ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
FACULTY OF TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING

CRITICAL COMPARATIVE FEATURE ANALYSIS OF STRUCTURAL SOFTWARE (SAP2000 AND STAAD.Pro) AND THE NATURE OF THEIR PIRATED COUNTERPARTS

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I. ABSTRACT

Being in the mist of the computer era, it's hard even to imagine the challenges faced in the structural world when such software did not exist. In this 'time is money' world reducing the time for analysis and design of a certain structure from months to seconds is a miraculous achievement. This thesis is believed to make us even more appreciative of the technological era we're in witnessing the evolution of structural software.

Although extremely useful in tackling routine and tiresome analysis activities in engineering, software by no means shall be taken as replacement for engineers. The basic engineering inputs of formulating models and applying engineering concepts and judgment at every step of the whole analysis and design process remain largely of the engineer's task. In contrary to the overgrowing 'software worship' practice in our country, engineers are to check software result validity. Engineers should also spend enough time in exploring features of engineering software with proper assistance from their respective manuals. Instead of wrong software adaptation habit of one engineering firm from another, the software features have to be thoroughly investigated so as to prefer one software over another for a specific task.

The other important issue which needs to be addressed regarding engineering software practice is the widespread use of pirated software products. The result reliability of pirated versions is put to the test by running four different types of structural models on a licensed SAP2000 V-12 and a pirated SAP2000 V-12 version. The results obtained showed small percentage differences which might suggest good "crack" quality for this particular package used. But this by no means shall justify the use of pirated products for a number of reasons to be discussed in this thesis.

The above implementations are set to narrow the gap and building trust between the seemingly rival so called "academic engineers" and "practicing engineers" by providing tangible functionalities and limitations of the structural software and evaluating the questionable validity of using pirated products.

CHAPTER ONE - INTRODUCTION

1.1 GENERAL

There is no question that the use of software has easened the analysis and design procedures of structures. But using software requires an earnest understanding of engineering concepts behind the software functionality. One has to fully understand the basic assumptions and considerations made when the software was originally developed. Lacking the required knowledge of the basic engineering principles can easily lead to devastating results.

When using commercial engineering software we have to study in depth the merits and demerits of one software over the other. Though they usually own similar character in basic principles, the comparison processes needs a very close look at the full application and utilization of each software with its limitations. Commercial software are becoming more and more competitive by highly upgrading their features on every new version. So a careful examination of their features is necessary for comparing software functionality in different aspects.

In this Master's thesis I have tried to compare two popular structural software packages namely SAP2000 (Structural Analysis Program) and STAAD.Pro (Structural analysis and design program). I have tried to evaluate these software packages from both analysis and design points of view. The selected comparison parameters include modeling, analysis, design output, import export utilities, ease of learning, cost and result reliability. Before the comparison is made a brief description about the comparison criteria is first discussed.

Some opinion of international users and engineering software surveys are also included in the next sections of this thesis. These sections will give a broader sight over the application of these software packages worldwide. The next section deals with the controversial subject of software piracy with special focus on engineering software packages. A small survey is carried out regarding the current practice of software application in the local consultancy industry. Moreover I have produced four different structural models using a licensed and pirated versions of SAP2000 and analyzed the results. Finally conclusions and recommendations are given at the last section of this thesis.

1.2 OBJECTIVE OF THE STUDY

In the last few decades the structural engineering world has been blessed with several powerful structural software packages. Out of several powerful general-use engineering software packages SAP2000 and STAAD.Pro have somehow succeeded in gaining popularity in the local consulting industry.

Despite the fact that numerous local users apply these software packages in different engineering practices, very few users truly understand the engineering principles behind their interfaces as well as their full feature application.

The general objective of this Master's thesis is therefore to provide state of the art review of both software (SAP2000 and STAAD.Pro) in order to familiarize users to various useful features offered by the packages. Moreover further task is carried out in studying the effect of software piracy on these packages. The exploration of a pirated version in contrast to a licensed version is limited to SAP2000, as it was impossible to get access to a licensed STAAD.Pro package in the local consulting industry.

