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SOFTWARE SYSTEM FOR SELECTING THE COMPOSITE MATERIAL USED TO MANUFACTURE UPHOLSTERED FURNITURE

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Abstract: *The work presents a software application used to select a material from a range of composite materials based on plant fibers. The need for the application resulted from the participation in a research project whose beneficiary is the company TAPARO SA from Targu-Lapus. The company's activity is the production of upholstered furniture, and it has developed a range of thermoplastic composite materials intended to replace wood. The selection is made according to certain requirements imposed by the beneficiaries of the finished products and the properties of the material. The application consists of a database and a graphic interface for its management.*
Key words: *software application, material selection, composite material, plant fiber, furniture industry.*

1. INTRODUCTION

Furniture industry in Romania is an economic sector, which contributes significantly to the country's GDP. It is the second largest contributor, in terms of benefit, after IT, to the production process [1].

However, furniture production is negatively influenced by unfavorable economic contexts, which can lead to its reduction. Wood shortage is one of the factors, which contributed to the decline of this activity. The limited offer of wood as raw material and the sharp increase of its price are due both to a much more restrictive legislation regarding forest exploitation, and the economic crisis triggered by the war in Ukraine.

Given that there are no strategic measures of support of this field of activity at national level, the manufacturers look for alternative solutions of replacement or reduction of the amount of wood used in furniture production. A subarea, which proves this approach feasible, is upholstered furniture production. The structure of smaller furniture pieces (stools, chairs, armchairs), or the larger ones (sofas) includes structures made of chipboard or fiberboard which can be replaced by a number of composite materials, which include composite materials made of a mixture of natural fibers with thermoplastic materials.

The company Taparo S.A. from Targu-Lapuș, Maramureș county, has been interested in the creation of this type of materials for a long time. It has completed thorough research activities within this field, through its own research department, or in partnership with different research institutions. The current paper is the result of a number of research activities completed within the project entitled "The establishment of a center of excellence within the area of composite materials at Taparo S.A.", code mySMIS 121434. Within this project, and the ones that preceded it, composite materials were developed, on an experimental basis, using specific technologies: interweaving, CAFT, La Roche.

In the production process of the new materials, a wide range of natural fibers and thermoplastics was used: hemp, flax, poplar, willow, coconut, miscanthus, polypropylene, biocomponent plastic fiber, in different combinations and percentages. Their mechanical consolidation through thermoforming was achieved based on criteria such as the number of layers of material, their orientation, temperature, and duration. Physical

and mechanical properties of the thermally consolidated composites were determined (tensile strength, elasticity modulus, Poisson coefficient, etc.) [2, 3, 4], and the possibility of redesigning a few upholstered furniture items was analyzed so that they, or parts of them, could be made of composite materials [5, 6].

The above-mentioned research proved that the range of products, which can be achieved under such circumstances, is large. The selection of the appropriate material for an application involves the consideration of criteria such as resistance to stress, cost effectiveness, product usage environment, as well as other requirements imposed by the beneficiary of the product.

In order to complete a quick search for materials that comply with the established criteria, a software system made of a database and a graphical user interface necessary for data access was conceived.

2. DESIGNING THE STRUCTURE OF THE DATABASE

2.1 General aspects

A database represents a software product, and its design involves a set of stages and principles, which should be considered when designing any product: the analysis of the requirements that the database should meet the formulation and analysis of the solutions, and the conceptual and detailed design [7, 8].

Nevertheless, there are certain aspects that characterize the design of this type of product which were considered [9].

For the design of the database, the relational model [10] was chosen, and the implementation was made using the server Oracle Database Express Edition. According to this model, the structure of the database was achieved by completing a set of specific stages, which are listed below:

- Establishment of the goal of the database.
- Identification of the necessary information to be stored.
- Transforming these pieces of information into columns by establishing the name under which they should be found in the database, the length, the type of data, the validation restrictions, etc.
- Establishing the main tables and grouping the columns into tables.
- Defining the primary keys useful for the unique identification of the information registered in a table.
- Creating the relations between the tables necessary for the establishment of a number of rules of referential integrity, and for the association between the data memorized in different tables.
- Revising the structure of the database.

