EXPERIMENTAL SECTIONS
IN THE HUNGARIAN ROAD MANAGEMENT

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Abstract

In the preparatory phase of new construction, rehabilitation and construction technologies there are several options to apply. The decision support can rely on computerised design programmes, laboratory test series, accelerated loading tests, monitoring of experimental (test) sections (and their eventual combination). These decision support means basically differ from each other from the view-point of time need and accuracy. This paper concentrates on the role and risks of experimental sections generally and in the Hungarian road management, highlighting some case studies. Sophisticated (professional) design, very careful construction, timely maintenance, as well as regular monitoring with expedient processing of condition data time series are all needed for the real success of an experimental section. If any of these preconditions is lacking, there is a real danger that misleading conclusions are (can be) drawn from the actual performance of the experimental section for the expected performance of the new construction or maintenance technology to be implemented. The Hungarian case studies to be outlined are connected with cement concrete pavements. Every case study is evaluated for its level of success; the eventual mistakes made there are also highlighted. Some general conclusions are drawn to provide information for the less experienced road sector stakeholders who plan to build trial section before implementing a promising new road technology in the near future.
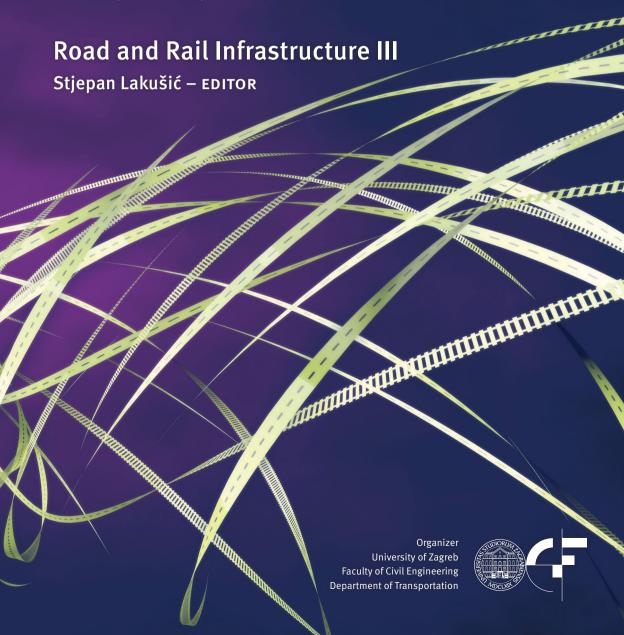
Keywords: experimental section, road management, cement concrete pavement, continuously reinforced cement concrete pavement, whitetopping

1 Previous investigation of the suitability of innovation

It is evident that the continuous development and implementation of innovative materials and technologies can be considered as a must in every national economy sector. This statement is valid also for road engineering since the up-to-date road construction and maintenance techniques using innovative, high-performance materials are badly needed for meeting the challenges coming from the combined, synergic effect of ever increasing traffic and environmental load. However, the planned wide use of new materials and/or methods presupposes the proving of expected good performance as a reason for introducing the innovative material or technique instead of (or at least in addition to) the traditional "old" one. The typical investigation types for getting previous evidence about the suitability of the innovative procedure are: computerized performance models, laboratory test series, accelerated loading tests and trial (experimental) section monitoring [1].

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1.1 Computerized performance models

Special computerized (e.g. finite element) models are available worldwide to forecast the performance of various pavement structure compositions. The expected deterioration of selected – eventually critical – condition parameters (stresses, strains, deformation etc.) as a result of the cumulative, synergic effect of mechanical and environmental loads can be obtained after relatively short running time as the output of the model. The real challenge for the engineer is the realistic selection of the programme inputs, the mechanical properties (e.g. E-modulus) of the pavement structural material in question. Similarly, it is a hard task to choose each characteristic deterioration mode to be considered in the calculation. This approach does not take much time but the level of accuracy in its results is rather limited due to the generalization and simplification of the inputs considered.

1.2 Laboratory test series

Another methodology for the forecast of the performance of an innovative material or technology is producing test specimens and carrying out special laboratory investigations. Typically, not only the samples made by innovative technologies are tested but also reference specimens are investigated in order to compare the performances. Even if the planned material composition is used in the laboratory test series, it is important to select the investigation methods which are more or less able to simulate the characteristic deterioration modes of the structure in question. The limitations of this relatively quick methodology are, among others, as follows: environmental loads cannot be considered at all or at least not realistically; the relatively small size of the laboratory samples tested results in different performance from that of the relevant built road element.

