Subject : QUALITY CONTROL TESTS FOR EARTH WORK FOR DAMS AND THE PROFORMA FOR RECORDING OF THE RESULTS.

GCM No. CMN/1557/ 53140-K dated 17th January 1664.

It was observed from the forms used for reporting and maintaining records of quality control tests for earthwork by the field officers that these varied from projects to project and were not adequate and comprehensive enough to ensure an effective check on the execution of earth dam works and to finally preserve this record in a form in which the data can be readily used for future studies. Central Designs Organisation, therefore, examined the aspect of quality control and suggested the revised criteria of quality control and standard forms for recording of the results of quality control tests. It is desired that these should be adopted on all important earth dams.

2. In these proformae the principal departure from the existing practice is in case of soils that consist almost exclusively of coarse grained particles *i.e.* sand and gravels. These soils when compacted according to procedures outlined for determining proctor maximum dry density, have density and moisture relationship that co-relates poorly with other properties. Further more, the compaction curves are erratic and often do not produce a definable maximum density. It has been found that when shearing strength of these soils is co-related with changes in density in the range between minimum and maximum obtainable densities, a fairly reliable relationship exists. Further more, it has been found that with reasonable amount of construction control a given type of compaction efforts can be expected to produce a related relative density. In practice relative density of 70 per cent has been found satistactory in most conditions. More specific values are given accompanying proforma.

3. Previously summary of the results of the quality control tests was being submitted monthly to the Chief Engineer (I.P.) In accordance with the instructions issued in the Government Circular Memorandum No. MIP/7062/64448-K, dated 19th October 1962, it will not be necessary to send such summaries henceforth to the Chief Engineer (I. P.); — It will, at the same time, be desirable to prepare such monthly, abstracts from time to time and keep them readily available at the project head quarters to facilitate quick review of the test results. These summaries will also be useful for further designs as they will bring out the differences between the properties of the soils as attained in the field and as predetermined in the laboratory. Therefore, a proforma is also suggested for such summary which should go a long way in preserving the record of the soil test results in readily inteligible form.

Subject : DISPLAY OF ALIGNMENT OF FIELD CHANNEL FROM OUTLETS

GCM No. FYP-2061-P, dated 6th November 1961.

Water courses of field channels from outlets form one of the most vital components of a canal system under an irrigation project. Upon the timely completion and commissioning of these field channels depend the utilisation of irrigation waters carried by our canals. The existing rules require these filed channels to be constructed and maintained by the cultivators themselves.

2. The construction of these filed channels can progress swiftly and the desired result achieved in time only if the Public Works Department Officials in charges of irrigation management, work in co-ordination with the cultivators. The former, on their part, should assist the later so far as the technical aspects of the construction of field channel are concerned, the prime factor being the most suitable alignment bearing on the local topography of the Command under each outlet.

3. Government has, therefore, directed that village maps (preferably white prints), showing revenue survey numbers, the part of the canal system etc., with the most suitable alignment of the field channel under each outlet prominently marked thereon should be publicly displayed in places such as choras, panchayat halls, etc., of each village. Such maps should be given a wide publicity well ahead of the irrigation season, so that the beneficiaries will get adequate time to study and appreciate them and follow them during the construction of field channels. If necessary, the irrigation staff should invariably render necessary guidance to the cultivators, so that they can be fully benefited from the assistance so offered.

GC. No. BIA-1064-P dated 29th February 1964.

4. It has been understood that while following the alignment for construction of water Courses, the section adopted by different cultivators are not uniforms. They are generally too small to carry discharge of 1 to $1\frac{1}{2}$ cusecs.

5. Canal officers are therefore requested that some standard section depending on the slope of the ground should also be suggested and displayed alongwith the alignment on village maps. A section of Canal with a bed width of one foot and side slopes of of 1 to 1 having a flow depth of 9 inches to one foot should normally suffice.

6. The canal officers are, however, requested that they should varify the adequacy or otherwise of this section in relation to local conditions, and display the most suitable section alongwith the alignment of the water course. This will enable the cultivators to follow a uniform section throughout the length of the water course.

