LEADING ROADS TO CARBON-NEUTRALITY

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The International Road Federation (IRF), in pursuit of its commitment to environmental conservation and as part of its contribution to worldwide efforts aimed at combating climate changes, has undertaken a research program intended to provide road contractors, governments and road industry professionals with a decision-making tool which helps reducing Greenhouse Gases (GHG) emissions from road infrastructure.

OBJECTIVES

The main objectives of this project has been to generate durable, long-term results in the environment and to actively participate in the shaping of relevant sustainable road development policy. The ultimate goal of this tool is multifaceted:

- performing a detailed environmental analysis of road projects,
- setting the stage for a comparative analysis of various road-building techniques and materials,
- offering a careful choice of potential road construction materials,
- optimizing the road construction site supply scheme regarding raw materials providers, choice of suppliers, delivery locations and materials transport modes,
- deriving a detailed estimation of GHG emissions specifically ascribable to the road construction industry,
- informing and assisting both road contractors and public agencies with the selection of appropriate offsetting plans,
- ultimately, providing a tool that could get us closer to the dream of carbon neutral roads.

Research steps

The work program was planned around a series of successive and interconnected steps, summarized as follows:

1. compilation of an exhaustive inventory of GHG emission sources throughout the road infrastructure life cycle,
2. estimation of the appropriate intensity levels for assessing these emission sources.
3. bibliographical research and collection of recent recognized data on emission factors: GHG emission estimates produced according to procedures and methodologies prescribed by the Intergovernmental Group of Experts on Climate Evolution (IPCC).
4. calculation of anticipated GHG emissions:
   - Emissions = Σ Source$_i$ *Emission Factor
   - with Source: $S_i = (A*I)_i$, where sources are specified in units compatible with the emission coefficient; A = activity level and I = intensity.
5. calculation of emissions for a more efficient development scenario (emission mitigation option), followed by scenarios comparison.

Emission sources

The accounted sources for emissions are related to the various road construction phases, beginning with land clearing until the end of the infrastructure life cycle. Three basic phases can be distinguished:

- preconstruction,
- road construction,
- infrastructure maintenance.

The following have been incorporated into the preconstruction phase:

- land clearing: based on the ground surface area cleared per unit of road surface, an estimation can be generated for both machines use and fuel consumption. The transport and replanting of trees are also taken into account at this point.
- cut export and fill imports to and from the road site: based on a simplified diagram, the user selects the sites that are concerned and introduces the respective distances, tonnages and transport modes, as illustrated *figure 1 page 66*.

The International Road Federation (IRF) was founded in 1947 to promote development and maintenance of better, safer and more sustainable road networks.

PIARC and IRF regularly collaborate for the world congresses organised by each organisation.

