

Development of CAE Standardization System for Motorcycle Parts with Navigating Function for Designers

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ABSTRACT

“Motorcycle parts CAE standardization system” that focused on CAE for designers (hereafter termed “designers’ CAE”) has been developed. This system simplified the analytical condition settings by unique navigation function that was suitable for designers’ CAE, and realized prevention of redoing due to misunderstandings and operation errors. And also, the individual differences in analyses were eliminated by standardizing the methods for analysis and condition settings. In addition, the comparison of the analytical results was facilitated by the data accumulation using this system, and evaluations of the results and the fixed form report making were semi-automatically carried out by the function of “Analysis Tag.” Thus this system reduced the working hours of designers’ CAE by 75%, and enabled effective supports for design operations.

1. Introduction

With the progress of generally-applicable CAD tools in recent years, the CAE functions applicable on CAD systems have been enhanced along with the simplification of control operations. Consequently, the hurdle for designers’ CAE is lowered, and it is rapidly pervading along with an increased demand for maturation of designs on the desktop at the initial stage of the development process. In motorcycle design sections of Honda, the number of users of CAE for designers has increased approximately 2.5 times in these five years (Fig. 1).

On the other hand, there is an issue that the designers tend to forget the analysis processes and/or the operations because the majority of designers use CAE with a low level of frequency. Figure 2 shows the distribution of the frequency of use of CAE by designers. More than 50% of designers use CAE less than 20 times per year, and cases in which the designers did not use CAE for more than a year are not uncommon. For designers, CAE is a method of reviewing designs, and it is natural for them to use the method only when necessary. Such a trend is therefore a matter of course.

For designers’ CAE having such characteristics, a variety of attempts have been made such as the simplification and/or automation of operations^{(1), (2)}.

However, there are such issues that a simple automation makes the analysis process into a black box and disturbs

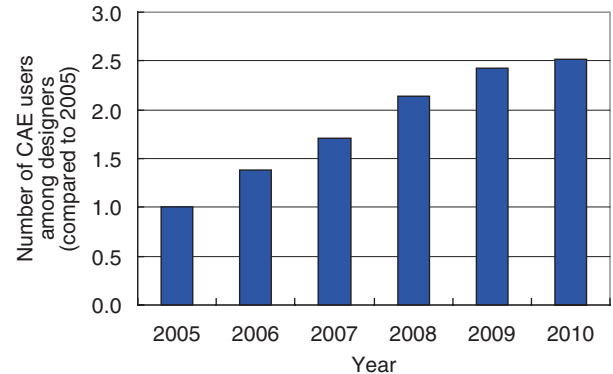


Fig. 1 Increase in number of CAE users among designers (compared to 2005)

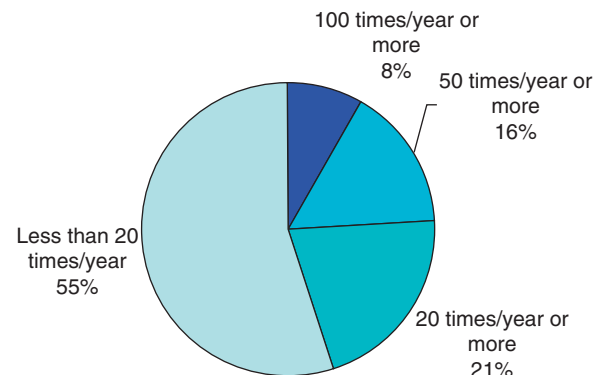


Fig. 2 Frequency of CAE use by designers

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application of CAE to other parts. In view of that, we have developed the “CAE standardization system for motorcycle parts”, which is equipped with the navigation function for easy understanding of the analysis processes, for effective use of CAE by designers. This paper introduces the features of this system and discusses its effects.

2. Issues of CAE for Designers

The following issues have become conspicuous as a result of the rapid increase in the use of designers' CAE.

2.1. Redoing in Analytic Work

Figure 3 shows a breakdown of categories for requests for support from CAE users. It can be understood from the graph that there are considerable misunderstandings and operational errors. It is thought that many cases of redoing occur until acquisition of a proper analysis result due to mistakes in areas such as settings due to insufficient knowledge and unintended operating errors, especially in the case of designers who use CAE infrequently as mentioned earlier or in the case of beginning users.

