training should not be a goal, but a condition for learning process radically different from subject-oriented approach realized before. In this case a teacher has to be a technical assistant with organizational and consultant functions in joint labour [3].

The urgency of determining pedagogical conditions for potential application of creative activity in technology training shows the necessity of conducting research in this area.

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Experience in Design and Implementation of Educational Software within Strength of Materials and Structural Mechanics Disciplines, TSUAB

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Abstract

The article presents the results of software implementation into education process provided by the department of "Structural Mechanics", TSUAB. These software packages are intended to solve problems in the disciplines "Strength of Materials" and "Structural mechanics". They allow checking the correctness of manual calculations, rapidly finding and eliminating the mis-takes being made, avoiding a great number of typical calculations. The de-veloped software packages are characterized by advanced interface; the ini-tial data are presented in a way that is familiar for students; the software packages are free.

Key words: strength of materials, structural mechanics, educational software, generator of "bending" problems.

Modern higher education could hardly be imagined without application of computing techniques. At civil construction universities, delivery of the disciplines related to material strength issues should be always supported by software LIRA-SAPR, SCAD for civil and structural engineering [1, 2]. Unfortunately, time is always required to examine and properly apply the mentioned and analogous software packages. In most cases, discipline curricula do not include time to study these software tools. In addition, the software packages provide the final calculation results based on the initial data without showing the whole calculation process. This fact impedes stage-by-stage evaluation of students' knowledge. Due to the mentioned facts, a number of universities have developed their own software packages for problem solving within such disciplines as "Strength of materials" and "Structural mechanics" [3–6]. As a rule, these software packages are available only for students of these universities. Mathcad, Microsoft Excel and etc. allow solving only those problems for which solution templates have been preliminary developed [7, 8].

Since 1995, in the Department of Structural Mechanics, TSUAB, free educational software for engineering calculations and graphical design has been developed [9–12, 14–18]. These software packages are aimed at problem solving within certain blocks of the above-mentioned disciplines, therefore, students need little time to familiarize with them; as a rule, for this purpose an educator should show the way initial data are prepared and calculations are done based on the example of one typical problem. All input data are not different from the information studied within the course and graphically shown including

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sizes, types and location of control network and acting loads.

The main advantage of the software is the possibility to evaluate students' knowledge at each stage. They allow quickly identifying and correcting the mistake in complex problems, for example, at calculating statically indeterminate systems via the force method or displacement approach. Solving a number of problems, for example, when designing a bending line of a beam, calculating three-hinged arch or solving flat stress problem, a student has to do a great number of basic calculations by himself/herself. When applying the developed software, in the case of correct calculations a student is provided with the calculation results in terms of distribution diagrams, deflections, deviation angle, etc. which he/she can apply in further engineering calculations and graphical design. All software packages are designed using Object Pascal programming language in visual environment Borland Delphi 7 [13].

The software "GeomW" [10, c. 3–20, 14, 18] is intended to calculate geometric characteristics of plane cross section (fig. 1). To prepare the initial data, all sections are divided into simple figures: rectangular box, right triangle (left), semi-circumference, quadrant, flanged beam, U-section, equal angle, unequal angle (right, left). For each figure, relevant dimensions, geodetic control network and deviation angle in respect to the initial location are input. The rolled sections are selected from gage materials provided by the software. The geometric characteristics of the entire section are control values and hidden from a user. Incorrectly calculated values are colored. In this case, a student is able to find mistake in calculations checking the values of geometric characteristics of each figure. Formulas for simple figures and gage materials of the rolled sections are given as reference data.

The software "BeamW" [10, pp. 21–29, 18] builds distribution diagrams of bending moments and deviation angles in statistically determined beam (fig. 2). For calculation, the initial parameters method is used. The initial data are as follows: beam length; cross-section coordinates; data on the loads acting on a beam. The control values are reaction of support, bending moments and transverse forces in two selected sections; deflection and deviation angle in one section. The calculation results are given in the software window if the corresponding control values are correctly determined. If necessary, it is possible to check the correctness of initial data determination – deflection and deviation angle at the central point.