At the same time, in the process of data structuring, rules of normalization were applied, which led to the completion of a structure which grants a solid database and eliminates the risk of storing redundant information.

2.2 Designing the database COMPOSITES

The realization of an application to enable the selection of composite materials based on the needs of the customers involves the creation of a database to store the data regarding the formulations of composite materials, their characteristics, the products/structures made of composite materials, customer requirements, elements necessary for the calculation of costs, etc.

The goal of the current database is the store all the information necessary for the selection of the type of composite material based on a number of criteria. They regard mainly the aspects listed below:

- Types of constituents of the composite material.
- Certain physical and mechanical parameters of the composite (strength, rigidity, etc.).
- Fire resistance.
- Aspects related to esthetics.
- Requirements regarding the cost of the product realized exclusively from composite material.

In order to achieve this goal, the pieces of information necessary for storage in the database entitled COMPOSITES were identified, and the tables in which they are included were established, according to table 1.

Table 1

List of tables in the structure of the database

No.	Name of the table	Contents
1.	MATERIALS	General data which describe the type of composite material.
2.	CONSTITUENTS	Data regarding the types of constituents that can be part of the composite materials.
3.	FORMULATIONS	Data regarding the composite material's formulation: type of constituents, their percentage.
4.	MATERIAL PROPERTIES	Data regarding the physical and mechanical properties of the composites.
5.	TECHNOLOGIES	Data regarding the codification of the technologies used to obtain the composite materials.
6.	EXPOSURE TYPES	Data regarding the codification of the manner of exposure of the composite material.
7.	CONSTITUENT TYPES	Data regarding the codification of the types of constituents.

Details regarding the structure of the first four tables are shown in figures 1-4.