CHAPTER TWO - COMPARATIVE FEATURE ANALYSIS (SAP2000 AND STAAD.Pro)

2.1 GENERAL

2.1.1 SAP2000

The SAP2000 (Structural Analysis Program) name has been synonymous with state-of-the-art analytical methods since its introduction over 40 years ago [23]. Founded in 1975 by company President Ashraf Habibullah, CSI (Computers & Structures Inc.) is recognized worldwide in the development of software tools for the analysis and design of civil structures. CSI products are licensed to thousands of structural engineering firms in more than 100 other countries [23].

The development of CSI software spans four decades, starting with the research of Dr. Edward L. Wilson at the University of California at Berkeley. The revolutionary SAP program was first released in 1970, and Dr. Wilson has subsequently been recognized by national and international engineering societies as one of the preeminent researchers in the field of computer aided structural analysis.

Each of CSI's programs is tailored to specific classes of structures, allowing the engineering community to work at efficient levels that are possible with "general purpose" type programs. SAP is intended for use on civil structures such as bridges, dams, stadiums, industrial structures and buildings. ETABS has been developed specifically for multi-story building structures, such as office buildings, apartments and hospitals. The SAFE System provides analysis and design of concrete slabs and foundations.

CSI is also known for unsurpassed product support. User support activities include advice on structural systems, interpretation of structural behavior, clarification on various aspects of building codes, and opinions on special modeling problems and other subjects related to computerized structural analysis and design.

SAP features user interface powered by analysis engine and design tools for engineers working on transportation, industrial, public works, sports, and other facilities. 3D object based graphical modeling environment to the wide variety of analysis and design options are completely integrated across one powerful user interface. This intuitive interface allows creating complex structural models that can be generated and meshed with templates built into the interface.

2.1.2 STAAD.Pro

STAAD.Pro is a general purpose program for performing the analysis and design of a wide variety of types of structures. The basic three activities which are to be carried out to achieve that goal - a) model generation b) the calculations to obtain the analytical results c) result verification - are all facilitated by tools contained in the program's graphical environment.

STAAD.Pro was developed by practicing engineers for practicing engineers around the globe. It has evolved over 28 years and is constantly guided by a premier industry-based steering committee [22]. The company claims that STAAD.Pro is the choice of 47 out of 50 leading Structural Engineering firms, 46 out of 50 state Dots and 7 out of the top 10 engineering universities [22]. STAAD.Pro features a user interface, visualization tools, analysis and design engines with advanced finite element and dynamic analysis capabilities.

Slabs and other surface entities like walls are modeled using plate elements. Large surface entities may have to be defined using several elements and this sometimes requires a tool called a mesh generator. The design philosophy and procedural logistics for member selection and code checking is based upon the principles of allowable stress design. Two major failure modes are recognized: failure by overstressing and failure by stability considerations.

Members are proportioned to resist the design loads without exceeding the allowable stresses and the most economical section is selected based on the least weight criteria. The code checking part of the program also checks the slenderness requirements. STAAD revolutionized the concurrent use of spreadsheets, an AutoCAD-like graphical modeler, and a text-based input language editor. It’s embedded with over 40 step-by-step movie tutorials and hundreds of examples and verification problems. Along with movie tutorials, STAAD also include an online help documentation that

provides examples and explanations on hundreds of topics. In addition, STAAD offer an unparalleled certified training program as well as on-site and in-house trainings.

Currently, the program support over 70 international codes and approximately 20 US codes [22]. Unlike most structural software, STAAD.Pro can be customized by the user to exactly fit design needs. STAAD.Pro is developed on an open architecture called OpenSTAAD. All of the functions related to input or output are available to the user, such as Get Maximum Bending Moment or Add Uniform Load. STAAD also include a parametric library of pre-built commonly used structures like trusses, buildings, mats, etc. that can be customized by for modeling repetitive structures. The user can even add a template. In addition, STAAD.*Pro* has an embedded VBA (Visual Basic for Applications) editor which enables users to write their own design, loading, or post-processing routines directly in the STAAD environment.

