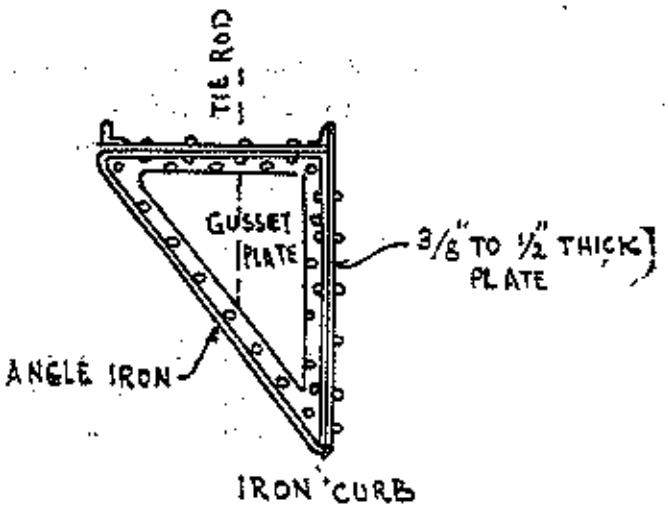
(2) Well curbs.—The cutting edge and the curb should be laid larger than the steining about ½ inch to 2 inches (13 mm. to 50 mm.) beyond the outside diameter of the well steining to lesson the frictional resistance in sinking. The thickness of the curb and the cutting edge should be regulated by the nautre of the soil and the character of the obstruction likely to be encountered. If boulders are probable, the cutting edge shall be proportionately strong. The curb shall be of chisel shape with vertical outside.

Well curbs shall be made of wood, iron or reinforced concrete, and shall be as specified in the design drawings. Sketches of wooden, iron and reinforced cement concrete well curbs are given below :—



WOODEN CURB

FIG:-22.1 (a)



IRON CURB

FIG:- 22.1 (b)

