IS 14343 (1996): Choice of grouting materials for alluvial grouting - Guidelines [WRD 8: Foundation and Substructures]

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जलोद मृदा में घोल अभिपूरण सामग्री का चुनाव — मार्गदर्शी सिद्धान्त

Indian Standard

CHOICE OF GROUTING MATERIALS FOR ALLUVIAL GROUTING — GUIDELINES

ICS 91.100

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

April 1996 **Price Group 5**

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Foundation and Substructures Sectional Committee had been approved by the River Valley Division Council.

Grouting in alluvial soils can be resorted to as a temporary measure in case of stabilising the foundation soil of any adjoining building during excavation for foundation; and as a permanent measure like stopping seepage through foundation of a dam. Before commencing any grouting project, it is essential that full consideration be given to all available grouting materials, in order to choose the most appropriate materials for a particular application. From a practical point of view grouts are usually divided into two broad groups namely particulate grouts (suspensions) and non-particulate grouts (solutions). This division is important in grouting, since the presence of solid particles in a grout immediately places an absolute limit on the type of ground which the grout can effectively permeate. In other words the pore size in alluvium must be sufficiently large for the solid particles to pass through.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

AMENDMENT NO. 1 MARCH 2011
TO
IS 14343 : 1996 CHOICE OF GROUTING MATERIALS FOR ALLUVIAL GROUTING — GUIDELINES

(*Page* 1, *clause* **3**, *line* 6) — Substitute 'non-particulate (*see* **6**)' *for* 'chemical (*see* **6**)'.

(*Page* 2, *Table* 1) — Substitute the following for the existing:

PERMEABILITY	GROUTABILITY
K = less than 10^{-6} cm/sec	Ungroutable
K = 10^{-6} cm/sec to less than 10^{-5} cm/sec	Groutable with difficulty by grouts having viscosity lower than 5 cP and ungroutable at higher viscosities
K = 10^{-5} cm/sec to less than 10^{-3} cm/sec	Groutable with low viscosity grouts but with difficulty when viscosity is greater than 10 cP
K = 10^{-3} cm/sec to less than 10^{-1} cm/sec	Groutable with all commonly used chemical grouts
K = 10^{-1} cm/sec or more	Groutable with suspended solids grout or chemical grout with filler

(*Page* 4, *Table* 2, *col heading* 3) — Substitute '**Optimum Dosage** (percentage by weight of cement)' *for* '**Optimum Dosage** (percentage by weight)'

(*Page* 5, *clause* **6.3**, *para* 5, *line* 5) — Substitute 'A newly made silica gel will, upon standing, exude water and shrink and this process is called synersis.' *for* 'A newly made silica gel will, upon standing, exude water and shrink.'

(*Page* 6, *clause* **6.4.2**, *Title*) — Substitute '*Lignosulfonate Grouts*' *for* '*Lingnosulfonate Grouts*'.

(*Page* 7, *Fig.* 2C) — Delete.

(*Page* 8, *Fig.* 2D) — Delete.

(*Page* 8, *clause* **6.6.2.2**, *line* 4) — Substitute 'Materials which are highly sensitive, cause difficulty in handling. Prior knowledge of sensitivity of chemical grout to particular *p*H is useful. If not, trial experiments should be conducted.' *for* 'Materials which are highly sensitive cause difficulty in handling.'

(WRD 8)

Reprography Unit, BIS, New Delhi, India

Indian Standard

CHOICE OF GROUTING MATERIALS FOR ALLUVIAL GROUTING — GUIDELINES

1 SCOPE

1.1 This standard lays down guidelines to cover primarily both suspension and solution grouts with particular reference to alluvial grouting. Under suspension grouts, grout materials like cement, clays, bentonite, flyash, etc, are covered, whereas under solution grouts, chemical grout materials are covered.

1.2 This standard does not cover compaction grouting or grouting for reducing compressibility of soil which is excluded from the scope of this standard.

