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# Pavement structures for long life and extreme load

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## Abstract

In this paper is description of the approach to solution the problem of pavement design the structures for longer design period and /or for heavy traffic load e.g. on bus stops. In paper is scheme of pavement design procedure and description of asphalt pavement rehabilitation scenario.
This paper was elaborated within the framework of the research grant of the project „The Environmental Capacity Parameters of Transport Infrastructure" VEGA No. 1/3314/06 [1].

## Introduction

The aim of pavement structure design is to find a type of structure for the site (region) under consideration that will withstand to traffic load and climate – induced stresses and strain remaining undamaged and in good serviceability. The design procedure of new pavement is used for estimation of pavement composition and layer thicknesses. Very important input data and characteristics taking into consideration are:

- traffic load
- subgrade bearing capacity
- climate conditions and
- material characteristics.

There are two general types of pavement design methods: empirical methods and analytical methods. First, there are the methods based on an empirical approach, using observations of road sections. These methods are easy to use with pavement structures that have already been studied and which are therefore included in the nomograms.
Analytical methods are more widespread. These methods are based on modelling of pavements structures (Burmister – type), i.e. structures composed of infinite layers in the horizontal plane, laid on a semi-infinite subgrade, with homogeneous, isotropic and elastic materials, where the layers are subject to circular loads. As a function of layer characteristics (thickness, modulus of elasticity, Poisson ratio) this model gives an assessment of loads within the structure, even thought modelling does involve simplification with respect to the complex mechanical behaviour in the pavement. Fatigue laws provided by laboratory tests are used to estimate the maximum allowable loads after a defined number of standard (axle) loads. These methods can by adapted to a large number of cases (climate condition, materials, vehicle types).

The analytical design method for flexible pavements with mechanistic approach used in Slovak Republic is characterized by scheme on fig. 1.

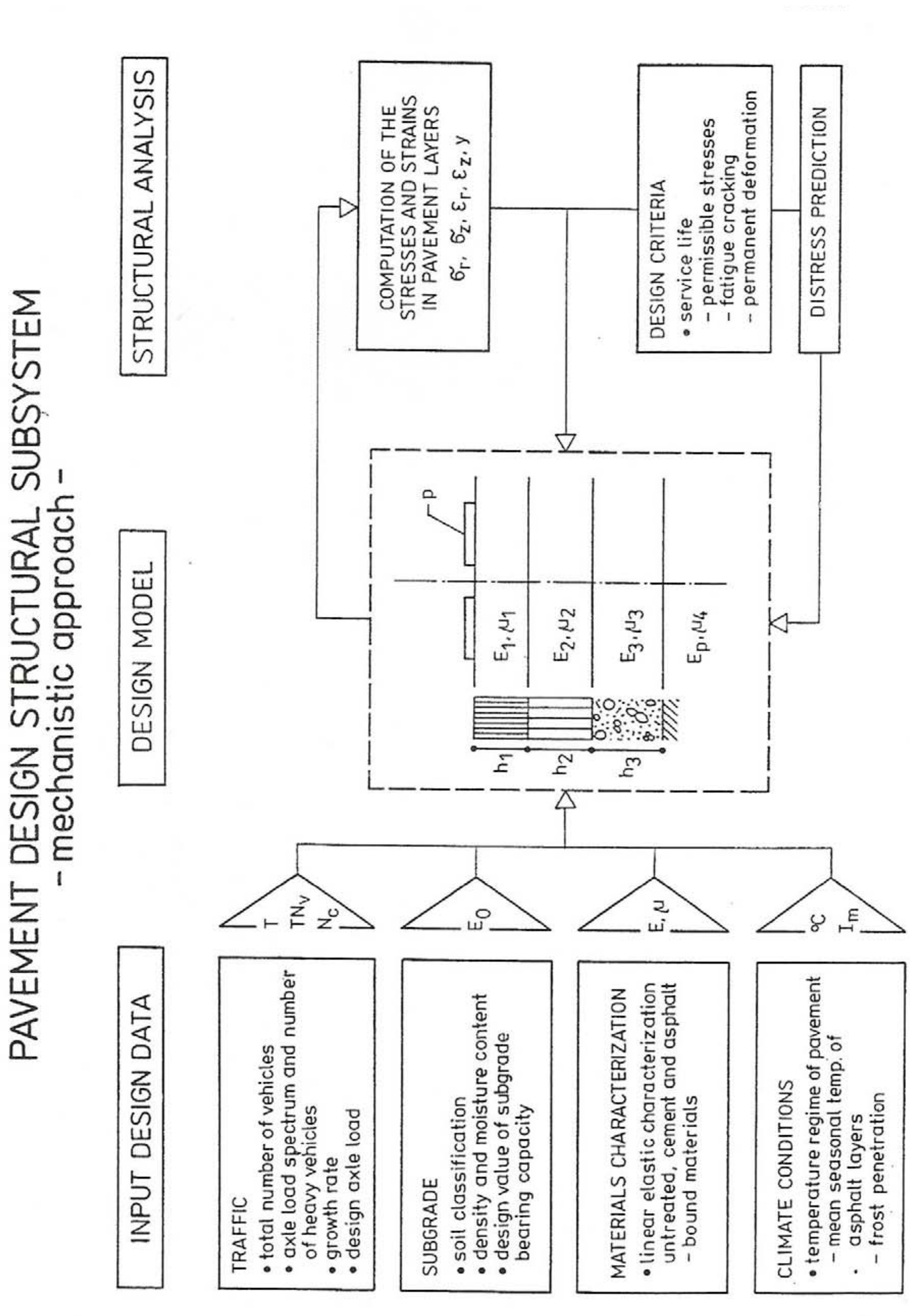
PAVEMENT DESIGN STRUCTURAL SUBSYSTEM
- mechanistic approach -
INPUT DESIGN DATA
DESIGN MODEL
STRUCTURAL ANALYSIS
TRAFFIC
• total number of vehicles
• axle load spectrum and number of heavy vehicles
• growth rate
• design axle load
T
TNv
Nc
SUBGRADE
• soil classification
• density and moisture content
• design value of subgrade bearing capacity
E0
MATERIALS CHARACTERIZATION
• linear elastic characterization untreated, cement and asphalt - bound materials
E, μ
CLIMATE CONDITIONS
• temperature regime of pavement
- mean seasonal temp. of asphalt layers
- frost penetration
°C
Im
p
h1
h2
h3
E1, μ1
E2, μ2
E3, μ3
Ep, μ4
COMPUTATION OF THE STRESSES AND STRAINS IN PAVEMENT LAYERS
σr, σz, εr, εz, y
DESIGN CRITERIA
• service life
- permissible stresses
- fatigue cracking
- permanent deformation
DISTRESS PREDICTION

