# Plug-ins State of Art in BIM Software

## Repositories Assessment and Professional Use Perspective

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**Abstract.** The increased need for optimization in design processes has led BIM software users to customize their projects by the use of programming and external applications. This paper presents the state of art of Revit plug-ins by means of an explorative, quantitative study of current repositories and the proposition of a categorization system to identify to which purposes the tools are being developed. Then, through a questionnaire to AEC professionals, assessment on the use and necessity of the tools is made by comparing the user experience with the proposed state of art categories.

**Keywords:** BIM, Revit, Plug-ins, Programming, Survey

## 1 Introduction

With the uprising of different modeling necessities and unique uses of BIM software, the users' community started to develop and upload a great amount of tools to assist the project practice, among the different aspects of BIM technology is the use of applications external to the main platforms, tools known as plug-ins, add-ins or apps, which use the programming already established by the BIM software to manipulate different features of the design environment, possessing defined purposes such as adding versatility to the existing functionalities.

BIM professionals can use the plug-ins to achieve particular goals of design processes, as well as to increase their productivity, letting the applications execute repetitive tasks, perform calculations or run commands in sequence through programming routines, among other uses.

The process of developing plug-ins is currently given by the community of BIM technology users, who look for specific solutions for a variety of project situations. One of the prominent communities is Autodesk App Store, composed of members who use the authoring tool Autodesk Revit, which through its Application Programming Interface (API) allows them to interact with the tool's functionalities, enabling the production of content for the repository [1].

The potential of tailoring an existing software to specific project needs lies in the increased range of possibilities and to overcome platform limits, even though customizing a software to specific user needs is a new practice in architecture, it has already been widely implemented in mechanical engineering and design [2].

Among the added possibilities of using external tools to complement design processes, also stands out the project integration and information sharing provided by plug-ins along BIM platforms, which subsidizes project management by facilitating BIM model interaction, providing support to existing management features and encouraging holistic project development [3].

Plug-ins can also be used to facilitate cost, scheduling and sustainability analysis for construction projects, while these tasks are usually complicated by the several constructive system alternatives, along with the ever-changeable design processes and decision making, an external tool can, for example, help increase synchronization and automate processes by interrelating the model's existing information with another external software or servers that contain data relevant to the task at hand, allowing for agile decision making and a larger pool of solution possibilities [4].

Even though the importance of sustainable design has been growing in the construction industry, energy and performance analysis still does not have the required integration to BIM design processes, with these steps usually being fulfilled only after the architectural design is completed [5]. In such environment, plug-ins and programming can increase the viability of assessing different technological solutions at the project's initial stages [6], allowing designers to focus on achieving less negative impacts on building life cycle and energy efficient design [7].

The current state of BIM-based software has a gap in the field of solutions optimization, with performance feedback being necessary to enable decision making support and designers' creativity. Thus, the use of external and multidisciplinary programs, integrated with the main BIM platform, can enhance the parametric approach of authoring software as Autodesk Revit, improving project performance [8].

This paper focuses on assessing the current state of the art of Autodesk Revit plug-ins, with the objective of analyzing the development of recent external extensions, by exploring the current add-ins, tools and applications, reviewing the present repositories and elaborating a comprehensive category system. This enables the inspection of needs and implications on different areas by means of a user perspective study, conducted through a questionnaire to AEC professionals, to elucidate how plug-ins are implemented in their design processes, as well as if the tools meet expectations of use.

## 2 Methodology

The methodology of this paper is composed in a two-part study: first, a quantitative search of existing plug-in repositories for the authoring tool Autodesk Revit is done, so they can be separated in categories and the state of art of these applications can be shown. Then, by means of an interview with Brazil's AEC professionals, a qualitative questionnaire is carried out, allowing discussion about the use and necessity of programming and external applications in BIM software.

The choice of Autodesk Revit as the software of interpretation derives from particular reasons: firstly, because its API's – Application Programming Interface – functionalities and possibilities, which serves as Revit's main development tool, allow users to manipulate, organize and research different ways to interact with existing functions, therefore enabling creation of a variety of plug-ins [9]. Secondly, due to the initiative of established community, which develops the programming practice, uploading and discussing produced content through the Revit API Forum and Autodesk App Store [10].