2 REFERENCES

The Indian Standards listed below are necessary adjuncts to this standard:

IS No.	*Title*
269 : 1989	Specification for 33 grade ordinary portland cement (*fourth revision*)
383 : 1970	Specification for coarse and fine aggregates from natural sources for concrete
1344 : 1981	Specification for calcined clay pozzolana
1489 (Part 1) : 1991	Specification for portland pozzolana cement: Part 1 Fly ash based (*third revision*)
1489 (Part 2) : 1991	Specification for portland pozzolana cement: Part 2 Calcined clay based (*third revision*)
1892 : 1979	Code of practice for sub surface investigations for foundations (*first revision*)
3812 : 1981	Specification for fly ash for use as pozzolana and admixtures (*first revision*)
4999 : 1991	Recommendations for grouting of pervious soils (*first revision*)
5529 (Part 1) : 1985	Code of practice for *in-situ* permeability test: Part 1 Test in overburden
11293 (Part 1) : 1985	Guidelines for the design of grout curtains: Part 1 Earth and Rockfill dams
12584 : 1989	Specification for bentonite for grouting in civil engineering works

3 GENERAL

Grout materials can be broadly classified into two groups:

a) Particulate grouts, and
b) Non-particulate grouts.

The functional difference between particulate (*see* **5**) and chemical (*see* **6**) grouts is that the penetrability of the former is a function of particle size, while in the latter, it is a function of solution viscosities.

Suspension grouts actually require a small quantity of water for gellification/hydration. However, in order to increase their flowability, a high proportion of water is added initially. Most of this excess water is separated during passage of grout through voids. In solution grouts, on the other hand, the final water solid ratio is same as the initial.

4 CHOICE OF A GROUT MATERIAL

4.1 Selection of grout materials involves a balance between various desirable characteristics of grout materials as well as requirement of grout slurries such as particle size, viscosity, gellification time, gel strength, stability and permanence coupled with economy. Grout solutions should be non-toxic, non-corrosive and non-exploding.

4.2 Choice of grouting materials and mixtures for appropriate field conditions are given in IS 4999 : 1991. Permeability is the soil property most closely related to groutability. The general relationship between these two factors is shown in Table 1.

5 PARTICULATE GROUTS

5.0 Particulate grouts are suspensions or multiphase systems capable of forming subsystems after being subjected to natural sieving processes, with chemical properties which must be carefully scrutinized so as to ensure that they do not militate against controlled properties of setting or strength.

Table 1 General Relationship Between Permeability and Groutability
(*Clause* 4.2)

PERMEABILITY			GROUTABILITY
K	=	10^{-6} cm/sec or less	Ungroutable
K	=	10^{-5} or 10^{-6} cm/sec	Groutable with difficulty by grouts having viscosity lower than 5 cP and ungroutable at higher viscosities
K	=	10^{-3} to 10^{-5} cm/sec	Groutable with low viscosity grouts but with difficulty when viscosity is greater than 10 cP
K	=	10^{-1} to 10^{-3} cm/sec	Groutable with all commonly used chemical grouts
K	=	10^{-1} cm/sec or more	Groutable with suspended solids grout or chemical grout with filler

5.1 Characteristics of Grout Materials

5.1.1 *Cement*

Ordinary portland cement suitable for cement concrete is generally used for grouting, especially for consolidation grouting. For curtain grouting, however, portland pozzolana cement can also be used. Cement for grouting should conform to IS 269 : 1989 or 1489 (Part 1) : 1991, 1489 (Part 2) : 1991.

5.1.2 *Clays*

Clays have a special value as a grout constituent. They are complex comprising of minute mineral particles mostly smaller than 2 micron and chemical analysis has demonstrated the presence of the following essential constituents silicon dioxide, aluminium oxide, ferric oxide and water with calcium oxide, magnesium oxide, potassium oxide, sodium oxide and phosphorus oxide. The commonest minerals present are kaolinite and montmorillonite with silica/alumina ratios of 3 : 6 and 3 : 5 respectively. Not all clay minerals are useful in grouting, but sodium and calcium montmorillonites are useful because they have suitable water absorption properties and can produce gels at low concentrations. Clays have special value as a grout constituent because of their ability to form gels and also their small particle size. As a first guide in selection of clay, particle size distribution and liquid limit provide useful means of eliminating the poorer samples. Normally a clay having 50 to 60 percent particles smaller than 0.002 mm is preferred. The sand size particles, if present, in the clay are generally removed through processing in hydrocyclones. Details of a typical hydrocyclone are shown in Fig. 1. Normally a clay with liquid limit less than 60 percent is not considered suitable for grouting.

In soils of low permeability, clay-cement grouts cannot be used because the cement particles would be preferentially filtered out during the injection process. Clay-cement grouts are used primarily for the treatment of rather coarse alluvial soils and fractured rock strata so fluidity is not too significant, because the openings available in the ground are large enough to accept cement particles without any risk that filtration may occur. The permeability of such ground will exceed 10^{-1} cm/s.