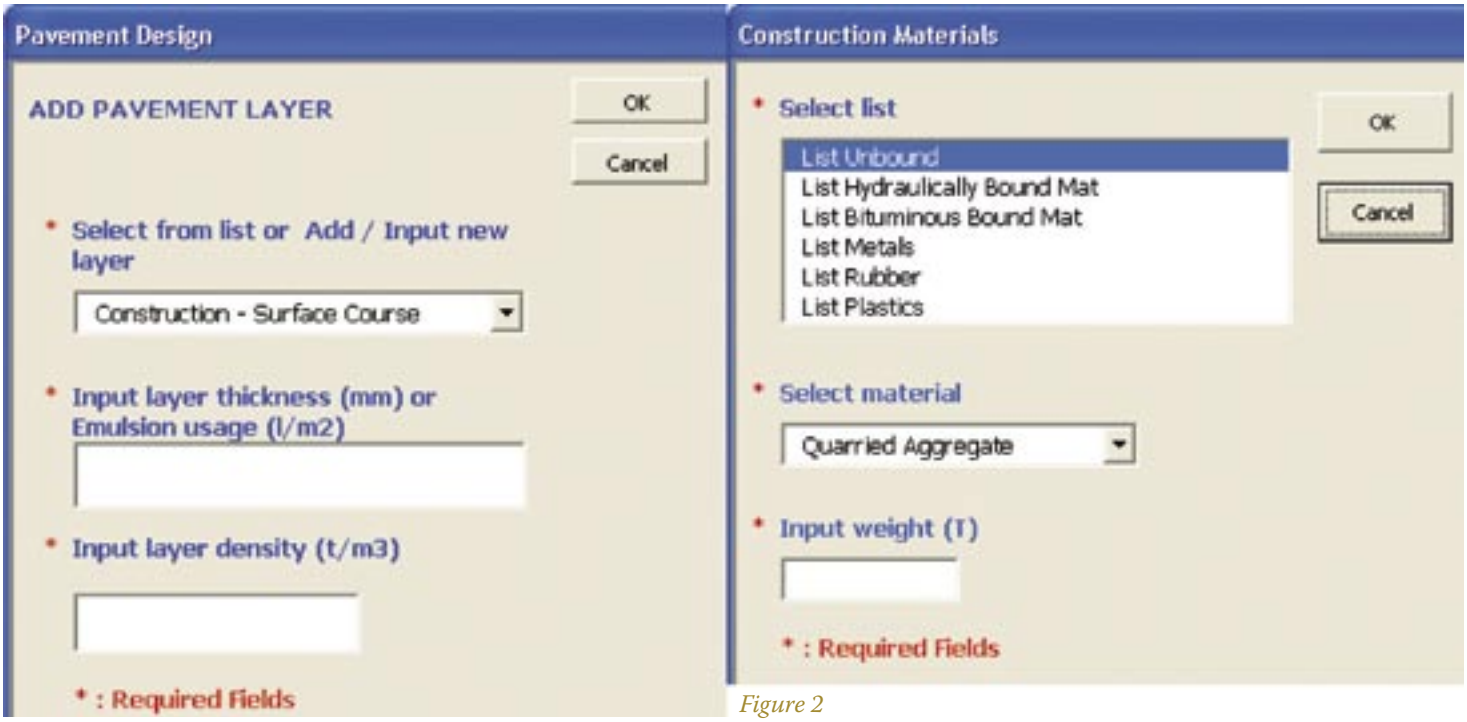

Figure 2

During the construction period, emission sources are analyzed within 4 distinct groups, focusing respectively on: the worksite, the construction materials, materials transportation, and road construction machinery use, i.e.:

1. Worksite: Electricity and fuel consumption on the construction site are identified and evaluated.

2. Pavement construction materials: The calculation tool has been designed to allow the user to make an emissions calculation of the pavement layer by layer. *Figure 2.*

The user enters the set of information relative to each layer (thickness, density) and then selects the component materials. Several lists of materials have been compiled, namely:

- list of aggregates,
- list of bituminous bound materials,
- list of hydraulically bound materials,
- list of metals,
- other (plastics, rubber, etc.).

3. Material transport: a detailed diagram describing the construction materials transportation has been developed, as described *figure 3, page 68.*

This material transport model has integrated the following parameters:

- for aggregates - Two possible quarry sites are considered. Aggregates are transported either directly to the road site (granular materials for sub-base and filter drain) or first to the mixing plants (granular materials used for mixtures) then to the road site;
- for bituminous materials - This aspect encompasses bitumen transport from the refinery to two possible mixing plant sites, and then from the plants to the road site. The model also accounts for the transport of emulsions directly from refinery to site;
- for cement - The transport of cement both directly to the site and to the mixing plant has been foreseen in the methodology adopted.

4. Use of construction machinery: This final analysis group relates to all layers constituting the pavement, assembled according to the *figure 4, page 69*.

The calculation model evaluates the number of working hours per type of machine and type of pavement layer. The total consumption of fuel is determined on the basis of the characteristics and efficiency of the material used.

Finaly, this same sequence (steps 1 through 4) is run for all maintenance activities over the course of the infrastructure life cycle.

MODELING APPROACH AND RESULTS

The modeling approach herein employs an "Input-Output" structure.
See *figure 5, page 71.*