### 2.1 Revit Plug-in Repositories Assessment

The Revit plug-in state of art searching is done through exploratory analysis of existing repositories, taking Autodesk App Store as the main content source, which, as of the date of this study, possesses 583 Revit plug-ins available for purchase or download, divided in 15 default categories. The search is then complemented by secondary repositories, which are characterized in this paper as websites that contain at least 3 Revit plug-ins available for purchase or download.

However, albeit a solid starting point for beginners, the categories proposed by Autodesk App Store have very varied concepts, specific information on apps is given through category filters which are defined by the peer who submitted the application, who can have a different understanding of the category meaning and may select multiple categories for a single plug-in, consequently enabling irregular concepts about its categorization. The process of classification is further complicated by the fact that the filters do not subtract each other, in other words, applying two or more filters will show results in an additive way, not enabling a search through intersection of filters.

A new categorization is proposed, in a way so that the quantitative plug-in amount searched in the repositories can be grouped in classifications defined by keyword-based criteria. The initial category definition is done by analyzing the Autodesk categories through an iterative and exploratory process: a sampling of up to 20 plug-ins from each of the 15 Autodesk categories is set, and through a text analyzer tool of Microsoft Excel, the most frequently used words of the group sample are revealed. Words that are inserted in compatible contexts with each other, form a new category, this process continues until at least 15 relevant keywords (Table 1) are enough to explicit and separate a general concept as well as to match the proposed category description, as follows:

**Structural**: tools related to structural design, calculation, dimensioning, detailing and analysis, presenting materials like concrete, steel and timber in situations where they act as structural elements: beams, columns, slabs, roofs, bracing, trusses, foundation, among others.
**MEP** – Mechanical, Electrical, Plumbing: tools associated with complementary building projects such as mechanical, electrical and hydraulic installations and facilities, or to serve as subsidy for flow, pressure, circuits or ventilation system calculations.
**Performance**: tools focused on performance, building life cycle assessment, energetic efficiency, thermal, acoustic and light comfort, water consumption, sustainable materials and emission control, plug-ins related to building environmental sustainability.
**Productivity**: tools connected to schedules and workflows, used to generate reports, quantity take-off and help in performing repetitive tasks in design processes, used to streamline designers' activities or to automate actions.
**Conversion**: tools with the sole purpose of converting files, being able to import and export a variety of formats with the objective of enabling interoperability between software or the generation of documentation.
**Component**: tools related to parametric design of walls, windows, doors and other family components, as well as product detailing and graphic representation improvement, annotation tools and rendering related applications.

**Table 1.** Proposed categories and keywords

| Structural | MEP | Performance | Productivity | Conversion | Component |
|---|---|---|---|---|---|
| structur | duct | environm | table | ifc | wall |
| steel | mep | performance | sheet | pdf | window |
| bridge | pipe | impact | schedule | convert | paramet |
| frame | pip | cycle | quanti | export | dimension |
| beam | circuit | assess | takeoff | dwg | room |
| collumn | pressure | energy | take-off | link to | family |
| concrete | water | heat | automatic | impot | product |
| wood | flow | efficien | quick | share | detail |
| reinforce | fixture | thermal | annotat | extract | curtain |
| brace | cable | consumption | filter | enhance | component |
| timber | ceiling | daylight | workflow | external | factory |
| slab | ventilation | eco | estimat | document | seek |
| truss | conduit | rain | productivity | dxf | families |
| l analysis | electric | certificat | purge | server | section |
| robot | hanger | illumin | provide | excel | render |

Then, each of the main and secondary repositories' plug-ins is filtered by a Plug-in Detection Device, a tool created in Microsoft Excel which counts the number of times the keywords appear in the text of the plug-in being analyzed, presenting in a radar graph the most dominant category, allowing identification and storage of information with context awareness and increased accuracy by using the same method on each of the plug-ins.

The text in the name, presentation, features and characteristics of the plug-in are analyzed, the keywords are counted and the category which possesses the higher number of compatible keywords classifies the plug-in in it, in the case of a draw or if the Plug-in Detection Device does not elucidate a category sufficiently, a re-reading of the text of the plug-in description is made and the category context that most closely resemble the proposed features' description qualifies the plug-in.