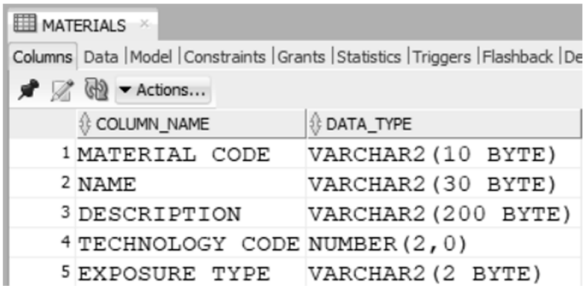

Fig. 1. Structure of the table MATERIALS

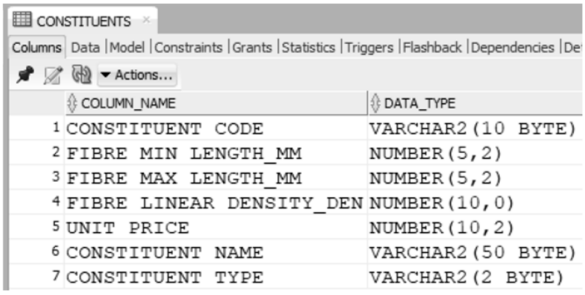

Fig. 2. Structure of the table CONSTITUENTS

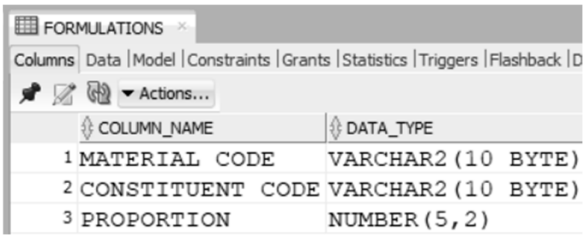

Fig. 3. Structure of the table FORMULATIONS

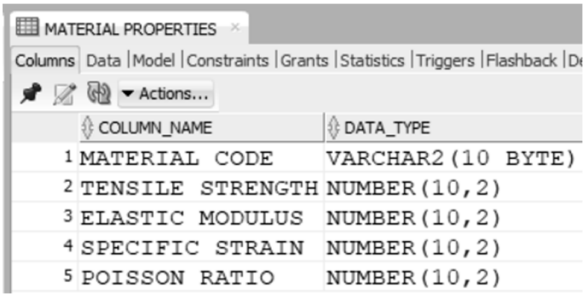

Fig. 4. Structure of the table MATERIAL PROPERTIES

In the case of most of these tables, primary keys were used as they are necessary both for the unique identification of the rows of data, and the establishment of the connection between the tables. Details in this sense are presented in table 2.

Between any two tables that comply with the necessary requirements, links were made by adding a foreign key, and rules of referential integrity were imposed with the goal of keeping the integrity of data.

A list including the linked tables, the columns included in the foreign key, and the relationship type is presented in table 3.

The last stage of the process of conceptual design of the database COMPOSITES consisted of a revision of its structure.

Thus, the degree to which certain requirements regarding the normalization of the database are met was checked.

Table 2

List of primary keys

No.	Name of the table	Structure of the primary key
1.	MATERIALS	MATERIAL CODE
2.	CONSTITUENTS	CONSTITUENT CODE
3.	FORMULATIONS	MATERIAL CODE, CONSTITUENT CODE
4.	MATERIAL PROPERTIES	MATERIAL CODE
5.	TECHNOLOGIES	TECHNOLOGY CODE
6.	EXPOSURE TYPES	EXPOSURE TYPE
7.	CONSTITUENT TYPES	CONSTITUENT TYPE

Table 3

Details regarding the foreign keys

No.	Parent table / Child table	Foreign key structure	Type of relations
1.	TECHNOLOGIES/MATERIALS	TECHNOLOGY CODE	one-to-many
2.	EXPOSURE TYPES/MATERIALS	EXPOSURE TYPE	one-to-many
3.	CONSTITUENT TYPES/CONSTITUENTS	CONSTITUENT TYPE	one-to-many
4.	MATERIALS/FORMULATIONS	MATERIAL CODE	one-to-one
5.	CONSTITUENTS/FORMULATIONS	CONSTITUENT CODE	one-to-many
6.	MATERIALS/MATERIAL PROPERTIES	MATERIAL CODE	one-to-one

Consequently, a flexible structure of the database was obtained that will make possible the completion of potential subsequent changes by reducing resources and costs.

3. DESIGN OF THE GRAPHICAL USER INTERFACE FOR THE ACCESS OF THE DATABASE COMPOSITES

3.1. General considerations regarding the design of the graphical user interfaces

A designer of a database can have access to the data stored in it, in an easier manner, only by means of using an interface delivered by the company which produces the management system of the database. This manner of interacting with the database is "secured" through the professional training of the IT specialist.

Things are different in the case of the users that are not familiar with the management systems used when creating the database. They need interface applications to guide and control them in terms of access to the data, rules regarding data editing, etc. The graphical interfaces offer the users the possibility of working intuitively with the database, by activating certain graphic elements representing windows, menus, groups of pages, keys, navigation toolbars, areas of text editing, etc.

Similar to the case of databases, the design of graphic interfaces requires the compliance with certain specific principles, such as: simplicity, esthetics-use balance, visual and functional density, user-friendliness, easy assimilation, effectiveness, insurance of feedback and control, etc. [11, 12].

3.2. Design of the graphical interface SELCOMPAPP

3.2.1. Conceptual design

At conceptual level, the starting point of the graphic interface SELCOMPAPP is the main window of the application (figure 5).