SPECIFICATION NO. 22·1—Open Wells

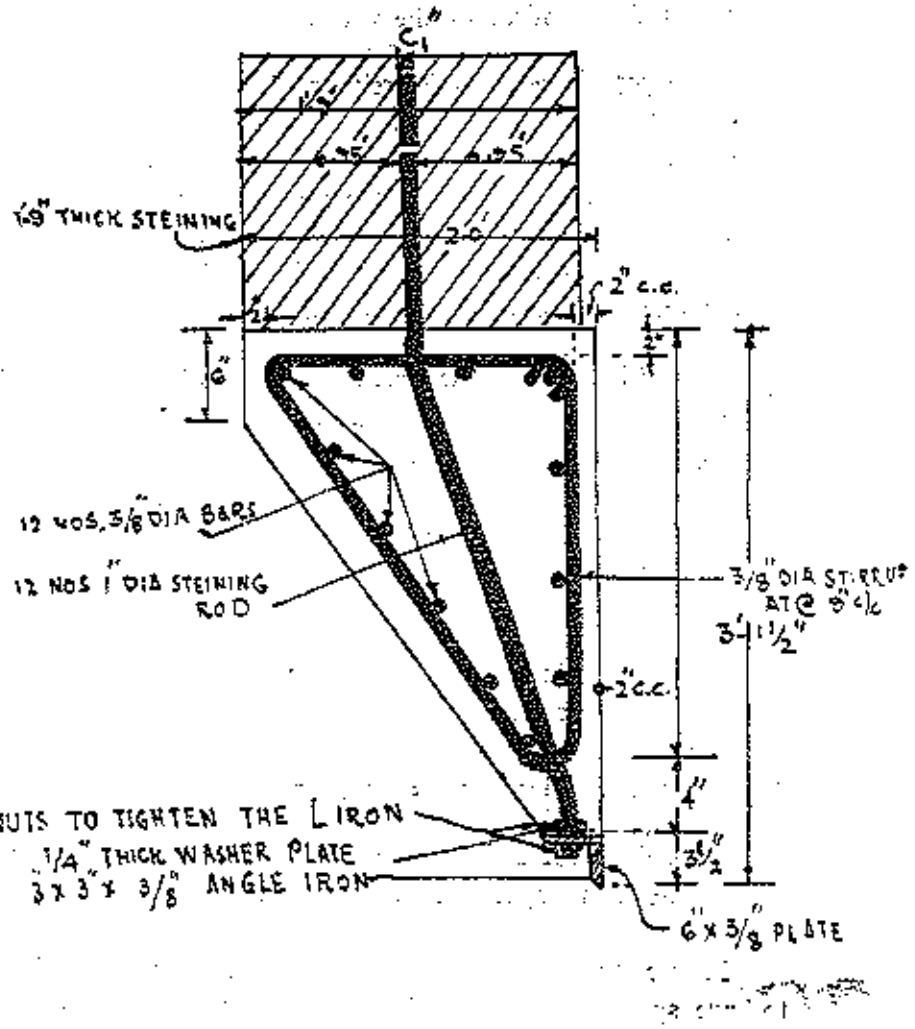


FIG:- 22·1(c) TYPE DESIGN OF R.C.C. WELL CURB

SCALE: 1/10

NOTE:- THIS DRG. SHOWS A TYPICAL SECTION, BUT THE ACTUAL DIMENSIONS AND QUANTITY OF STEEL SHALL VARY ACCORDING TO DESIGN IN EACH INDIVITUAL CASE

Wooden well curbs should be made of hard and durable wood, such as kikar, shisham, sal or tamarind, which would not rot due to continuous immersion in water. The wooden curbs shall be made of two thicknesses of wood for wells 6 feet (2 Metres) in diameter and under, and of three thicknesses for large wells, strongly dove-tailed and dwelled together and secured by iron bolts, as detailed in the

design, or as ordered by the Executive Engineer. When the rings cannot be made of one piece across the width, the concentric rings shall break joints, the upper and lower courses to be alternately one-third and two-thirds of the whole width.

For larger diameter wells, reinforced concrete or iron curbs will be more economical. The iron curb shoud generally be made of 6 to 8 triangular frames made up of angle irons covered by $\frac{3}{8}$ inch to $\frac{1}{2}$ inch (10 mm. to 12 mm.) thick plate. In case of reinforced concrete curbs, reinforced concrete shall conform to the specification no. 10.8. The steel reinforcement shall comply with specification no. 3.20. The concrete shall be of 1 : 2 : 4 mix.

(3) **Cutting edge.**—The cuttin gedge shall be fabricated from the steel sections specified on the plans. Steel shall conform to specification no. 3.19 for structural steel. The steel sections shall not be heated and forged into shape. 'V' cuts may be made in the horizontal portion uniformly throughout the length to facilitate bending. Such 'V' cuts shall not be less than 8 in number. The sections shall then be cold-bent and pressed to shape and 'V' cuts electrically welded together.

(4) **Well steining or lining.**—The steining shall be brickwork, stone masonry, or precast concrete blocks or segments, or cast *in situ* concrete as may be specified and will be executed to the relevant standard specification for the masonry specified.

Brick work for steining shall be first class burnt brickwork and shall conform to specification no. 11.1.

In case of wells of 10 feet diameter (3 metres) and less, it is desirable to have specially moulded bricks for well steining. If specially moulded bricks can not be made available locally, the edges of bricks shou ld be dressed to avoid wide and V-shaped joints.

Unless otherwise stated, the steining in cement concrete shall be of 1 : 3 : 6 mix. and shall conform to specification no. 10.4. The concreting shall be poured in the best manner possible and the building up of the steining shall proceed in convenient lifts. The steining shall be built up equally around its whole circumference vertically in one straight line from bottom to top. The horizontal joints between successive stages of concreting shall be made absolutely water-tight by keeping the top surface rough so as to bond the well to the next height steining.