### 2.2 Professional Plug-in Use Diagnosis

The second part of the study consists of a qualitative questionnaire composed of three sections, created from Google Forms, with the objective of diagnosing the design practices of Brazil's AEC professionals in the field of BIM tool usage, seeking to understand how plug-ins are implemented in design processes, which are the most used types of applications and if they are effective in achieving their purposes.

The questionnaire is composed of three types of responses: characterization responses, free narrative responses and Likert scale responses. Characterization responses are presented solely for displaying the professional profile of the respondents, with questions of single or multiple alternative selection. Likert scale responses are composed by questions where the respondents must express their opinion about statements with five possible positions (1 for Totally Disagree, 5 for Totally Agree).

In free narrative responses, professionals answer questions by text boxes in the questionnaire, the most notorious answers are selected, while similar answers are concatenated, this is made to further highlight characterization and generate discussions based on the professionals' perceptions about design processes.

The questionnaire is sent by email to several recipients in an exploratory manner, with selection criteria defined as: AEC professionals in Brazil, that work in offices, institutions or construction companies, that utilize BIM technology in their design processes.

Firstly, a declaration of consent is presented highlighting the questionnaire's academic purpose, then in Section 2, data on general respondent information is collected for sample characterization: educational background, location, project experience time and BIM technology experience time.

Plug-in and extension concepts are then presented in the questionnaire through Section 3, where respondents answer questions about productivity, utility and usage of programming in design processes, which plug-ins are used in their design processes, as well as if they have developed plug-ins. Lastly, respondents may demonstrate their need for solutions in a specific area, by suggesting and describing a plug-in they would like to be developed.

### 2.3 Comparative Studies

Through presentation of Revit plug-ins state of art and diagnosis of plug-in use by professionals, it is possible to compare the availability of plug-in categories in repositories with the plug-ins used and suggested by the professionals. This is done by intersection between questionnaire informed data and the proposed plug-in categorization.

The questionnaire is then used to validate the categories proposed in the state of art, as well as to add plug-ins used by the professionals that were undiscovered or that were not covered in the methodologic procedures to the state of art database, therefore serving as means of feedback to the proposed categories.

The narrative responses where the respondents explicit the plug-ins they utilize and suggest are interpreted by similarity of category description and then used for comparison with the state of art presented, to assess if what is developed in the repositories reflects the use and needs of the questioned professionals.

# 3 Results and Discussion

## 3.1 Revit Plug-ins State of Art

Quantitative result on repository research enables the identification of which plug-ins are the most commonly produced by the community, as well as what paths this segment of BIM technology development is heading on.

By exploratory analysis of current repositories, it was possible to collect 583 Autodesk Revit plug-ins from Autodesk App Store and 214 plug-ins from secondary repositories, for a total of 797 applications found (Table 2), within which 16 were added from professionals' suggestion, a stage of this study that will be detailed later.

**Table 2.** Plug-in Repositories

| | | | |
|---|---|---|---|
| Autodesk App Store [10] | 583 | RevitWorks [17] | 5 |
| Tools4revit [11] | 23 | David Pinto Consultoria [18] | 3 |
| AGACAD [12] | 33 | CGS Plus [19] | 9 |
| AEC-APPS [13] | 54 | IdeateSoftware [20] | 4 |
| CASE Apps [14] | 44 | RTVTOOLS [21] | 7 |
| Kiwicodes [15] | 12 | Professional's Suggestion | 16 |
| BIM Interoperability Tools [16] | 4 | **TOTAL:** | **797** |

All plug-ins passed through the Plug-in Detection Device, to perform keyword occurrence analysis in the plug-ins' description texts, in order to determinate its dominant category in a graphical manner (example in Fig. 1), then by exhaustive analysis of repository content and separation of plug-ins in their matching dominant categories, the state of art of plug-ins developed for Revit as of the date of this study can be shown (Fig. 2).