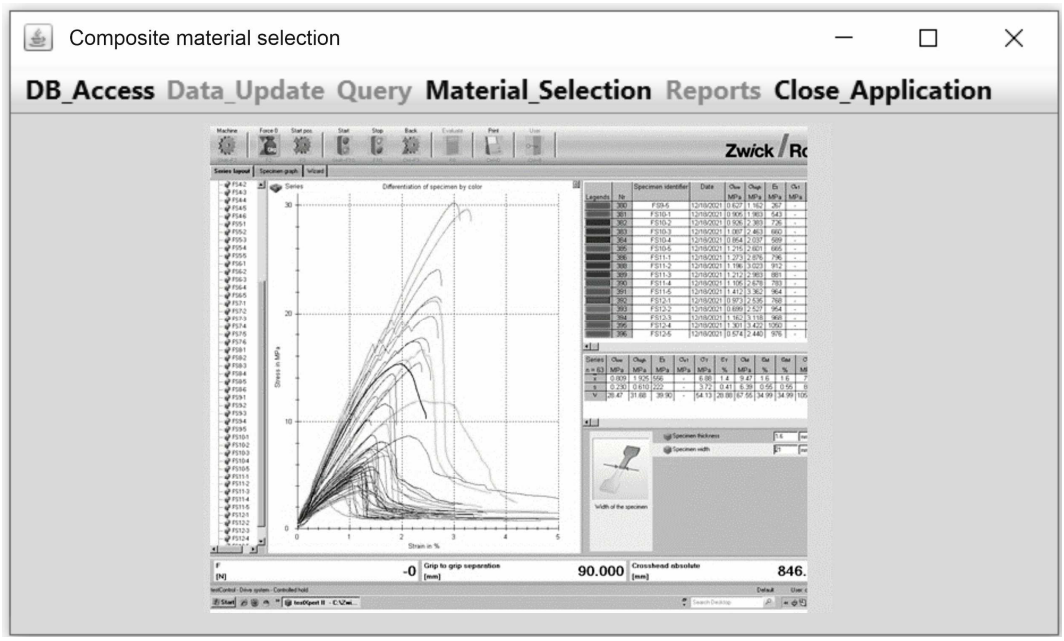

Fig. 5. Main window of the application SELCOMPAPP

A system of menus is attached to it, and this ensures the functionality of the application.

The application is conceived as a set of modules, each of them solving a category of tasks, namely:

- Module for connecting to/disconnecting from the database COMPOSITES.
- Module for updating the data in the database.
- Module for querying the database.
- Module for selecting the composite material depending on certain criteria.
- Module for report completion.
- Module of connecting to/disconnecting from the database.
- Module of data updating.

3.2.2. Detailed design

The application is designed using the platform Java Standard Edition and the technology Java DataBase Connectivity (JDBC). JDBC is a standard interface of application programming, which allows the connection between a server of relational database and of programs written in Java.

JDBC consists of a set of classes, which mediate the realization of the connection with most of the systems of management of relational databases (SGBD), including Oracle, the running of SQL statements, and the processing of their results.

In what follows details regarding the design of two components of this application are presented, namely:

Design of the module for connecting to/disconnecting from the database

The interaction of a user with the database COMPOSITES requires the use of an account created and stored apriori in the database. The limits of this interaction are established by assigning certain privileges of access to the objects in the database.

This module is integrated in the application SELCOMPAPP through the first menu (object *accessDB*) and the two menu items (the objects *connect* and *disconnect)* which belong to the menu toolbar *mainMenu* attached to the main window of the application (figure 6).

