
Desktop Automation for Structural Engineers

Practical Applications and Benefits of Multiframe
Automation for Structural Engineering Professionals

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Introduction

As engineers carry out more and more of their work on personal computers, it becomes increasingly important to standardise processes and procedures to ensure consistent, efficient results in their design work. Today's structural engineer typically uses a range of desktop software for writing, drawing, calculations and structural analysis and design. While all of these pieces of software have evolved, little has happened to improve data interchange and consistent automation of design practices across the range of software in use. The Version 8.0 release of the Multiframe structural analysis and design software from Formation Design Systems, is the first structural engineering product to introduce a compatible, consistent method of automating design activities between word processing, drawing, drafting, calculations and analysis. In this paper, some of the technology behind Multiframe Automation is described, as are a number of practical examples of how it may be used and the specific benefits and solutions that result.

History of Automation

Since the introduction of VisiCalc in the early 1980's, Lotus 1-2-3 in the late '80's and Microsoft Excel some years later, engineers have used spreadsheets to assist in solving design problems. Over time, spreadsheet models have become more and more complex, and the reliability and accuracy of spreadsheets has been very dependant on individual user control. Few organisations have established standards for spreadsheet preparation, use and maintenance. As the complexity of engineering spreadsheet models has increased, engineers have turned to the use of macros to automate the running of repetitive or time consuming design tasks. Each of the spreadsheet programs mentioned above has used a different macro, or automation system, with no common macro language between programs. Organisations have also utilised other, equally incompatible macro systems such as Lisp in AutoCAD, custom scripts in database systems and so on.

Current State of Automation

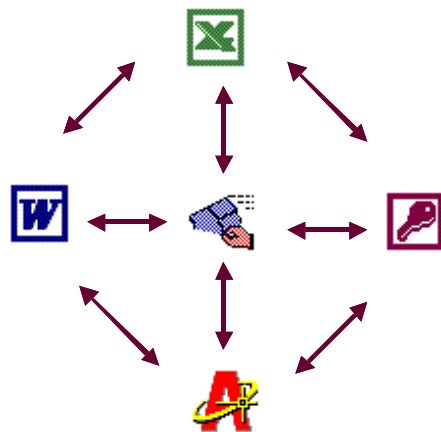
Today, engineering design offices have, to a large extent, standardised on the use of Microsoft products including the Excel spreadsheet as a part of the Microsoft Office suite of software. The use of macros in this suite has evolved so that now all programs support the same macro programming language - VBA, or Visual Basic for Applications. Following Microsoft's adoption of this standard, a large number of other software vendors have also added support for VBA into their products making it the most widely used macro/user programming system. Examples of this in the engineering world include AutoCAD, MathCad,

Mathematica, Visio, etc. The version 8.0 release of Multiframer is the first structural engineering program to include VBA support.

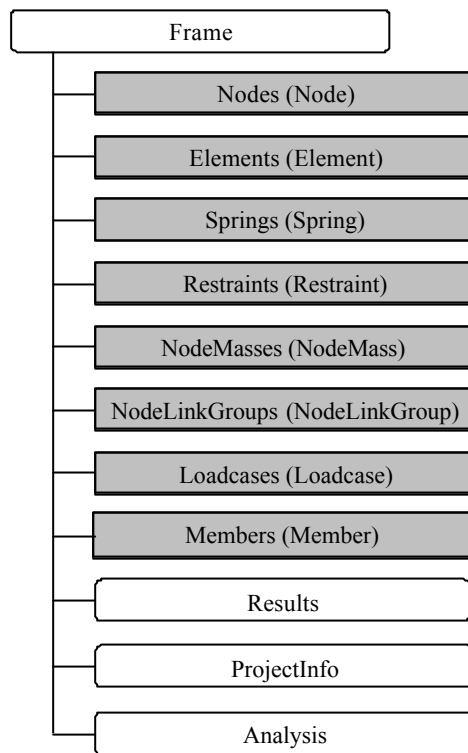
Engineers now routinely use VBA macros to automate repetitious or complex spreadsheet tasks. These macros can be created in two ways: a simple record and play approach where the user performs a series of actions which Excel records and then plays back; or direct authoring of macros using the VBA language. The VBA authoring is carried out in a graphical environment with an excellent integrated help system and browser for information about what kind of objects can be used in the macros. For a spreadsheet these objects include Cell, Row, Column, Chart, Sheet, Workbook etc. This visual environment is used by all of the Microsoft Office products as well as in AutoCAD and other third party products.

