Recommended Computer Aided Design Software for EASE Engineering PLC

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Abstract

The paper focuses on selecting the most suitable Computer-Aided Design (CAD) software for EASE Engineering PLC's post-tensioning design automation needs. AutoCAD, BricsCAD, ProgeCAD, and ZWCAD were evaluated based on their in-built functions, automation capabilities, and compatibility with EASE Engineering's drafting requirements. The findings consider affordability, API support, AutoLISP processing capacity, and overall suitability for the specific needs of post-tensioning design. It has been noted that ZWCAD is the most suitable option with regards to affordability and overall performance.

Keywords: *CAD, AutoLISP, DCL, API, Dynamic block*

1 Introduction

EASE Engineering PLC, is believed to be the first company that introduced design and construction of post-tensioning for building and bridge in Ethiopia. Being the pioneer in the field the company needs to implement all the efficient tools that are currently in the market in order to be ahead of competitors that are entering the market. A Computer Aided Design (CAD) software is among the different design tools the company uses. This CAD software is used to convert the design output of other structural analysis and design software into a structural drawing. This conversion is a very time consuming operation when done manually and often many of the tasks need to be automated with scripting languages that are shipped with most CAD tools.

The need for accuracy and speed in drafting work is growing in the Ethiopian construction sector, where EASE Engineering is a part of. The organization is always seeking for ways to optimize the drawing process for post-tensioning systems. Drafting tasks that are automated may result in fewer errors, more time saved, and better project outcomes overall. EASE Engineering is thus driven to investigate and contrast the in-built functions as well as automation capabilities of AutoCAD, BricsCAD, ProgeCAD and ZWCAD. Thus, the objective is to investigate and compare the in-built functions and automation capabilities of AutoCAD, BricsCAD, ProgeCAD, and ZWCAD.

2 Related Work

Computer-Aided Design (CAD) is a technology that revolutionized the process of designing and drafting by enabling engineers, architects, and designers to create precise digital representations of physical objects or structures. CAD software allows users to create, modify, analyze, and optimize designs with ease and accuracy. It has become an essential tool across various industries, including automotive, aerospace, architecture, construction, electronics, and manufacturing.

CAD software provides a virtual workspace where designers can sketch, model, and simulate their ideas in 2D or 3D formats. These tools offer a wide range of features, including parametric modeling, which allows users to define geometric relationships and constraints to create dynamic designs that can be easily modified. Additionally, CAD software often integrates with other technologies such as computer-aided manufacturing (CAM) and computer-aided engineering (CAE), facilitating seamless workflows from design to production.

CAD software vary in complexity and capability, catering to different needs and skill levels. Some popular CAD programs include SolidWorks, Inventor, and AutoCAD, each with its own strengths and specialties. These tools empower designers to visualize concepts, detect errors early in the design process, improve collaboration among team members, and ultimately bring innovative ideas to life with efficiency and precision.It is apparent that CAD tools have made production of design drawings very efficient as opposed to the manual production of design drawings. One can use the array of functions that are shipped with these tools. However, the environment of construction greatly varies and the functions in these tools are seldom comprehensive. Different authors try to address the further automation of these tools using APIs. The research by Sheng Jin et al. [1] proposes an innovative method for automatic CAD design in construction engineering. The method uses on-site geomorphological data to generate 3D CAD models and 2D drawings, reducing labor and time costs. Implemented through the API of CAD systems, the method also incorporates mixed reality technology to validate assembly results, providing a realistic and efficient experience for users and customer. Li et al. [2] try to examine for instance the C# .NET API of AutoCAD in creation of plugins and generation of graphics. This article shows that CAD software might have insufficient or missing functions required by some fields as compared to others. Therefore, it is necessary to carry out secondary development of CAD and design professional modules that conform to specific fields [2]. This can extend the application range of CAD, and can also improve the designer's work efficiency and reduce the errors in design, which has strong practical value.

