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RW/NHVI-67(9)/85 *Dated the 12th December, 1985*

To,

All Chief Engineers of States and Union Territories dealing with roads

Subject : Introduction of the technique of reinforced soil structures as applicable to roads

In the recent years various techniques of reinforcing soil have been adopted in developed countries for improvement in the strength and properties of soil with varying degree of success. It is believed that in several situations commonly met with in highway engineering works use of these techniques can be successfully tried to provide economic solutions to problems. With a view to deriving benefit from these techniques as well as to develop adequate expertise in this country on their intricacies and applicability, the Ministry has decided to encourage their adoption in appropriate situations. Some patented techniques of this genre are also there, which can be availed of on payment of requisite royalties. In this connection, a brief note broadly describing two of the soil reinforcing techniques are enclosed herewith for consideration of their suitability for adoption in the field.

2. In order to be able to include in the 1986-87 Annual Programme a few appropriate schemes where such techniques can be gainfully applied, it is suggested that at least one suitable introductory scheme may be identified and proposed for carrying out soil reinforcement work in your State. The scheme may preferably be on a National Highway.

It is further requested that your considered views on the subject of soil reinforcement and the extent of its applicability in your region may please be forwarded to this Ministry. In case any particular technique is recommended for specific situations obtaining in your part of the country, the same may also be indicated.

3. An early action in the matter will be very much appreciated.

A Brief Note on Reinforcement of Soil for Highway Works

Soil is one of the principal materials for construction of highways. Therefore, modification and improvement in its properties, strength and functions have always been a fit concern of the highway engineers. Recent years have seen the development of diverse new technologies for mobilising soil properties to the use of economic engineering constructions. Soil reinforcement is one of such ingenious techniques. Various methods have been proposed and also used with different degree of success for reinforcing soil — some of them with technical improvements on age-old practices. Two of the better known methods are briefly outlined below to cite as illustrations :

(i) Reinforced earth retaining walls.

(ii) Use of geotextile for reinforcement of soil.

2. **Reinforced Earth Retaining Walls**

2.1 This is a proprietary method protected by a patent obtained by the French architect and engineer Henri Vidal. The method can be utilised only on payment of agreement price to him or to agent companies authorised for marketing of the system.

2.2 The method employs galvanized steel strips placed in horizonal layers throughout the mass of a select back-fill material and connected to precast concrete facing panels. The typical precast panel (Figure 1-Annexure) is in thick cruciform shape, with 1.5 m × 1.5 m × 180 mm in size and weights approximately one tonne. The reinforcing strips are in 60 mm wide and 5 mm thick rolled ribbed steel, hot-dip galvanized for corrosion protection. The ribs improve the pull out resistance. Galvanized bolts are used to connect the strips to the facing panels. Cork strips are placed in the horizontal joints between panels and polyurethene strips in the vertical joints. The panels are interconnected with vertical steel dowels and can tolerate movement endowing the system with a certain degree of flexibility.

2.3 Reinforced earth can be considered to be a composite material formed by the association of earth and reinforcement, where the frictional force between the earth and the reinforcement mobilizes the tensile strength of the reinforcement. In a sense the concept of reinforced earth is similar to that of reinforced concrete and the structural design procedure can be likened to the design procedure for reinforced concrete in similar placement.

The forces to be resisted by the reinforcement at any level are determined by basic soil mechanic principles, taking into account all external loading, geostatic and hydrostatic forces as well as dynamic forces due to moving or seismic loads. The cross-sectional area of reinforcement necessary to resist these forces is then calculated using normal working stresses for the reinforcement material. In addition, allowance is made for calculated metal loss due to corrosion during the service life of the structure. Finally, the

1-Amended vide circular dated 28/29.12.1987

length of reinforcing strips required to safeguard against a bond failure is determined. The procedure and calculations are repeated for each lift of reinforcement.

The design procedure for evaluating general stability of the retaining wall as a whole i.e. base pressure and safety against sliding and overburning are similar to those for flexible gravity structures. However, because of their ability to sustain substantial settlements, reinforced earth structures can be designed for higher allowable bearing capacities than traditional structures more susceptible to settlement damages.

