CONTROL OF PLATFORMS AND ECONOMICAL ROADS WITH A NEW CONTINUOUS METHOD TO ASSESS THE STIFFNESS

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ABSTRACT :

A new high cadency apparatus : the Portancemetre, has been implemented to give a continuous measurement of the load bearing capacity of the platforms. It judges the stiffness of the structure, and thus gives useful information for monitoring the homogeneity and the conformity of subgrades.
The principle is a low width vibrating wheel equipped with sensors giving at every time of the periodic movement : the vertical dynamic force, and the vertical displacement at the contact wheel-soil, when rolling. These informations are exploited in term of stiffness, or modulus using a straight correlation with plate tests. The result is plotted versus the longitudinal profile of the embankment, and many possibilities are offered by the program : determination of average and minimal values in the total section or sub-sections, homogeneous zones, percentage in the distance in conformity with the specifications, …
The apparatus is rolling at 3,5 km/h and is capable to measure modulus in the range 30 MPa to at least 300 MPa. About 15 km of distance per day is able to be controlled in operational conditions, with a continuous information. The control may be made in one, two or more parallel lines, depending of the width of the platform.
Due to the good mobility of the apparatus which is towed by a 4 WD vehicule, and the measurement capacities , it is also expected to use it on unbound roadbase layers of economic roads, to assess their quality.

KEY WORDS : ASSESSMENT / MEASUREMENT / MODULUS OF ELASTICITY / QUALITY / ROAD

1. INTRODUCTION

The paper describes a new continuous method to assess the modulus of road or rail track platforms after construction. The method is operational and particularly useful for some important jobsites such as motorways or high speed lines, but also interesting for smaller sites because of the good mobility of the apparatus.
It is also presented some preliminary results showing the opportunity to use the continuous method for pavement conditions survey in light traffic or economic roads.

2. PRINCIPLE OF MEASURE

The apparatus (Figure 1) is a narrow vibrating wheel with suitable characteristics, towed by a 4WD vehicle. The vibrating wheel is equipped with sensors to measure simultaneously the dynamic force and the soil deflection. The force-deflection relationship

Figure 1 – Vehicle and vibrating wheel

is used to calculate the stiffness of the subgrade, from which modulus is determined. This processing has already been described in detail (Morel & Quibel, 1998) ; only the essential characteristics are recalled hereafter :

2.1. Force measurement

The vertical component of the dynamic force is continuously calculated during every cycle of vibration, from accelerometers, mass parameters, and phase angle between the centrifugal force and the amplitude.

2.2. Measurement of soil deflection

A double integration of vertical acceleration leads to the vertical amplitude of the vibrating wheel, and thus to the deflection during the application of the force. The slope of the first part of the loop force-displacement represents the soil stiffness.

2.3. Calibration

The stiffness leads to the modulus, using an experimental calibration on a large number of tests. The tests have been performed at the Centre d'Expérimentation Routière, on platforms between 10 MPa and 500 MPa. The reference test for the calibration is static plate test (EV_2 value), but might also be an other in situ test method for determination of the modulus.

2.4. Wheel travelling and speed measurement

The travelling speed is measured, and the covered distance as well. It is also possible to equip the apparatus with a positioning satellite system to locate the measurements.

2.5. Data acquisition and processing

In this application, the loop force-displacement is built on average force and deflexion signals for 30 consecutive periods. With a 35 Hz vibration frequency and a 3,5 km/h (1 m/s) travelling speed of the apparatus, modulus is measured for better than each meter length.

The successive values give a continuous longitudinal profile of modulus. The real-time processing allows the operator in the vehicle to see the variations of bearing capacity. After measurements on one track, the pringing of the results on board is possible, or at the office at the end of the measurement campaign as well.

3. USE AND EXAMPLE ON PLATFORMS

The requirements are generally a minimum 50 MPa of modulus. But, for better valorization of naturel material resources and optimization of pavement construction, the platforms of important jobsites are expected to be over 120 MPa or sometimes 200 MPa. The development of soils stabilization allows to obtain such values. It is therefore important to check if all the points of the platform are corresponding to the requirements.