A study by Anastasios et al. [3] examines the creation of an application that automates

the design process for a typical pneumatic double-acting cylinder based on predetermined parameters. The authors show that for repetitive tasks such as building the double-acting cylinder can be overwhelming for a drafter and takes too much time that could be better allocated. So using APIs one can draw the cylinder instantly by just using a dialog box to enter the required parameters such as diameter and with the click of a button the required graphics can be generated. Applications like these can aid the productiveness of many designers and labor forces that produce a limited range of products or that are specialized in a specific range of mechanical systems (i.e. machinery) [3]. Another paper by I. A. Magomedov et al. [4] tries two CAD tools that were developed by two different companies for the purpose of 2D/3D modeling and analyzing. They compared two software, Solidworks (by SolidWorks Corp.) and Inventor (by Autodesk Inc.). The parameters chosen as the basis of comparison in this paper were functionality, market share, user friendliness and availability. The authors underline the importance of correct outcome from the software packages in engineering when choosing software.

3 Comparative Analysis

Among the varieties of options provided by the providers, the following are used for the purpose of this comparison AutoCAD 2022, BricsCAD Ultimate 2024, ProgeCAD Professional 2024 and ZWCAD Professional 2024. All of the drafting work in EASE Engineering PLC is done in 2D, hence, our main focus in this paper will be in 2D aspects of the programs even though all four programs have 3D drafting capabilities. In addition Windows OS is used as the basis for comparison because it is the main OS used in the company.

According to Open Design Alliance (ODA), a professional application development platform, the source code they provide to members of their consortium consists of 20M+ Lines of code, 850 Person-years in development and 45 Projects. One of the ODA members, IntelliCAD Technology Consortium (ITC), provides a CAD programming platform as well. IntelliCAD is based on an API provided by ODA and expands on it. Developing a CAD software from the ground up is evidently a very expensive task. And as a result, BricsCAD uses the ODA technology while ProgeCAD and ZWCAD are powered by IntelliCAD. Both ODA and ITC are not affiliated with Autodesk Inc. who is the owner of AutoCAD.

The applications will be compared based on their capability in:

- Interface and Usability: User interface and the ease of getting used to the applications.
- Price and Licensing: Modalities of licensing and affordability.
- Features and Capabilities: In-built functions that are shipped with the products.
- Compatibility: File formats that are supported by these products.
- System Requirements: Resources required to run the applications.

- API Support: Programming languages supported to be able to introduce user defined functions and extend application capabilities.
- Performance and Speed: Execution times required by the applications for tests that are performed using a custom made (built with AutoLISP API) program.

The applications under investigation are evaluated against these parameters and the results obtained are presented below.

Interface and Usability: All three of the CAD applications have a user interface that is similar to the pioneer application, AutoCAD. They all come with command lines, toolbars and menus which are more or less in similar positions, with a customizable interface. Anyone who has been using AutoCAD, will not be facing a steep learning curve to switch to any of the three applications.

Price and Licensing: Pricing as well as modalities of payments greatly vary among these programs. The licensing is no exception, licensing ranges from subscription to perpetual.

Table 1: Pricing and licensing

Application	**Perpetual**	**1 month**	**1 year**	**3 year**	**Flex**
AutoCAD	-	$245	$1975	$5925	Min - $300 for 100 tokens (Pricing is variable)
ZWCAD	$1199	-	$432	$1166	-
ProgeCAD	$399	-	-	-	-
BricsCAD	$2100	-	$1120	$3020	-

AutoCAD used to provide perpetual licenses, however, as of January 2016 it has stopped selling new perpetual licenses and moved to plan subscription instead. In addition it has introduced a new method which it calls, Flex. Flexes can be used as per usage that can be useful for users who want to use a specific tool for short periods at times, with 7 tokens/day. And on the other hand ProgeCAD only provides perpetual license and no additional renewable fees as can be seen in Table 1.

