Pavement surface characteristics evolution

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Context

- Cooperation between LCPC and "Autoroutes du Sud de la France" (ASF)

- **LCPC**: French national organization for applied research and development in civil engineering

- **ASF**: private organization operating the leading motorway network in France (around 2,700 km of toll motorway)
Context (Ct’d)

- **LCPC**: modeling the evolution of pavement performance indicators (for structure or surface conditions)

- **ASF**: optimizing maintenance management system by use of predictive pavement performance models

- **LCPC** carries out statistical analysis of the (large and well-informed) database “ArgusBase” managed by **ASF** through periodical monitoring campaigns
Available data

- Focus on 2 major **skid resistance (SR)** indicators evaluated on 100-metres long sections of slow lanes

- **Macrotecture**
  - capacity of the road to avoid the presence of any bulk water within the tire/pavement contact area
  - *sand patch texture depth (SPTD)*

- **Microtexture**
  - capacity of the road to avoid the presence of any residual film of water within the tire/pavement contact area
  - *coefficient of transverse friction (CTF)*
Available data (Ct’d)

- SPTD measured by Rugolaser®
  on 36,500 sections (around 78,000 data)

- CTF evaluated by Scrim®
  on 43,200 sections (around 92,000 data)

- ... sections with different types of wearing course:
  - 62% are **semicoarse asphalt concrete** (SAC)
  - 33% are **very thin asphalt concrete** (VTAC)
  - 5% are **porous asphalt concrete** (PAC)
Descriptive analysis of SPTD data
Descriptive analysis of CTF data
Grading composition

Portorož, Slovenia
ANOVA and multiple comparisons

• Statistical procedure:
  ▪ Analysis of variance (ANOVA) for the overall difference
  ▪ If significance, multiple comparisons for individual differences

• Difference between wearing course types
  ▪ \textit{SPTD}: VTAC > SAC
  ▪ \textit{CTF}: SAC > VTAC > PAC

• Difference between grading compostions
  ▪ \textit{SPTD}: coarse designs (0/14) > fine designs (0/10)
  ▪ \textit{CTF}: fine designs > coarse designs
  ▪ Critical size of the 0/6 sample
Statistical model for SR evolution

- **Dependent variable**: time to reach a *given* threshold of SPTD/CTF
  
  *given thresholds: 90%, 80%, 70%, ..., 20%, 10%*

- **Independent variables**:  
  - wearing course type  
  - grading composition

- **Link function**: regression model with underlying Weibull density of probability
Statistical model for SR evolution (Ct’d)

- **Censoring mechanism** if time to reach threshold is not an inspection time

  Left censoring, right censoring, interval censoring

- Estimations of the two Weibull distribution parameters

- Estimations of the regression coefficients associated to the independent variables
Statistical model for SR evolution (Ct’d)

- Hypothesis tests of significant effect of the independent variables
- Goodness-of-fit analysis
- Predictions on the long term (evolution curve)
- Individualization of evolution curve for each road section (observations per section $\Rightarrow$ corrective coefficient)
Definition of robustness

- Corrective coefficient is referred as **robustness of a section road** (*mechanical*, not *statistical* meaning)

- Robustness is defined for a class of pavement sections sharing all the same characteristics (*i.e.* same values of independent variables)

- Robustness is defined as the percentage of sections with less favourable evolution of SPTD/CTF

- Robustness is constant over time
Illustration of robustness

- Robustness 60%
- Robustness 70%
- Robustness 50%

60% of sections with CTF < 0.43
40% of sections with CTF > 0.43
Illustration of robustness (Ct’d)
Results

- Significant difference between wearing course types concerning the evolution of SPTD/CTF

- Doubtful significant difference between grading compositions (only for a minority of thresholds)

- Goodness-of-fit (residuals analysis) assessed
SPTD evolution

![Graph showing SPTD evolution with different age groups and lines representing VTAC and SAC]
CTF evolution

![CTF evolution graph](image)

- SAC
- VTAC
- PAC

Age

CTF
Illustration of observed vs fitted values
Conclusions

- Significant impact of wearing course types on the evolution of both indicators:
  - **SPTD**: VTAC have higher values than SAC
  - **CTF**: higher values for SAC, lowest for PAC — and VTAC in between

- Doubtful significant statistical effect of the grading characteristics (unbalanced samples)

- Fitted curves in strong agreement with observed values, allowing for predictions on the long term
Perspectives

- Include **traffic** as potential factor of the evolution of SR
  - *cumulated traffic as independent variable?*
    time-related independent variable
  - *cumulated traffic as dependent variable?*
    leads to very similar evolution curves
  - *class of (design) traffic as independent variable*

- Need to complete the database for grading 0/6
Perspectives

Thank you