After many experiments on different types of platforms, the apparatus showed to be a very convenient method. It is nowadays used in France, Spain, and Portugal.

The presented example of results in Figure 2 is coming from an embankment which was built with fine sand, the moisture conditions of which were scattered. A cementitious stabilization was made on the upper 0,15 m of the final layer. The new method showed, on about 400 m length section, that the bearing capacity was also scattered, between 46 and 260 MPa. The stabilization thickness is just sufficient to ensure minimal values of bearing capacity on some places where the natural sand was probably in wet conditions.

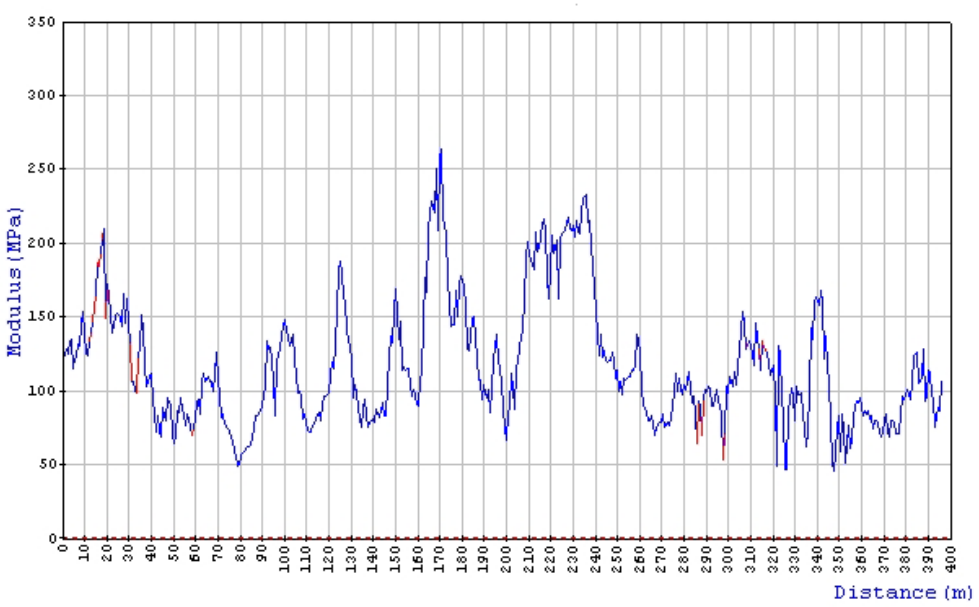

Figure 2 – Example of measurements on a platform

From the file containaing the modulus on about every meter length, the computer program allows further exploitations such as : average and minimal values of modulus E in a subzone, % of measures in conformity with the required modulus, standard deviation σ and coefficient of variation σ/E. The homogeneity of a platform may be appreciated by this coefficient, using the conditions in table 1. In the presented example, the value of the coefficient of variation is 36 %.

Table 1 – Interpretation with the coefficient of variation σ/E

Coefficient of variation σ/E	Homogeneity
< 15 %	Good homogeneity
15 – 20 %	Moderately scattered
> 20 %	Scattered, or with a contrast of subzones

4. PROSPECTS FOR USE ON LIGHT TRAFFIC OR ECONOMIC ROADS

In this way, the apparatus is also expected to give a continuous measurement of the modulus of the road, in order to check the low points, and to compare the evolution of resistance between periodical route investigations. The measurements are supposed to be gathered with another constatations such as visual surface deteriorations, or uneveness, … to allow the preparation of a suitable program of maintenance with an optimization of the costs, in repairing sections just in time.

The prospects concern unbound gravel roadbases, covered by a thin bituminous wearing course, or by a surface dressing.

The low cost of the survey method itself, especially interesting on economic roads, is based on the following aspects :

- Good mobility of the apparatus. The 4 WD vehicle with trailer is capable to go everywhere, and is not affected by critical points of low resistance during the survey or the laboratory-to-work journey.
- Single operator, who is able to drive without any other intervention after initializating the measurement process. The positioning satellite system can assist him in the location of the measurements which are recorded by the on-board computer.
- Travel speed during measurement, which seems to be possible over 10 km/h on current evenness routes, while having at least one value of modulus every meter length.
- Convenient software analysis, which may have a pre-diagnosis view just after a section survey, or a full analysis by treatment in homogeneous sections, or location of sections under pre-defined quality requirements.