વિષય : રાષ્ટ્રીય ધોરી માર્ગ ઓળંગતી નહેર ઉપરની સાયફન અને નાળામાં રેલ્વે ધોરણની પાઈપ વાપરવા બાબત

સરકારની જાણમાં આવ્યું છે કે રાષ્ટ્રીય ધોરી માર્ગ ઓળંગતી નહેર ઉપરના નાળા તથા સાયફનમાં કેટલેક સ્થળે 'આ' વર્ગની સિમેન્ટ પાઈપો વાપરવામાં આવી છે. રાષ્ટ્રીય અને રાજ્યના ધોરી માર્ગ ઉપર બહુ ભારે વજનવાળા વાહનોની અવરજવર થતી હોવાથી જો હલકા પ્રકારના પાઈપો વાપરવામાં આવે તો તૂટી જવા સંભવ છે. આથી સર્વે સ્થાનિક અધિકારીઓને ખબર આપવામાં આવે છે કે રાષ્ટ્રીય તેમજ રાજ્યના ધોરી માર્ગ ઓળંગતી નહેર ઉપરના નાળા અને સાઈફનના અંદાજ પત્રકોમાં રેલ્વે ધોરણની સિમેન્ટ કોંક્રીટની પાઈપોની જોગવાઈ કરવી.

પરિપત્ર ક્રમાંક ઓમ. આઈ. પી. ૧૦૬૪-આ. તા. ૧૬મી જુન ૧૯૬૪

Subject:— MINOR IRRIGATION PROJECT—CRITERIA FOR PROVIDING OF CUT OFF IN EARTHEN DAMS.

1. Introduction :

G. C. No. CME-2063, 1134-I dated 24th February 1965

The old practice of providing cut off to half the depth of water to be retained by the earth dam is, it appears still in vogue in some places. This practice is neither rational nor sound; in fact it may even prove dangerous. Instances can be quoted where non judicious use of this rule without considering the local geology and the structural necessity, has led to excessive seepage from under the cut off, leading many a time even to the failure of the dam by piping. No doubt there may be cases when the structures designed on the above criteria have apparently shown no signs of distress but while failures are clear indications of faulty criteria, the successful cases be taken as positively indicative of the adequacy of this criterion. The design of a suitable cut off therefore needs a very careful study.

2. Design Considerations :

Cut off trench in an earth dam is required from two main considerations ; (i) to minimise the loss of water through the foundation and (ii) for the safety of the dam against internal erosion due to high seepage gradients in the foundation.

3. Properties of Foundation Soils :

3.1 One of the very important classification of foundation soils signincant from the consideration of the design of the cut off is whether the soil is "residual" or "transported."

3.2 Residual Soils :

3.2.1. Residual soils are the products of weathering of the underlying parent rocks. With increase in depth, the effects of weathering get less pronounced, the strata becoming normally more water tight. A satisfactory positive cut off can be generally attempted for such a strata. Care has no doubt to be taken to check up open faults and fissures in the rocks below. These will need to be sealed by grouting.

3.2.2. *Disintegrated rock* .— is often termed as murum. Depending upon the minerological composition of rock and the extent of weathering, this murum can be pervious (1000 to 10,000 ft. per year) or relatively impervious (100 to 500 ft. / year) The latter should be acceptable for ending the cut off.

3.2.3. *Soft rock* :— is also likely to vary in its permeability characteristics within a fairly wide range depending upon its structure, Even in a porous or fissured rock, there is no possibility of internal erosion for relatively smaller heads of water (say upto 50 ft.) The principal criterion to be examined while deciding the cut off in such cases (soft rock) is the limit to which loss due to seepage will be permissible on a particular job. Nature of the treatemt necessary, if any, can be also decided from this consideration.

3.3. Transported soils :

3.3.1. In the case of transported soils, one is likely to meet with a great deal of variation in the nature and the charactanstics of the strata, which at best can be ascertained only by a carefully planned investigation. In the case of alluvial deposits, one may meet with either alternate layers of pervious and impervious strata or in some cases the impervious stratum may be available at so great a depth as to make the complete (positive) cut off uneconomical. In such soils exploration should be carried out at least to a depth of about one and a half times the depth of water to be retained.

3.3.2. There are also other types of river deposits (alluvial) which are marked by the hetereoginity of soil formation varying from a mixture of sand, silt and clay to open gravel and boulders and absence of clear stratification. These are also called talus soils. They are formed due to slopewash of hills and are generally found near the foot of the hills.

4. Cut off :

4.1. The cut off to be effective, has to be taken down to an impervious stratum. Partial cut off as such has hardly any value (if the deposits are homogeneous). This will be quite evident from a study of table 1 which gives the percentage discharge down stream of the

cut off for various interceptions (extracted from "Engineering for Dams" by Creager, Justin and Hinds-Vol. III, Page 695).

TABLE—1

Percentage cut off	Percentage Discharge
100	0
90	36
80	46
60	65
40	80
20	92
0	100

The above results are applicable only to homogeneous strata. If however the deposits are having a marked decrease in permeability with increase in depth partial cut offs taken down to suitable depths (depending upon the permeability and permissible seepage) may serve the purpose.