2.2. Differences in Methods and Settings between Users

Because multiple analysis conditions (including load conditions, constraint conditions, coupling conditions, and mesh settings) can be set even for identical CAE analyses, differences in terms of analytic methods and settings can occur between different users. When these types of differences exist, issues can arise especially when comparing analysis results. Even when two sets of results based on different mesh sizes exist and each one is valid individually, a comparison of such two results is inappropriate in many cases.

2.3. Effective Use of Past Analysis Results

Due to the changes of computation environment such as the advancement of hardware and applications, the size of analysis such as the analyze-able number of meshes are changing year by year. The scale of the analyses

that can be conducted using standard computational environments has increased approximately 100 times in the past 10 years. When computational environments change like this, the optimal values of elements such as mesh size settings also change. Results obtained in the past cannot be compared with the latest results under the same conditions, and it is therefore not possible to effectively use accumulated data.

2.4. Increased Work Hours due to Cumbersome Analysis Condition-setting

With the evolution of CAD tools and hardware environments, as discussed above, designers also have become able to conduct analyses of complex, large-scale assemblies. Analyses of this type necessitate a large number of troublesome condition-setting procedures, thus increasing the associated work hours.

3. Aims of System Development

The targets of system development to cope with the abovementioned features and issues of design CAE can be outlined as follows.

(1) Rather than automation of procedures, development of a navigation system for analytic procedures

Automation of CAE offers significant benefits in terms of reducing work hours and helping to prevent operational errors. However, the investigation results of parts for which the designer used CAE in recent one year showed that the frequently analyzed 10 parts made up a share of approximately 50%, while the other 50% was covered by more than 300 parts with a low frequency of analyses. The automation of analyses for all of these parts requires tremendous development work hours, which is unrealistic. Further, when the analysis is automated only for the high-frequency parts, although the automated parts can be analyzed easily, as the settings become a black box (i.e., how the analysis procedures are set up will be invisible), an application to other part will be impossible.

This system navigates a series of operations from the setting of analysis conditions up to the evaluation while keeping the user conscious of the process. Accordingly, not only the system leads the user to accurate analyses and/or evaluations, but it effectively supports designers who tend to forget operations due to a low level of frequency of conducting analysis, and at the same time allows the user to acquire skills that can be applied to other analyses.

(2) Development of a system that prevent redoes and setting differences between designers

The redoing due to misunderstandings caused by insufficient knowledge or experience and differences in methods and settings depending on the user should be prevented by standardization of setting of analysis conditions and evaluation of results, making the system such that allows proper execution of the standardized method. In addition, the redoing due to operating errors that

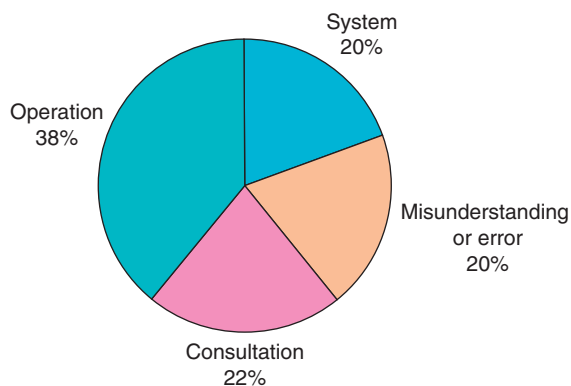


Fig. 3 Categories of requests for support from CAE users

occurs against the intention of the user should be prevented by simplification of troublesome condition settings that cause errors, and incorporation of a check tool that finds errors before execution of computation and such a process in which the user him/herself verifies the validity of the results after computation.

- (3) Development of a system that allows accumulation of analysis data under such conditions enabling its effective use

The analysis data and results should be accumulated in such a format that allows easy updating when necessary even when requiring a change of setting such as the mesh size due to changes of computation environment.

- (4) Development of a system able to reduce work hours for condition-setting

Because the increase in work hours for designers conducting CAE analyses represents a considerable burden, one of the aims for the system is to reduce work hours by simplifying troublesome and repetitive condition-setting procedures.

