AN EXAMPLE OF USE OF DMT AS AN HELP FOR EVALUATING COMPACTION OF SUBGRADE AND UNDERLYING EMBANKMENT

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JOB DESCRIPTION

-Rehabilitation of the road Dinajpur-Panchagarh (93 km), Bangladesh. Client : Italian Ministry of Foreign Affairs - Office of International Cooperation. Designer : Sauti (Roma-Italy). Contractor : Bonatti (Parma-Italy).
The road was initially built in the 1950s. Presently the paved surface appears severely damaged (Fig. 1) due to differential settlements of the underlying poorly compacted loose silt composing the embankment. The silt of the embankment was excavated from the adjacent ground surface, and therefore is the same soil as the foundation.

-Morphology : flat area, in the Ganges-Brahmaputra confluence region, very uniform conditions along the whole road.

-Existing embankment (Fig. 2).
Height : generally 1 to 2 m
Width at the top : pavement 4 to 5 m + 2 unpaved shoulders 1 to 1.5 m wide each
Pavement : typically 30 cm thick, made of etherogeneous cemented elements (bricks, concrete blocks, stones). It will be removed and replaced by compacted sand.

-Foundation soil : predominantly loose silt. Water level very near to surface. Seasonal floods keep part of the embankment submerged for periods of the year.

SPECIFICATIONS FOR THE SUBGRADE AND SUPERSTRUCTURE

The designers's road specifications were the following:

	Layer	Thickness cm	Modified Proctor %	CBR	Modulus Kg/ (plate) sqcm
Super-struc-ture	Base	15	100	80	800 (1.5-2.5)
	Subbase	20	100	30	600 (1.5-2.5)
	SUBGRADE	30	95	10	300 (0.5-1.5)
Embankment	New embankment		90		

Acceptance tests on the compacted subgrade showed for the majority of the locations a density of 95% to 96.5% of Modified Proctor (AASHTO T 180), with moisture content between 11% and 14%. The CBR=10 requirement for the subgrade was found in this case less restrictive than the 95% density requirement, since the majority of the laboratory 95% compaction CBRs (4-day soaked) were found in the range 18-22.

DMT INVESTIGATION

The scope of the DMTs was to investigate the compressibility of (a) old embankment, by sounding the old road (b) embankment & subgrade after compaction, by sounding sections of the road where the subgrade had been compacted to specifications.
Period : April-May 1993. Generally 1 sounding every km. Depth mostly 4m, depth interval 10 cm. Production : 12-15 soundings per day. The dilatometer tip was pushed by a 10 ton (100 KN) truck-mounted penetrometer (Fig. 3). Special very high strength tips were used (rated failure load 50 ton= 500 KN) to penetrate directly, when possible, the superstructure, thus avoiding holes. However no tests were performed, obviously, in the superstructure.

To analyse the results, the soundings have been subdivided into 4 categories, as shown in Fig. 4(a), depending on the location within a given road section and on the status of the works (before/after compaction).

The average profiles of M-DMT (abbreviated as M in the rest of this note and in the Figures) for each category are shown in Fig. 4(b). Such profiles were drawn based on the averages of the following elements extracted from the individual soundings of each category :

- -Average of the depths where M reached a maximum
- -Average of such maximum M values
- -Average of the depths where M decreased below 500 bar

M was assumed as the primary DMT parameter for evaluating compaction in consideration of the main objective of the works, that was reduction of deformability. M was preferred to Ed since M also includes Kd, partly reflecting horizontal stresses, playing a considerable role in reducing settlements of compacted granular fill (see e.g. Massarsch 1994).

MAIN FINDINGS

1. The DMT results in the old road (Fig. 5a) confirm that the silt of the old embankment is generally very loose (M≈40-120 bar), even looser than the originary silt in the foundation.

Traffic and desiccation have however produced a crust (M≈500-2400 bar) extending to a depth of 70-80 cm below the surface of the old road.

2. Soundings performed in the accepted subgrade yielded systematically profiles similar to that in Fig. 4b-categories 3 and 4 and Fig. 5b, with M reaching a maximum of 2400-2800 bar typically at 25 cm depth. This result appears to support the existance of relationships between DMT moduli and density and/or CBR (Borden et al. 1985,1986, Schmertmann 1988) and the potential of using M from DMT as an economical supplementary subgrade acceptance tool. For the latter scope one could develop, in the initial stages of the works, a "minimum acceptable M profile" similar to the one in Fig. 4b-Category 3, based on a series of DMTs on the accepted subgrade, then use such M profile as a subgrade acceptability benchmark.

