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To,

All Chief Engineers of States and Union Territories dealing with roads.

Subject : Guidelines for setting out of alignment, construction limits and achieving design embankment profile for highways

Most PWDs and other construction organisations for highways have some accepted procedures for construction of earth embankments for highways with setting out of alignment, construction limits etc. Detailed instructions also exist in some of the relevant publications of the IRC and in the Specifications for Road and Bridge Works of this Ministry. In a bid to recapitulate the existing instructions to serve as a guide to the field engineer engaged in actual supervision work, the same have been collected and prepared in the form of guidelines for internal circulation to the field supervising staff. A copy of the same is enclosed for your use specially in the National Highway Projects.

GUIDELINES FOR SETTING OUT OF ALIGNMENT, CONSTRUCTION LIMITS AND ACHIEVING DESIGN EMBANKMENT PROFILE FOR HIGHWAYS

1. Introduction

Detailed guidelines already exist in different publications of the Indian Roads Congress for setting out of alignment and construction limits in the field. The 'Manual for survey, Investigation and preparation of road projects' (IRC Special publication No. 19) and the 'Recommended practice for the construction of earth embankment for road works' (IRC : 36-1978) may be referred to in this connection. The book of Ministry's Specifications for Road and Bridge works also contain a separate subsection (305.3) devoted to construction operation. For the convenience of the field officers some of the relevant portions of these

are quoted below for guidance. These instructions cannot, however, be a substitute to the detailed instructions contained in these publications and the field engineer is advised to always refer to the original publications in case of additional information and for guidance regarding other connected points.

2. **Setting Out of Alignment**

2.1 **Staking Final Centre-Line**

2.1.1 First the working drawings are prepared on the basis of what is called the 'final location survey' to layout the final centre-line of the road in the field based on the alignment selected in the design office and to collect necessary data for the preparation of working drawings.

2.1.2 The two main operations involved in the survey are the staking out of the final centre-line of the road by means of a continuous transit (theodolite) survey and detailed levelling.

2.1.3 The centre-line of the road, as determined in the design office, is translated on the ground by means of a continuous transit survey and staking of the centre-line as the survey proceeds. All angles should be measured with a transit theodolite. Double reversal method should be adopted at all horizontal intersection points (HIP) and at intermediate points of transit (POT) on long tangents. The HIPs should be fixed on hubs driven flush with the ground and suitably referenced so that they may be relocated readily. These should be serially numbered for easy identification. On long tangents, the intermediate transit points (POTs) should also be fixed on hubs in the case of new roads, and by means of spikes or nails driven into the pavement in the case of existing roads after proper referencing. Method of referencing HIPs & POTs will be more or less the same as indicated in the sketches (Fig. 1) for setting out construction limits appended to those guidelines.

2.1.4 The reference points should be so located that these will not be disturbed during construction. Description and location of the reference points should be noted for reproduction on the final plan drawings. Distance of the reference points should be measured along the horizontal plane. Where the terrain is undulating, the distance is measured along the slope, the slope angle determined with a theodolite, and the actual horizontal projection calculated.

2.1.5 All the curve points, namely the beginning of spiral transition curve (BS), beginning of circular curve (BC), end of circular curve (BC) and the end of spiral transition (ES) should be fixed and referenced in the same manner as for POTs described earlier. (For the procedure of setting curves, reference may be made to IRC : 38' Design Tables for Horizontal Curves for Highways.")

2.1.6 The final centre-line of the road should be suitably staked. Stakes should be fixed at 50 metre intervals in plain and rolling terrain, and 20 metre intervals in hilly terrain. The stakes are intended only for short period for taking levels of the ground along the centre-line and cross-sections with reference thereto. In the case of existing roads paint marks may be used instead of stakes.

2.1.7 Distance measurements along the final centre-line should be continuous, following the horizontal curves where these occur.

2.1.8 At road crossings, the angles which the intersecting roads make with the final centre-line should be measured with the help of a transit theodolite. Similar measurements should be made at railway level crossings.

2.2 **Proper Protection of Points of Reference**

2.2.1 Among other things, field notes should give a clear description and location of all the bench marks and reference points. This information should be transferred to the plan drawings, an to computer memory also where facility for such storage exists, so that at the time of construction the centre-line and the bench marks could be located in the field without any difficulty.

2.2.2 At the time of execution, all construction lines will be set out and checked with reference to the final centre-line established during the final location survey. It is important, therefore, that not only all the points referencing the centre-line should be protected and preserved but these are so fixed at site that there is little possibility of their being disturbed or removed till the construction is completed.