4. Standardization of Analytic Methods

In order to realize the aims outlined above, 15 structural parts with a high level of demand for CAE analyses were selected on the basis of the investigation of the frequency with which CAE analyses were conducted, and methods for condition-setting and evaluation of results were standardized for each part. Because the technical discussion in this paper is conducted from the system perspective, discussion of the concrete details of this standardization will be omitted. Nevertheless, the standardization of analytic methods represented an essential precondition for the development of the system. However, because only by standardization, it is insufficient for everyone to execute the method surely, the development of a mechanism that ensure adherence to the standardized analytic process is important.

5. System Configuration and Overview

5.1. Basic System Configuration

Figure 4 shows a diagram of the system configuration. Generative Structural Analysis (GSA) is a CAE function of CATIA V5, a CAD system in use in Honda⁽³⁾. Because all settings are linked to 3D-CAD data in the GSA module, analytical conditions can be set on the basis of shape alone. Due to the change from the conventional mesh-based setting to the shape-based setting, it became easy for even designers with limited experience to conduct CAE.

The developed system is built on GSA using the configuration shown above. Because all the graphical user interfaces (GUI) used by the designers work on CATIA V5, designers are able to conduct analyses using an operating environment with which they have had experience on a daily basis. In addition, the creation of a

system based on GSA functions means that it is able to be used in combination with standard GSA functions, and thus possesses a high level of general applicability.

5.2. System Overview

This section provides an overview of the system, with the footrest holder standardization system as an example. Figure 5 shows an outline of the system's navigation functions. By executing the steps in the menu from the top, the designer can properly conduct the standardized analysis and evaluate the result. In addition, as the flow of analysis itself is not peculiar for each part, the designer can naturally learn the general flow of analysis by practicing the analysis steps.

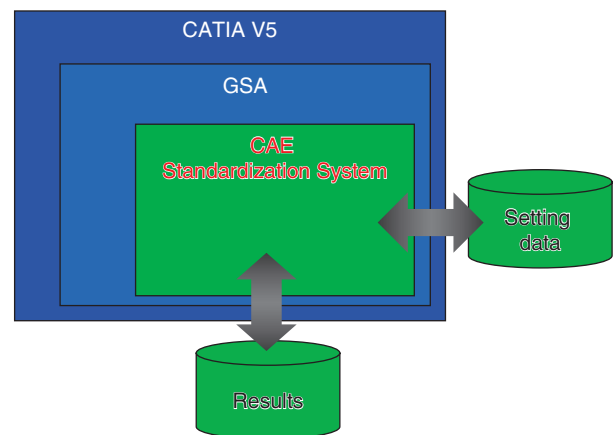


Fig. 4 System configuration

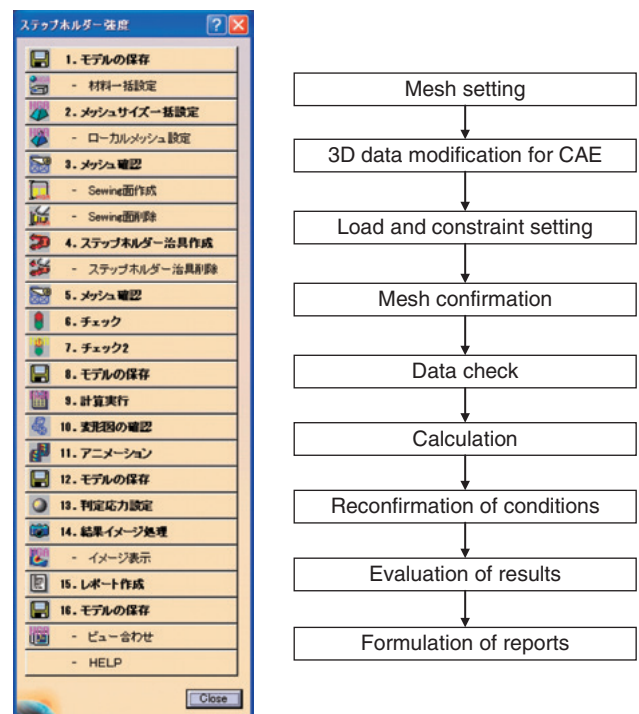


Fig. 5 Outline of navigation function

5.2.1. Mesh setting

Mesh settings such as mesh size and element types are the important condition settings when conducting CAE analysis. To eliminate the issue of difference of mesh setting depending on the user, the setting window in this system is designed in such a manner that the mesh setting determined by the standardization for each part is usually automatically input without allowing the user to make modifications (Fig. 6). However, because there are cases in which it is not possible to generate meshes for the specified settings using currently available meshers, a mechanism through which the correction of the setting was enabled by checking the modify check box, and change information from the standard was output to the report was introduced.

