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Hungarian experiences in innovative low-volume road pavement structures

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Content

1. Introduction

Low volume roads – high total mileage, limited role in national economy, but important for quality of life. Thus, very poor quality is unacceptable.

Uncontrolled depletion of natural, non-renewable resources + management of increasing quantity of waste → diverse application of waste materials in road construction and maintenance.

Three groups: recycling, industrial by-products and low-quality natural materials.

2. Highway categorization I.

Hungary (Central Europe):

- 93,000 km², 9.8 million inhabitants,
- 32,000 km national highways, including 2,200 km expressways,
- 170,000 km local (municipal) highways,
- highway categorisation by 10 ton equivalent single axle load repetitions during design life.

2. Highway categorization II.

Traffic design categories		Design traffic (number of 10 to standard axle loads)	
Designation	**Sign**	**from**	**to**
Very light	A	$3x10^4$	$1x10^5$
Light	B	$1x10^5$	$3x10^5$
Medium	C	$3x10^5$	$1x10^6$
Heavy	D	$1x10^6$	$3x10^6$
Very heavy	E	$3x10^6$	$1x10^7$
Extreme	K	$1x10^7$	$3x10^7$
Extraordinary	R	$3x10^7$	-

2. Highway categorization III.

- Traffic category A: „low-volume roads”.

- Entire length of low volume roads in Hungary 90,000 km (a high share of the network).

- Obviously, development of innovative construc-tion and maintenance techniques for the low-volume roads.

3. Structural design I.

UT 2-1.503 „Structural design of low-volume roads” Road Technical Directives

*M*ain topics:

a.) Basic design principle

b.) Design steps

c.) Role of subgrade soil type

d.) Standard pavement structures

e.) Role of subgrade soil type

3. Structural design II.

ad a.) Basic design principle

Catalogue of standard constructions for low-volume roads

Standard pavement structure of low-volume roads with unbound base course

Base course type				
Mechanical stabilization (ZM)		**Dense graded stone base (FZKA)**		
80mm asphalt	80mm concrete stone	60mm asphalt	80mm concrete stone	Surface dress-ing or cold asphalt
200mm ZM	230mm ZM	200mm FZKA		300mm FZKA

3. Structural design III.

Standard pavement structure of low-volume roads with hydraulically bound base course

Base course type			
Cement stabilized base (CK)		**Lean concrete (C12)**	
40mm asphalt	80mm concrete stone	60mm asphalt	80mm concrete stone
150mm CK		150mm C12	

3. Structural design IV.

ad b.) Design steps:

- identification of traffic design category,
- soil type,
- standard pavement structure,
- checking the resistance to freeze-thaw damage.

3. Structural design V.

ad c.) Role of subgrade soil type

Upper 0.5m of subgrade soil is investigated.

If slightly cohesive or cohesive soil:

+ 200-250mm **granular soil** OR

+ 150mm cement or fly ash **stabilized soil** layer → min. E_2 = 40 MPa modulus value.

4. Special asphalt mixture I.

A special asphalt mixture type has been used in Hungary for low volume roads. (“**Finnish asphalt**”, an asphalt technology adapted to Hungarian conditions):

-**patented** bituminous **binder** (similar to cut-back bitumen),

-**readily stored** and **laid** for the construction and repair of low volume road pavements,

-produced in close **proximity to construction site** at a temperature of 90-110^{o}C,

.

4. Special asphalt mixture II.

Three variants: 8-11-22mm max. aggregate grains

Used as **top layer** of a national or local highway of ≥2,000 vehicles per day.

Placed using asphalt **paver or grader**.

High compactibility → **pothole repair** or **profile correction** (**cut** with asphalt cutter saw, **remove** any moving parts, **clean** the pit free of water and dust).

4. Special asphalt mixture III.

No bituminous **undercoating** under favourable weather conditions.

Possible enhancement with **bitumen emulsion** just in cold weather.

Spread 15-20mm **higher** than the desired level, depending on pothole depth.

Compaction by **manual** compaction devices or **vehicle** tyres.

5. Industrial by-products I.

Blast furnace slag: utilized in pavement construction after **stocking** in the open air for **at least 4 months**.

Resilient **modulus exceeds** those of **traditional** granular **materials** → thinner and cheaper pavements.

Remarkably **good** technical **quality** and **economic advantages** also for low quality roads.

Durable **surface dressings**.

5. Industrial by-products II.

The use of **granulated blast furnace slag** (GBFS) – a poorly graded by-product of the iron industry – **mixed** with an **old** base and wearing course **aggregate** on a low-volume gravel road is an economical option, since GBFS has **latent hydraulic** properties.

5. Industrial by-products III.

Utilization of blast furnace **slag** started in Hungary **in the 1950's** with water-bound **macadam base courses** without any previous screening.

From 1976 on, elaboration of **proper techniques** using crushed and sieved slag as **aggregate in** asphalt and cement concrete **mixtures**.

Granulated slag,together **with lime**, **binder** for **base** and pavement **strengthening layers**.

5. Industrial by-products IV.

KTI's initiation: slags were officially **qualified from waste** materials **to** construction **products** meeting relevant standard requirements.

As a consequence, the **need** for air-cooled and crushed slag has considerably **increased** → **shortage** of the materials in some regions.

5. Industrial by-products V.

Sand fraction of blast furnace slag can be used for **de-icing** in winter road maintenance (**replacing** less environmental-friendly **NaCl**).

KTI’s **country-wide cadaster** for recording blast furnace **slag deposits** with main physical **characteristics**; their majority **meets** the **requirements** for road **crushed stones**.

5. Industrial by-products VI.

Addition of self-cementitious **fly ash improves stiffness and strength** of base materials of low volume roads (recycled pavement material, road surface gravel or subgrade soil).

Estimation of **target resilient modulus** to be measured during construction → modulus of **laboratory mixed** specimens reduced by **1/4 to 1/3**.

6. Cold remix I.

Synergetic detrimental effect of **mechanical and environmental loads** → one or more condition parameters of pavement reaches **intervention level** → **pavement rehabilitation**.

Of the possible renovation techniques, especially in case of **poor bearing capacity**, appropriate **remixing** technology a promising solution.

A 5 km long **cold remix renewal project** of a forest road was built in Hungary.

6. Cold remix II.

Bearing capacity measurements **before** reconst-ruction, then **3-year** long **pavement monitoring** (bearing capacity and condition observations) on annual basis.

R**esults** were **better than expected** contributing to the recent state-level **new specification** (**bro-ken asphalt** is **product**, **not waste** material)..

Short (2-3 km long) pavement sections → **rental** of machine park **not cost effective.**

7. Substandard materials I.

Local, **substandard materials** (p**oorly graded and uncrushed aggregate, cohesive fines in aggregates, dune sands,** etc.) in low volume pavements instead of relatively expensive conventional materials → significant **economic savings**.

HOWEVER, **difficult** to evaluate **quality** and may **invalidate** generally accepted pavement **design assumptions**.

7. Substandard materials II.

May adversely affect the pavement **performance**.

Eventually **adjustments in construction procedures** to accommodate their characteristics.

The economics and the obvious environmental **advantages** must be **balanced** against the additional **potential difficulties** mentioned.

8. Concluding remarks

Special emphasis on construction, rehabilitation and maintenance technologies for low-traffic roads.

Moderate but still sufficient quality requirements, optimal **trade-offs** between **functional, quality of life and environmental** aspects.

Directions: **recycling** of “old” road materials, use of industrial **by-products** and utilization of “**low quality” raw materials**.

- **Thank you for your kind attention!**