Compatibility: Design drawings used in the construction industry among many others use the unofficially standardized DWG file format. DWG is the native file format for AutoCAD, developed by Autodesk. All four applications work with the DWG file format. Import and export with one another work seamlessly. In addition, construction drawings are exchanged between multiple stakeholders of a project very frequently. AutoCAD is the most widely used application in Ethiopian construction industry and compatibility of other CAD

applications with AutoCAD carries a lot of weight in the selection of the most suitable software for EASE Engineering PLC.

System Requirements: AutoCAD has been around for over 40 years and has acquired a large user base and significant resources. As a result it has extensive feature set and a wide range of tools, which has caused it to demand more computational resource than any of the alternative CAD applications chosen for this study. As can be seen from Table 4.4.1 AutoCAD requires a minimum disk space of 10 GB as opposed to the 2 GB required by ZWCAD/BricsCAD and 4 GB by ProgeCAD. The memory requirement is no exception, it requires 4 times that of what is required by ZWCAD. However, most computers that are commercially available these days are not resource deficient. And consequently, a user is more concerned with the availability of tools and performance.

Table 2: System Requirements

Requirement	**AutoCAD**	**ZWCAD**	**ProgeCAD**	**BricsCAD**
Operating System	64-bit Microsoft® Windows® 11 and Windows 10	Microsoft® Windows 7 sp1 and above	Microsoft® Windows 7 and above	64-bit Microsoft® Windows® 11 and Windows 10
Processor	2.5–2.9 GHz processor	Intel® Pentium™ 4 1.5 GHz or equivalent AMD® processor	2.2 GHz or faster 64-bit (x64) processor	Intel® Core™ i5 AMD Ryzen™ 5
Memory	8 GB	2 GB	4 GB	8 GB
Display Resolution	1920 x 1080 with True Color	1024*768 VGA with True Color	-	Full HD (1920 x 1080) True Color display
Display Card	1 GB GPU with 29 GB/s Bandwidth and DirectX 11 compliant	1GB, support OpenGL 4.2	-	1 GB VRAM
Disk Space	10.0 GB	2 GB free space in OS disk, 1 GB free space in installation disk	4 GB	2 GB
.NET Framework	.NET Framework version 4.8 or later	-	-	-

Features and Capabilities: In general AutoCAD has by far the most features, hence, the higher disk space requirement shown in Table 4.4.1. However, for the case of this comparison which only focuses on the 2D features, all four programs achieve the basic requirements, except for some differences in the way they each handle dynamic blocks, a feature that's frequently used in the drafting of post tensioning strands as a way to quickly change between live and dead end representations. Dynamic blocks are a proprietary pieces of Autodesk. All of the other three programs do not allow directly editing of dynamic blocks made with AutoCAD. Nonetheless, ZWCAD has its own alternative which it calls flexblocks. Flexblocks function the same way the AutoCAD dynamic blocks do, however, in order to edit dynamic blocks created with AutoCAD it must first be converted to ZWCAD's native type as shown in Figure 1.

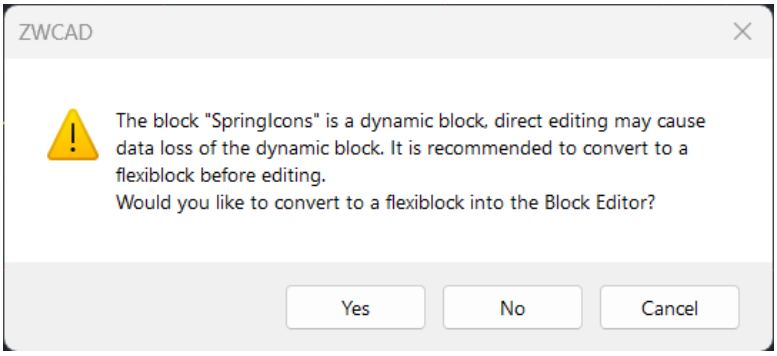

Figure 1: ZWCAD's prompt when attempting to edit a dynamic block

BricsCAD also allows to fully utilize dynamic blocks created with AutoCAD, however, in order to edit them they must first be converted to BricsCAD's native type called parametric blocks as shown in Figure 2. Both ZWCAD and BricsCAD perform the conversion automatically based on the user's preference.

