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The development of a road materials database for Gautrans

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Abstract:

The data required for a road materials database was identified and a basic structure formulated during 2003. A set of Excel workbooks and associated worksheets was developed as a foundation for the database and as an interim means of gathering test data. A modular approach was used to minimise processing time. This was implemented using data from a recycling project and various deficiencies were identified. The database was restructured, eliminating the Inventory module, as the existing information used in the PMS database could be used directly and data input thus minimised. The information that was in the original inventory and is not included in the PMS database has been added to the individual spreadsheets where appropriate.

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Road material database, APT, HVS, LTPP

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Develop database and implement

Related documents:

Contract Report CR-2003/25

Signatures:				
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TERMS OF REFERENCE

CSIR Transportek was requested by Gautrans during 2003 to develop a road materials database. The terms of reference for the study were to:

- Determine what data should be included in the database
- Design a database structure
- Develop an Excel spreadsheet for temporary collection of data
- Provide assistance to the database programmer during the programming of the database (programming by M Verbruggen)

The implementation phase of the project was awarded at the end of 2003 and the following objectives were identified:

- A workshop with Gautrans, CSIR and selected practitioners be held during which the database will be populated using real data (Road P243 is suggested). This will illustrate the practicalities and any problems, as well as obtaining input from the practitioners who will ultimately be responsible for providing the necessary data. It will also provide any fields that may have been omitted in the draft database (Task 1).
- The spreadsheets will then be modified where necessary before consultation with the database programmer (M Verbruggen). Initial consultation will involve aspects concerning the direct transferability of data from spreadsheets to the database to minimise data processing for each project on behalf of Gautrans. Ongoing liaison during the programming operation will be maintained to ensure that the database provides the required functionality (Task 2).
- Once the database is operational, develop spreadsheets for general use by practitioners to facilitate rapid data transferral to the database (Task 3).

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1. INTRODUCTION

Preliminary spreadsheets including all of the necessary documentation were developed during Phase 1 of this project and presented in CR-2003/25[1]. Following the award of the implementation phase of the project in December 2003, population of the spreadsheets with data obtained from a full-scale recycling project commenced. This was carried out following discussions and meetings with staff of the Gautrans Laboratory.

In this report, the findings of the discussions and spreadsheet population together with the resulting changes to the database structure are described.

2. POPULATION OF THE DATABASE

The proposal for implementation of the project indicated that a workshop with Gautrans, CSIR and selected practitioners would be held during which the database would be populated using real data (Road P243 was suggested).

Various discussions were held with Gautrans and the available information regarding Road P243 was obtained. During the discussions, it was evident that the summarised construction (as-built) records were insufficient for use in the database, as they consisted primarily of mean test results with their associated statistical properties (eg standard deviations). In order for the database to be of any benefit, the actual data at specific chainages is essential. Gautrans then obtained the more complete information for the project from the relevant consultants.

A review of this information indicated that no benefit would be obtained by holding a workshop during which this data would be put into the database, due to the anticipated duration of this exercise. Transportek thus undertook to input the necessary data in order to identify problems and shortcomings. This was done for a number of kilometres near the HVS test sites on Road P243. A meeting was then held with Gautrans and Ms Verbruggen to discuss the way forward.

At this meeting it became evident that the Inventory portion of the database essentially duplicated much of the information in the PMS database inventory. It was thus decided that this could be eliminated completely and the road materials database would be linked directly to the PMS inventory.

Certain properties included in the road materials database inventory and not included in the PMS inventory would need to be added to the materials database spreadsheets where necessary.

Similarly, the traffic component of the materials database inventory could be linked to the traffic database in use at Gautrans and thus eliminate the need for this information. It should be noted, however, that up-to-date traffic information will be necessary during use of the database for road performance modelling analysis.

The original database required climatic information (monthly rainfall) for each site. After discussions with Gautrans personnel, it was decided that this would be an onerous and probably unnecessary task. As the South African Weather Service (situated in Rigel St, Erasmus Rand: Cell 082 233 8484) maintains daily records from numerous stations around the country, it is proposed that this source of information be utilised for any climatic data required. Specific details for a road would thus need to be obtained from the nearest weather station to the road. Although it is known that rainfall is highly variable with strong localised influences, the information obtained in this manner is generally considered to be adequate. Intense rainfall that affects road performance is usually more widespread than localised rainfall that has a lesser influence on road performance, particularly of sealed roads.