3. Use of Geotextiles for Reinforcement of Soil

3.1 Synthetic fabrics usually made from polymer materials and used as an aid to geotechnical constructions are commonly known as geofabrics or geotextiles.

They generally differ from one another by the method of construction of the fabric (woven, knitted, non-woven etc.) and also by the type of ploymers (polyester, polypropylene, polyethylene etc.) which constitute the fibres.

3.2 The synthetic fabrics may be used for various purposes in civil engineering works and their use as reinforcement in soil is one of them. When in use as reinforcement the geotextile is placed in the soil mass which is not able to withstand the tensile loads applied on it, its function there being to assist in carrying the tensile load and thereby improve the stability of the system. Some of the common applications of geotextile as reinforcement in road works are :

(i) as embankment reinforcement
(ii) in retaining walls and
(iii) use in subgrade stabilisation.

The actual functions of the fabrics in all the above cases are not identical, although partly the requirements of function of textile in case (i) above may be similar to that in case (iii). In the first two cases the function of the reinforcement is to prevent rupture of the soil mass and consequent failure and in the third case the purpose of the reinforcement is to limit the strains in foundation in situations where the actual stress in embankment is well below the ultimate failure stress :

3.2.1 Embankment reinforcement

The geotextile placed in this case (Fig. 2 — Annexure) supplies extra tensile strength in the soil mass and adds to the stabilising forces against failure. The tension in the fabric is to be resisted by the friction (or adhesion) between the geotextile and the soil.

The situation may, however, have added complications in case the embankment is on soft subgrade instead of a stable foundation.

3.2.2 In retaining walls

Ordinarily, a soil wall of some height will not be stable enough to retain itself or its backfill unless it is suitably reinforced. Experience have shown that when provided with layers of geotextile in suitable design. (Fig. 3 — Annexure) the friction between the soil and the geotextile mobilises its tensile force which acts as a reinforcement in the soil wall which may now be stable and strong to withstand an extent of backfill.

3.2.3 In subgrade stabilisation

In this case the placement of the geotextile (Fig. 4 — Annexure) provides additional strength akin to reinforcement to stabilise the system under its own load as well as the external load applied to it.

Here the purpose of the tensile reinforcement provided in the form of geotextile is to limit the deformation in the subgrade under the load. This also reduces the chances of fatigue-cracking with repetition of load and rutting in the road due to accumulation of inelastic deformations.

3.2.4 Strictly speaking, the geotextile layer placed in this case performs more functions than that of a reinforcement. It can be said to have two primary functions and two subsidiary ones.

An aggregate material as it is, can hardly take any tensile load. The primary functions of the textile here are to provide adequate lateral restraint (by soil textile friction) and make the fill material capable of taking tensile load. The two other functions are to act as a separator for the subgrade material and also to allow drainage along the plane of the textile. Simultaneous with its function as an element of tensile strength it acts as a separator which facilitates the aggregate fill to distribute the wheel-load affectively without allowing any migration of the weak subgrade material into the same or vice-versa thus preventing the exchange of places between the two. The overall effect of the above three functions is to have minimum requirement of aggregate cover fill and enable better distribution of load to take place through them. This may led to considerable economy in certain situations.

In addition to the above the geotextile allows drainage of water along the plane of the textile resulting in dissipation of pressure and gain in effective stress in the soil matrix below. Also, it may be noted from sketch shown in Fig. 4 of Annexure that this drainage may take place even along a slightly uneven plane of actual separation.

3.3 The geotextile properties which are important and are required to be mobilised in varying degrees in the above mentioned cases (Para 3.2.1 to 3.2.4) are its tensile strength, modulus, creep-characteristics as well as the value of soil textile friction. Permeability is an added attribute although not directly in aid of reinforcement function. A great deal therefore depends upon the choice of the textile for a particular situation of treatment.