5.1.3 *Bentonites*

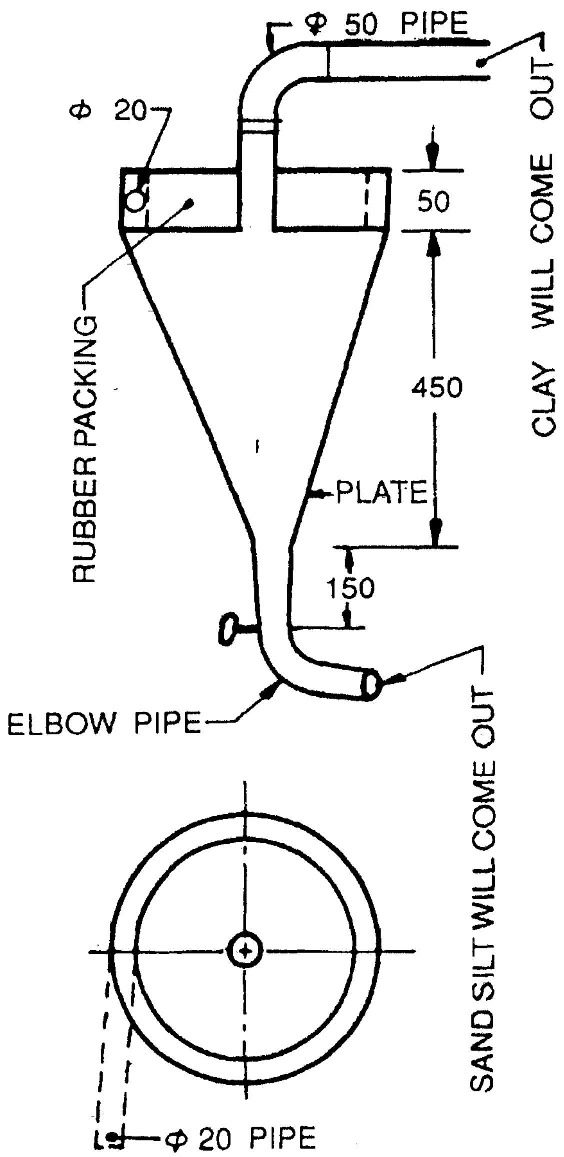
Bentonite is a volcanic clay, rich in colloids. It tends to hold the cement particles in suspension and acts as a lubricating material. When mixed with cement, sodium bentonite (a type of clay) changes to calcium bentonite, which then flocculates. The flocs are gelatinous and large and prevent sedimentation of cement particles. Thus it is a common additive for reducing bleeding. Bentonite delays setting of cement and increases penetrability and workability of grout. For detailed requirements of bentonite *see* IS 12584 : 1989.

5.1.4 *Pozzolana*

Pozzolanas as silicates and alumina silicates are not cementitious but react with free lime in cement, in presence of water, to form cementitious compounds. Pozzolanas naturally available include finely ground shale, pumicite and diatomite. Flyash, a byproduct of pulverised coal and blast furnace slag are examples of artificial pozzolana. Since fly ash and slag are waste products they are normally used as cheap bulk fillers in low strength grouts for cavity filling. Fly ash shall conform to IS 3812 : 1981 and calcined clay pozzolana shall conform to IS 1344 : 1981.

5.1.5 *Admixtures*

It is well known that lean cement grouts show high bleeding percentages, prolonged gel times and low strengths. Proper use of admixtures can improve these unfavourable properties to some extent. For example a good accelerator like sodium silicate or calcium chloride can reduce the gel time, an expander like aluminium powder can reduce the



All dimensions in millimetres.

FIG. 1 ILLUSTRATION OF A TYPICAL HYDROCLONE

bleeding percentage and a fluidifier like calcium lingnosulfonate can help in increasing the unconfined compressive strength of grout. Some admixtures and their dosages as well as effects are given in Table 2.

There are, however, certain drawbacks in using admixtures. Addition of a third or even fourth ingredient complicates the mixing procedure, for example an admixture may not behave exactly the same way with all cements and its effect could be temperature dependent.

5.1.6 *Filler Material*

Sand (4.75 mm to 75 micron) can be added to lean cement/water suspensions to form an economical grout where penetrability criteria is satisfied. Sand shall conform to IS 383 : 1970.

5.1.7 *Water*

Water used for grouting shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious. Potable water is generally considered satisfactory.