5.2.2. Correction of models for CAE

In recent years, simplification of shapes for use in CAE (elimination of unnecessary file, hole, etc.) is not frequently conducted, and in many cases 3D shapes for designs are used in analyses as it is⁽⁴⁾. However, there are cases in which it is necessary to correct shapes when setting conditions for CAE.

In the example of footrest holder shown by Fig. 7 as an example, while there is no necessity for 3D design drawings of the shape of the contact surfaces of the footrest bar stopper, it is necessary to set conditions for CAE.

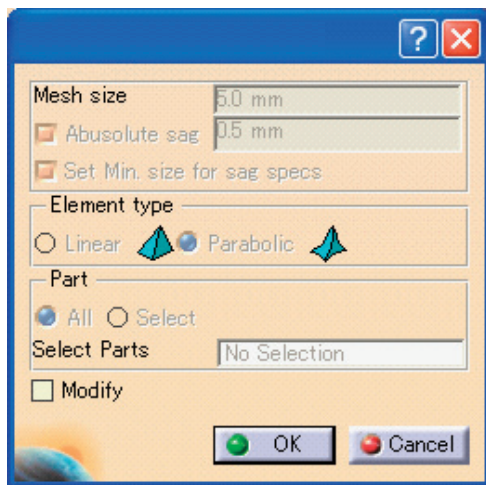


Fig. 6 Dialog box for mesh setting

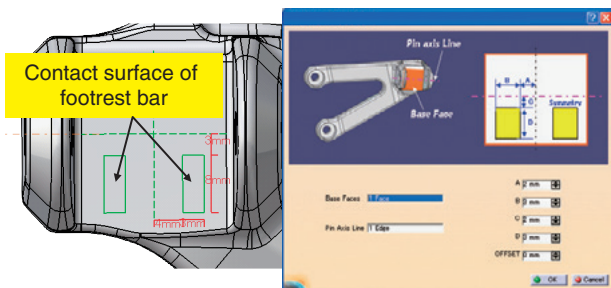


Fig. 7 Assist function for creation of contact surfaces for design of footrest bar

These contact surface shapes have to be created by a CAD function, and because this interrupts the flow of the CAE operations, the process involves a considerable amount of operating stress and a large number of work hours. The developed system permits practicing of this operation within the navigation menu without switching to the CAD function, thus reducing wasteful work hours.

5.2.3. Setting of load and constraint conditions

Figure 8 shows the window for setting load and constraint conditions. The setting of load and constraint conditions is the most important element in conducting CAE analyses, but at the same time differences between users tend to occur also in these operations. In the developed system, these operations have been simplified for correct setting of standardized conditions. With only the minimum necessary selection and input, the system permits creation of load, constraint and coupling conditions. For example, although no column for the input of load values is displayed on the window, fixed standardized values are automatically employed. The simplification not only allows observing of the standardized settings, but also reduces work hours and operation stress, and prevents mistakes.

5.2.4. Checking the mesh

The authors believe that the ultimate image of designers' CAE is that there is no need for the user to be aware of the mesh. However, at present auto-mesh functions and analytic scales are inadequate, and it is necessary to check aspects of the mesh including its density and shape prior to proceeding with computations. As indicated in Section 5.1, the current CAE function that permits setting only on the basis of the shape allows computation without viewing the mesh even once. In order to prevent such a situation, a mesh-check process was introduced to the navigation functions in the developed system.

Basically appropriate meshes are created in most cases if the standardized mesh setting is used. The deliberate addition of the mesh-check process in this system is not

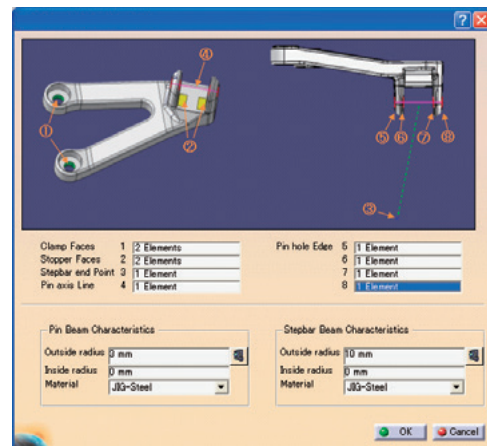


Fig. 8 Assist function for load and constraint condition setting

only for confirmation of actual operation, but also for acquisition of a regular practice for the user to make the mesh checking as a process of general analysis.