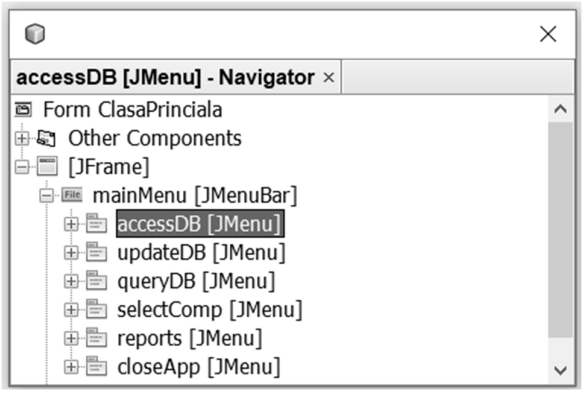

Fig. 6. Application menu

The answer of the application to the pressing of any of these items is described in the *actionPerformed()* associated method. To exemplify this, the method *connectActionPerformed()* is presented in figure 7.

```
1494    private void connectActionPerformed
1495        connectD.setVisible(true);
1496        connectD.setLocation(500, 300);
1497        connectD.pack();
1498    }
1499
```

Fig. 7. Method *connectActionPerformed()*

When using this method, the dialog window *connectD* becomes visible, and the user provides his credentials. The validation of the credentials and the access/denial to the database constitute the code of the method *confBActionPerformed()* of the button *confB* contained by the *connectD* window (figure 8).

When the end of work with the application SELCOMPAPP is desired, disconnection is possible by selecting the menu item *disconnect* from the menu *accessDB*.

```
private void confBActionPerformed(java.awt.event.ActionEvent evt) {

    utiV = utiT.getText();
    char[] tabC = parP.getPassword();
    parV = new String(tabC);
    String connString = "jdbc:oracle:thin:" + utiV + "/" + parV + "@127.0.0.1:1521
    try {
        ods = new OracleDataSource();
        ods.setURL(connString);
        con = ods.getConnection();

        informPanel.showMessageDialog(connectD,
                "Success! The connection to database is working.");
        disconnect.setEnabled(true);
        queryDB.setEnabled(true);
        updateDB.setEnabled(true);
        reports.setEnabled(true);
    } catch (SQLException ex) {

        informPanel.showMessageDialog(connectD,
                "Wrong credentials!", "Error Message", informPanel.ERROR_MESSAGE);
    }
}
```

Fig. 8. Definition of method *confBActionPerformed()*

Design of the module of data updating

The module of data updating is reachable by means of the menu *updateDB* (figure 9).

The application SELCOMPAPP is conceived to include code sequences to update every table in the database COMPOSITES (FORMULATIONS, MATERIALS, CONSTITUENTS, etc.). In order to illustrate this, the project of the component of updating is briefly presented in the table FORMULATIONS.

Its functionality is achieved through the methods associated with the graphic objects included in the dialog window *updFormulationsD* (figure 10).