3. **Setting Out of Construction Limits**

3.1 As already described in the previous paragraphs as a first step to the start of construction, the alignment of the road finalised shall be marked on the ground.

3.2 **Centre-line and Reference Pegs**

On long tangent sections, points on transit shall be fixed at least every 500 metre in plain terrain and 250 metre in rolling and hilly terrain. The centre-line pegs in case of points of transit may preferably consist of concrete hubs driven flush with the ground. These points shall be referenced by means of what are called 'reference pegs' fixed normal to the centre-line of the road on either side at a distance of 20 to 25 metre from the centre-line peg so as to be in a position safe from interference by clearing or other earthwork operations. It may also be ensured that the reference points do not fall within borrow areas, service roads for construction traffic and their location so clearly marked that construction traffic or earthmoving machinery do not foul with them. Reference pegs shall consist of angle irons embedded in concrete or permanent bench mark pillars of design approved by the Engineer.

3.3 Reference pegs shall be established on curved sections as well where these may be located at a distance of 10 to 12 metre away from the apex points of the curves in extension of the tangent lines.

3.4 **Intermediate pegs**

Intermediate pegs shall be fixed along the centre-line of the road once the points of transit have been established. The interval between intermediate pegs may be 50 metre on straight sections and 20 metre on curves and transition spirals, in case of roads situated in the plain or rolling terrain. In hilly terrain, the interval between intermediate pegs should be reduced to 20 metre on straight sections and 10 metre on curves. These pegs may consist simply of stakes driven in the ground.

3.5 **Batter pegs**

After intermediate pegs have been established, batter pegs marking the limits of the embankment shall be fixed on both sides. Batter pegs are meant as guides for the plant when commencing the earthworks. To ensure their safety, it will be desirable to fix the pegs about 0.5 to 1.0 metre (minimum 0.5m but preferably 1m) back from the actual limit of the fill and to paint them in a distinctive colour.

3.6 Sketches explaining the setting out of control pegs for embankment construction are given in Fig. 2 appended to these guidelines.

4. **Staking and Profile Making**

4.1 For most situations commonly met with the conventional method of staking and profile making (described subsequent paras 4.1.1 to 4.1.4) shall prove to be adequate. The arrangement of strings and stakes followed in it also ensure the level of the loose fill and that of the compacted layer to a reasonable degree of accuracy along the entire cross-section and the slopes. The procedure is simple though a bit time consuming and can be followed easily by the field staff with good results.

4.1.1 **Marking of Alignment**

Fixing of the centre-line as per the approved drawing by means of a continuous transit theodolite survey has already been mentioned in the previous paragraphs. Sometimes small brick-pillars (20 cm × 20 cm in cross-section and 1 metre high on ground) are constructed in semi-permanent specifications. These are placed only on one side of the alignment at 20 m to 25 m (depending upon the availability of land) away from the centre-line at 200 metre interval. The pillars are so located that they do not foul with construction traffic, earthmoving machinery or fall in areas earmarked for borrowing or excavation. The road-side face of the pillar contains in legibly painted letters and numerals the relevant informations pertaining to the point like chainage of the alignment at that point, the final levels of the subgrade the road surface etc. and also details of crust composition. In case comprehensive working drawing with details of cross-section are available separately in book form for each section construction of brick pillars are not essential

4.1.2 **Staking and Marking the Profile**

The profile marking work can be carried out at points along the alignment at an interval not exceeding 20 m (for hilly terrain) to 50 m (for plain and rolling terrain). Two thin Sal ballah poles or bamboos may be temporarily embedded into the ground at the toe-points of embankment (with the help of the batter pegs) on both sides. The poles shall be painted in alternate yellow and black shades of 15 cm height. For convenience of working the top of the poles may be kept at the same level with the help of a levelling instrument.

4.1.3 Sequence of Operation for Laying of Layers

4.1.3.1 Sequence of operation for laying the first and the subsequent layers have been indicated in the sketches (Fig 3.1 to 3.4) enclosed. The figures shown are illustrative for a sideslope of 1 : 2. Sketches for different side-slopes may be prepared on the same lines.

4.1.3.2 First Layer

A horizontal string S_1-S_2 may be tied at both ends to the poles P_1-P_2 at a height of one-and-a-half-rung (225 mm) of the poles measured in the pole with the lower ground level at the point of embedment. Loose earth may be laid in the full width between the poles upto the level of the string for the purpose of compaction. Compaction of earth is to be carried out as far as possible upto the edges of the laid earth.