Table 2 Admixtures for Grouting
(*Clause* 5.1.5)

Admixture	Chemical	Optimum Dosage (percentage by weight)	Remarks
Accelerator	Calcium Chloride	1 - 2	Accelerates set and hardening
	Sodium silicate Sodium aluminate)	0.5 - 3	Accelerates set
Retarder	Calcium Lingnosulphonate	0.2 - 0.3	Also increases fluidity
	Tartaric acid) Sugar	0.1 - 0.5	
Fluidifier	Calcium Lingnosulphonate	0.2 - 0.3	
	Detergent	0.05	
Expander	Aluminium powder	0.005 - 0.02	Up to 15% pre-set expansion
	Saturated brine	30 - 60	Up to 1% post-set expansion

5.2 Characteristics of Grout Slurries

Grout slurry should have good penetrability (which is based on particle size of grout materials), high fluidity, stability, controllable gellification time and high set strength.

5.2.1 Penetrability is the property of the grout which mostly controls the selection of a particular grout for treatment of soil. Penetrability of a grout depends mainly on the average particle size of the grout material and the average size of openings in the soil. While average particle size of a grout material can easily be ascertained and controlled, it is difficult to ascertain the size of average openings in the alluvium to be treated. Some estimation of the average opening in the soil can be had from *in-situ* permeability test and grain size curve of soil. From these D_{15} of the soil can be judged. As an initial guide $\frac{D_{15} \text{ (soil)}}{D_{85} \text{ (grout)}}$ should be kept more than 25. This will ensure reasonable penetration of grout into the soil to be treated. Table 1 should be referred to for selection of grout on the basis of permeability.

5.2.2 *Viscosity*

Once the grout materials are selected for a particular grouting project based on particle size requirement, the next stage is to decide the proportion of these materials in the grout mix, such that the resulting grout slurry has sufficiently low viscosity to be easily pumped, but not so low as to travel undesirably long distances without appreciable pressure drop. Viscosity of a grout can be measured in laboratory by a rotational viscometer. However, this type of instrument is not commonly used. Therefore some form of funnel viscosity is usually preferred for giving information about fluidity of the grout slurry. A description of measurement of fluidity by Marsh Funnel Test is given in Annex A. The Marsh Funnel Test is a good indicator of true viscosity of the grout slurry, it is also an important index property for quality control of field mixes.

5.2.3 *Stability*

A stable mix will generally maintain its characteristics during pumping, penetration and final gellification.

Stability of a grout suspension is commonly determined by a bleeding (or sedimentation) test. A stable mix is taken as one having less than 5 percent bleeding.

The stability criteria is not applicable to cement and other cement grouts which would have a water/solid ratio considerably smaller than the initial value after deposition and setting.

5.2.4 *Gellification Time*

A fundamental requirement of a grout is that it shall develop adequate gel strength after a controllable interval of time. This should be determined by relevant test procedures. This requirement is not applicable to cement grout.

5.2.5 *Set Strength*

The set strength of a grout is generally determined in terms of unconfined compressive strength and laboratory vane shear strength. It is also desirable in certain situations to determine strength of grouted soil either in the field or in the laboratory. The strength requirement of a set grout/grouted mass should correspond to the purpose of grouting.

6 NON-PARTICULATE GROUTS

6.0 Non-particulate grouts are solutions or intimate one phase systems, retaining an originally designed chemical balance until completion of the relevant reactions. Solutions in which the solute is present in the colloidal state are known as colloidal solutions. Chemical grouts fall under this category.

6.1 Chemical Grouts

Some of the widely used chemical grouts are given in **6.3** to **6.5**.

6.2 Salient Features of Chemical Grouts

6.2.1 Chemical grouts should have the following properties to be an ideal grout material:

a) A powder readily soluble in water (this eliminates the expense of transporting a solvent, water being the least expensive solvent).
b) Inexpensive and derived from chemicals in abundant supply.
c) Stable at all anticipated storage conditions.
d) Nontoxic, noncorrosive and nonexplosive.

6.2.2 The grout solution should be:

a) A low-viscosity solution, preferably that of water.
b) Stable under all normal temperatures.
c) Catalyzed with common, inexpensive chemicals stable under all normal temperatures.
d) Of stable *p*H on the positive side (so that it may be used in conjunction with cement).
e) The end-product should be:
   i) permanent gel,
   ii) unaffected by chemicals normally found in groundwater, and
   iii) of high strength.