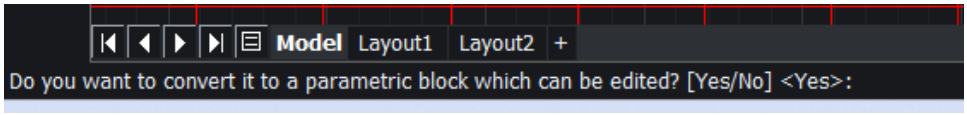

Figure 2: BricsCAD's prompt when attempting to edit a dynamic block

ProgeCAD has no alternative entities. Figure 3 shows the message that is generated by ProgeCAD to use the REFEDIT command when a user attempts to edit a dynamic block created by AutoCAD, which makes the dynamic block lose its dynamic property and become a regular block.

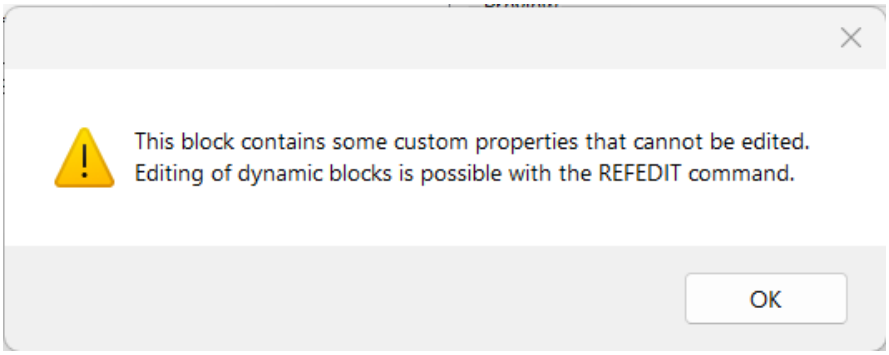

Figure 3: ProgeCAD's message when attempting to edit a dynamic block

Their capabilities can be compared with regards to their support to APIs which is regarded as the gateway to extend and test the capabilities of the programs with regards to the user's specific needs.

API Support: There are many APIs that are shipped with most of the CAD applications. However the most commonly used languages currently are C++, .NET, VBA, LISP and DCL. Table 3 shows the availability of those APIs in each applications.

Table 3: API Support

Language	**AutoCAD**	**ZWCAD**	**ProgeCAD**	**BricsCAD**
C++	✓	✓	-	✓
.NET	✓	✓	✓	✓
VBA	✓	✓	✓	✓
LISP	✓	✓	✓	✓
DCL	✓	✓	✓	✓

Two of the APIs, List Processing (LISP) and Dialog Control Language (DCL) have been chosen to create the logic and dialog boxes, respectively, in order to test the performance and speed of the programs.

Performance and Speed: Two of the most repetitive tasks that are done in EASE Engineering PLC are calculating tributary areas in order to calculate what portion of the slab loads are transferred to the corresponding column below and to consequently calculate check for punching shear. This task is frequently performed to quickly check software outputs and to have quick estimations manually. And the other repetitive task is the comparison of different versions of drawings to check for shifts in column locations and changes in slab layouts.

These operations have been automated by the author of this paper using AutoLISP. AutoCAD's IDE for AutoLISP was used for coding and debugging. A key issue that was noticed in this phase were:

- AutoCAD and BricsCAD both possess an internal IDE for AutoLISP.
- ZWCAD does not ship with its own AutoLISP IDE but can connect to Visual Studio and use it for coding and debugging
- Even though ProgeCAD can accept AutoLISP files and run them (to a certain extent) it was noticed that it does not ship with its own IDE. And no documentation has been found whether or not it can use external IDEs for coding and debugging.