SPECIFICATION NO. 22·1—Open Wells

(5) **Tie-rods.**—Where specified, the curb will be secured to the steining by iron tie-rods or holding-down bolts. Tie-rods shall be threaded at both ends and secured to the well curb through holes drilled in the centre of the curb by nuts and washers. Unless otherwise specified, tie-rods shall be 1 inch diameter (25 mm.) and in ten feet (3 metres) length, placed not more than four feet (1.2 metres) apart circumferentially measured. It shall be specified whether the upper end of the tie-rods shall be threaded through iron plates or through a 3 inch (75 mm.) wide and ⅜ inch (10 mm.) thick flat iron bond ring temporarily secured to keep the rods vertical and immovable while the steining is being built around them. The upper nuts on the tie-rods should be secured down to press against the top of the steining.

3. The following procedure for sinking open wells for foundations or water supply shall be adopted :— **Well-sinking.**

Oper excavation in the form of a circular or rectangular pit shall be carried down to the ground water level or to the bottom of clay or non-water bearing strata whichever is higher ; before the well curb is laid. The pit should be larger in diameter or dimension than the curb or steining, as specified by the engineer-in-chrage. Where the ground water level is quite deep the depth of open excavation shall be fixed by the Executive Engineer keeping in view the nature of the soil and the safety of the workmen. After laying the curb at the bottom of the open excavation and building up the steining the well shall be sunk to the ground water level like normal sinking. The sinking will, however, be termed as dry sinking and shall be paid as such. Sinking below the ground water level shall be termed and paid as wet sinking. **Excavation.**

Where it is necessary to sink well foundations in water, unless otherwise specified, an island of earth shall first be formed at the well site, the island should have a diameter of at least 10 feet (3 metres) more than the outside diameter of the well to be sunk. The soils forming this island must be free from stones, bricks, or other hard materials which are liable to impede lowering of well. The island shall be brought up at least one foot (30 cm.) above the water-level before the well curb is laid. If so directed, the island slopes and sides, shall be adequately protected against erosion.

Note.—If wells other than single circular are adopted, the island shall have space not less than 10 feet (3 metres) beyond the lines joining the extreme faces of the well.

SPECIFICATION NO. 22·1—Open Wells

Laying the curb and steining.

The curb shall be levelled truly, and placed in exact position before the steining is commenced. In case of reinforced cement concrete curbs, the inside forms carrying the weight of the curb shall be removed only after the expiry of seven days after laying concrete.

In order to obtain perfectly vertical descent and to enable the direction of the sinking of the well to be easily corrected, the first height of the steining shall be built up to a much shorter height. The first height shall not exceed 6 feet (2 metres) and the second height 8 feet (2.5 meters). Subsequent height shall be built to convenient heights not exceeding the diameter of the well. The steining should be carried up truly vertical and central over the curb leaving the outer $\frac{1}{2}$ inch to 2 inch (13 mm. to 50 mm.) margin as mentioned in paragraph 2. Thickness of the steining shall be as specified.

If plastering of the outside face of the lining is desired to facilitate sinking, it shall be so specified.

Note.—The height of the steining shall be marked continuously from the bottom of cutting edge in feet (metres) painted in black on the inside to record the well height as the steining work progresses.

Sinking.

After the lining has been built up to a height mentioned above, a temporary loading platform shall be constructed on top of the steining. This platform should be built after the mortar in the masonry or cement concrete, as the case may be, has set and the steining is sufficiently strong to withstand loading and accidental shock. Load may be applied in the form of gunny bags filled with earth or in any other manner, subject to the approval of the Executive Engineer. The load should be placed on the outer edges of the platform, leaving sufficient clear space in the middle for lifting the excavated material by means of a pulley arrangement.

Sinking should be facilitated by excavation of soil inside the well and below the curb. Where possible, this may be done by digging and scooping with 'kassies', shovels, or spades, and loading the excavated soil in a big basket which is pulled out by the pully arrangement. On large scale jobs, where the wells have to be lowered to great depths and substantial flow of water is encountered, excavation by a 'Jham' dredging, pumping or bailing may be resorted to, if permitted or ordered by the Executive Engineer. Where a boulder or piece of rock met with is met it shall proferably be broken by a chisel made of

cluster or rails dropped from the top of the well. Where blasting is absolutely necessary, the type and extent of charge used in each case shall be determined by the Executive Engineer.