AstraWMs" and "AstraWMp" [15, 18] are used by students for engineering calculations and graphical design on the following topics "Calculation of statically

Fig. 1. Windows of software for calculating geometric characteristics of plane cross sections

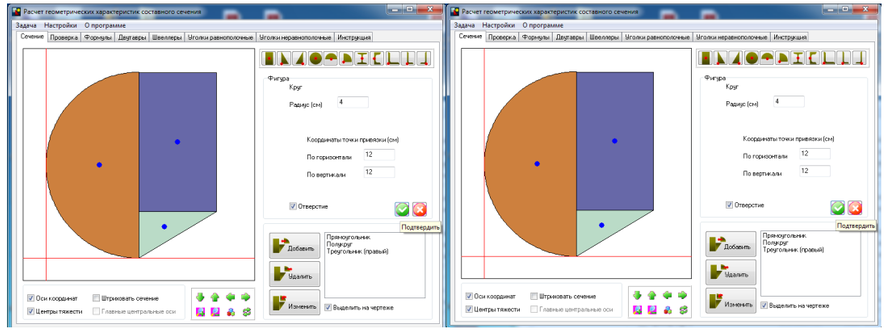
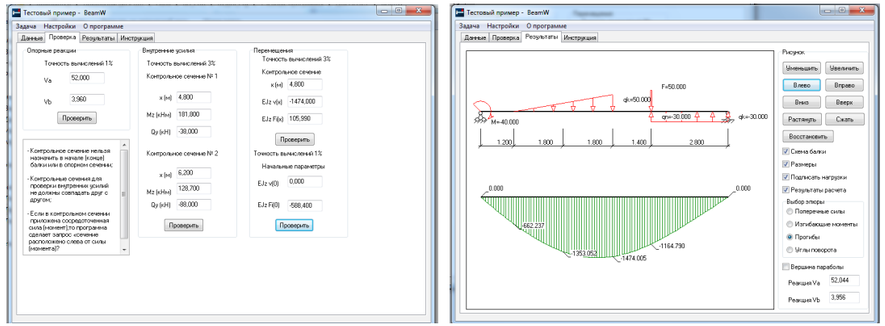


Fig. 2. Windows of the software to calculate beam deflection

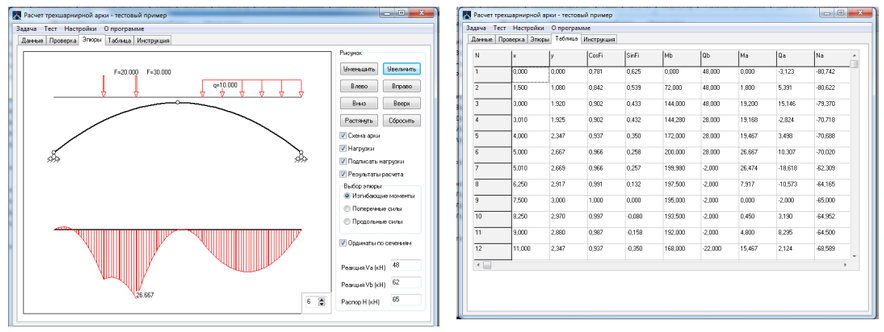


indeterminate systems via the force method" and "Calculation of statically indeterminate systems via the displacement approach". A student is provided with an opportunity to check the correctness of manual calculations in terms of building distribution diagrams showing bending moments; calculations of canonical equation coefficients; calculations of indeterminate values; building of final distribution diagrams of internal forces. The software is equipped with a wide range of filters, zooming application, distribution of forces based on the elements, etc. The calculation is rooted in the finite elements method which is a basic one in engineering construction analysis [19].

Software "ArkaW" [10, p. 30–38, 18] allows defining internal forces and reaction of supports in the three-hinged arch (fig. 3). A student manually calculates the bending moment, traverse and longitudinal forces for a control section of the arch; if the results are correct, they are shown on a display screen including data on all sections (table of values, distribution diagrams of internal forces).

Assessment of students' knowledge is an integral component of education (admission tests, current tests, final tests). Software TestW [16] is intended for assessing students' knowledge of the disciplines related to material strength issues and is operated in two regimes (fig. 4). The first regime involves formulation of questions and possible answers. To develop a test, it is required: to provide the title of the discipline;

Fig. 3. Windows of software for calculating three-hinged arch



to provide the title of the discipline block and upload the question which has been preliminary saved as PDF file. Depending on the question type, a type of an answer is selected (single selection answer, multiple choice, round figure, real number, word). The software allows editing the question, provides a certain number of points for a correct answer, includes a question into the base (excludes from the base). Knowledge assessment is carried out either within one discipline block or throughout the discipline (in this case the set number of questions is randomly chosen from the question base). To date, the department of Structural Mechanics (TSUAB) has developed the test in the following disciplines: "Engineering Mechanics", "Material Strength", Material Resistance", "Elastic Theory", "Numerical methods for calculating engineering constructions", "Nonlinear problems of structural mechanics".