A runtime analysis was performed by registering the start and completion times of the scripts on the machine the applications are being tested on in order to have an approximate execution time. Therefore, it should be noted that the duration mentioned in the paper is specific to the machine it was tested on. Regardless of the effort to keep the machine in similar state, it should be noted that the state of the machine is prone to changes as a result of factors that cannot be controlled and could have an effect on the measure of the time a task is completed.

Specification of the machine used for testing was:

- Processor - 11th Gen Intel(R) Core(TM) i7-11800H @ 2.30GHz
- RAM - 16.0 GB
- OS - Windows 11 Pro, 64-bit operating system, x64-based processor

Tributary areas

For this script an algorithm that is used to produce Voronoi Diagrams have been adopted. The script implements the drawing of lines, creating boundary polylines, inserting points, deleting entities and inserting blocks. Rectangular slab shown in Figure 4 consisting of 459 columns (blocks) is used for the comparison of performance.

Execution time recorded:

- AutoCAD – 22 seconds (Figure 5)
- ZWCAD – 2.22 minutes (Figure 6)
- BricsCAD – 49 seconds (Figure 7)
- ProgeCAD – The script generated stack overflow error and aborted (Figure 8)

Dialog Box Design

Dialog Control Language (DCL) is used to check the ability of each application to produce the expected dialog boxes. Figures 9 - Figure 12 show that all four applications