5.2.5. Model check

In the check function shown in Fig. 9, frequent misunderstanding, setting that may cause an issue although not really an error, unique prohibition, etc. are automatically checked and made visible from the type of model setting. By this means, it makes users aware of misunderstandings and errors prior to execution of the computation, and thus prevents redoing after the computation.

5.2.6. Conducting computations

When computations are conducted using this system, a use history is automatically recorded to allow for grasping of status of applications of the standardized system to each part. Based on this use history, the effects of standardization are checked, and the application of standardized procedures to new parts is reviewed.

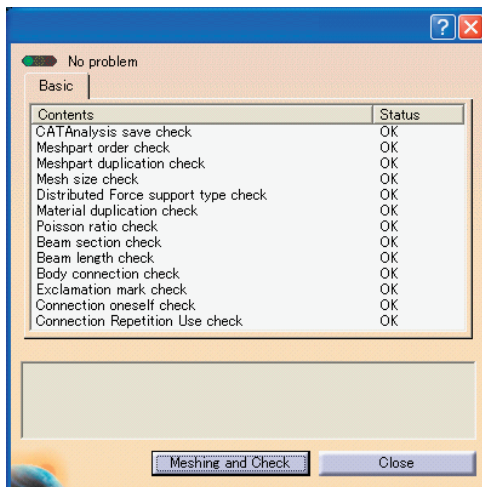


Fig. 9 Dialog box for data check function

5.2.7. Rechecking analysis conditions

When the computation has been completed, the first thing that must be done is to recheck the correctness of the computation conditions. As the most simple and effective way, the process that displays magnified deformation animation is added in this system. This makes it possible for the user to verify visually that the computation conditions had been as they had imagined.

5.2.8. Evaluation of results

In the evaluation of results of strength analysis, the maximum stress is used as the value for evaluation in many cases. Normally, a reading of the maximum value is taken by seeking the node where the maximum value is obtained in the proximity by manual operations after showing the stress distribution by a stress-contour diagram, etc. and determining where the high stress is occurring. Although some application software has a function for searching of a maximum value, as such software simply searches the maximum value of the entire model, a singularity not appropriate to use for evaluation or a value outside of the area subjected to the evaluation is searched in some cases. There is also such an issue that when the reading of a value is taken by a manual operation, it would be challenging to identify a value of what node is used for the evaluation when the model is viewed in a later day.

A unique Analysis Tag function was developed in order to resolve these issues (Fig. 10). This function allows saving of the node, value, comment, etc. used for the evaluation as model data. Even when a third-party views the model, the grounds of evaluation are clear. In addition, the implementation of a maximum value search function in areas of occurrence of high stress helps to prevent maximum values from being overlooked and reduces differences in evaluations due to different users.

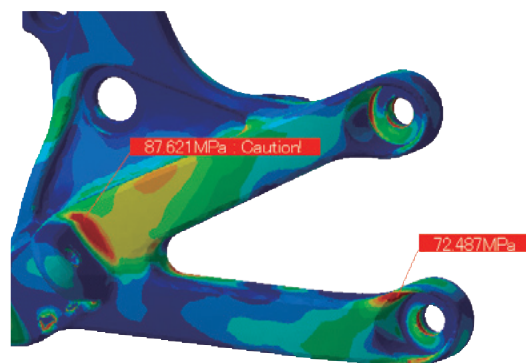
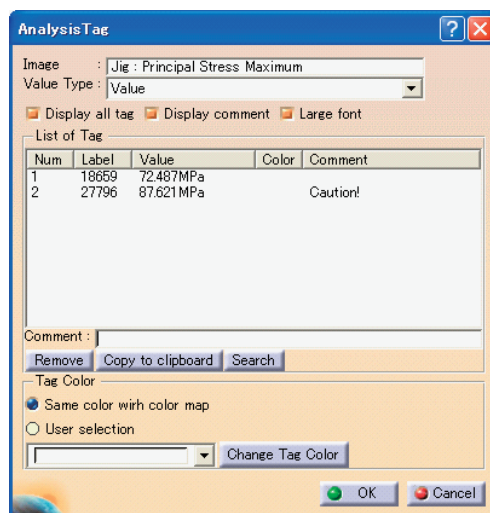