2.2 COMPARISON CRITERA

2.2.1 Modeling

Modeling a structure using software highly depends on the engineering assumptions considered. Generating models is the most important step in the analysis and design procedure of any structure. The required engineering concepts and parameters are mostly applied at this stage. Once the structural model is properly created the analysis and design procedures are simply computational processes. Therefore high level of care should be taken as to how precisely we model our structure.

In STAAD.Pro there are two methods for building a model and assigning the structure data which are using the command files and using the graphical model generation mode or graphical user interface (GUI).

The Command File is a text file which contains the data for the structure being modeled. This file consists of simple English-language like commands, using a format native to STAAD.Pro. This command file may be created directly using the editor built into the program, or for that matter, any editor which saves data in text form, such as Notepad or WordPad available in Microsoft Windows.

The graphical method of creation involves utilizing the Modeling mode of the STAAD.Pro graphical environment to draw the model using the graphical tools, and assigning data such as properties, material constants, loads, etc., using the various menus and dialog boxes of that mode. If the 2nd method is adopted (using the GUI), the command file gets automatically created behind the scenes. The graphical model generation mode and the command file are seamlessly integrated. So, at any time, you may temporarily exit the graphical model generation mode and access the command file. You will find that it reflects all data entered through the graphical model generation mode. Further, when you make changes to the command file and save it, the GUI immediately reflects the changes made to the structure through the command file.

In SAP2000 the model template form allows for the quick generation of numerous model types using parametric generation techniques. The model can be started using the grid generation. When laying out the grid, it is important that the geometry defined, accurately represents the major geometrical aspects of the structure. The model features of both software are comparatively tabulated as follows.

Table 2.1 Modeling feature analysis of SAP2000 and STAAD.Pro

No.	Features	SAP2000	STAAD.Pro
	Modeling		
1	Parametric mesh model	✓	✓
2	Specification of Member Orientation Using Reference Vector	✓	✓
3	Roaming grid labeling for construction lines for easy beam/column placement		✓
4	Selective labeling to turn on/off individual beam/plate/solid labels with new shortcut keys		✓
5	Auto mesh of user-defined polygonal element boundary by simple mouse clicks	✓	✓
6	Unlimited Undo and Redo		✓
7	More structure wizard models including user-defined parametric structures to create any structural template		✓
8	Define any point as the center for cylindrical and reverse cylindrical coordinate system		✓
9	User-defined steel databases to add customized sections or steel libraries		✓
10	Interactive menu-driven model generation with simultaneous 3D display	✓	✓
11	Multiple and customizable views that can be saved for future sessions	✓	✓
12	2D and 3D graphic generation using rectangular, cylindrical and reverse cylindrical coordinate systems	✓	✓
13	Segments of repetitive geometry may be used to generate complex structural models		✓
14	Generate, copy, repeat, mirror, pivot, for quick and easy geometry generation	✓	✓
15	Quick mesh generation	✓	✓

Table 2.1 (cont'd)