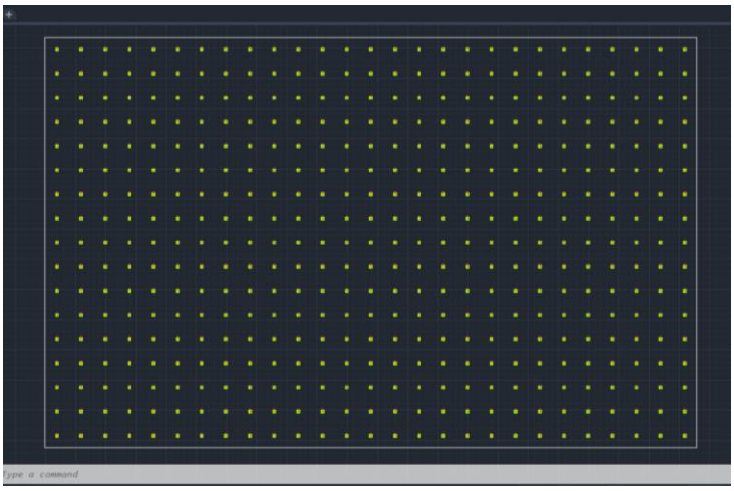

Figure 4: Slab and column layout before "Tributary area" script is run

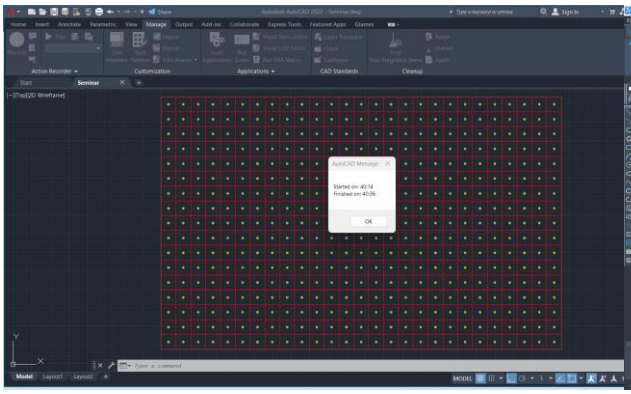

Figure 5: AutoCAD output after the "Tributary area" AutoLisp script is run

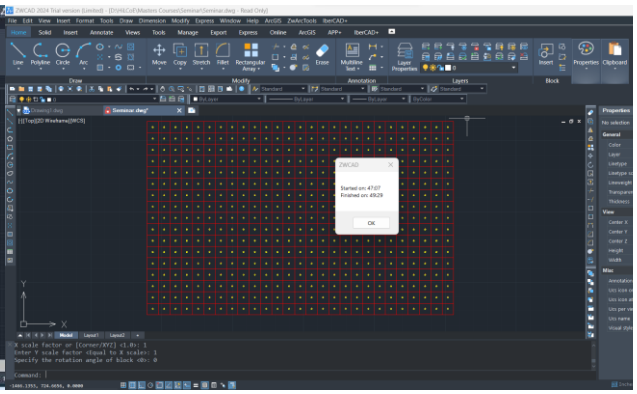

Figure 6: ZWCAD output after the "Tributary area" AutoLisp script is run

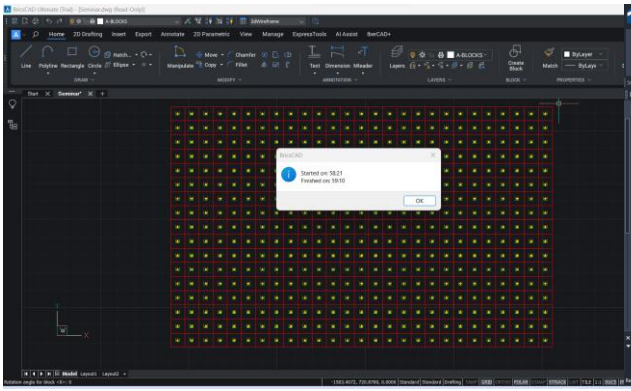

Figure 7: BricsCAD output after the "Tributary area" AutoLisp script is run

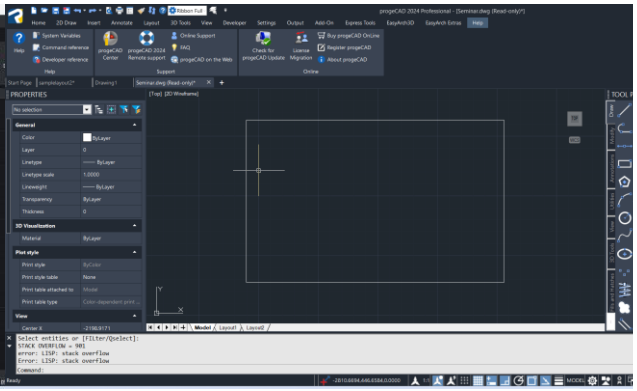

Figure 8: ProgeCAD output after the "Tributary area" AutoLisp script is run

displayed the dialog box as required with minor misalignment of components observed.