At present time, a few preliminary tests have been done with the operational apparatus for platforms, on different sections of roads near the CETE Normandie Centre. Further tests are still necessary to check if it is relevant on other structures, to optimize the method, and to compare it with classical tests. Nevertheless, the following results show already now the interest of the method.

4.1. Example on a local CETE access road with heterogeneous sections (Figure 3).

The road is made up in situ coarse granular materials, insensitive to water, covered by a surface dressing. Three measurement passes have been made at the same speed conditions (3,5 km/h). The reproducibility is quite favourable.
On this road, a more strengthered section can be observed in the last part of the survey. The apparatus is capable to measure modulus over the present range of 30 to 300 MPa for platforms. Some tests on a cement gravel during the hardening period showed that 500 MPa were possible.

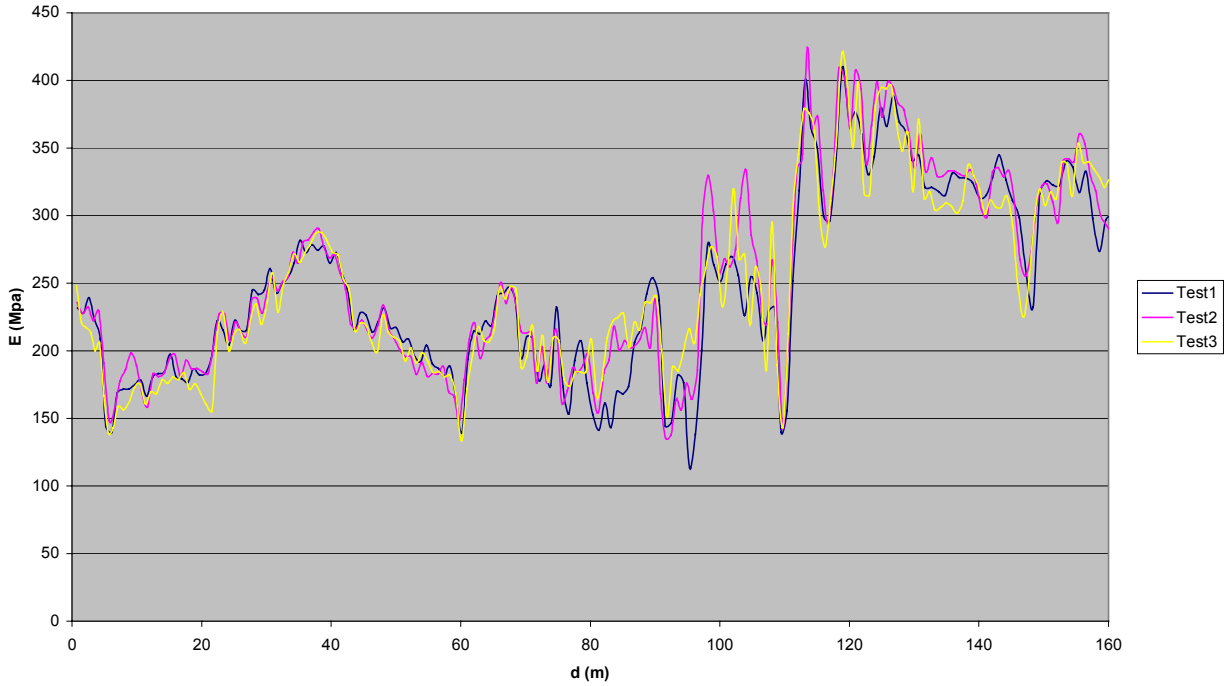

Figure 3 – Reproducibility of measurements (3,5 km/h) –
Heterogeneous road with surface dressing

4.2. Example on a forestry road with thin bituminous wearing course (Figure 4)

The thickness of the wearing course is about 3 cm. It covers a natural silty and sandy gravel material. The results obtained here come from different travel speed. The road has a good evenness. The same operational process is employed, i.e one average value of modulus calculated on 30 consecutive periods of vibration. This process leads to one average value every 0,83 m at 3,5 km/h, 2,4 m at 10 km/h and 4,8 m at 20 km/h.
On this 350 m section test, the modulus by the apparatus is between 100 to 250 MPa. The road visually shows no beginning of distress. Its behaviour is very satisfactory.