1.3 Accelerated laboratory tests

A lot of countries operate accelerated loading testing (ALT) facilities (circular tracks, linear tracks with load moving to and fro, etc.) which are usually open-air but a couple of them were made in buildings. In some cases, the artificial, (almost) continuous loading is performed by multi-axle, heavy trucks; however, it is more wide-spread that continuously moving, highly loaded wheels or axles are used for this purpose. Several technological variants – including reference one(s) – can be loaded simultaneously allowing a direct comparison of their performances. Another positive feature of this performance prediction procedure is that no previous "speculation" on the expected pavement deterioration modes is needed; the actual, experienced changing in the initial condition parameter levels provides information about the critical mode(s). However, some 10-year highway traffic load can be performed in ALTs in a month or two; the repeated environmental load of a highway section under "normal" traffic cannot be simulated when using accelerated loading facilities. (The ALTs in buildings can have the possibility to change air temperature, relative humidity, sub-grade moisture content, etc., but it does not allow realistic simulation). It is worthwhile to mention that building and operating accelerated loading facilities are rather expensive.

1.4 Trial (experimental) section monitoring

It is obvious that the construction and monitoring experimental (trial) sections can provide the most reliable forecast (prediction) about the performance of a new material or technology if, among others, the following important preconditions are met: careful selection of the location and sufficient length of experimental section(s); the Client's detailed disposition including the need for reference section; professional and thorough pavement design; well-equipped contractor motivated to innovation; effective quality management including continuous and

tight independent quality control; careful planning of the monitoring of the trial and reference sections including the condition parameters investigated, measuring techniques (devices) to be used, durable marking of point-like measuring spots if any (in case of the use of non-continuous measuring techniques); selection of measuring frequency (typically every year); sophisticated evaluation of the condition data time series obtained for comparing the performances of innovative and traditional variants. Even if every precondition listed before are satisfied, and so, reliable performance prediction can be expected, the time-consuming nature of the methodology cannot be ignored.

2 Case studies of Hungarian road experimental sections

The long-term monitoring results of experimental sections (preferably together with neighbouring reference sections) can provide more certain and more reliable information about the appropriateness of the new material or technology than the other approaches.
Next two Hungarian case studies will be shown for road experimental sections pointing out their goals (the new technology to be demonstrated), the (eventual) reference sections, the frequency and period of monitoring, condition parameters to be monitored, measuring techniques applied, evaluation of the results and discussion of the actual level of success to have used the experimental section for assessing the performance of the innovative material or technology.

2.1 Case study on various cement concrete technologies

However, the first trials with cement concrete pavements were carried out in Hungary already in 1911, and a lot of them were constructed since, Ministry for Transportation decided to continue motorway construction programme using exclusively asphalt pavements from 1976 on. As a rather negative consequence, building of cement concrete pavements ceased on other – non-expressway – roads, as well. It was just in 1998 – following a 22-year break – that a ministry decision initiated the preparatory activities for restarting the cement concrete pavement construction in Hungary. KTI Institute for Transport Sciences, Budapest was commissioned to the preparatory activities [2]. The latest relevant foreign experience was gathered. The following three alternative technological variants were chosen for detailed investigation and the comparison of their actual performances:
· jointed and dowelled cement concrete pavement;
· jointed and dowelled cement concrete pavement with "exposed aggregate" surface;
· continuously reinforced cement concrete pavement.

After having evaluated the results of a detailed laboratory test series, the mix recipes were developed for the experimental sections. 35 to 42 MPa compressive strength range was selected with 0.40 to 0.42 w/c-ratios for each concrete mixture variant. (Plastificator was added in 0.10 to 0.12% of weight of water, and air-entraining agent in 0.04 to 0.08%).
As a site of the trial sections, a heavily trafficked – above 1100 heavy vehicle/day – secondary road (road 7538) close to the Slovenian state border was chosen. (In accordance with the Hungarian ministerial orders in 1999 – when trial sections were designed and constructed – no experiment was allowed to make on a main national public road). The road needed a complete pavement structure reconstruction due to its total failure. In addition to the three cement concrete experimental subsections with a length of 500m each, a neighbouring reference (control) subsection of 500m was also built using high modulus asphalt pavement with modified binder.