3. REDEFINED DATABASE STRUCTURE

With the elimination of the inventory component of the database, additional data was necessarily required in the road data component. In addition, the use of links as would be defined in the inventory falls away and for each road a continuous record of material and test information by chainage is developed.

Redefinition of the spreadsheets also indicated that single structures for each component (layer) of the road including all roads would be cumbersome. It was thus decided that separate workbooks be retained for individual roads in which all data pertaining to each pavement layer in the road would be entered. In this way, analysis of individual problems or sections of road would be more direct, and updating following maintenance or rehabilitation would be simpler. The road number will link each road to the inventory. Sub-levels store data on the subgrade, each layer and the surfacing with additional sublevels storing data on the specific base and surfacing design details. These include specific investigations such as stabilization designs for treated materials, Marshall testing for asphalt, concrete mix designs and specialised testing such as dynamic triaxial testing.

The following minimum data requirements were considered necessary:

Subgrade

- Chainage
- Grading (per cent passing 63, 53, 26.5, 19, 13, 9.5, 6.7, 4.75, 2.0, 0.425 and 0.075 mm sieves), grading modulus and maximum size)
- Atterberg Limits (liquid limit, plastic limit, plasticity index, bar linear shrinkage)
- Mod AASHTO maximum dry density and optimum moisture content
- California Bearing Ratio (at 100, 98, 95 93 and 90 per cent Mod AASHTO compaction) and swell
- Material classification (Weinert[2], COTO[3] and AASHTO[4])
- Field information (density, moisture content and relative compaction)

Lower selected and upper selected layers

- As for subgrade; plus
- Thickness

Lower and upper subbase layers

- As for selected layers; plus (for pre and post construction)
- Stabilizer detail (type, content, unconfined compressive strength (UCS), indirect tensile strength (ITS) and initial consumption of stabilizer (ICS))

Base

- As for subbase layers; plus
- Aggregate strength data (10%FACT, ACV, wet/dry 10%FACT ratio)
- Flakiness

Base design detail

Untreated material

- Chainage and sample number for material removed from the road
- Borrow pit number and sample number for material sampled in borrow pits
- Grading (per cent passing 63, 53, 26.5, 19, 13, 9.5, 6.7, 4.75, 2.0, 0.425 and 0.075 mm sieves), grading modulus, maximum size and flakiness index
- Apparent relative density, bulk relative density and water absorption
- Atterberg Limits (liquid limit, plastic limit, plasticity index, bar linear shrinkage)
- Mod AASHTO maximum dry density and optimum moisture content
- California Bearing Ratio (at 100, 98, 95, 93 and 90 per cent Mod AASHTO compaction) and swell
- Material classification (Weinert, COTO and AASHTO)
- pH, electrical conductivity and soluble salt content
- Aggregate Strength (10%FACT, aggregate crushing value (ACV), aggregate impact value (AIV))
- Durability (durability mill index (DMI))

Treated material (cementitious stabilizers)

- Stabilizer type and content
- ICS
- Strength (UCS, carbonated UCS, ITS and strain at break)

- Atterberg limits after treatment
- Durability (wet and dry brushing, erosion, erodibility)

Treated material (bituminous stabilizers)

- Stabilizer type and content
- Strength (UCS, ITS and strain at break)
- Atterberg limits after treatment
- Durability (test to be determined)

Prime

- Chainage
- Prime type
- Application rate
- Spray temperature
- Kinematic viscosity

Tack coat

- As for prime

Surfacing

- Chainage
- Seal
    - Average least dimension (ALD)
    - Aggregate strength (10%FACT and ACV)
    - Water absorption
    - Binder application
    - Stone application
- Asphalt
    - Marshal stability and flow
    - Maximum theoretical relative density and bulk relative density
    - Thickness
    - Density
- Concrete
    - Strength

Reseals

- As per surfacing

Surfacing design detail

- Source (stone, binder, batching plant)
- Aggregate

    - Grading analysis
    - Flakiness index
    - Average least dimension
    - Sand equivalent
    - Durability (10%FACT, aggregate crushing value (ACV), polished stone value (PSV))
- Binder/asphalt
    - Penetration (before and after rolling thin film oven test)
    - Softening point (before and after rolling thin film oven test)
    - Viscosity (before and after rolling thin film oven test)
    - Ductility (before and after rolling thin film oven test)
    - Spot test
    - Adhesion
    - Water content
    - Particle charge
    - Binder content
    - Permeability
- Marshall mix design properties (voids in mix, voids in mineral aggregate, indirect tensile strength, dynamic creep)
- Ball penetration
- Concrete
    - Water : cement ratio
    - Cement content
    - Slump
    - Strength

Cross-reference to relevant paper files and reports on seal/asphalt/concrete design must be included. In addition any other reports relating to the road, such as rehabilitation designs, deflection measurements (usually related to the PMS or investigations of specific problems) must be cross-referenced.