4.1.3.3 Second Layer

Subsequent layers of embankment shall not be placed until the layer under construction has been compacted to the specified density. After the compaction of the first layer has been completed, two small wooden pegs (about 50 cm long) may be fixed in the ground (in such a manner that they can* be taken out easily) at a distance of 30 cm inside from pole P_1 and P_2. As in the case of the first layer the height of the horizontal string S_1 and S_2 may now be increased by 225 cm above the compacted first layer and loose earth may be laid for compaction in the width between the too small wooden pegs upto the level of the string. The projections in the ends of the compacted layers may be cut by 30 cm at the edges for making the side slopes after the construction of the embankment is completed. The extra quantity of earthwork is involved shall not be paid as it is a constructioned requirement to ensure the desired degree of compaction which otherwise is not possible to achieve by normal means of compaction.

4.1.3.4 Subsequent Layers

In subsequent layers the entire operation shall be repeated in a similar manner by fixing string, laying loose layer and compacting.

Achievement of uniformity in level in spreading of earth in the longitudinal direction can be checked at regular interval of time by longitudinal strings at different points between the string profiles described above.

The method has been shown in the sketches in Figs 3.1 to 3.4 appended to these guidelines, where the broken lines show the proposed final embankment and the firm lines show the layer of loose compacted earthwork.

Necessary modification has to be made in the procedure for the work, in which depending upon the nature of material and compaction equipment available, a different layer thickness has been allowed by the Engineer.

4.1.3.5 Final Embankment and Subgrade Layers

In the final embankment layer i.e. the layer just below the subgrade and in the subgrade layer earthwork shall be carried out very carefully. In such cases the help of an additional small peg may be taken fixed at the centre of the embankment width for achieving the specified cross-fall (camber) requirement.

In case of construction of final embankment layer subgrade with super elevation the calculated difference in level between the two edges of the road has to be taken into account and suitable modification has to be made in string profile for the same.

Both the compaction and the finish of the layer shall be strictly as per the specified requirement of subgrade and the profile shall be checked with the template and shall be passed if within the specified tolerances.

4.2 However, for certain situations where a large fleet of heavy equipment are in operation in close succession it may not be possible to keep the string in a taut condition for long and its use may be restricted to intermittent checking only.

4.2.1 In such situations the usual method is to make a temporary marking on the stake itself with the help of the levelling instrument and the staff indicating the level of the loose and the compacted layer and control the earthwork as per the same. In such cases the stakes may be put up at critical points (like meeting point of the back slope of the adjacent high ground, the point where the design prism of the embankment intersects the natural ground etc.) or at 10 metre interval all along the cross-section.

4.2.2 Depending upon their location and purpose such stakes are generally called work stakes, slope stakes or grade stakes.

The work stakes are laid first in the order of precedence. These indicate the location and difference in elevation (either by '+' or '−' sign or by 'P' or 'C' prefix of the design grade of the embankment at that location with respect to the ground level. These are essential for commencing construction.

In case of large embankments or excavations, it becomes difficult for the machinery to accurately fill or cut, maintaining the desired slope without a guide. Slope staking involves the placement of stakes along the slope at measured distances from the baseline and recording on them the required cut and fill amount for achieving the design profile.

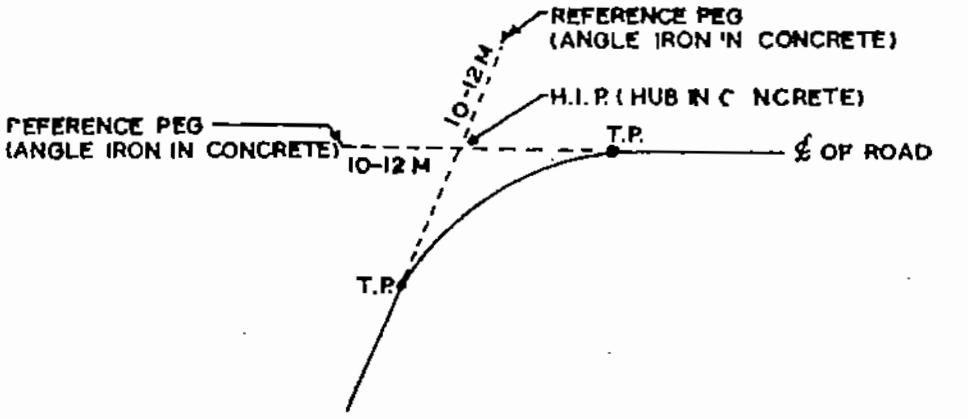
The grade stakes are put up last after the rough design prism has been constructed by means of the work and slope stakes. The grade stakes indicate the final profile and are placed at centre, on the shoulders/verge at intermediate points if the cross-section width warrants such a provision and also at side slope ends and ditch-points which mark the change in slope.