Analyzing the results, it becomes possible to verify a considerable quantity of external applications being developed with various file conversion purposes, as well as tools with the objective of manipulating and detailing components, however the most prominent category is Productivity, which represents that 36.17% of the plug-ins analyzed are developed to automate repetitive tasks, manipulate schedules and workflows, among other uses related to this category. In contrast, only 3.38% (27 plug-ins) were classified as Performance, even though it's a category that aims to cover multiple concepts such as energy efficiency, environmental impact and comfort.

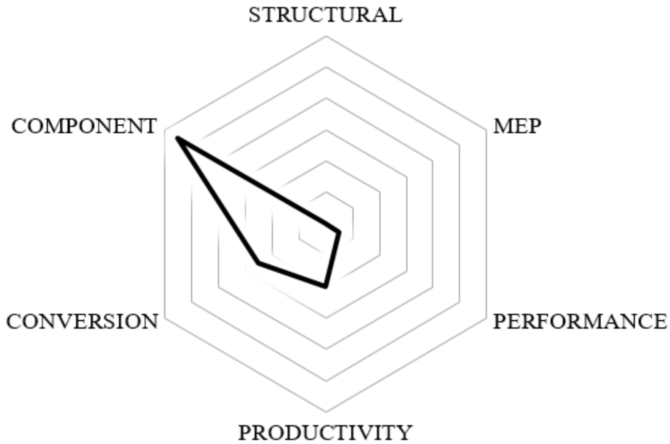


**Fig. 1.** Plug-in Detection Device classifies a plug-in as Component-based

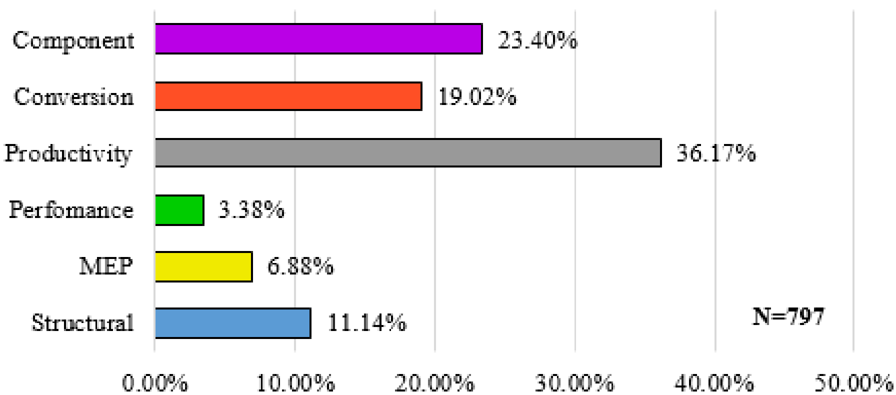


**Fig. 2.** Revit Plug-ins State of Art

### 3.2 Professional Use Characterization

The questionnaire was sent by e-mail to the recipients following methodology criteria and as result covered 29 professionals. According to characterization steps, the questionnaire is composed with professionals graduated in schools of Architecture (62.07%), Civil Engineering (34.48%) and Business (3.45%), moreover, some respondents stated they also graduated in areas such as Electrical Engineering, Design and Building Technician Course. The respondents work in offices, institutions or companies in Brazil, located predominantly in the states of Rio Grande do Sul (10 respondents) and São Paulo (8 respondents), other locations are Rio de Janeiro, Paraná, Paraíba, Mato Grosso (2 respondents each), Goiás, Distrito Federal and Bahia (1 respondent each).

The working time with projects was declared to be 6 to 10 years in 27.6% of responses, and more than 10 years in 48.3%, demonstrating that the profile of the respondents is that of professionals potentially experienced in project practice. Working time with projects specifically using BIM technology was declared as less than 2 years in 10.3% of responses, 2 to 4 years in 31%, 4 to 6 years in 17.2%, 6 to 10 years in 13.8% and more than 10 years in 27.6% of responses, which allows to observe a variability in the adoption of BIM technology throughout the years by different companies in various locations in Brazil.

Among the respondents, 58.6% declared using plug-ins or extensions related to BIM authoring tools in their design processes. The professionals then were presented to some statements, and by Likert scale responses, could express their opinion in values from 1 (Totally Disagrees) to 5 (Totally Agrees) in relation to plug-in, extension and programming use for diverse purposes. Table 3 shows mean and standard deviation values from the statements' responses.