16	Import AutoCAD DXF files	✓	✓
17	Access to text editor		✓
18	User-controlled scale factors for deflected or mode shapes		✓
19	Structure Wizard to create meshes with holes and curved surfaces		✓
20	Full 3D rendering capability with lighting and shading		✓
21	Fireproofing on columns, beams and braces	✓	✓
22	Auto-meshing of complex slab systems. Automatically refines the mesh if columns or openings or wall lines are added		✓
23	Dynamic auto-scaling of all force diagrams while zooming		✓
24	Re-indexing of stress contour values and ranges during zooming		✓
25	Backup manager and auto-save to automatically save, retrieve, compare and restore current or older versions of the same file	✓	✓
26	Color-coded element display based on attributes	✓	✓
27	User-defined axis of rotation for viewing	✓	✓
28	Automatic wall-slab interface with proper boundary connectivity		✓
29	Object Based Graphical Interface	✓	✓
30	Area (Shell) and Solid Objects with Internal Meshing	✓	
31	Integrated Graphical Section Designer for Complex Frame Shapes	✓	
32	Bridge Wizard for Bridge Modeling	✓	✓
33	Accurate Dimensioning with Guidelines and Snapping	✓	
34	Auto Edge Constraints for Mismatched Shell Meshes	✓	
35	Quick Draw Options for Object Creation	✓	
36	Tendons in Frame, Shell and Solid Objects	✓	
37	Parametric Bridge Cross Sections	✓	✓
38	Definition of Highway Layout Lines	✓	
39	Automatic Generation of Code Lateral Wind and Seismic Loads	✓	
40	Wind Loads on Open Structures	✓	
41	Transfer of Loads from Area Objects to Framing Systems	✓	
42	Application of Lane Loads to Bridge	✓	✓

2.2.2 Analysis

Before designing a given structure we have to be able to determine the stresses (external and internal) being imposed on the structure. In order to do this, structural analysis procedure is required. It is very important to know the engineering methods used by the software for analysis. A deep knowledge in the analysis method being applied is very useful as to determine the reliability of the result and the limitations of the analysis methods for a given model. The analysis features in both software, SAP2000 and STAAD.Pro, are comparatively tabulated below.

Table 2.2 Analysis feature comparison of SAP2000 and STAAD.Pro

No.	Features	SAP2000	STAAD.Pro
1	**Analysis**		
2	Staged construction (construction sequence loading), including multiple scenarios	✓	
3	For the special case of pushover analysis including effective damping computations, capacity spectrum computations and demand spectrum comparisons are also performed	✓	
4	Nonlinear frame, cable and link elements	✓	✓
5	P-Delta analysis	✓	✓
6	Large displacement analysis	✓	
7	Eigen analysis with an accelerated subspace iteration algorithm	✓	
8	Ritz analysis for optimal mode superposition basis	✓	
9	Modal analysis including P-delta, large displacement and construction effects	✓	
10	Modal combination by the SRSS, GMC(Gupta) and 10 Percent methods	✓	
11	Directional combination by the SRSS or factored absolute sum method	✓	
12	Use either the Wilson FNA method or a direct integration method	✓	
13	Ground acceleration excitation	✓	✓
14	Multiple base excitation	✓	✓
15	Load forcing functions	✓	
16	Transient or steady state	✓	
17	Nonlinear frame and cable elements	✓	✓

Table 2.2 (cont'd)

18	User defined truck, lane and train loads	✓	✓
19	Capable of handling complex lane geometries	✓	✓
20	Automatically calculates all possible permutations of traffic loads	✓	✓
21	Provides correspondence between response components	✓	
22	Determination of maximum and minimum displacements and reactions	✓	✓
23	Calculation of multiple modes for any number of load combinations	✓	✓
24	Ability to run selective analysis cases	✓	✓
25	Create and run new cases while keeping results already calculated	✓	
26	P-Delta analysis including stress stiffening effects	✓	✓
27	P-Delta including small delta	✓	✓
28	Modal analysis including stress stiffening	✓	✓
29	Buckling load analysis	✓	✓
30	Multiple analysis in same run	✓	✓
31	Tapered tubular cross-sections such as hexagonal, octagonal, etc.		✓
32	Plate elements contain extra "drilling" degree of freedom		✓
33	Unidirectional support (compression-only/tension-only supports) for generation of soil springs		✓
34	Master/slave capabilities		✓
35	I-beam warping end restraint added as an option for torsional stiffness		✓
36	Buckling analysis	✓	✓
37	Plate elements consider inclined supports	✓	✓
38	Member and spring specification	✓	✓
39	Fixed, pinned and spring supports with releases. Also Inclined Supports	✓	✓
40	Automatic spring support generator for mat foundations		✓
41	Active/Inactive members for load-dependent structures		✓
42	Compression-only and tension-only members, multi-linear (non-linear) spring supports	✓	✓
43	Determine stresses and forces along any cut line through a group of plates by cutting with a plane		✓