The pavement structure variants were as follows:
· experimental subsection 1:
    · 220 mm jointed and dowelled cement concrete pavement;
    · 150 mm mixed-in-plant cement stabilisation base course;
    · 100 mm mixed-in-place cement stabilisation sub-base.
· experimental subsection 2:
    · 220 mm jointed and dowelled cement concrete pavement with exposed aggregate surface;
    · 150 mm mixed-in-plant cement stabilisation base course;
    · 100 mm mixed-in-place cement stabilisation sub-base.
· experimental subsection 3:
    · 170 mm continuously reinforced cement concrete pavement (CRCP);
    · 150 mm mixed-in-plant cement stabilisation base course;
    · 100 mm mixed-in-place cement stabilisation sub-base.
· reference subsection:
    · 30 mm stone mastic asphalt with modified binder;
    · 80 mm asphalt binder course with modified binder;
    · 90 mm asphalt base course with modified binder;
    · 150 mm mixed-in-plant cement stabilisation base course;
    · 100 mm mixed-in-place cement stabilisation sub-base.

The construction of the trial sections was basically influenced by the extremely rainy spring and summer of 1999. That is why the design bearing capacity of 50 MPa at the surface of sandy gravel capping layer could not be reached, its stabilisation with cement was decided by the Client.

The trial subsections were built with 6m pavement width following the width of the secondary road. Just one of the traffic lanes was allowed to be closed during the construction. No continuously reinforced cement concrete pavement (CRCP) had been built in Hungary before the experimental section on road 7538. The relevant foreign literature was utilized in the design (thickness, dilatation structure, anchoring to prevent the horizontal end movement of CRCP, positioning of reinforcement etc.).

The principal goal of the experiment was to evaluate and to compare the performances of the four pavement structure types under "canalised" heavy traffic load. (The lorries run in very narrow wheel paths due to the 3 m traffic lane width).

The monitoring of the trial subsections was done first with a frequency of 6 months and later 12 months. The condition evaluation methodology all pavement condition parameters related to every possible failure type. Table 1 presents the failure types and condition parameters considered.

Table 1 Possible distress types and condition parameters measured on various subsections

Failure type	Condition parameter	Pavement		Spacing of evaluation
		Asphalt	Concrete	
Longitudinal deformation	unevenness	X		continuous
Slab faulting	unevenness		X	continuous
Rutting	transverse profile	X		3 fixed cross sections/subsection
Loss of skid resistance	skid resistance	X	X	50 m in alternate traffic lanes
Wear of aggregate grains	macro roughness	X	X	50 m in alternate traffic lanes
Surface defects	visual evaluation	X	X	continuous
Poor bearing capacity	bearing capacity	X	X	3 fixed cross sections/subsection
Pavement edge distress	pavement width	X	X	100 m

The location of measuring points was marked by durable painting on the pavement surface. The visual pavement survey resulted in a distress map with the location, type and severity of each surface defect detected. The first condition survey was performed in November 1999 to fix the initial (0) condition of the experimental section. The regular monitoring of the trial and reference sections has made it possible to identify the deterioration process of each condition parameter. Just some of the results are identified:

· already at the end of the first year, several punch-outs presented themselves on the continuously reinforced concrete trial part section; their further deterioration made it necessary to patch them using asphalt mixture to prevent the accidents coming from the sudden unevenness of the pavement surface; the subsequent investigation of the reasons of the very early deterioration has revealed the poor design (too thin pavement layer, too narrow pavement etc) as a decisive parameter;

· the tendency of surface roughness deterioration characterized by macro roughness and skid resistance (actually the combination of macro and micro texture of pavement surface) can be divided into 3 phases; in the first 2 years, an intensive deterioration is observed, the speed of this deterioration is significantly slows down in the period of 3-10 years of pavement age, while practically unchanged roughness values can be detected when the age of pavement exceeds 10 years; as an example, Table 2 presents some statistical parameters of the macro roughness and skid resistance values measured on the surface of jointed, dowelled cement concrete pavement with "traditional" surface at the age of 0, 2, 8 and 13 years (the pavement ages were selected of the almost continuous data time series for representing the three deterioration phases mentioned before). After 13 years of traffic load, both the texture depth and SRT-values deteriorate to nearly the same levels independently on the pavement and surface type selected, at the same time the standard deviations of the measuring data masses are much lower after high number of vehicle repetition number than immediately after the opening to traffic of the road with new pavement. The SRT-values of 50-55 and the texture depth ranges of 0.30-0.50 mm measured on the test cement concrete pavement surfaces after 13 years of traffic load with high heavy vehicle share are still appropriate (safe) values.