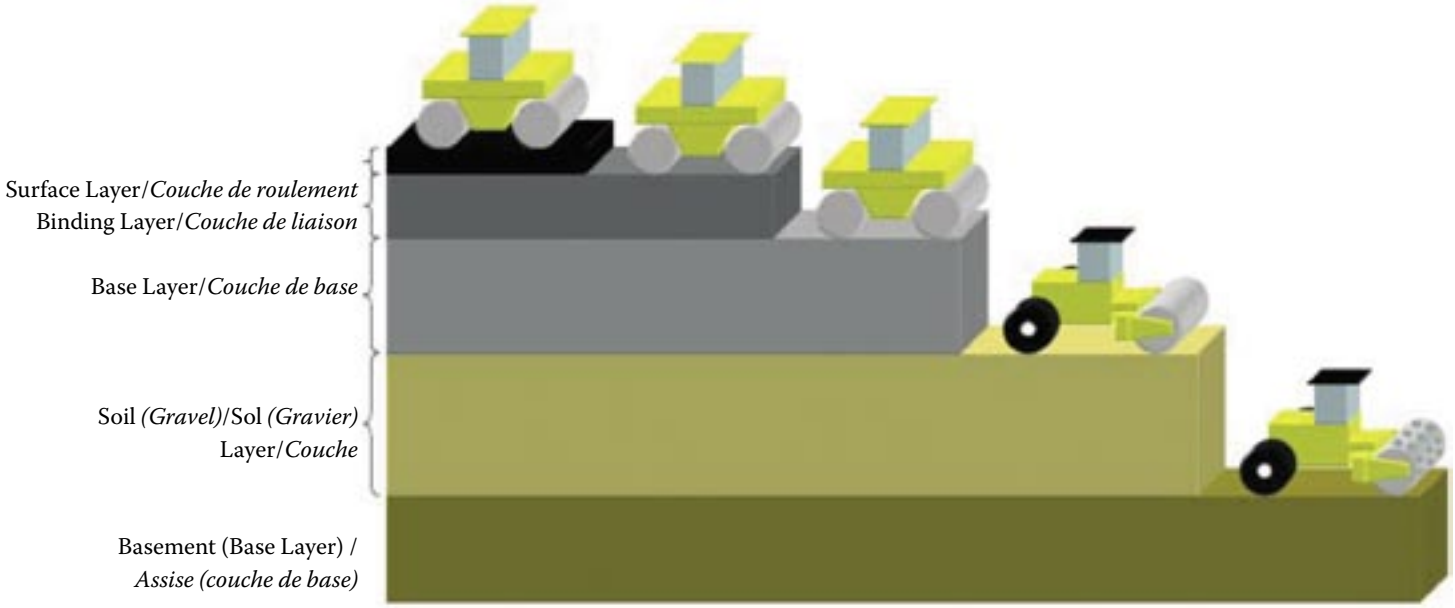

Figure 4 © *Ammann Group, 2008*

The calculation model is composed of a simple set of equations and enables estimating the total GHG emissions (outputs) generated by each emission source preliminarily identified and quantified (inputs). The calculations undertaken refer to the entire life cycle of the road infrastructure and are repeated for different scenarios and different construction techniques.

Results are expressed in terms of Tons of Carbon Dioxide (CO_2).

Model strengths

Throughout its development, the calculator tool has been tested and output has been compared with an extremely diverse range of situations.

The basic data were collected in close collaboration with IRF members agreeing to be partners to this research project.

Among the data collected, distinctions are drawn between:

- the inventory of emission sources,
- data and standards relative to the evaluation of these emission sources,
- the database of emission factors pertaining to the set of identified sources.

As the research project unfolded, the information compiled was submitted for an assessment by competent experts across the various regions of the world. As a result, beneficial suggestions were received and incorporated, a step that serves to complement the database and lends a global dimension to this effort.

The emission factors database is currently undergoing scientific evaluation by the LAVOC Traffic Facilities Laboratory at Switzerland's Ecole Polytechnique Fédérale in Lausanne (EPFL).

Validation process

In addition to validating the individual databases mentioned above, we have performed the following activities through the Federation's project partners:

- validation and improvement of the modeling approach and calculation equations,
- verification of the relevance of the pavement structure categories covered as well as the resultant calculations of construction materials volumes and tonnages,
- approvals for the raw material transport model developed,
- confirmation of the calculated number of construction machines working hours,
- tests and identification methods for potential modeling errors,
- comparison of the calculation model results with other sources and tools,
- use of the calculator for a practical road-building scenario.

FUTURE DEVELOPMENTS

This project's ultimate objective is to encompass the entire road infrastructure and facilities. As such, the next modules to be introduced beginning in 2009 will focus on:

- road signing (vertical / horizontal),
- safety barriers,
- waste treatment and recycling.

These modules will be added onto the base (pavement) module in order to yield a comprehensive tool. However, the individual modules will each remain a standalone component so as to respond to specific needs raised by the various potential users.