Ideally, no such chemical exists. However, every criterion listed can be found in one or more commercially available materials. It is important, therefore, to determine which grout properties are critical to a specific project in order to have a sound basis for selecting a grout.

6.3 Silicate Grouts

Alkaline and non-alkaline type of chemical grouts include all alkali silicates with inorganic and organic compounds which may be broadly called sodium silicate formulation.

Sodium silicate (n-SiO_2 Na_2O) is commercially available as an aqueous solution. The silica/alkali ratio 'n', if between 3 to 4, is more suitable for grouting. When sodium silicate solution and a concentrated solution of appropriate organic and inorganic salts is mixed, the reaction forming a gel is virtually instantaneous. The commonly used inorganic soils are sodium bicarbonate and sodium bisulphite and sodium and potassium chlorides. Generally used organic salts are acetates and ketones.

In all silicate based grouts, strength and viscosity are the functions of sodium silicate content and are directly related to each other. However, a peculiar characteristic of silicate grout is a reversal in temperature-gel time relationship at low temperatures. When temperature of the grout solution drops below 15°C, gel-times start getting shorter. In field work, this could cause unanticipated flash sets when working at temperatures near freezing.

Portland cement can be used as catalyst. However, the use of normal cement reduces the penetrability of grout suspension. Sodium silicate solution is generally considered totally non-toxic and free of health hazards and environmental effects. Sodium salts may sometime cause environmental hazards in special circumstances. Some of the organics used for reactions may have toxic, corrosive and/or environmental effect.

Although most of the silicate formulations are considered permanent materials the end product is sometimes subjected to a phenomenon called synerisis which often tends to cause doubt about permanence. A newly made silica gel will, upon standing, exude water and shrink. The total water loss is related to gel properties, generally decreasing with increasing silicate content and shorter setting times. Syneresis also takes place in the voids of a stabilized soil mass. In a soil where voids are completely filled with new gel, the shrinkage accompanying syneresis results in an increase in residual permeability after several weeks.

As soils become progressively finer, the practical effect of syneresis becomes smaller. For medium and fine sands, effects are generally considered negligible.

6.4 High Polymer Type Chemical Grout

The groups of compounds classified as high polymer type grouts are given at **6.4.1** to **6.4.4**.

6.4.1 *Acrylamide Grouts*

A acrylamide grouts consist of a mixture of two organic monomers, acrylamide (or methanol acrylamide, methacrylcyanide) and meththylene bis-acrylamide, a cross linking agent. The other activators used are TEA (Triethanolamine) and DMAPN (Dimethyl amino propionate). The acrylamide grouts are considered to be an ideal grout. They can penetrate more readily, maintain constant viscosity during the induction period and have better gel time control and adequate strength for most applications. Acrylamide grouts are more costly than silicate grouts and are neurotoxic. The stiffness of the grouts can be changed by changing the acrylamide to methylene ratio. The values of unconfined compression (UC) and Young's Modulus increase with the increase in percentage of methylene bis-acrylamide from 3 to 10. Grout solution with up to 20 percent solids have viscosities well under 2 cP. The gels are considered permanent. The minimum concentration of grout from which a gel will form is temperature dependent.

6.4.2 *Lingnosulfonate Grouts*

Lignosulfonates are the waste liquor by-products of the wood processing industries. Lignosulfonate grouts consists of lignosulfonate and a hexavalent chromium compound. Generally calcium lignosulfonate is used with sodium dichromate. Initial viscosity varies from 3 to 8 cP. The strength of the soils grouted with lignosulfonates is of the same order of magnitude, but somewhat less, than that of acrylamide grouts. Since lignosulfonates are by-products of other processes, they are relatively cheaper and can compete on cost basis with any other chemical grout. Lignosulphonates are considered to be permanent materials. However, they are toxic and should be handled with care.

6.4.3 *Phenoplasts*

Phenoplasts are polycondensates resulting from the reaction of a phenol or aldehyde. Mostly resorcinol and formaldehyde are used and sodium hydroxide is used as a catalyst. The only control of setting time is the dilution of grout components. Setting time varies greatly with solution *p*H, being shortest for any given grout concentration at a *p*H slightly above 9. Initial viscosities of resorcinol-formaldehyde grouts range from 1.5 to 3 cP for concentrations normally used for field work. The viscosity remains constant at those low levels until gellation starts. The strength of soil grouted by this grout is comparable to high concentration silicates. The strength of soils stabilised by resorcinol formaldehyde grout is directly proportional to the resin content. Resistance to wet-dry cycles is poor and can lead to complete disintegration. Phenoplasts always contain a phenol, formaldehyde and an alkaline base. All three components are health hazards and potential environmental pollutants. Gels formed are generally inert (non-toxic and non-caustic).