Table 2   Some statistical parameters of macro and micro roughness (measured using sand patch method and British pendulum) obtained at different ages of cement concrete pavement surface (test section road 7538)

Statistical parameters	Texture depth [mm]				SRT-value			
	at pavement age [year]							
	0	2	8	13	0	2	8	13
Mean value	0,99	0,67	0,52	0,40	79,4	63,4	60,7	51,9
Minimal value	0,70	0,42	0,37	0,31	66	53	58	50
Maximal value	1,27	1,16	0,72	0,51	90	72	65	54
Range	0,57	0,74	0,35	0,20	24	19	7	4
Standard deviation	0,17	0,17	0,08	0,07	6,55	4,56	1,78	1,29

2.2 Case study on whitetopping technologies

Laying thin cement concrete courses on asphalt pavements with repeatedly deformed surfaces is considered as a possible rehabilitation technique. When designing the first Hungarian whitetopping experimental section, the following technological features were considered:

· the thin cement concrete layers have 120-150 mm thickness, while the ultrathin ones are 50-120 mm thick;

· 20 years of life time can be expected on any old – asphalt or cement concrete – pavement if various technological preconditions are met;

- old pavement should have sufficient, homogeneous bearing capacity without fatigue cracks, rutting cannot exceed wearing course;
- concrete slabs are square;
- layers should be bonded to decrease bending stress in the structure;
- min. 75 mm remaining asphalt layer(s) thickness in the old pavement structure before using whitetopping is required;
- old pavement surface has to be sufficiently rough and clean for ensuring effective bond with thin cement concrete course;
- properties of whitetopping recipe: fibre dosage, high early strength;
- the layer is built without dowels and joint sealing;
- effective curing is a must.

A highly trafficked main road no.5 (daily 2750 heavy vehicles) at the outskirt of the city Szeged was selected as a site of the first Hungarian whitetopping experimental section [3]. The top layers of an extremely rutted, 7,0 m wide asphalt pavement section of 85 m length were milled, and thin cement concrete course was laid. The main elements of cement concrete recipe are:
- aggregate   1,832 kg/m^3;   · cement   420 kg/m^3;   · water   168 kg/m^3;
- plastic fibre   1 kg/m^3;   (CEM I 42.5 N)   · plastificator   6,3 kg/m^3.

Compressive strength amounts to 27.2 N/mm^2 after 1 day, 39.3 N/mm^2 after 2 days and 43.1 N/mm^2 after 28 days. After 10 months of traffic load, 1.2 mm texture depth and 68 SRT-value were the average roughness values. The number of cracked slabs of 1.75 m x 1.75 m size reached 41, that is, almost 22 % of the 188 concrete slabs by 2013. Most of the cracks can be found in the outer lane, close to the two ends of the test section. Two of the worst slabs had to be replaced; otherwise local asphalt patching was performed. The reasons for the unexpectedly high percentage of early cracks are as follows:
- the actual heavy traffic load of the section was much higher than expected, among others, due to the many permissions given by Highway Authority for passing overloaded vehicles on the section;
- at the end of the experimental section, the heavy lorries reaching the first whitetopping slabs traveling from the connecting rutted asphalt pavement surface exerted high load causing their quick failure;
- at the other end of the section, a lot of multi-axle heavy road vehicles have to decelerate and stop because of the signal-controlled junction;
- manual laying resulted in the relatively low homogeneity of slab quality.

3   Concluding remarks

Experimental sections have a major role in the validation of new technologies and materials. However, they can provide reliable and useful data just if their design, construction, maintenance and operation are performed properly. Two Hungarian case studies are shown highlighting also the reasons of eventual improper performance. It could be concluded that the synergic effect of careful design, high-level construction (with competent and innovation devoted contractor) and the efficient independent quality control can be considered as important prediction for the success of road experimental sections.

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