Automation in Multiframer

In 2001, Formation Design Systems took the decision to become the first structural engineering software company to support automation compatible with VBA. This allows structural engineers to write their own design macros which can link together structural design software with word processors, spreadsheets, databases, drawing tools and any other desktop software. This decision resulted in the November 2001 release of version 8.0 of Multiframer. Formation Design Systems uses the general term “Multiframer Automation” to describe the set of macro and scripting capabilities which this release provides. These capabilities allow users to access or manipulate structural data within the model using VBA and other macro and programming languages.



The Multiframer Automation interface provides a complete model of all the objects found in a typical structural model using terminology familiar to structural engineers. For example the following diagram shows some of the objects in the physical structure which are available to manipulate using automation.



Who Will Use Automation?

So who is going to use Multiframe Automation and what will they use it for? We expect that the use of automation will primarily fall into 5 categories –

- Individual design engineers doing routine calculations
- ‘Power Users’ creating more complex solutions to particular problems
- Consulting groups using automation to standardise documents and calcs
- Third party developers developing ‘add-ons’ to Multiframe
- Development of add-ons by Formation Design Systems

Individual design engineers will use automation to write macros to solve commonly recurring design and analysis problems. Examples would include: a macro to create a particular frame shape or set of load cases that are commonly used; an import utility to put members from Multiframe on to particular layers of an AutoCAD drawing; a standard summary document which must be produced for each analysis job. Macros would be created as required, usually in Excel and typically adapted from one of the samples provided with Multiframe.

‘Power Users’ are those engineers that have developed a high level of proficiency with spreadsheets, scripting and macro usage. They often have a complex problem that they need to solve frequently - a particular type of reinforced concrete design for example - and have developed sophisticated spreadsheets which help them solve these problems more rapidly and with fewer errors. Such users will typically update their existing spreadsheets so that input information is loaded directly from the Multiframe model and perhaps so that

multiple design checks can be run over a selected range of members. Advanced users will be able to configure their spreadsheets to automatically optimise a Multiframe structure using the goal seeking and iteration functions built into Excel.

Consulting groups will use automation to introduce more standardisation into their design processes. This could include template documents for design summaries, standardised checks for particular design types or automatic generation of reports for presentation to the architect or client. Consulting engineering companies will also use automation to provide a high degree of repeatability in their operations by using a systems approach to the way documents and calculations are stored, modified and approved.

Third party software development companies will use the Multiframe Automation interface to create products which link directly with Multiframe. This could include programs for less common design problems like cold formed steel design or composite design, which would allow the user to create and analyse the structure in Multiframe, but provide custom extensions such as modifying section properties or performing checks for code compliance.

Lastly, Formation Design Systems itself will release a range of add-on documents and/or modules which provide additional functions outside the main Multiframe program. This could be as simple as responding to a technical request by preparing a spreadsheet which shows the user how data could be extracted from a Multiframe model to provide what they require, or as complex as a complete executable program which dynamically exchanges data with Multiframe.