4.2 If it is not feasible from economic considerations to provide a positive cut off by taking it down to a relatively impervious stratum (*i. e.* in case this is met with at uneconomical depths), the courses normally open are;

(i) to have an open cut off down to the depth to which excavation is feasible, and provides a grouted cut off below extending down to the impervious stratum.

(ii) Provide an upstream impervious blanket of adequate length, with a shallow cut off and adequate drainage on downstream wherever necessary.

(iii) provide a concrete diaphragm cut off.

It may be noted that sheet pile cut offs are not now generally favoured (except perhaps as a second line of defence) as they have not been found to be quite effective.

4.3 Open cut off combined with a grouted cut off below:

While grouting of joints and fissures in rock may not be now considered outside the reach of even minor works, grouting of alluvial strata by injections of clay and cement is comparatively a recent technique requring a very eleborate and detailed investigations and laboratory testing. The process of grouting also is not so simple. This will be therefore outside the perview of such Minor Irrigation tanks.

4.4 Shallow cut offs with an upstream impervious blanket:

4.4.1 Provision of an upstream blanket is comparatively an easier proposition worth adopting in minor irrigation projects where provision of cut offs taken down to an impervious stratum works out either uneconomical due to its greater depth or high water table involving heavy pumping or is unfeasible. Providing an upstream impervious blanket increases the length of the path of flow and thus helps in reducing the seepage. It is a general practice to keep the length of the impervious blanket equal to 6 to 8 'H' measured from the upstream toe of the hearting in the dam where 'H' is the depth of water above ground level. The thickness of the blanket should be about 4 feet minimum. In many cases natural blanket may be available. In that case care should be taken not to remove this impervious layer while borrowing the earth for the dam at least within a distance of 10 'H' from the upstream toe of the dam. The blanket should consist of soils of low permeability. The plasticity should not be however high as they are liable to develop to cracks, on exposure.

In case, soils of the high plasticity are required to be used (because of the non-availability of other suitable soils), the surface of the blanket should be covered for depth of about 3 feet by a layer of any soil that may be cheaply available near by but these should not be highly plastic.

4.4.2 A combination of impervious blanket with a partial cut off trench will be helpfull in cases where the top strata are relatively more pervious and the horizontal permeability is much higher than the vartical permeability due to stratification. Intercepting such strata by a partial cut off would help in reducing the seepage. In any case for reasons mentioned later, open cut off to a minimum depth of about 5 feet is required to be provided irrespective of whether a blanket is necessary or not.

4.4.3. Relief wells :

In cases where upstream impervious blanket (with or without a partial cut off) is relied upon for reduction in seepage it is essential to provide for the relief of excess hydrostatic (or seepage) pressure which are likely to be built up or persist near or even beyond the down stream toe of the dam. Necessity of such provision is now universally recognised.

This can best be provided by means of toe drains with relief wells at suitable interval (100 to 200 feet) penetrating either partially or fully the pervious strata, depending upon the degree of stratification or anisotropy (different vertical and horizontal 'K') of the strata.

4.4.4 One of the limitation of the blanket is that the blanket is not effective against the internal erosion in case of hetereogeneous soil formation (Talus). In such a case a positive cut off is required by resorting to modern methods of construction or alternatively the site has to be abandoned.

4. 5 Concrete diaphragam.

Providing a concrete diaphragm by specially devised trenching machines is an effective way of putting thin deep concrete cut off sufficient flexibility to prevent cracking. In our present stage of development of this technique in India, it can at best be thought of for major schemes (In case of Ukai, for example, it is proposed to adopt this technique.) As mentioned earlier, sheet piles which were some time back used to serve as cut offs in difficult situations are generally not favoured now because of the difficulty in effecting good contact with the rock on which they rest, and the leaky joinsts. Besides, these are difficult to drive in bouldery strata.

4. 6 Other considerations. :

From the considerations given below the depth of the out off should not be less than say about 5 feet. (except where good rock is met with at a lesser depth.)

(i) The holes of the anthills extend generally down to this depth. If they are observed to extend to even greater depths, the cut off should be taken deeper.

(ii) Due to cultivations, the soil in the root zone is more pervious and loose than the soil below.

(iii) In most of the soils, cracks due to drying are seen to extend to this depth. In very clayey soils they may extend even deeper, in which case, the minimum depth is required to be fixed accordingly.