The well shall be kept absolutely plumb as far as possible during sinking operations and in case tilting occurs, the same shall be set right immediately by the contractor before proceeding further with sinking. Three or four plumb bobs should be suspended around the interior of the well to ensure the accuracy of the sinking. In the final position, a tilt of not more than 1 in 200 shall be permitted.

If the well remains tilted or moves out of position by any cause whatsoever after the process of sinking, and any enlargement of structure above, if it is necessary, shall be done at the sole expense of the contractor.

If the wells have to be sunk near existing structures and buildings on yielding or loose soils all precautions as directed shall be taken against possible damages to the foundations of structures in the vicinity prior to dredging out the materials from inside the well.

When two wells have to sunk close to each other or where the distance between them is not greater than the diameter of the wells, they should be sunk alternately, one sunk, half diameter in advance, as the wells when they are being sunk simultaneously tend to draw towards each other. When two parallel rows have to be sunk very near to each other, say 2 or 3 feet (60 cm. to one metre) apart, one row should be sunk before the other, or they can be started at different ends, or from the centre towards the ends, the object being to disturb as small an area as possible of the soil in the locality of the wells at any one time. It is also advisable to sink the wells that are in one line alternately in preference to sinking the next adjacent as the sand or soil around the well will be in an agitated state under sinking operations, and there will, therefore, be a tendency to cant over and to become jammed. When wells have to be sunk to considerable depths, the interval between them should be as much as possible, in order to prevent contact caused by deviation from perpendicularity in sinking.

In sinking groups of wells jointed together, the excavation in all the wells of one cluster should be carried on simultaneously and equally to facilitate sinking evenly.

Completion when the curb with steining reaches the prescribed level or strata, the space around the steining should be filled with clay puddle. The clay should be consolidated by ramming and watering in successive layers of about one foot depth.

SPECIFICATION NO. 22.1—Open Wells

If the steining splits during the sinking operation or within 6 months after completion, and in the opinion of the Executive Engineer be unsound, it shall be dismantled as a whole or in parts according to circumstances and then properly reconstructed and repaired.

Foundation wells and those that are accessible to flood waters shall not be left partially sunk during the rainy or flood season.

When the well has been sunk to the desired depth and before it is sealed, the depth to which it has been sunk will be measured by the engineer-in-charge and entered into the measurement-book, and contractor will sign the measurement book as a token of this correctness. The final level at which the well is to rest shall be determined by the engineer-in-charge. Any further increase or decrease in the well depth shall have to be carried out by the contractor and payment made as per Schedule of Rates. The well will be plugged only after the same has been finally examined by the engineer-in-charge. The engineer-in-charge will approve of any well being plugged in writing.

In the case of foundation wells, wherever and as specified the wells should be plugged with concrete at the bottom. As fresh concrete particles will not stand under hydrostatic pressure, it is necessary that the water level in the well should be brought to the normal conditions to be in level with the outside water level before plugging is started.

The concrete of specified mix and conforming to specification no. 10.4 shall be deposited in still water, unless otherwise specified, by specially designed water-tight collapsible or emptying buckets or by tremie consisting not less than 8 inch (20 cms.) in diameter and having a hopper of sufficient size at top. The placing operations shall be continued without break till the full thickness of the plug is formed to effectively seal the interior without laminations. After depositing, concrete shall be allowed to set for 14 days or as specified; the water shall not be pumped nor disturbed during this period.

The plug shall then be tested by pumping the well dry or as directed; if much leakage be found during the pumping, more concrete shall be deposited until a safe height is reached to effectively seal the leakage of water into the well at the cost of the contractor if the defect is proved to be due to poor workmanship and Executive Engineer's decision in this regard shall be final.

Note:.—In very deep wells the depth of depression of water level should be limited to safe hydrostatic head that the plug height should permit.

SPECIFICATIONS NO. 22.1—Open Wells

After the bottom plug has been laid and tested by pumping the well shall be filled up with clean coarse sand and compacted up to the level of the top plugging, flooding with water as layers are built up.

