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INTELLIPave - AN EVOLUTIONARY INTELLIGENCE APPROACH TO ASPHALT PAVEMENT MODELLING

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Artificial intelligence, neural networks, asphalt pavement modeling

ABSTRACT

This research describes an approach to model and predict the asphalt behavior using artificial intelligence tools. To that is used a large database containing variables related to climate, traffic and the pavement characteristics and for a full cycle of the pavement service life. The data is organized and optimized using soft computing tools in order to balance the importance of each variable to destruct the pavement. A trained neural network set is used to replicate and practical use of the produced model.

AN ARTIFICIAL INTELLIGENCE BASED APPROACH TO ASPHALT PAVEMENT MODELING

This research have as objective to apply, to evaluate in real conditions and validate a new approach to model and predict the behaviour and durability of the asphalt pavements, based in advanced techniques taken from evolutive intelligence and soft-computing. It is believed that this new approach, holistic and systemic, will allow to by-pass the limitations of the present, developed half of century ago and based on empiric and empiric-mechanistic methods.

To meet the objective will be used as source a database of the Mn/Road Project (Minnesota, USA), which contain the detailed history of the service life for instrumented test sections of asphalt pavements, suitable to be used in this new approach.

It will be used records taken by electronic sensors, with respect to data for a full period of the service life cycle of the asphalt pavements, taken over 10 years and the transit of about 100 millions of vehicle axles, generating 2 billions of terms with the detailed record of each vehicle that crossed the pavement (date, time, axle configuration, weight by axle, speed, tire type and pressure, stresses in the tire-pavement contact area), under the climatic conditions at the moment (air and pavement temperature, rain, wind speed, solar and UV radiation, humidity in the granular pavement layer) and the structural answer of the pavement due to the vehicle crossing (strains and stresses in key points of the asphalt concrete and granular layers), i.e., in other words, this new approach for modeling will consider in an explicit way all variables known as important for the pavement service life, without simplifications or concessions; the new way to handle the model will allow to include and preserve, in an implicit and indirect way, all the other variables, even the most insignificant or unknown, and even if no information is available about that variables.

The information in the database will be filtered, qualified and organized in order to construct a matrix of numbers; the matrix will be optimized with the use of advanced techniques of soft computing (e.g. particle swarm optimization, SOMA, evolutionary genetic algorithms, logic-mathematic functions) and equational systems to determine the importance of every variable and every vehicle to the ruin of the asphalt pavement. This optimization will allow the creation of a “matrix of performance” which will be used as a source of “experiences, knowledge and intelligence” to train a neural network set that will be able to do predictions about the behavior of the asphalt pavements to design new pavements or manage existing pavements; so that the problem just need to be presented with a format consistent with the model, with information about the vehicles, climate and structural answer. To design new pavements the structural answer can be simulated with finite elements software.

The innovation and flexibility of this new approach will allow to solve problems that are challenging the engineering for decades. Among that problems are the possibility to use multiple parameters, objectives or subjectives, as criteria to evaluate the quality and usefulness of the pavement, allowing the manager (of the pavement network) or designer, to simulate different future scenarios, looking at compatible the technical needs with the available funds. For example, will be possible to use as criteria (1) the percentual of cracked area of the pavement, (2) structural capacity, (3) deep of the wheel track, (4) the roughness (related

to driver confort), (5) the macro texture (related to tire adherence and driver security) or (6) the value of the property for the highway, just to name a few. Another benefit of this new approach is in the possibility of the knowledge to be accumulated and registered in a scientific way, allowing the "learnings" about the performance of one pavement to be inserted in the matrix of performance as a way to improve the accuracy of the future predictions in a continuous form.

TEAMS AND AWARDS

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REFERENCES

Akram, T., T. Scullion, R. E. Smith e E. G. Fernando. "Estimating Damage Effects of Dual vs. Wide Base Tires with Multidepth Deflectometers." *Transportation Research Record 1355*. Transportation Research Board. Washington, D.C. 1992.

Bell, C. A., S. U. Randhawa e Z. K. Xu. "Impact of High Pressure Tires and Single-Tired Axles in Oregon." *Proceedings, Transportation Research Board, 75th Annual Meeting*. Washington, D. C. Janurary 7-11, 1996.

Brademeyer, B.D. et al. "Analysis of Moving Dynamic Loads on Highway Pavements. Part II: Pavement Response." *Proceedings, International Symposium on Heavy Vehicle Weights and Dimensions*, Kelowna, British Columbia. 1986.

Brown S. F. "Material Characteristics for Analytical Pavement Design." *Developments in Highway Pavement Engineering, Chapter II*. P.S. Pell ed. Applied Science Publishers Ltd. 1978.

Cebon, D. "Theoritical Road Damage Due to Dynamic Tyre Forces of Heavy Vehicles." *Proceedings, Simulated Damage Caused by a Tandem-Axle Vehicle: Part 2*. I. Mech. E., Vol.202, No. C2. 1988. pp. 109-117.

Chen, H.H., K.M. Marshek and C.L. Saraf. "Effects of Truck Tire Contact Pressure Distribution on the Design of Flexible Pavements: A Three-Dimensional Finite Element Approach." *Transportation Research Record 1095*. Transportation Research Board, Washington D.C. 1986.

Christison, J. T. "Evaluation of the Effects of Axle Loads on Pavements From In Situ Strain and Deflection Measurements." *Internal Report HTE-78/02. Transportation and Surface Water Engineering Division*, Alberta Research Council. 1978.

Harr, M. E. "Influence of Vehicle Speed on Pavement Deflections." *Proceedings, Highway Research Board, No. 47*. 1962. pp. 77-82.

Hudson W. R., S.B. seeds, F.N. finn e R.F. carmichael III "Evaluation of Increased Pavement Loading." *Final Report: Arizona DOT 84-59-1*. ARE Inc. Engineering Consultants. Texas. 1986.

Huhtala, M. "The Effect of Different Heavy Freight Vehicles on Pavements." *Presented at the Tenth International Road Federation World Meeting*. Rio de Janerio. October 1984.

Salini, R.; Neves, J. and Abelha, A. "The Road Map to Apply Evolutionary Intelligence to Asphalt Pavement Modelling". *22nd European Conference On Modelling And Simulation*. Nicosia, Cyprus: 2008.

University of Minnesota. "Load testing of instrumented pavement sections - literature review." Minnesota: Minnesota Dept. of Transportation, Office of Materials and Road Research, 1999.

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