Automation Case Study

It's useful to look at how the above capabilities might be deployed in practice. The following is a case study, based on a real world example, of how an engineering company might use automation to improve their productivity. XYZ Engineering provides analysis and design services for the telecommunications industry. Their primary business is designing towers to hold mobile phone transmitters. XYZ have a range of standard tower designs that they modify for each client to suit the particular location and equipment. Towers must be costed and designed in accordance with foreign as well as domestic codes. XYZ prepare a spreadsheet which contains a number of macros to generate the structural geometry in Multiframe based on input parameters entered by the user. This allows the standard tower models to be generated with differing heights and bracing configurations. A second set of macros in the same spreadsheet generates the required set of load cases and loads. After running the non-linear analysis in Multiframe, a second spreadsheet is used to find the highest stresses and deflections in the structure. Multiframe's Steel

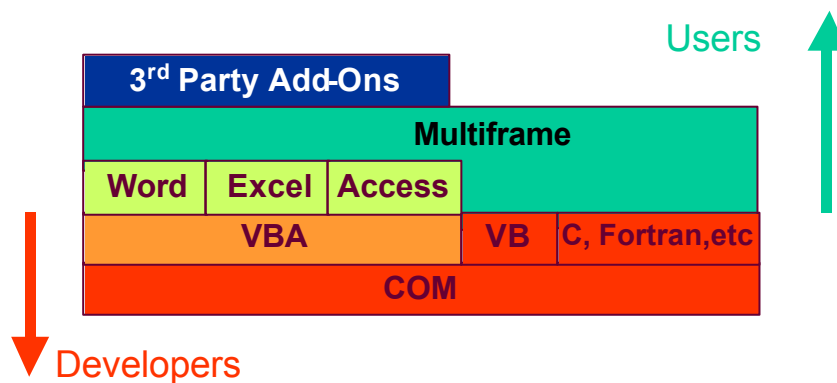
Designer is used to check for compliance with the local code while the spreadsheet performs selected checks for the applicable foreign code. XYZ also have a Microsoft Access database that they use for managing the materials used in each project. The database includes costing information based on the sizes, numbers and lengths of sections used. XYZ add a macro to their database which automatically imports a table of section lengths and sizes from the Multiframe model and produces a preliminary cost estimate and bill of materials.

Lastly, a Word template document is used to produce a standard summary report for the client. This report is then updated by hand as required.

The use of Multiframe Automation by XYZ Engineering ensures that work is performed more quickly, that there is greater consistency between jobs, and that any documentation produced is of a uniformly high standard and accuracy. As their business grows and changes, XYZ Engineering is able to easily update their automation macros to include their most recent requirements.

Automation Technology

There is no need to be a programmer, or even to have any knowledge of programming, in order to make effective use of Multiframe Automation. However, for those interested, or for systems administrators or technical managers needing detailed system information, the following sections describe some of the technology found behind the scenes.



A number of key technologies work together to provide a complete automation solution. These include COM, the Common Object Model developed by Microsoft as a common interface to allow communication between all Windows programs. COM allows programs written in different programming and scripting languages to communicate in a compatible way. These languages include VBA, Visual Basic, C, C++, Delphi, Java, Fortran etc. COM has now been extensively used in a wide variety of applications including internet services. It is possible to use ASP pages on a web server to access data from a Multiframe model and publish it via the web.