4.2.3 For staking along cross-section sometimes the top width of the proposed cross-section is extended by a couple of metres (depending upon the height of the fill) at both ends to cover the area of the sloped sides also. After the compaction tests are carried out by the prescribed method the slopes are cut on the sides. This, it is reported, ensures better compaction of edges of the embankment though involves extra earthwork, which is not to be paid extra as it is a methodology to ensure desired degree of compaction at edges of the embankment.

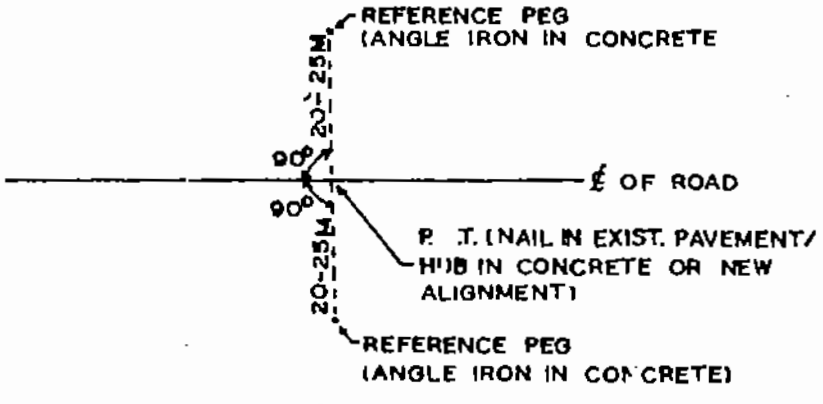
4.2.4 In such cases for achieving accurate side slope profile the slope is cut with the help of machines (autograders etc.). If strings are not being used for obtaining correct side slopes, slope-templates may be got prepared (for the required slope profile) and used for the purpose of checking.

4.2.5 For works involving very large quantity of earthwork or design embankments with cut and fill balancing proposal an additional category of stakes called 'Haul Stakes' are provided. These are strips of small wooden boards placed at the top of stakes with arrow marks indicating the haul points, the direction of haul and fill. The haul stakes are quite helpful for projects involving large areas of earthwork or multiple cut-and-fill for economy in material utilisation and completion of projects as per design provision.

4.3 For most purposes the conventional method described in para 4.1 will be adequate and fool-proof. However for large work of more dynamic nature deploying heavy mechanised fleet the method described in para 4.2 may be adopted. This will however require more of attentiveness and sincerity on the part of the field staff who have to calculate, control and check the level achieved with instruments constantly during the progress of the work.

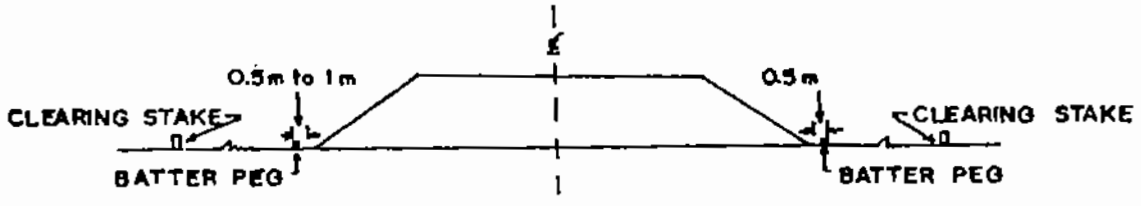


(a) REFERENCE PEGS AT HORIZONTAL INTERSECTION POINTS (H.I.P.) AND AT CURVES.



(b) REFERENCE PEGS AT POINT OF TRANSIT (P.O.T.)

FIG. 1. SKETCHES EXPLAINING THE METHOD OF REFERENCING HORIZONTAL INTERSECTION POINT (H.I.P.) POINTS AT CURVE AND POINT OF TRANSIT (P.O.T.)