**Table 3.** Plug-in and programming statements and professional agreement

| Statement | N | Mean | Std. Dev. |
|---|---|---|---|
| 1- The use of plug-ins and/or extensions can improve productivity. | 25 | 4.60 | 1.31 |
| 2- The use of plug-ins and/or extensions optimizes decision making steps. | 24 | 4.42 | 1.07 |
| 3- The use of plug-ins and/or extensions simplifies repetitive design processes. | 25 | 4.60 | 1.24 |
| 4- Project area professionals can use programming to reach new levels of excellence in design. | 27 | 4.59 | 1.34 |
| 5- Project area professionals can use programming to reach new levels of excellence in performance. | 28 | 4.61 | 1.36 |

Based on this question, it is possible to affirm that there is agreement between the professionals, which demonstrates that the respondents believe in the potential of programming as a way to increment their design processes. This conclusion becomes clearer when professionals answer the following: "How can programming help in improving design processes?" Following narrative question methodology, among the main responses are: (i) productivity improvements: enabling automation of repetitive tasks, checking and validation of standards and methods, performing manual tasks such as family editing with agility, reducing operational tasks, (ii) accuracy improvements: reducing the margin of error in complex modeling processes, identifying conflicts and consequently minimizing rework, (iii) design improvements: increased productivity provides more dedicated time for solution development and compatibilization, enabling the design of more complex forms with more details and annotations, as well as generative design, (iv) interoperability improvements: facilitating interchange between BIM applications, freeing models of some restrictions between platforms, (v) management improvements: facilitating coordination and communication among team members, offering solutions directed to specific company flows, reducing wastes from mistakes and making it possible to increase company profits.

When questioned whether they develop plug-ins, 5 professionals (17.2%) declared yes. Some functionalities raised for the developed plug-ins were: numbering and creation of structural elements, topographical surface finishing, automatic creation of wall coating, synchronization of schedules with budget and cost composition data lists, design and documentation of partition walls, information management at the construction site, creation of parametric components and communication management among company professionals.

When asked to quote through text field, names of plug-ins they use in their design processes, a total of 43 plug-ins names were raised, of these, 27 were already included in the quantitative research of plug-in repositories, the 16 remaining were searched for their functionalities and then used to increment the database of secondary repositories, providing feedback to the state of art.

Through Plug-in Detection Device, it became possible to research the use of plug-ins by the professionals, following the same categorization methodology, enabling assessment of main purposes of the tools used (Fig. 3).

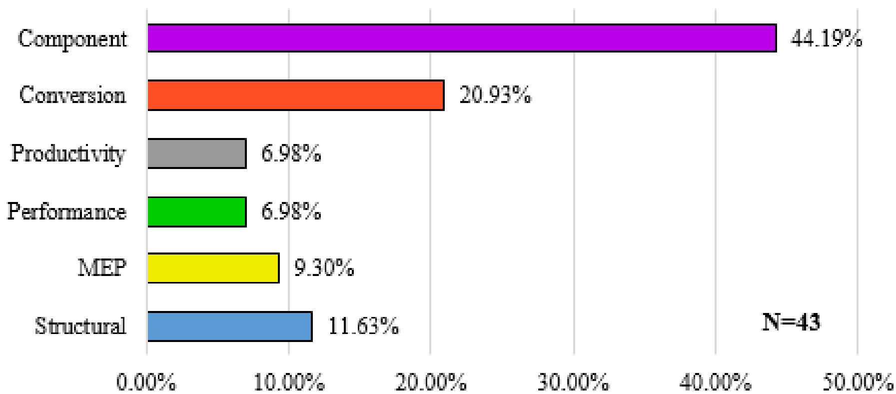


**Fig. 3.** Revit plug-ins by professional use

From Figure 3, it is possible to notice the predominance of Component based plug-ins (44.19%), which reflects a possible relation with the current state of BIM technology implementation of the respondents, most of which are graduated in Architecture, who can use plug-ins of this nature for purposes of modeling families, designing and rendering buildings and interiors.

The predominantly cited Conversion plug-ins (20.93%) are related to increased cross-platform collaboration and information maintenance, enabling additional ways to integrate information modeling between different software, sometimes to complement the interoperability of IFC format, which, as presented previously, has different levels of agreement in relation to its utility in design process by the respondents.