It can be shown the good concordance of the measures at different speed, although the position of the apparatus in the transverse profile may have some little changes from one pass to another. The smoothting of the curves are quite visible after 10 km/h.

To avoid the smoothing, it will need to analyse the results by an average value on only 5 periods, corresponding to a step of 0,40 m at 10 km/h and 0,80 m at 20 km/h. The choice of 30 periods is justified only on earthworks platforms where the presence of some stones at the top of layers needs such an analysis.

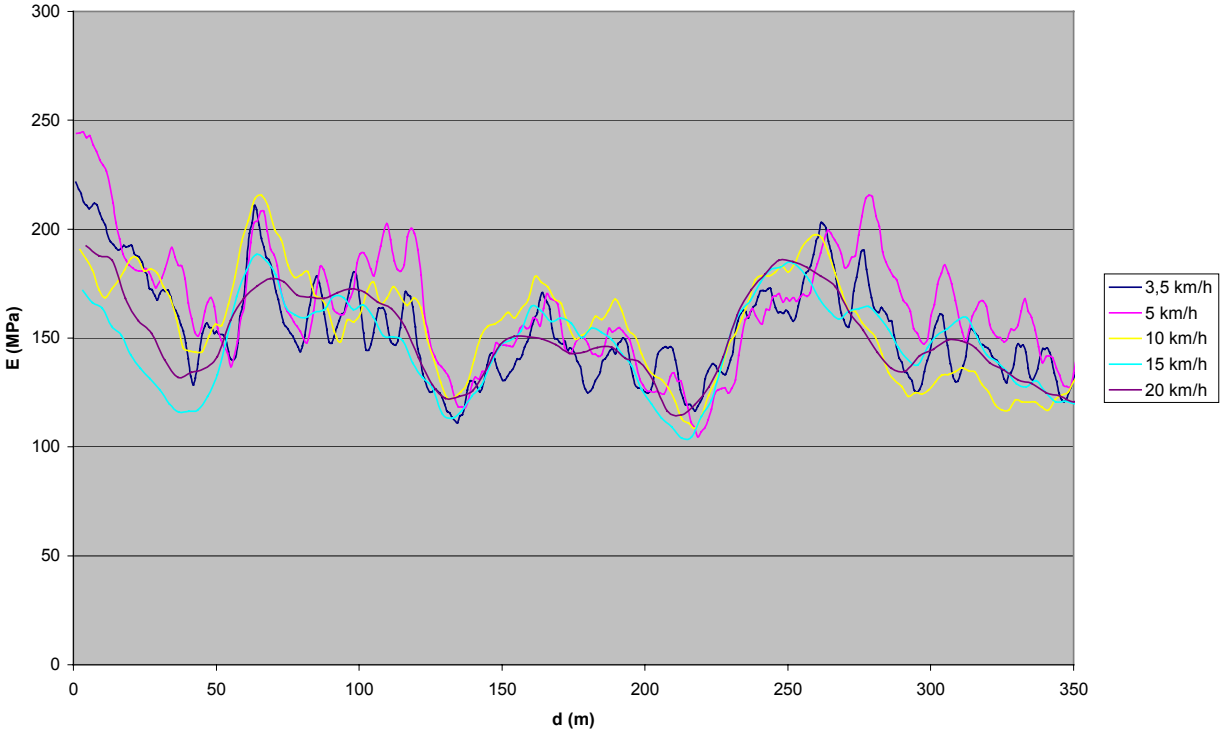

Figure 4 – Measurements at different travel speeds –
Roads with thin bituminous wearing course