3. Of the 3 DMT test depths (generally 10, 20 and 30 cm below top of subgrade) the maximum M was generally found sometimes at 20 cm, sometimes at 30 cm, in nearly equal proportion (with an average of 25 or 26 cm, Fig. 4b-categories 3 and 4). It is noteworthy that even in the traffic crust of the old road shoulder (Fig. 4b-category 1) M reached its maximum at an average depth of 26 cm.

4. If, in future investigations or for research purposes, closer data points in the subgrade are required, two possible ways of achieving it could be the following : (a) Reduce the depth interval from 10 to 7-8 cm (however some pairs of adjacent DMT soundings with different depth intervals should first be performed in order to verify that in the soil under study the depth interval does not influence significantly the results) (b) Run pairs of adjacent soundings with out-of phase test depths such as 10-20-30 cm and 5-15-25 cm.

5. Difficulties lamented by the contractor in compacting the subgrade to the specified density are a consequence of the abundant water expelled by the underlying loose silt in the densification process. Such water brings the humidity of the layers added on the top much above optimum. Difficulties are attenuated, but not eliminated, using heavy static rollers instead of vibratory rollers.

6. Compaction of the subgrade at the top of the old embankment produces an M increase well below the 30 cm of the subgrade (Fig. 4b-category 4). In other words it is difficult to compact the subgrade without also compacting the underlying loose silt. In the new bodies of embankment, densified in layers, it turned out easier and faster to compact the subgrade and to concentrate the compaction action just in it (Fig. 4b-category 3).

BIBLIOGRAPHY

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Fig. 1 – Old road. At center the damaged pavement. Laterally the two unpaved shoulders.