**Fig.1**

## Traffic load

Traffic data are the main input for pavement design. To design any pavement structure we have to know the actual loading to which it will be subjected during the design life. In the case of a road pavement it can at best be expressed as cumulative totals of axle loads. In general, all design method reduce traffic data to a cumulative number of equivalent standard axles (Ps). Ich real axle Pi (kN) is converted into an equivalent number of standard axles Ps using an aggressiveness factor α:

$$\alpha = k\ (Pi\ /Ps)^{n}$$

For asphalt pavements the exponent (power) is usually equal to 4, (or 3,5 – 5,0). In Slovak design method the standard axle is single 100 kN with dual wheels (p = contact pressure is 0,60 MPa). To convert the data from traffic counts (or counting studies), the same approach is used in all methods. The basic data are annual daily mean traffic figures, the percentage of heavy – duty vehicles and the traffic growth rate.
The design of pavement for long time (longer design period e.g. 25, or 30 years) as the question of pavement structure rehabilitation scenario (program). One example from the research in past time is next.
The road pavement differs from other engineering structures in terms of the loads to which they are subjected. These are primarily caused by long-term traffic loading. The bound pavement layers should be capable of with standing a certain number of loading of a given magnitude before failure. In addition, repeated loading causes permanent deformations (ruts). Deformations finally can exceed the limits of serviceability of the pavement. According the literature the risk of deformation (ruts) in relation to total weight of heavy vehicles and speed is on the scheme (fig. 2).
General data and figures about transport, number of heavy vehicles on the roads and development in this area shows, that in this situation is typical to solve the problem of road pavement for longer service time (design period) and pavements for heavy (extreme) load e.g. pavements on bus stops.

## Pavement Rehabilitation Scenario

Design of asphalt pavement structure

| | | |
|---|---|---|
| 40 mm | SMA | Split mastic asphalt |
| 50 mm | AC | Asphalt concrete 11, binder |
| 100 mm | AC | Asphalt concrete 16, base |
| 200 mm | CBBM | Cement bounded gravel material, $C_{516}$ |
| 200 mm | UMG | Sand and gravel |