5. Investigations :

5.1 Trial pits.

5.1.1. The purpose of the trial pits is to acertain the type and charecteristics of the sub surface strata which will help in determining the depth to which the cut off may be required to be extended. The total number of trial pits required will depend upon the general geology of the area. In the preliminary investigations, the pits may be had at an interval of say 500 feet on the flanks and about 50′ to 100′ intervals in the river channel depending upon its width. If the results of these trial pits indicate a large variation in the soil strata, it may be necessary to supplement the information by taking additional pits at suitable locations.

5.1.2 Keeping in view the purpose for which the sub-surface investigations are to be carried out, it is obvious that the pits should be taken down to about to 2' to 3′ in impervious layer which may be either clayey soil or hydraulically sound rock. In case such a layer is not struck at a depth upto which the trial pits can be normally excavated, it will be necessary to take as couple of bores to ascertain the depth at which such a strata can be expected to be met with. For minor Irrigaion works, it may be normally necessary to explore the sub-surface to a depth equal to or about 1½ times the height of water to be retained.

5.2 Logging of the strata. :

5.2.1. The strata exposed in the trial pits will have to be very carefully logged with respect to :—

(i) the type of soil;

(ii) its permeability characteristics;

iii) sub-soil water table and

(iv) joints, fisures, lenses etc.

5.2.2. As the design of the cut off will primarily be guided by the classification and other details given for the sub-soil strata, it is necessary that the person entrusted with the visual inspection and logging of the strata has an adequate background or experience and is sufficiently trained in this technique. So far as soil classification is concerned, it is advisable to follow the classification as prescribed in the Indian Standards Specification No. 1948-1959. It is essential that the result of the trial pits are plotted on the L.S. itself. A sample sheet is given in Plate-1.

5.2.3. Experience in the past has shown that for want of laying down and insisting upon some uniformity of practice in this regard, much difficultiy has been experienced, many a time leading to defective designs. Loose description of soils such as overburden, yellow soil, brown soil, black soil, murum, rock, black rock etc., obviouly do not give any indication about either the type of soil *i.e.* sandy, silty or impervious clayey etc. or its permeability *i. e.* pervious, semipervious, which in fact, are the two important significant characteristics which need to be known before cut off trench can be designed. The necessity of following a uniform practice of classification of soils need, therefore, hardly be overamphasised even in case of minor irrigation tanks.

5.2.4. A word of caution about a few snags that may confront one engaged in the indentification and classification of the sub-strata may not be out of place here.

(i) It is quite likely that an inexperienced classifier would classify as "rock" any material which is hard to excavate or which comes out in pieces that could not be crushed in a dry state. This is sometimes likely to be quite misleading. The real test of rock is that the sample should retain its shape on immersion in water for a reasonable length of time. In some instances it did happen that was actually a "shale" of the "Compressed Silt" type was wrongly classified as 'rock' as it did look like rock; but after a few minutes of immersion in water it completely disintegrated into a fully silt.

(ii) When a material is classified as 'murum' it has been normally the practice to assure it as a material good enough for casing *i. e.* pervious. This may be misleailng. as murum can well be as impervious as clay. In such cases it is quite obligatory to state definitely whether what is termed as murum is open *i.e.* pervious or is tight *i.e.* impervoious. A simple field test is to add a little moisture to the sample and remould it in hand. By the "feel" one would be able to indicate whether the murum is of the pervious or the impervious type.

(iii) In case of alluvial deposits, one should not stop the trial pits at the first sight of impervious strata because, as already indicated earlier, this strata can as well be under lain by a more pervious strata. Presence of such a strata if not detected may lead to disastrous results. This points to the necessary of taking trial pits to sufficient depths to detect such layer. It may be necessary to even take deep bores in cases where trial plts cannot be taken down to sufficient depths.

6. Conclusion :

This note is drawn out mainly for use in designing cut off for minor irigation works. Attempt has however been made to bring out in as simple a manner as possible the fundamentals of the designs of the cut off for a dam in normal conditions. Planning a cut off in intricate geological situations, (which may arise even in case of minor tanks) is quite difficult and should be entrusted to persons having an adequate background and experience in this field. Obviously would be beyond the scope of this brief note to cover such cases.

The first method is preferable and should always be aimed at but in some places where problem of getting man and materials is acute and their arrangement is likely to take some time, the second method may be adopted but it should be for a temporary period and immediately the berm should be laid after placing pervious sand and gravel in the pond created by ring bund. It is also the experience that after the ring bund is constructed surrounding the sand boil, the adjoining land also becomes active and boils are likely to appear in that area also. Ring bunds should therefore be extended to these areas. In this way the sphere of ring bund and the seepage berm increases until the desired width is achieved.