4. Apart from offering new option or design alternatives for tricky or problematic situations, there are a number of practical advantages associated with the use of these new materials/technologies.

4.1 The reinforced earth constructions have the added advantage of :

(i) Comparative ease and speed of construction;

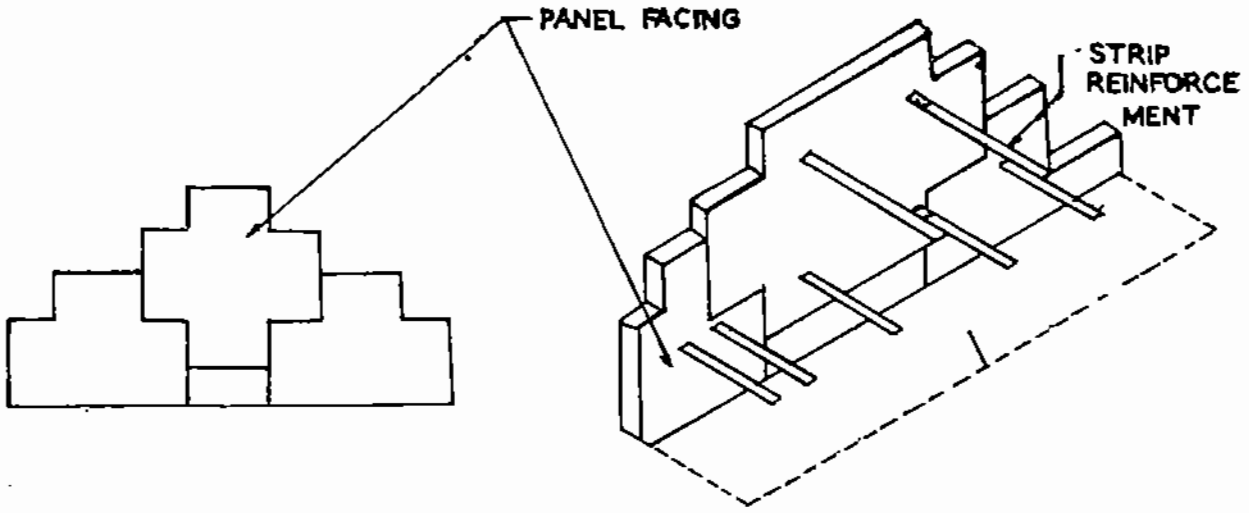

FIG 1

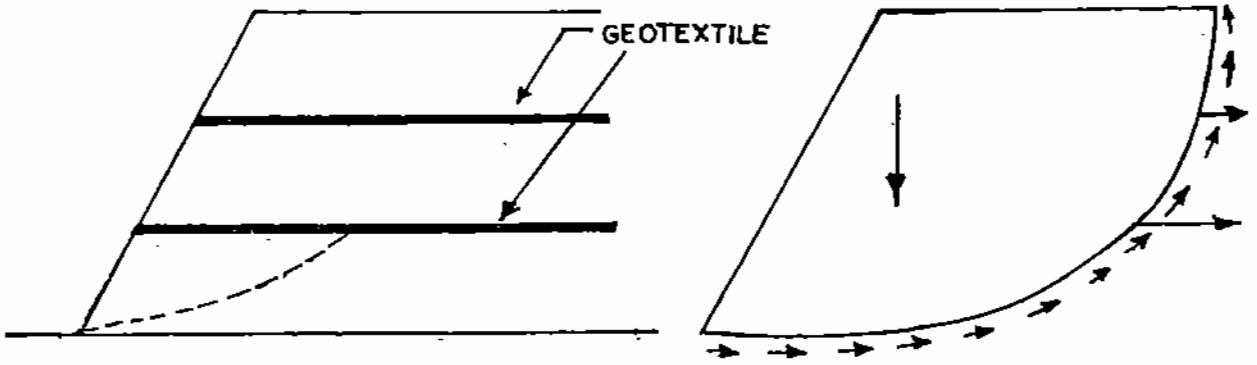

FIG. 2

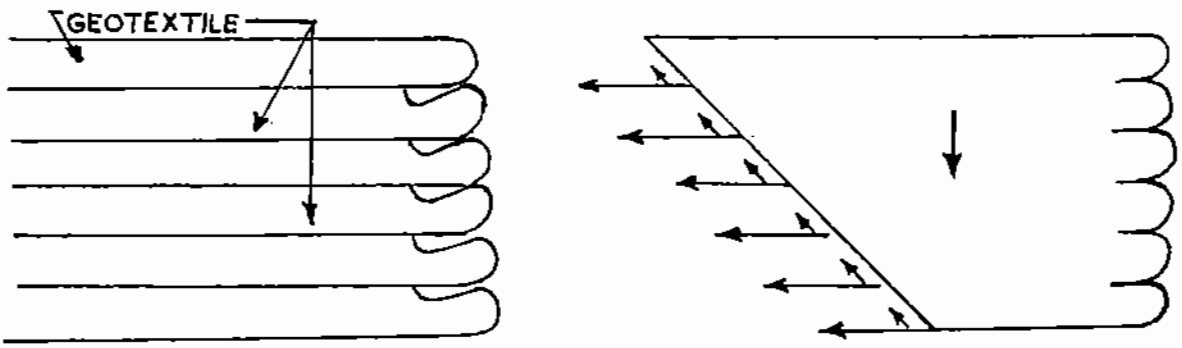

FIG 3

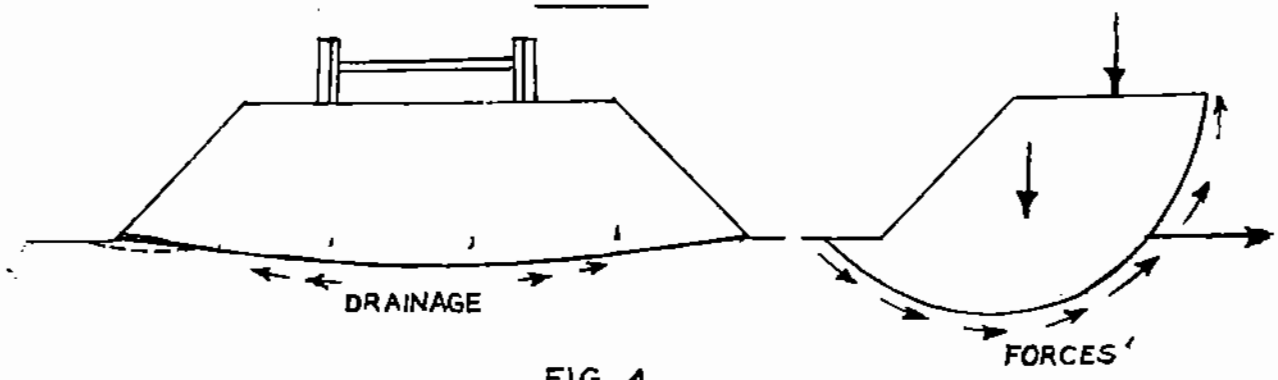

FIG. 4

(ii) Offer better and neater finish with aesthetic possibilities;

(iii) Land width or actual embankment width requirement can be reduced which may prove to be a boon specially in urban and difficult or congested construction sites;

(iv) Stage construction possibilities increase both in the horizontal and the vertical direction; and

(v) There is also a possibility of re-use of certain materials when used in purely temporary constructions.

Similarly, the innovative uses of geotextiles have also to offer a number of efficient and cost effective alternative options for some common highway construction problems :

(i) They also are characterised by ease and speed of construction, the placement in most cases being achieved by simply unrolling the textile with minimal ground preparation work;

(ii) reduction in aggregate or fill requirement;

(iii) reduction in loss of aggregate or fill in weaker subgrade material;

(iv) providing economic method of separation (without imposing any load) preventing upward movement of fines from below; and

(v) allowing quicker drainage.

Overall, they open up entirely new vistas of exciting opportunities in future for the technical dare and potential of the highway engineer.