The software "Beams_frames" [17, 18] allows checking the correctness of calculations of support reaction and internal forces in the statistically determinant beams and frames (fig. 5). The computational algorithm of the software is based on the finite elements method. The bending moments, traverse and longitudinal forces are measured at the beginning and the end of each section. In the case of correct calculations, distribution diagrams of internal forces with characteristic offsets are shown on a display screen. The software provides students with opportunity to create the calculating schemes in two ways: randomly specified by a user or set according to the requirements of engineering calculations and graphical design performed in the Department of Structural Mechanics. In addition, there is a tab where the problems of various difficulty are generated. The initial data in terms of section sizes, places of acting forces and force values are randomly selected. This generator is recommended for independent student work, for instance, training for final certification.

All software packages are registered in the Record of Software Applications and available as EXE files [18]. In addition, software instructions, lectures, presentations, reference books and other teaching aid are available in the website [18].

Many years of experience in application of the developed software packages has revealed the following:

- a sharp decrease in time for search and correction of the mistakes made during manual calculations, which positively affects the training process;
- engineering calculations and graphical design performed via software packages significantly increase the interest of students in the studied discipline, which, in its turn, contributes to better understanding of theoretical knowledge and acquisition of practical skills;

Fig. 4. Windows of software to design tests and students' knowledge assessment

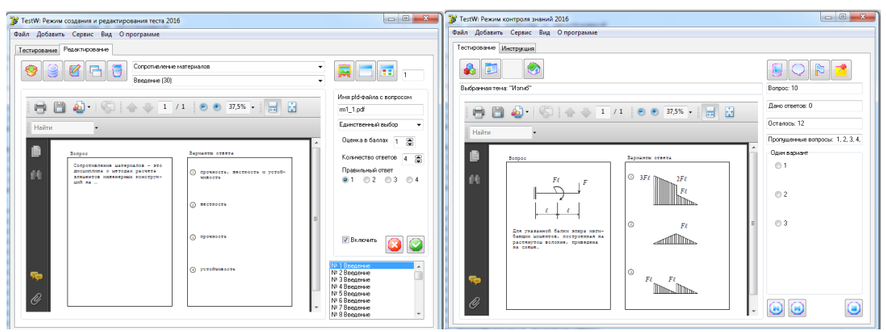
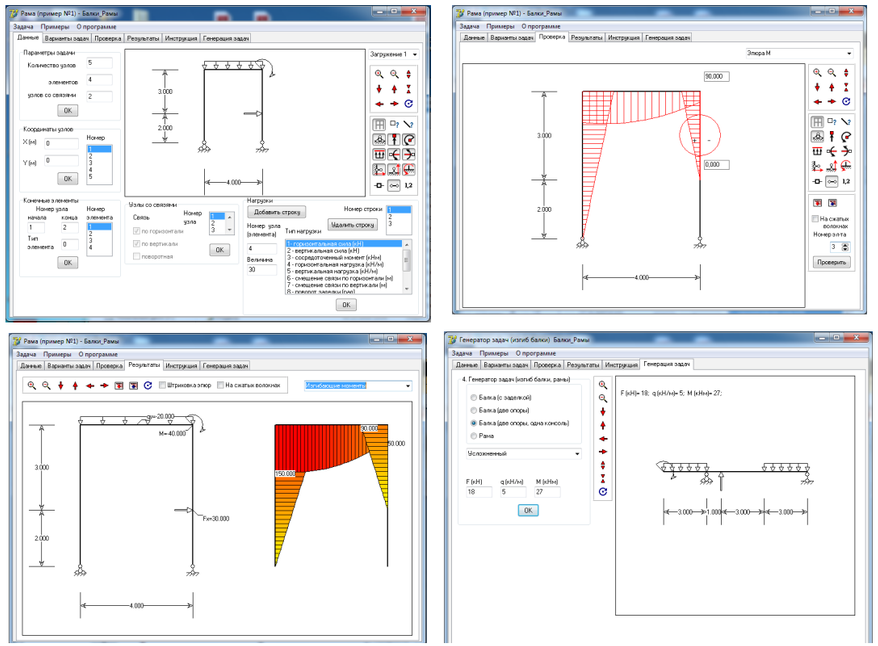


Fig. 5. Windows of software for solving problems of defining internal bending forces



- the developed software packages are particularly useful for e-learning as an effective tool of students' independent work;
- students acquire skills (calculation scheme design, preparation of initial data followed by obligatory monitoring, analysis of obtained results, search for mistakes and their correction) which are necessary for further work with software packages intended for engineering construction calculations during course paper and final paper design.

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