Unless otherwise specified, top plugging shall be of cement concrete 1:4:8 proportions by volume.

Unless otherwise specified, foundation well shall be capped with a reinforced concrete slab.

Measurement.

5. The item of well sinking shall be paid on the basis of volume displaced. For calculating the volume, the gross cross-sectional area enclosed within the external edge or edges of the steining will be multiplied by the depth through which the bottom of cutting edge of well curb has been sunk.

Rate.

6. Unless otherwise specified, the rates for well sinking cover the cost of pulsometer, gentry and kentledge, etc., as well as loading and unloading of kentledge and bailing or pumping of water where required, including removing the excavated soil to a distance of 200 feet (60 metres). Cost of cutting edge, curb, steining, tie-rods, sand filling, plugging and plastering, if any, shall be paid extra.

SPECIFICATION NO. 22.2—Special Well Foundations

General.

1. These specifications shall apply to special open caisson foundations for heavy loads, suitable where strata of clays and other cohesive impervious soils lie above the hard strata on which it is proposed to rest the foundation. Also, there should not be any substantial flow of water. There are two standard types the Chicago open-well method and the Gow caisson.

Gow-caissons.

2. This type of foundations may be specified where heavy concentrated loads have to be carried through a maximum of 40 to 50 feet (12 to 15 metres) of clay strata, to rock or other suitable formation.

A set of removable telescoping welded steel sheet cylinders 7 to 8 feet (2 to 2.5 metres) long should be ready at the site, the number and sizes being as predetermined in design. The cylinders should be marked and arranged in the order in which they have to be lowered, the largest diameter cylinder being lowered first.

A shallow starting pit should be excavated at the desired location, and the first cylinder placed in it. The cylinder should then be forced into the ground, truly plumb, by driving and excavating inside the cylinder and below the lower edge of the cylinder. After the first cylinder has been installed with its top close to the ground surface, a second cylinder, usually 2 inches (50 mm.) smaller in diameter than the first unit, shall be placed inside the first one and forced into the ground by driving and excavating until its upper end is approximately flush with the lower end of the first cylinder. This process should be continued with cylinder after cylinder until a stratum of hard ground is reached. If specified, the diameter of the lower end of caisson should be increased by the excavation of a chamber generally called a "bell".

After excavation has been completed, concrete of an approved quantity should be poured into the caisson. The steel cylinder sections should be withdrawn as the concrete is poured.

Chicago open well Method.

3. This method may be specified where soil conditions are similar to those suitable for Gow caissons, but where depths greater than 50 feet (15 metres) have to be penetrated. Also the clay should be stiff enough to permit unsupported excavation of wells in about 4 feet (1.2 metres) deep sections. These wells may vary from 3 to 12 feet (one to 4 metres) in diameter.

At the specified location, a hole about 4 feet (1.2 metres) deep and of the desired diameter should be dug and the sides should then

be sheeted with 2 inch × 6 inch (5 cm. × 15 cm.) or 3 inch × 6 inch (7·5 cm. × 15 cm.) wood planks in 4 feet (1·2 metres) length. The sheeting or lagging should be immediately braced by two or three hoops, composed of steel bars, angles or channels. These hoops should be made in semi-circular shape, with the ends bent inwards to form flanges that are to be bolted together. As soon as the bracing of one section is completed, the next section should be excavated and the lagging for the later should be placed abutting against the lagging for the section above.

These wells are usually exacavated by manual labour using shovels or spades. The number of men who should work in the well should be determined in the field, and it will depend upon the diameter of the well and the nature of the soil. Proper care should be exercised to fit the lagging tightly against the clay to prevent local failures or flow of soft material. The spoil may be removed from the well by buckets operated by a windlass or pully arrangement. Where specified, the lower portion of the well should be excavated and enlarged in the shape of a bell at an angle of 45 degrees.