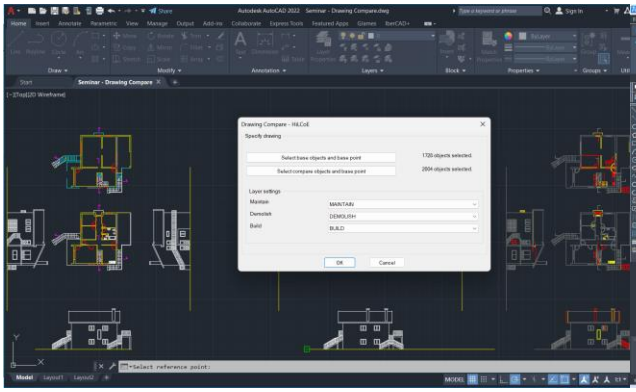

Figure 9: AutoCAD dialog designed with DCL

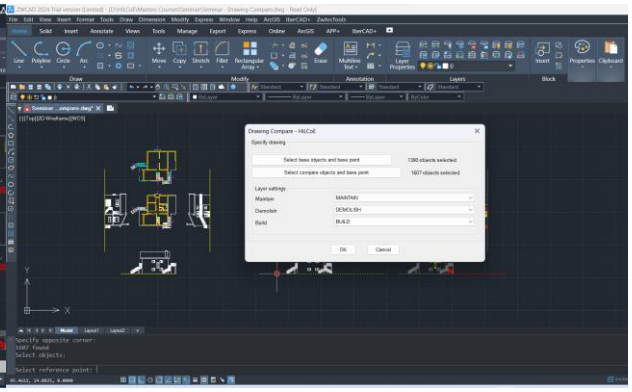

Figure 10: ZWCAD dialog designed with DCL

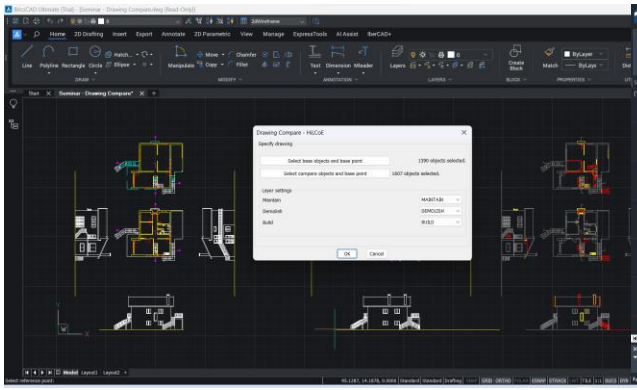

Figure 11: BricsCAD dialog designed with DCL

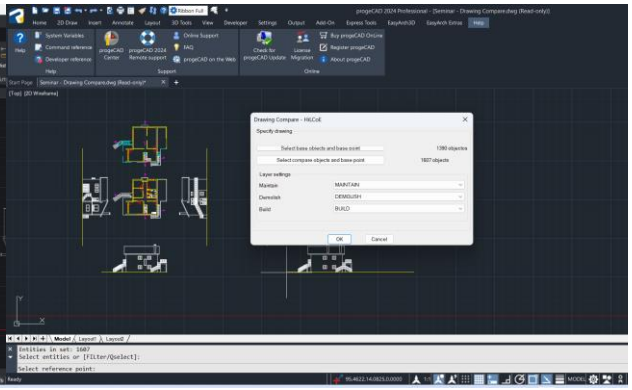

Figure 12: ProgeCAD dialog designed with DCL

The final script used for the measurement of the performance is a script that compares two drawings and produce a third drawing that has a color code of Gray (unchanged), Yellow (Exists in the first drawing, base objects, but not in the second) and Red (exists in the second drawing, compared objects, but not in the first). The two drawings to be compared are shown in Figure 4.7.3.1, base objects are in the left (1390 objects) and compared objects (1607 objects) are the ones on the right. And the drawing produced by the "Drawing Compare" script can be seen in the far right side of Figures 13 – Figure 17. Three of the applications produced the expected output while ProgeCAD aborted the routine without producing a result as shown in Figure 17.

Execution time recorded:

- AutoCAD – 31 seconds (Figure 14)
- ZWCAD – 4 seconds (Figure 15)
- BricsCAD – 1 second (Figure 16)