4.3. Example on a forestry road with some damages (Figure 5)

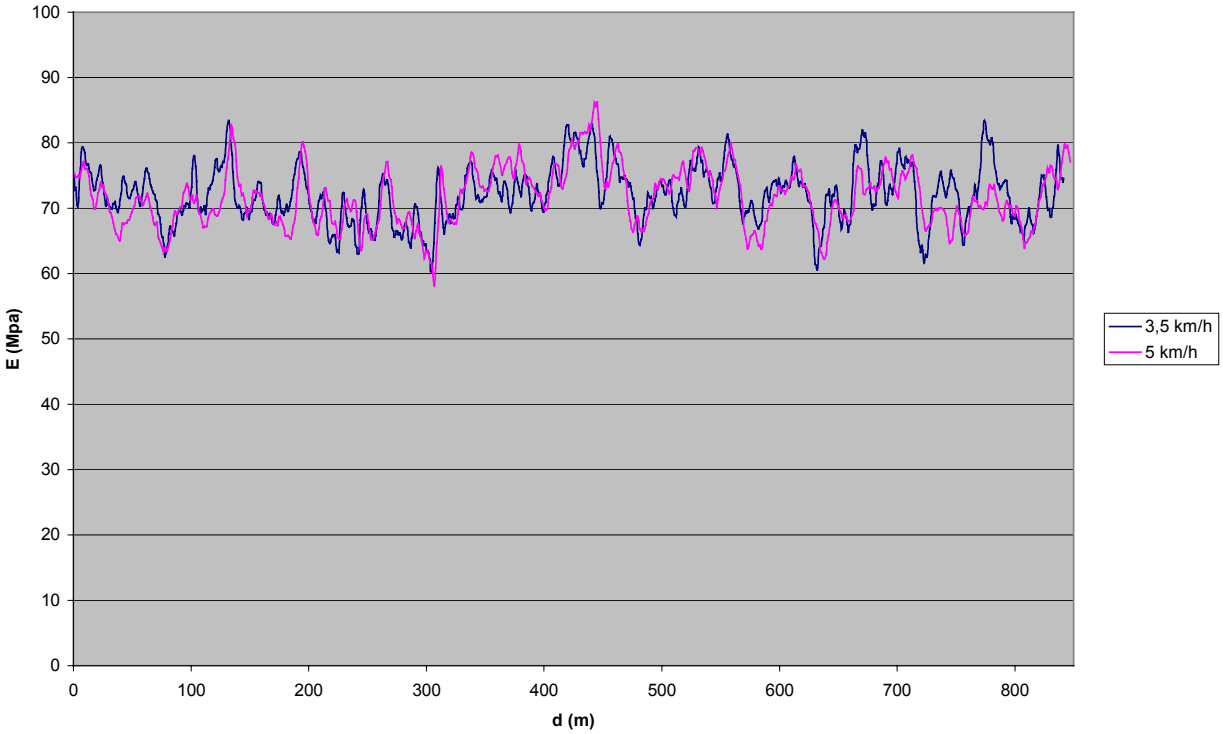

Figure 5 – Measurements on a distressed forestry road with surface dressing

This section is not so far from the one exposed in 4.1, with about the same subgrade, but it has not been improved like the 4.1. To the contrary, it ramains with an old surface dressing ; some works consisting to dig a trench all along one side of the road for laying a

gaz transport pipe had been done. The recent passages of site machinery, and those in the past of forestry trucks, caused large unevenness ; numerous potholes have been repaired on this section.
It can be seen that the level of modulus is rather low, between 60 and 80 MPa, on the whole 900 m road section. The reproducibility between the two passages at low speed is quite perfect. Due to the large unevenness and surface deficiencies, the maximum travel speed of the apparatus would be limited to 10 km/h in this area.

5. CONCLUSIONS

The new method is now operational in road of rail track platforms control, to give a continuous information of the modulus in the range 30 to 300 MPa. It can be expected 15 km/day of measurements at a travel speed of 3,5 km/h with a single operator.

The preliminary tests done to study the feasability of using the apparatus for pavement condition survey of light traffic or economical roads is encouraging.

The results show a good reproducibility of the method, a possibility of travel speed measurement of at least 10 km/h in current evenness conditions, and perhaps more, a sampling of less than 1 meter length of the road by adjusting the number of vibration periods taken in account for the determination of modulus.

After a research program to optimize and confirm the interest of the method, it can be expected a 50 km/day pavement condition survey at economical conditions, even in zones with locally non-easy access.

6. REFERENCES

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