As soon as the excavation is completed and the spoil removed, concrete of desired consistency should be poured or chuted into the well. Where the clay is stiff and stable, the lagging and bracing may be removed as concrete is poured but where the clay is at all soft, the lagging and bracing should be left inside the well.

SPECIFICATION NO. 22-3—Open Caissons

Control.

1. Caissons for foundations of bridges, building and other heavy structures, can be divided into three general types; caissons, open caissons, and pneumatic caissons. These specifications shall apply to box and open caissons only, pneumatic caissons being treated separately in specification no. 22-4.

All caissons have one characteristic in common with each other and with foundation wells; they form a permanent shell for, and an integral part of the foundations.

Caissons may be made of timber, metal or concrete.

Definitions.

2. A 'box caisson' is open at the top and closed at the bottom, while an 'open caisson' is open both at the top and bottom. An open caisson is very similar to a foundation well, but it may be bigger, cellular in strucutre, and rectangular in shape as compared to a well. Caissons differ from foundation wells in that they are built away from the site, then towed or floated to the exact position and sunk in place.

Box caissons.

3. A box caisson should be used where no excavation is required or where the caisson has to be placed on piles.

The box caisson should be constructed on the river bank or water-edge, then towed to the proposed site and sunk. Sinking can be facilitated by letting some water into the box, and also loading it with ballast, masonry or concrete as desired. Box caissons shall not be used where the depth of water is greater than 40 feet (12 metres) or the waters are swift and turbulent, or where properly trained operators and workers are not available for this kind of specialized work.

Open caissons.

4. Open caissons shall generally be specified for use where exacavating is to be done through subaqueous soil. Open caissons can be further classified as (a) single-wall open caissons, (b) cylinderical open caissons, and (c) open caissons with dredging wells. All open caissons should be provided with proper cutting edges.

Where little or no sinking is required or where the material to be sunk through is very soft, rectangular single-wall caissons made of thoroughly caulked timber framework of 12 inch × 12 inch (30 cm. × 30 cm.) timbers should be used. Material from within the caisson should be removed by any suitable means and where necessary, water-jets should be used to facilitate sinking. After the caisson reaches its final position, concrete should be deposited through the water, if

necessary, to a depth of at least 4 feet (1.2 metres) to harden and form a plug at the bottom. The caisson should then be dredged or pumped dry and filled with concrete or masonry, as specified. If it is desired that the caisson should not extend above low water, a coffer-dam should be built on top of the caisson to keep the flood waters out of the working space.

Details.

5. Details of caisson design, construction, and sinking, etc. shall be specified for each particular job, and the Chief Engineer's approval shall be obtained before a typical kind of caisson is specified for foundations of a structure.

SPECIFICATION NO. 22.4 – Pneumatic Caissons

General.

1. A caisson open at the bottom and closed at the top, in which compressed air is utilized to keep water and mud from coming into the box, is called a pneumatic caisson. These caissons shall generally be specified for pier foundations, where it is not practicable to dig through wet ground in the open in order to reach rock or other suitable stratum below the main excavation.

On account of its greater cost, the pneumatic method shall not be used when some other method is possible provided the work could be done by such other method with certainly and without hazard to the success of the undertaking.

The cassion.

2. The pneumatic caisson generally consists of a working chamber 6 to 7 feet high (1.8 to 2 metres), surmounted by a crib and coffer-dam, the crib being filled with concrete except for the working 'shafts'. The working chamber should be air and water tight, the shafts with suitable air-locks being used as inlets and outlets for men and materials. The caisson should also be fitted with a suitable cutting edge. Pneumatic caissons shall be made of timber, concrete, or steel, according to the designs supplied.

Sinking

3. The site should be cleared of mud and soft deposits and levelled. In swift streams with soft deposits, the bed on the upstream of the caisson should be properly protected against scouring and undermining by paving with sand bags, as deemed necessary by the Executive Engineer.