In order to optimise use of the database, an effective search facility that can isolate and extract data for individual projects, test methods, material types, climatic indices, etc will be essential.

4. DEVELOPMENT OF THE DATABASE

The revised database structure was applied to the workbook and the formats modified. Each project will only consist of one workbook, with up to eleven (11) individual spreadsheets. Only the relevant spreadsheets need be completed for each road. Where rehabilitation or maintenance is carried out, only the information pertaining to the new works (often only base and surfacing) will be available. Information related to the underlying layers will need to be extracted from older records in order to build up a complete database for each road.

The workbook for each road consists of the following worksheets:

- Subgrade
- Lower selected layer
- Upper selected layer
- Lower subbase
- Upper subbase
- Base
- Base design detail
- Prime
- Tack coat
- Surfacing
- Surfacing design detail

The data requirements listed in Chapter 3 are accommodated in these worksheets.

Examples of the worksheet formats, with data from Road P243/1 (Vereeniging to Heidelberg) are provided as an illustration in Appendix A.

To assist with data input and interpretation, many of the spreadsheet cells have been supplemented with comments boxes. These provide equivalents of drop-down menus, help screens and various pertinent comments regarding the contents and required input of the cells.

5. DATA COLLECTION AND INPUT

5.1. Existing data formats

At the end of construction, a summary of the construction process, plans, cross-sections and as-built material data is presented to Gautrans by the Consulting Engineer. This is typically in hard copy form although the materials data are often provided as electronic copies using spreadsheets. The format of these spreadsheets complies with TMH10, "Manual for the completion of as-built materials data sheets"[5].

Form AB4 in TMH10 requires most of the data specified for collection and input into the database. However, the individual data presented on this sheet cover a section of road (or job lot) and many of the requirements are presented as means and standard deviations and are thus not suitable for use in the database. The accompanying test result summaries in the control test summary files presented to Gautrans, however, contain all of the relevant information on various forms specific to the Consultant/project.

This data needs to be provided to Gautrans in the format of the spreadsheets provided (Appendix A) for direct input into the database.

5.2. Database input

Extracting the data from the Control Test Summary paper file was extremely time-consuming, hence the need to ensure that all test and control data is provided in the format described above. Once the database has been established and any final minor changes made to the spreadsheets, it is recommended that all Consultants engaged for supervision of Gautrans Projects make use of these spreadsheets on their projects. Data can then be transferred directly into the database from these spreadsheets.

If the data is not provided in such a standard format, it is unlikely that this data will ever be captured effectively into the database, based on the pure volume of data generated during typical projects.

5.3. Specific Design Data

For treated base and surfacing designs in particular, design testing is carried out early in the project. This necessarily requires the use of randomly selected borrow pit samples, centre line samples on recycling projects, or samples from quarries or batching plants. The test results obtained are thus not necessarily related to any specific chainage on the road. During designs involving treatment of materials using, for example, bitumen, cement or lime, numerous tests to determine optimum stabilizer contents, material strengths or moduli, durability, etc are carried out. The tests selected and the test parameters (eg confining pressures and loading rates in triaxial tests) tend to vary from laboratory to laboratory and depending on the pavement design parameters. Much of this data is often available only in the form of design reports or documentation and these need to be filed in a system that can be easily accessed according to the report numbers recorded in the appropriate spreadsheets and database files.

5.4. Responsibilities

It is important that a Gautrans staff member is appointed as a champion of the data base, to ensure that all data is collected, entered into the data base and properly verified. This person would also liaise with the Project Engineer for all projects to ensure that the data is presented in the correct format and is manageable. The need for the data to be presented in the appropriate format should be included in the contract documentation for each project.

6. CONCLUSIONS

Following the initial development of the input needs for a road construction materials database, various implementation requirements arose. This report summarises the refinement of the spreadsheets developed for data input into the database following discussions and after carrying out a data entry exercise. Various changes to the proposed database were considered necessary to minimise the effort and time needed to capture the data.

The most important of these was to eliminate the need for a data inventory for each road and using the existing PMS data inventory records.

Revised spreadsheets that will allow all of the pertinent data to be captured on site and transferred directly to the database have been prepared.

7. REFERENCES

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APPENDIX A

SPREADSHEET FOR TEST DATA CAPTURE

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