Fig. 10 Function of the analysis tag

5.2.9. Formulating reports

This system semi-automatically creates a regular-form report indicating information necessary for a third-party when viewing CAE results. Information including the model data name, details of the settings for the analysis, information on changes to standardized settings, evaluation values obtained from the abovementioned Analysis Tag, and the results of judgments are automatically incorporated in these reports. Based on this data, the designer is easily able to complete a report by simply adding a discussion.

6. Effect of the Developed System

6.1. Support for Designers' CAE

The offering of the navigation system that suits characteristics of designers' CAE permits proper analysis even by a designer using CAE infrequently. Also, by repeating analysis by this system, designers can learn the general analysis process and increase their skill to apply CAE for parts other than the standardized ones.

6.2. Reduction of Redoing in Analysis and Differences in Settings between Users

Practicing of the analysis method determined by the standardization on this system permits reduction of redoing caused by an improper setting of analysis condition, etc. and differences of setting between users. In addition, the system's simplification of troublesome condition-setting procedures and the introduction of a check function have reduced the incidence of redoes due to operational errors.

6.3. Effective Use of Past Analysis Data

The accumulation of analytic data by the developed system has made it possible to easily update results even when there are changes in mesh settings due to changes in the computational environment, preventing accumulated data from becoming unusable in later comparisons. In addition, a unique Analysis Tag function has made it possible to leave a clear record of the basis for evaluation in the accumulated model data.

6.4. Reduction of Work Hours

The system's simplification of troublesome condition-setting procedures and its use of a navigation function have reduced operational work hours for designers by an average of 75% (Fig. 11). This is chiefly an effect of the simplified formulation of load and constraint conditions and the supplementary elements necessary for condition-setting (pre-processing) and the semi-automatic generation of evaluations of analysis results and standard reports (post-processing). In addition, the developed system has also enabled analyses that were previously challenging for designers due to the complex condition-setting procedures for the parts.

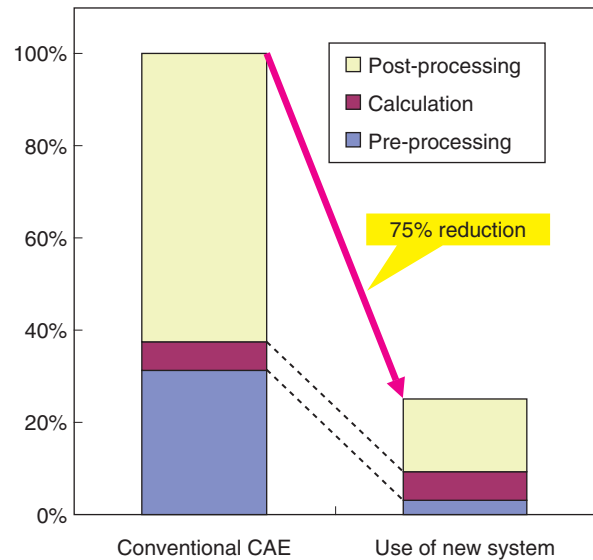


Fig. 11 Ratio of reduction of total work hours

7. Conclusion and Future Developments

The development of a CAE standardization system for motorcycle parts focusing on designers' CAE has reduced the incidence of redoes due to misunderstandings and of operational errors and differences in methods and settings between designers. In addition, by simplifying troublesome condition-setting procedures and the evaluation of results, the system has reduced operational work hours by an average of 75%. Because entire analytic procedures are available on a navigation menu, the system offers optimal support suited for the characteristics of designers' CAE, and at the same time, as designers can learn the general analysis process and increase their CAE skills, an application to those other than the standardized parts is enabled. In addition, the system also makes updating of accumulated data easy, allowing effective use of past analysis data.

The present system focuses exclusively on parts that can be reviewed using linear structural analyses. However, to fill the growing demand for the maturation of designs on the desktop, we will consider extension of application to areas including non-linear structure analysis in the future.

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