6.4.4 *Polyurethane Grouts*

Polyurethanes are plastics that are used in a wide range of fields as hard or elastic, and unfoamed or foamed materials. Polyurethanes are formed by the reaction of two components namely polyisocyanates and polyalcohols or with other chemicals such as polyethers, polyesters and glycols, which have hydroxyl groups.

The catalysts used are tertiaryamines and tin salts may be used to control the reaction rate. Surface active agents are used to control bubble size. The foam structure itself is produced by a blowing agent reacting chemically to produce carbon dioxide.

6.4.5 *Aminoplasts or Urea Resins*

The major ingredients of this type of grout are urea and formaldehyde. In addition to urea, melamine, ethylene and propylene urea, aniline and other chemically related materials can be used. These grouts will set only in acidic conditions, therefore, they should be used only when it is known that ground and groundwater *p*H is below 7. Urea formaldehyde grouts have viscosities between 10 and 20 cP. Soils stabilised by these grouts have strengths comparable to the phenoplasts. The grout is toxic and corrosive. However the gel is inert.

6.5 Other Chemical Grouts

It is possible, to a certain extent, to combine two available grouts so as to simultaneously obtain the optimum properties of each. To do so the materials must be chemically compatible. The silicates and the acrylamides can be used together. Polyesters and epoxies have been used to anchor rock reinforcement in drilled holes

6.6 Grout properties

Grout properties which are of importance may be broadly classified as given in **6.6.1** to **6.6.3**.

6.6.1 *Mechanical Properties*

6.6.1.1 *Permanence*

All grouts which contain water not chemically bound to the grout particles, are prone to mechanical deterioration if subjected to alternate freeze-thaw and/or wet-dry cycles. The rate of such deterioration varies with the amount of free water available in the grout as well as with the degree of drying or freezing. Chemical deterioration of grouts can occur if the grouts react with the soil or groundwater, or if the grout itself is soluble in groundwater or if the reaction products, which form the grout, are inherently unstable.

6.6.1.2 *Penetrability*

The comparative ability of grouts to penetrate a formation is mainly a function of their relative viscosities. Thus viscosity is used as an indicator of penetrability. A rough estimate of penetrability of various chemical grouts in relation to soil grain size can be had from Fig. 2. Alternatively, penetrability can also be related with permeability higher than 10^{-3} cm/s.

The usable viscosities of various materials depend on the minimum desirable field concentration of solids. The penetrability of various chemical grouts depends on the soil grain size. In terms of permeability a conservative criterion is that grouts with viscosities less than 2 cP, such as acrylamide based materials, can usually be pumped without trouble into soils with permeability as low as 10^{-4} cm/s. At 5 cP, grouts such as the chrome lignin and phenoplasts, may be limited to soils with permeabilities up to 10^{-3} cm/s, while silicate based grouts with viscosities of 10 cP may not penetrate soils with permeability below 10^{-2} cm/s.

6.6.1.3 *Strength*

Chemical grouts have little strength compared to cement. However, what is important is the strength of the soil formation grouted with chemical grout. In most of the uses strength of grouted soil remaining immersed in a saturated formation is more