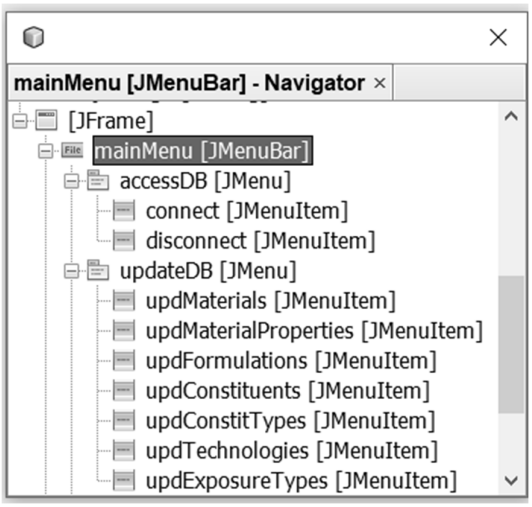

Fig. 9. Menu for data updating

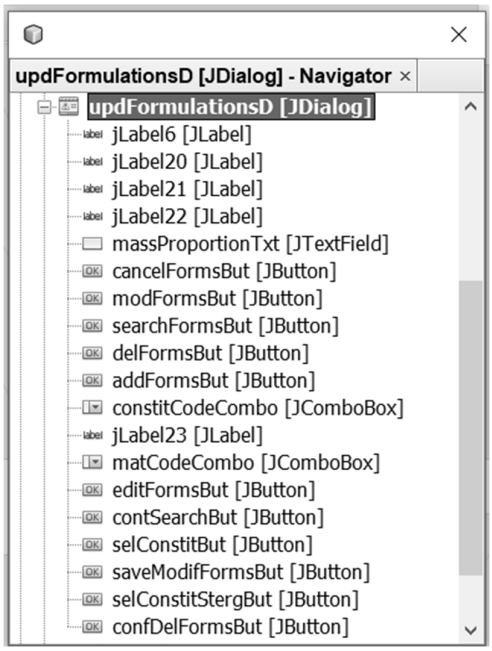

Fig. 10. Components of the dialog window *updFormulationsD*

The areas in the form assigned to the selection of the material and the constituents of a recipe (the objects *matCodeCombo* and *constitCodeCombo*), of JComboBox type, as well as the display/editing of the proportion of a constituent in the structure of the network (control *massProportionTxt*) are in a disabled mode before any action.

Their activation takes place when the user presses any of the buttons *editFormsBut* ("Edit"), *searchFormsBut* ("Search"), *modFormsBut* ("Modify"), or *delFormsBut* ("Delete").

When adding new records, or editing the existing ones in the database, after the preparation of data in the form, the action of the user will end successfully only if the data pass a validation test. Some of the validation conditions are listed below:

- The code of the material should be completed;
- The code of the constituent should be selected;
- The proportion of the constituent should belong to the interval (0,100];
- The sum of the proportion of every constituent of a recipe should not exceed 100 %.

It is important to underline that a great deal of the design of the application of interface with the database is not the object of the current paper.

4. CONCLUSIONS

The software system made of the two software products, the COMPOSITES database and the graphical user interface SELCOMPAPP, represent a necessary and useful tool in terms of selecting the composite material based on certain criteria, granted that the type materials can vary to a large extent.

In the process of designing the database, all the necessary pieces of information to be included in the database were identified.

The data structuring and its grouping into tables was made by applying the rules of normalization meant to avoid the risk of producing anomalies when adding, modifying or changing data.

Given that finding data regarding an entity, such as a particular material, for example, involves searching of information through different tables, primary and foreign keys were added. For the latter, rules of referential integrity were set with the aim of obtaining a robust and reliable database.

Also, considering the fact that the process of creation of the database concept included specific stages and principles of design, a database with a correct structure was obtained, which makes it possible to achieve potential subsequent upgrades with minimal costs.

The completion of the system with the graphical interface SELCOMPAPP was the result of the need to offer the users of the database an intuitive, effective, and reliable tool of access to the data, one that does require familiarity with the area at stake.

From a technical point of view, the interface application was created in the Java Standard Edition platform, by using the collection of classes JDBC and a specific driver to work with Oracle databases.

So far, the designed interface has ensured the connection to the database and the updating of its data. Its functionality is to be completed by the addition of new components necessary for it to achieve the goal for which it was designed.

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SISTEM SOFTWARE PENTRU SELECTAREA MATERIALULUI COMPOZIT UTILIZAT LA FABRICAREA MOBILEI

Rezumat: Lucrarea prezintă o aplicaţie software utilizată la selectarea unui material dintr-o mulţime de materiale compozite obtinute din fibre vegetale. Necesitatea aplicaţiei a rezultat din participarea într-un proiect de cercetare al cărui beneficiar este compania TAPARO SA din Târgu-Lăpuş. Activitatea acestei companii constă în producerea de mobilier tapiţat. Aceasta a dezvoltat o gamă de materiale compozite termoplaste cu scopul de a înlocui lemnul din structura unor astfel de produse de mobilier. Selectarea tipului de material se face în funcţie de anumite cerinţe ale beneficiarilor produselor, dar şi în functie de anumite proprietăţi ale materialelor. Aplicaţia constă într-o bază de date şi într-o interfaţă grafică necesară accesului la datele acesteia.

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