Current state of progress

We have finalized the basic "Pavement" module. The final version in Excel format will enable the development of both a web application and a desktop application for distribution on CD-ROM.

Updates

The emission standards will be reviewed on a yearly basis. The latest advances in research and most recent scientific studies will be included into regular database updates.#

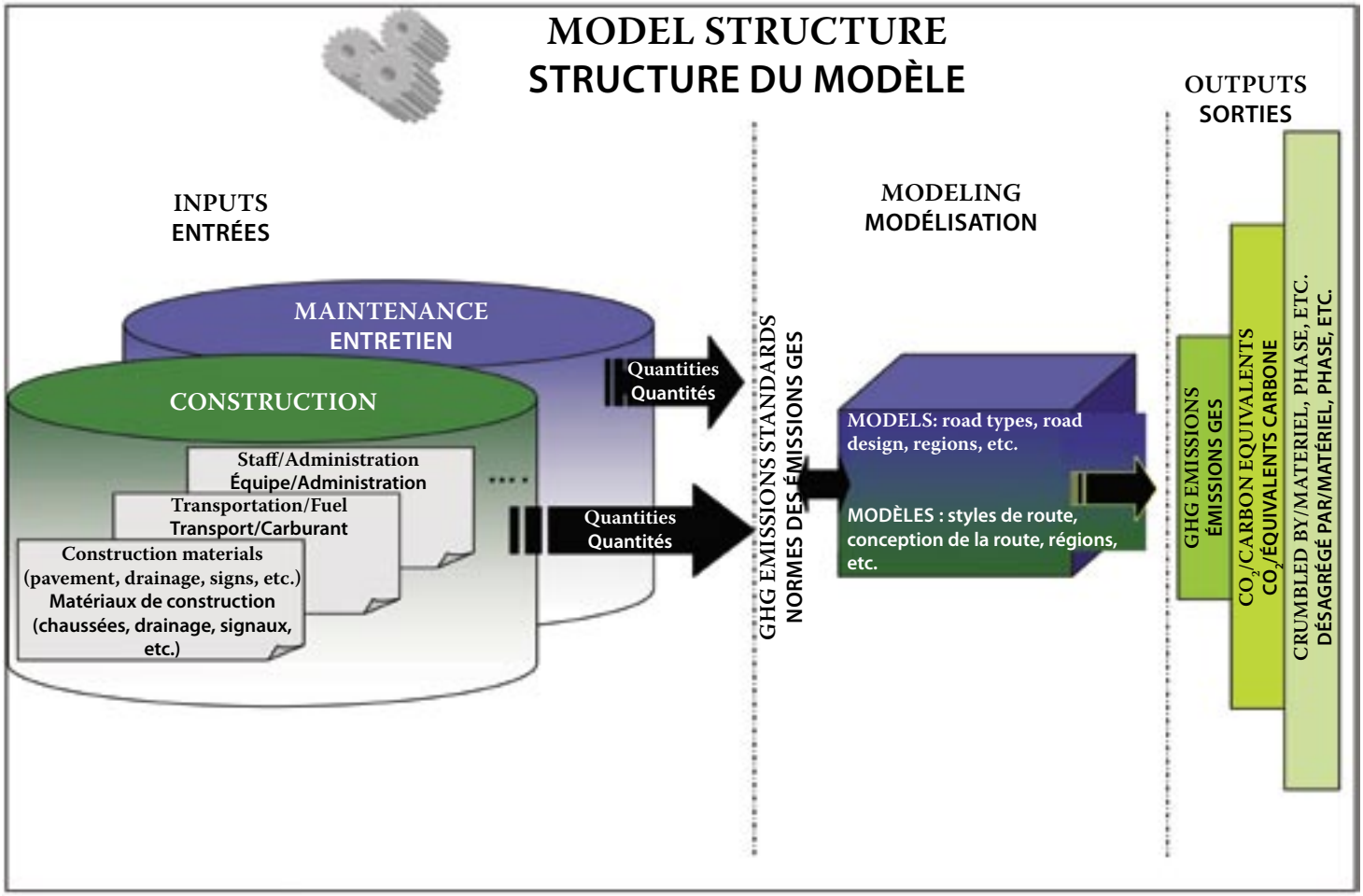

Figure 5