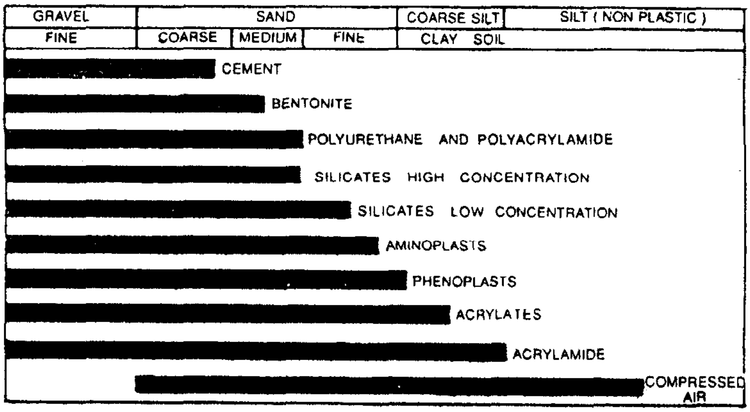


FIG. 2A PENETRABILITY OF VARIOUS GROUTS

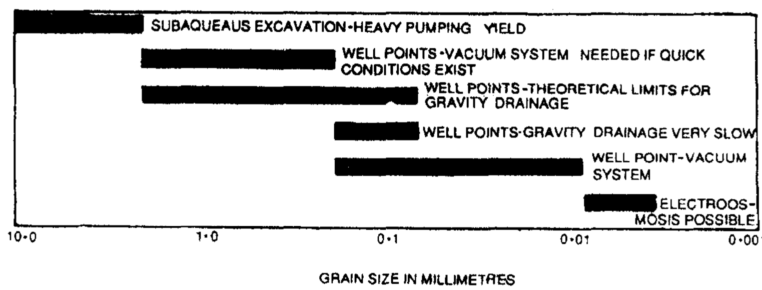


FIG. 2B EFFECTIVE RANGE OF GROUND WATER CONTROL MEASURES

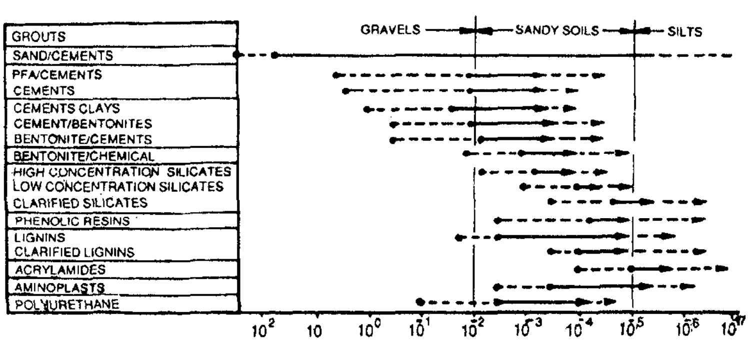


FIG. 2C INDICATIVE RANGE OF GROUND WATER TREATMENT

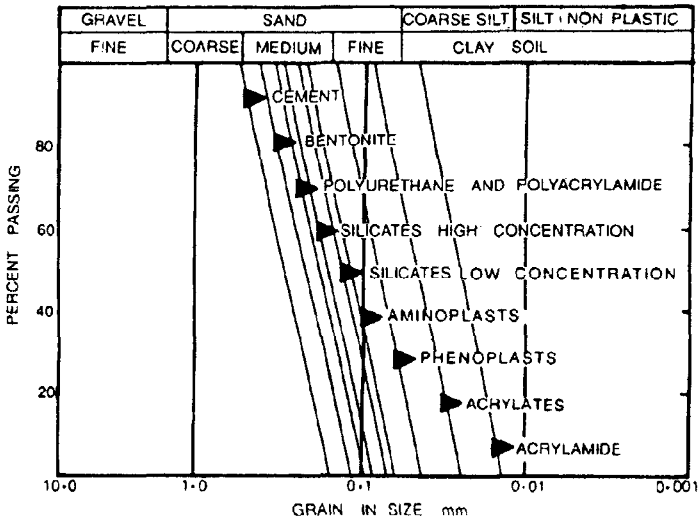


FIG. 2D GROUT PENETRABILITY

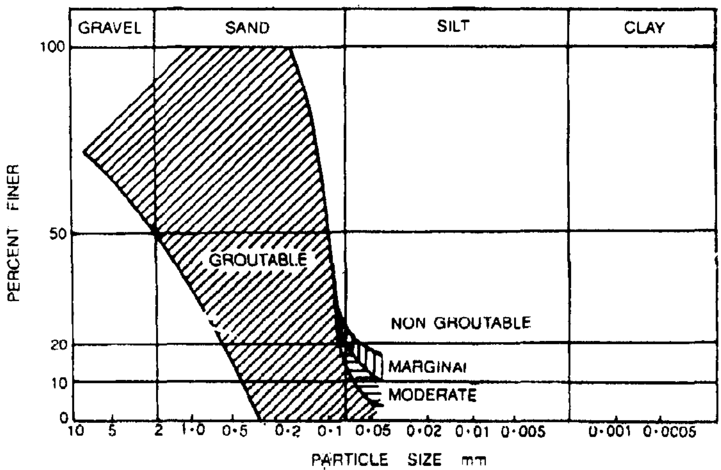


FIG. 2E GROUTABILITY OF SOILS BY VARIOUS SOLUTION GROUTS

important. This is termed as wet strength as compared to dry strength generally worked out in laboratory after air/oven drying. Unconfined compression tests are generally performed to evaluate strength of grouted mass, however, the triaxial test is a better choice.