Productivity plug-ins, albeit being the most frequently developed in repository communities (36.17% of state of art), were among the least utilized, with only 6.98% of use by the respondents. Such result makes it possible to infer that the plug-ins available in this category sometimes do not meet the specific needs of the professionals.

Performance plug-in category, although also little used by the professionals (6.98%) is available in much smaller quantities in repositories (3.38% of state of art), their uses by the respondents are related to sustainable building design, energy efficiency, accessibility and landscapes.

In MEP and Structural categories, similar percentages show approximation of use by professionals (9.30% and 11.63%, respectively) and available in repositories (6.88% and 11.14%, respectively).

Next, an analysis of respondents' plug-in needs was made. This time, the professionals could suggest by text field, a plug-in which they would like to be developed or that would be useful in their design processes. The suggestion text was interpreted through the described data and then, a matching category was proposed, based on the context of responses and following methodology. A total of 26 possible plug-ins were described. With this information, it was possible to compare the suggested plug-ins with state of art categories (Fig. 4).

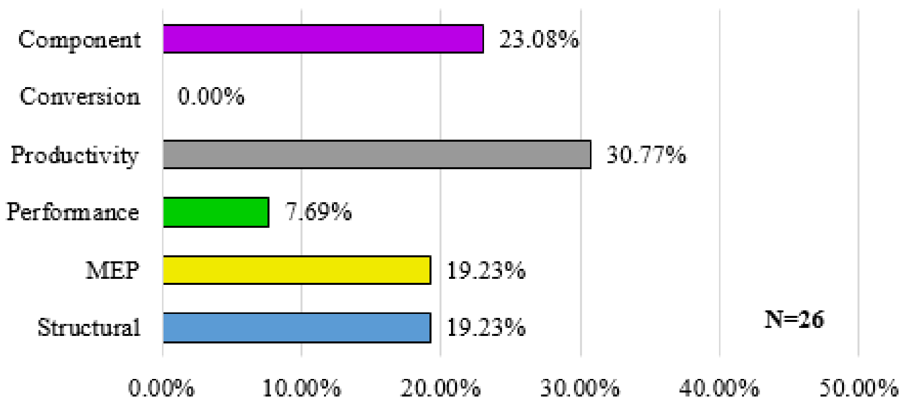


**Fig. 4.** Revit plug-ins by professional suggestion

The results of this interaction reveal that, although important to manipulate different file formats and to facilitate information interoperability, Conversion plug-ins weren't described in the suggestions. Instead, the respondents highlighted the necessity for applications in Component (23.08%), MEP and Structural (both at 19.23%) areas, presenting suggestions such as plug-ins for parametric furniture design, modular containers and generative design routines, as well as plug-ins that facilitate calculation related to electric projects, roof framing, reinforced concrete rebar and structural standard appropriate design.

The interest for new Productivity plug-ins (30.77%) when related with previous results of this category, indicate that plug-ins used by professionals (6.98% of use) possibly do not meet specific productivity demands of respondents, this information is further understood when a large number of plug-ins in this category are available in repositories (36.17% of state of art).

Performance plug-ins described (7.69%) were connected mostly to design focused on accessibility, not directly referring to life cycle analysis, sustainable design, energy efficiency or environmental impacts.

## 4 Conclusion

The contribution of this paper is the review and assessment of the current state of the art of Revit plug-in development, a quantitative research about plug-ins developed in repositories, which presents a classification of external applications in six distinct categories, making possible the discussion of trends and challenges for the industry with the arrival of new technologies.

Additionally, user perspective context was introduced through a questionnaire to AEC professionals: Brazilian architects and engineers, users of BIM technology and relatively experienced in design processes. It was possible to evaluate the proposed state of art of Autodesk Revit platform plug-ins, by means of interrogation about use and necessity of these tools in the respondents' context, allowing for comparison between plug-in development and user experience.

This paper may subsidize argument for the use of programming in BIM software, as well as the study of BIM in conjunction with plug-ins in AEC companies, helping in the development of this technological field of BIM and seeking to point out solutions for project optimization through the use of external tools and software customization.

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