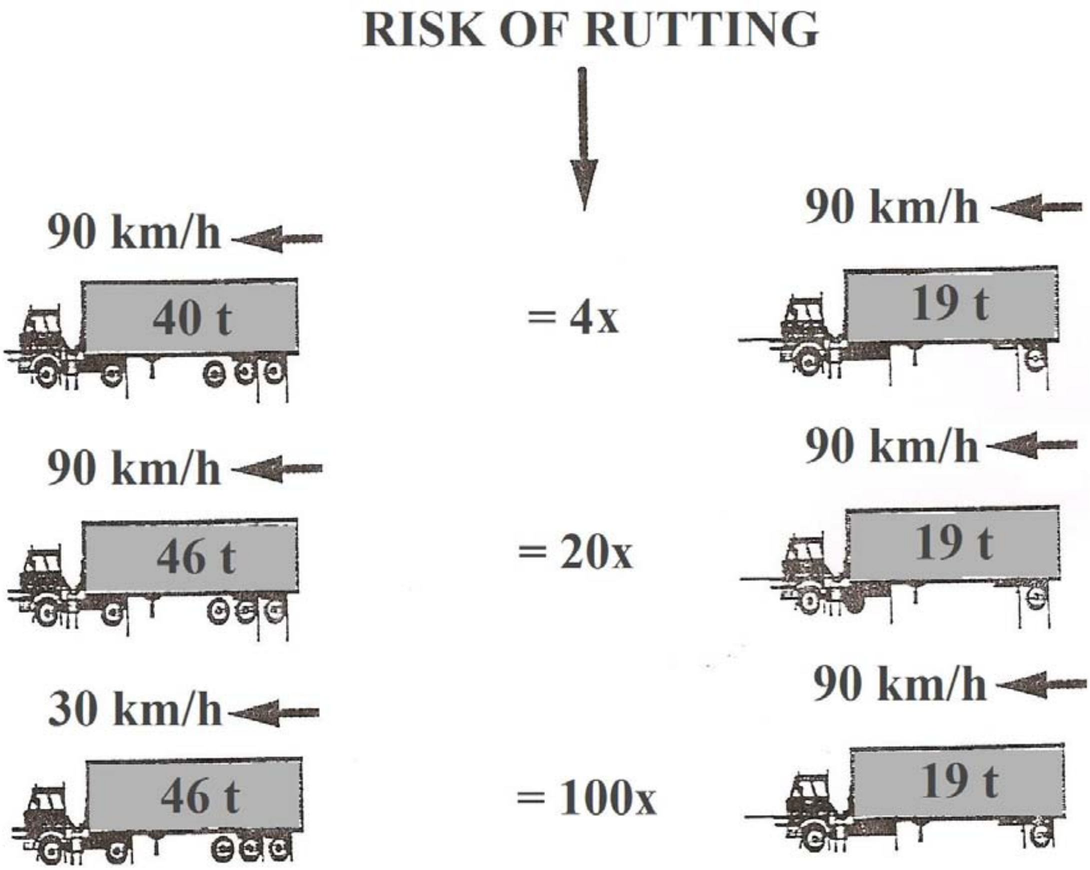


**Fig.2** Effects of different configuration of heavy vehicles

**Rehabilitation**

* during 3 – 5 years: cracks sealing (repair generally)
* after 9 years (slow lane and fast lane) area 60%
- milling 50 mm, new 50 mm SMA
  (40 mm asphalt concrete AC)

* after 18 years
- slow lane (100% area)
  • milling 100 mm, then 40 mm SMA new wearing course and 60 mm if recycling (hot or cold in place) AC
- fast lane (60% area)
  • milling 40 mm, then 40 mm SMA new wearing course

* after 27 years
- slow lane (100%) and fast lane (100%)
  • milling 60 mm, then 60 mm SMA new wearing course and 80 mm of recycling (hot or cold in place) AC.

**Pavement for bus stops**

One of the factors which influence the choice of public transport is the quality of pavements, generally on stops.

In present time in Bratislava town are approximately 800 stops of non-rail public transport. These stops carry vehicle load of buses and trolleybuses. They are constructed as separate structure or carry the load of public transportation means and other transport means (personal cars, trucks). Second case is worst and in this conditions case the serviceability of pavement (on bus stops) decrease rapidly. Deterioration caused by the movement, braking and acceleration of buses and trolleybuses is multiplied by the movement of other types of vehicles. Bus stops in central urban zone is now under reconstruction. On the asphalt pavements the deteriorations are shown as longitudinal and transverse unevenness, cracks, permanent deformations (ruts), damages near traffic lines. The designed and constructed are pavements with cement concrete surfacing – (slabs) reinforced or unreinforced, thickness 200 (250) mm on asphalt bounded aggregate (50 mm), soil cement stabilization (200 mm) and drainage layer – sand and gravel. The pavement structure design in evaluated from the point of single and repeated load in the view of vertical and radial stresses in pavement layers (cement concrete slab). Cement concrete slab is reinforced with steel net ( Φ 5 mm, 100 x 100 mm) in one third of its height**.** The design period of this pavement structures is 25 years.

For pavements without heavy traffic are used structures with cement concrete blocks. (On the fig. 3 is scheme the structure)

cement concrete block 80 mm

binder course, sand 4/8 mm, 30 mm
upper roadbase, gravel 8/16 mm, 50 mm

lower roadbase, gravel 16/32 mm, 200 mm

subbase, sand and gravel, 0/63 mm, 150 mm

**Fig.3** Pavement structure of cement concrete blocks

## Conclusions

The effect of traffic loads for pavement design is simplified. It is important not to calculate only the effect of different axles, but the effect of total vehicle or vehicle combination. According the calculation for design period 25 (or 30) years the total number of 10 tons standard axle load is more than $25 \cdot 10^6$ . For this traffic and long service life exists scenario for pavement rehabilitation.

## Reference


[1] The Environmental Capacity Parameters of Transport Infrastructure” Final Report of the research project VEGA No. 1/3314/06, DOS SvF STU Bratislava, 2008

[2] STN 73 6114 Vozovky pozemných komunikácií. Základné ustanovenia pre navrhovanie, platnosť od august 1997

[3] TS 0502 Navrhovanie netuhých a polotuhých vozoviek, MDPT SR, Bratislava 2002