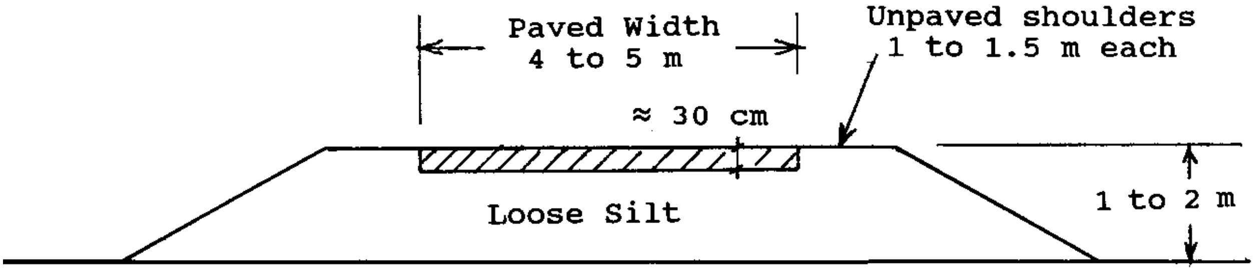

Fig. 2 – Typical cross section of the old road

Fig. 3 – Truck mounted penetrometer used for pushing the dilatometer blade

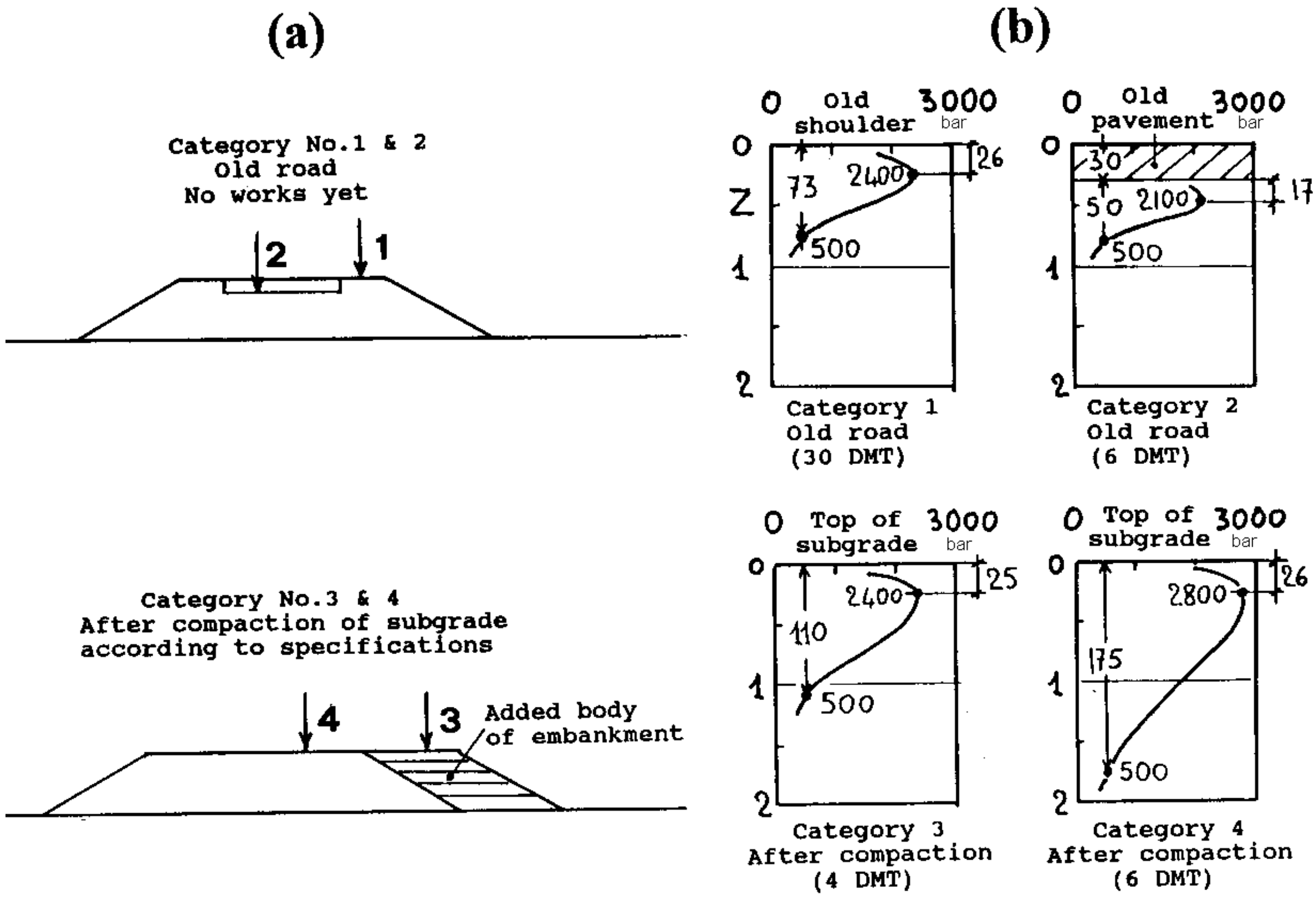

Fig. 4 - (a) Locations of the DMT of the 4 Categories
(b) Average M profiles for the 4 Categories

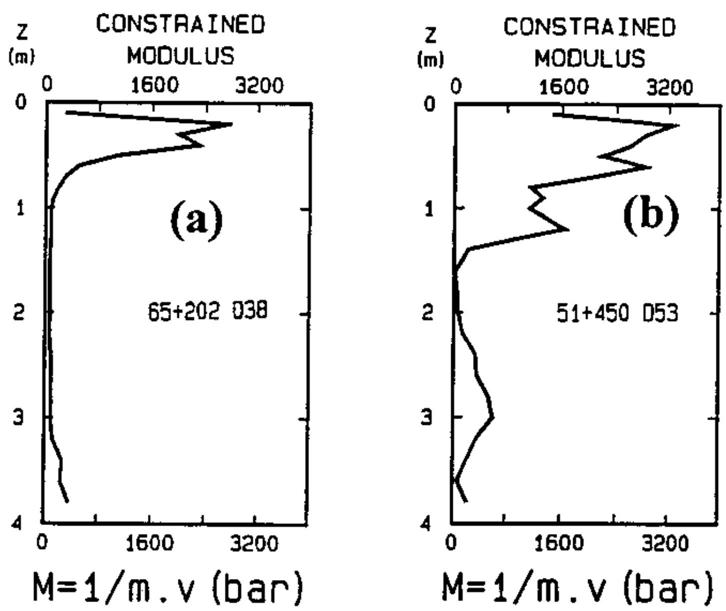

Fig. 5 - M profiles before/after compaction from two representative soundings.
(a) D38 : from shoulder of old road (uncompacted)
(b) D53 : from top of subgrade - Category 4 compacted according to specifications