Figure 13: Drawings to be compared by AutoLISP "Drawing Compare" script

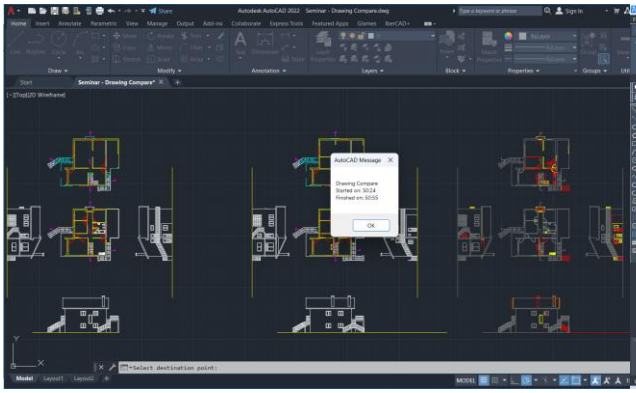

Figure 14: AutoCAD output after "Drawing Compare" AutoLISP script is run

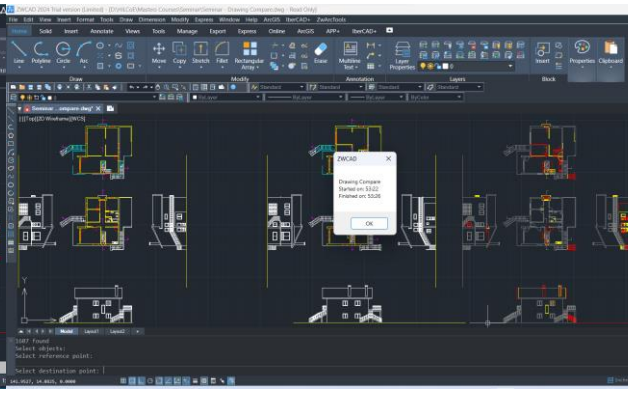

Figure 15: ZWCAD output after "Drawing Compare" AutoLISP script is run

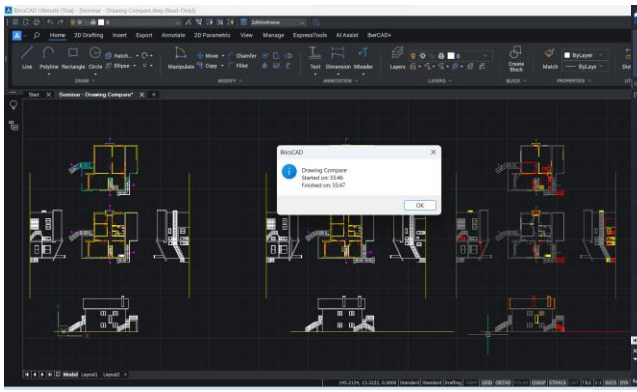

Figure 16: BricsCAD output after "Drawing Compare" AutoLISP script is run

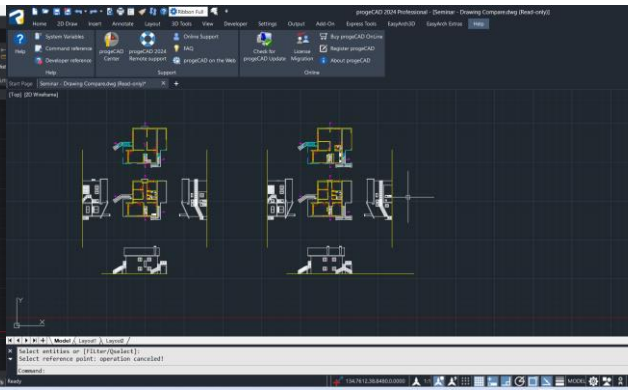

Figure 17: ProgeCAD output after "Drawing Compare" AutoLISP script is run

4 Conclusion

It is evident that AutoCAD is more advanced and has an extensive set of tools for 2D as well as 3D drafting works. A detailed documentation is provided for drafters as well as developers looking to streamline jobs on AutoCAD. Furthermore, there are multiple forums

and communities of users online which makes help more accessible than any of the other three. However, for the drafting needs of EASE Engineering PLC, the price is too expensive. The unavailability of perpetual licenses makes matters worse.

Even though ProgeCAD is the cheapest option, it lacks documentation and when it comes to its APIs it did not perform the basic tasks that were selected as the basis of comparison. The most probable cause for the errors in the AutoLISP scripts is assumed to be differences in function names and syntactic differences. But the unavailability of documentation and in-built IDE has made debugging impossible.

ZWCAD and BricsCAD on the other hand are both lightweight, cheaper than AutoCAD, fast in execution and user-friendly. Even though ZWCAD under performed on the "Tributary Area" script, its price makes up for it. The author has also found the user experience to be the closest to AutoCAD than the rest.

In conclusion, it is recommended that EASE Engineering PLC, adopts ZWCAD for its drafting work which gives it most affordable and highest performance for the drafting needs.

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