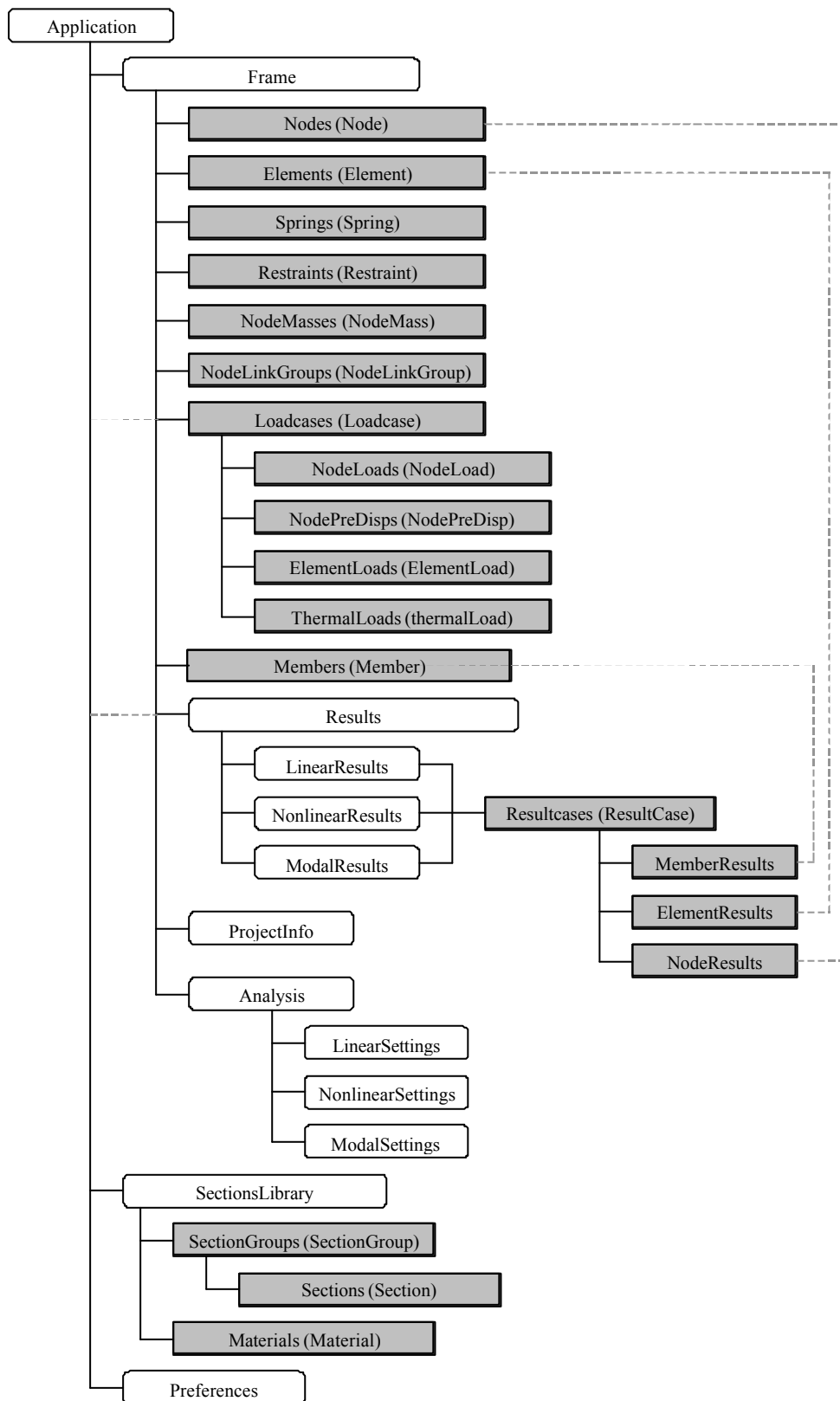
The VBA system is one specific implementation of an environment that is oriented around using COM services such as those provided by Multiframe. VBA provides a number of object models, one for each application in the

Microsoft Office family. The programming of the VBA macros is carried out in the visual VBA Editor included with all Office applications.

Lastly, the Multiframe Object Model, described in the next section, provides a comprehensive framework of objects which allow the user to manipulate the structural model inside Multiframe.

Multiframe Automation Object Model

The Multiframe Automation system is based on a model containing a number of objects. Each object has a number of properties and a number of methods for manipulating those properties. For example, a Node object has properties named x, y and z for its coordinates and a method named AddNode(x,y,z) to add a new node at a specific location. Similarly an Element object has a property named Length and a method named An overview of the major objects in the automation model follows below. A detailed explanation of the model can be found in the Multiframe Automation manual.



Conclusion

The Multiframe Automation system provides a complete environment for developing custom structural engineering analysis and design solutions. It lets individual engineers and engineering companies create macros which ensure a high degree of repeatability and reliability in the design process. When combined with the highly graphical visualisation capabilities of Multiframe, Multiframe Automation provides a 'best of both worlds' solution, allowing engineers to produce detailed and complex calculations and reports in the Microsoft Office environment, while still retaining the graphical ease of use of the Multiframe application.