6.6.2 *Chemical Properties*

6.6.2.1 *Gel time control*

The time lag from the mixing of the chemical components to the formation of a gel is referred to as gel time. With most grouts, the gel time can be changed by varying the concentration of either the activator, the inhibitor or the catalyst. If a wide range of gel time can be obtained and accurately repeated, gel time control is called good or excellent and if there is only a narrow range of gel time control, then it is termed fair or poor.

6.6.2.2 *Sensitivity*

The degree to which a chemical grout is sensitive to the *p*H of ground water, temperature conditions and chemical activity of dissolved salts in ground water is termed as its sensitivity. Materials which are highly sensitive cause difficulty in handling.

6.6.2.3 *Toxicity*

Some of the chemical grouts used in the past and/or still in use, are classified as neurotoxic, cancer causing, toxic, corrosive, highly irritating, etc. There have been a number of incidents of people adversely affected by exposure to grouts.

All chemical grouts should therefore be handled with care in the field, with safety and cleanliness equal to or better than the manufacturer's recommendations.

6.6.3 *Economic Factors*

Cost is a very important factor in selecting the construction method best suited to solving a specific field problem. When grouting is compared with other methods such as well pointing or slurry trenching, chances are that the cost comparison will be realistic. When comparing two different grouts, however, the mistake is often made of comparing raw material costs rather than in-place costs. Selecting the most suitable material for a specific job will generally overcome the possible lower material cost of other products.

ANNEX A

(*Clause* 5.2.2)

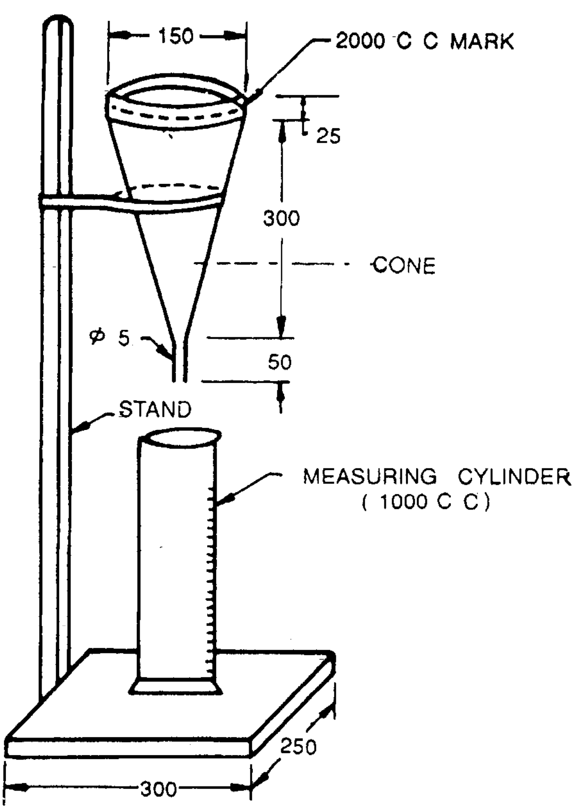
DESCRIPTION OF MARSH FUNNEL AND METHOD FOR DETERMINATION OF FLUIDITY OF GROUT SLURRY

A-1 DESCRIPTION OF MARSH FUNNEL

A Marsh Funnel as shown in Fig. 3 has a diameter of 150 mm at the top and a height of 300 mm, the bottom orifice outlet has an inside diameter of about 5 mm. The top of the cone has a screen with 1.5 mm openings, for screening out lumps of poorly mixed slurry.

A-2 METHOD

Pour 2 000 cc of slurry into the funnel. Record the time taken for 1 000 cc of the slurry to pass through the funnel into the measuring cylinder. The result to the nearest second is the Marsh funnel viscosity. For clear water at 21°C the Marsh funnel viscosity is 27 seconds. For grout slurries, the Marsh funnel viscosity has a good relationship with viscosity in centipoise determined by a rotational viscometer. The relationship is nearly straight line in the range of 30-40 seconds. This can be developed for each individual grout mix.



All dimensions in millimetres.

FIG. 3 ILLUSTRATION OF A TYPICAL MARSH CONE

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act, 1986* to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards Monthly Additions'.

This Indian Standard has been developed from Doc : No. RVD 8 (14).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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