Caissons should usually be sunk a little below water level before compressed air is applied except when these are placed in open water. The caisson should be loaded to have just enough weight to keep it sinking as fast as the materials are excavated from under the cutting edge. Excavation should be carried on continuously without letting the caisson stop at one elevation. Material should be excavated about a foot (30 cm.), somewhat deeper in clays, below the cutting edge, leaving one foot (30cm.) wide berm along the cutting edge. The material under the cutting edge should then be removed, and the air-pressure reduced enough to let the caisson settle to the bottom of the excavation. When passing through hard strata or boulders, it is important that the excavation should be made amply wide so that the caisson will not jam.

Boulders or rocks may be drilled and blasted in the working chamber in the ordinary manner but the men must be taken out of the working chamber at each blast. The excavated material should be removed by buckets working through air-locks, or by a blowout pipe. Sandy materials can be economically removed through the blowout

pipe when air pressure exceeds 10 lbs. per sq. inch (0·7 kg./sq. cm.) but clays, rocks, boulders should be removed by buckets.

Frequent checks should be made to see if the caisson is sinking vertically. If any cant is discovered, the caisson should be corrected plumb by undercutting the higher side and banking the other side.

Concreting, working chamber and shafts.

4. When the caisson reaches bedrock or other suitable strata, the working chamber and shafts should be cleared of equipment and loose materials, and then filled with concrete of specified quality. The pier or other superstructure should be started within the coffer-dam at the top of the crib, the coffer-dam being removed when the structure is complete. The caisson and crib remain as integral parts of the permanent foundations.

Working Limitations.

5. The pneumatic caissons shall not be used for depths of over 110 feet (34 metres) below water or ground water level, nor shall air pressure greater than 50 pounds per square inch (3·5 kg/sq. cm.) employed. Because of the rapidly increasing costs at the greater depths, it is not advisable to use this method to a depth of more than 90 ft. (28 metres).

Caisson Diseases.

6. As the air pressure in a caisson is increased, the fluids of the body absorb increasing quantities of the air in accordance with Dalton's Law of solution of gases in fluids. If the air pressure is reduced too rapidly when "locking out", the absorbed gases are thrown out of solution more rapidly than the body can eliminate them and bubbles are formed in the blood, tissues or joints. The decrease in pressure allows the entrained gases principally nitrogen to expand. This expansion may cause the blood vessels to burst. The formation of these bubbles in the joints produces the 'bends'. Paralysis results when bubbles are formed in the spinal cord. Very severe cases may result in collapse, followed by death.

Following precautions should be taken to limit the occurrence of the disease:—

(1) Each workman should be examined by a physician before being employed and at intervals not exceeding two months. The man should be young, of spare build, and with low blood pressure.

(2) The hours of work should be limited, and should be less at the higher pressures. The New York State Regulations (1921) specify hours of labour per man in any 24 hours as follows :—

Gauge pressure in lbs./sq. in.	1st period of work in compressed air-hours	Period of rest in normal air-hours	2nd period of work in compressed air-hours
0—20	4·0	0·5	4·0
21—29	3·0	1·0	3·0
30—34	2·0	2·0	2·0
35—39	1·5	3·0	1·5
40—44	1·0	4·0	1·0
45—49	0·75	5·0	0·75

(3) Decompression should be at a slow rate, and the time allowed for decompression should be increased with higher pressures. The time required may be reduced by adopting 'stage-decompression', in which the pressure is first reduced to half its original amount at the rate not exceeding 5 lb. (0·35 kg.) per minute and then reduced to normal at a much slower rate. For pressure under 20 lbs. per square inch (1·4 kg./sq. cm.), the rate of decompression may be fairly rapid. For higher pressures, the total time required should be about one minute for each pound (0·07 kg.) of gauge pressure.

(4) Care should be taken to avoid chill during and after decompression as noted above.

(5) The men should be required to remain near the work for at least one hour after decompression, as it has been found that a large proportion of cases of the disease occur within that time. The men should also be advised not to go to work with an empty stomach.

For the treatment of caisson diseases—hospital compression lock shall be provided on all such construction.

Details of caissons etc.

7. Details of caissons, air-locks, buckets, floating and hauling equipment, and the allied procedures, shall be subject to the Chief Engineer's approval.