IG.2. BATTER PEGS FOR DEFINING THE LIMITS OF EMBANKMENT

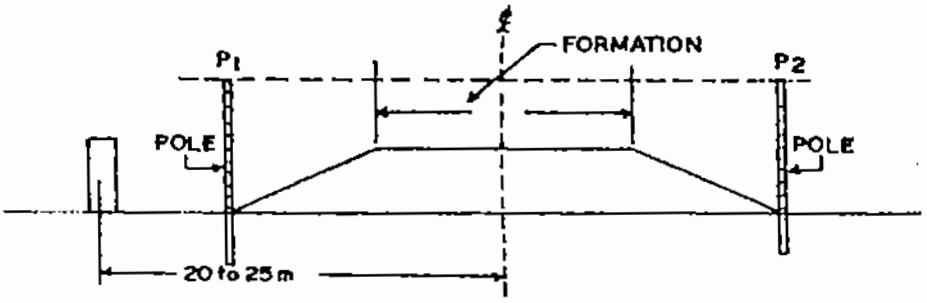


FIG. 3.1

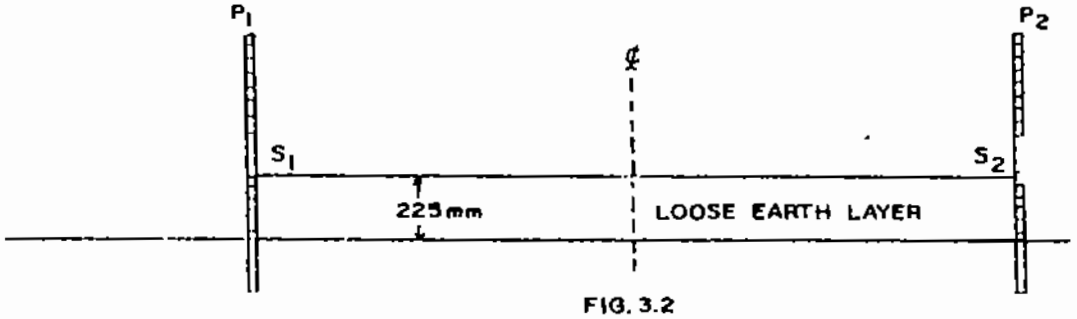


FIG. 3.2

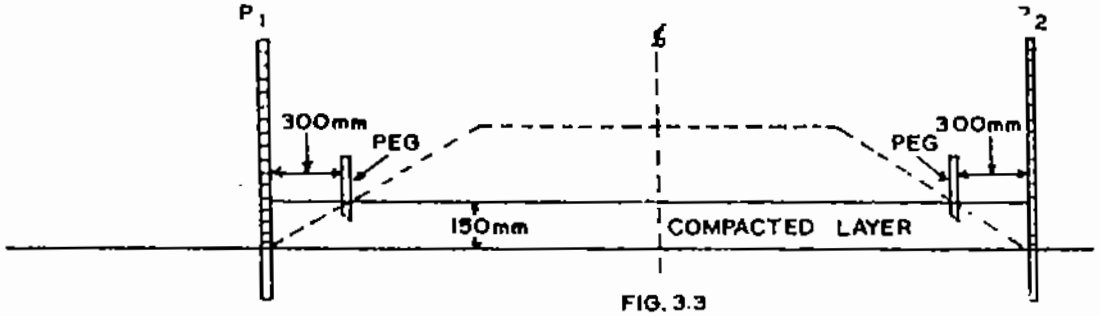


FIG. 3.3

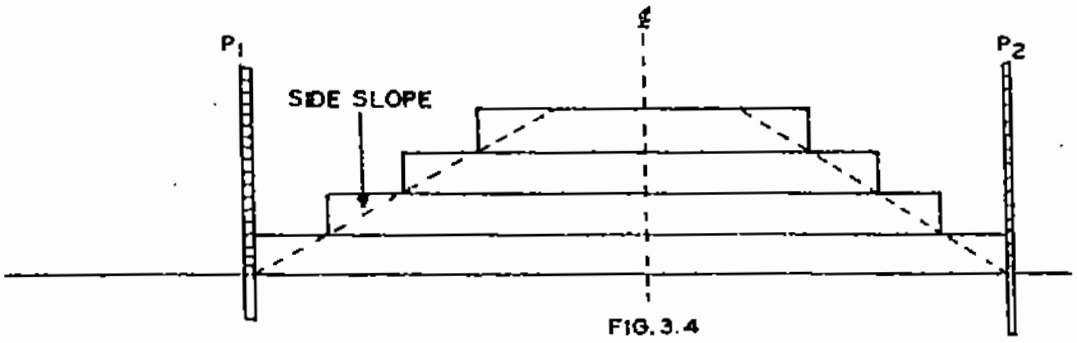


FIG. 3.4