Table 2.2 (cont'd)

44	Elbows (curved beams with pipe sections) can be modeled with an internal pressure		✓
45	Multi-linear spring curves can be assigned to elastic or plate mats	✓	✓
46	Beam, truss, tapered beam, shell/plate bending/plane stress and 8-noded solid elements	✓	✓
47	Full and partial moment releases (excellent for steel frames where releases defined by springs are hard to determine)		✓
48	Nonlinear cable members for cables	✓	✓
49	Modal damping for time history and spectrum	✓	✓
50	Composite damping to specify damping ratio for each member/element	✓	✓
51	Base shear calculation includes direction factors	✓	✓
52	Extraction of Frequency and Mode Shapes	✓	✓
53	Generate floor spectra from time history	✓	✓
54	Modal Damping Ratio for Individual Modes		✓
55	3D influence surfaces, traffic lanes, critical vehicle loading positions, etc. (optional)		✓
56	Influence area reported for spring supports for elastic mats		✓
57	Enhanced solid stress contour definition for brick elements		✓
58	Full buckling analysis to obtain buckling modes and factors for various loading conditions	✓	✓
59	Graphical and tabular representation of singularities / instabilities to exactly pinpoint the area of the structure affected.		✓

Both software use the finite element method for analysis. The computational efficiency of both packages is more or less parallel. Implying that the computational time for carrying out simple duties is almost similar in both cases. But for structures with very large number of members and irregularities, the computational procedure takes more time.

2.2.3 Design

The main purpose of the whole procedure revolves around this step. In this step we have to be able to suggest a suitable structural section capable of supporting the stresses expected on the member. This can be carried out using different design codes depending on the location of the practice and the assumptions made. The design features in both software, SAP2000 and STAAD.Pro are critically tabulated as follows.

Table 2.3 Design feature analysis of SAP2000 and STAAD.Pro

No.	Features	SAP2000	STAAD.Pro
	Design		
1	Steel Frame Design for AISC-ASD & LRFD, AASHTO, API, UBC, British, Canadian, Italian, Indian and Euro Codes	✓	✓
2	Concrete Frame Design for ACI, AASHTO, UBC, British, Canadian, New Zealand, Indian, Italian, Korean, Mexican and Euro Codes	✓	✓
3	Aluminum Frame Design	✓	
4	Cold-Formed Steel Frame Design for AISI Codes	✓	
5	Design for Static and Dynamic Loads	✓	✓
6	Straight & Curved Girder Design	✓	
7	Automatic Calculation of Moment Magnification Factors	✓	
8	Steel Frame Design Offers Automatic Member Selection	✓	✓
9	Virtual Work Based Optimization for Lateral Deflections	✓	
10	Grouping for Design Envelopes	✓	
11	Designed for Biaxial-Moment/Axial-Load Interaction	✓	✓
12	Seismic Check of Beam/Column Joints in Concrete Frames	✓	✓
13	Automated Effects of Panel-Zone Deformations on Lateral Drift	✓	
14	API Punching Shear Checks	✓	
15	P/T Concrete Box Girder Design	✓	
16	Design of HSS Section		✓
17	Design of tapered sections like I-beams and hexagonal, dodecagonal and octagonal tubes		✓

Table 2.3 (cont'd)

18	Design cold-formed and aluminum sections with full database library included		✓
19	AISC code check for members with cover plates		✓
20	Interactive steel designer to model enhanced physical members and report step-by-step calculations for each design clauses and formula	✓	✓
21	Moment and shear connection designer integrated with the steel designer to perform several column flange-beam moment and shear connections	✓	✓
22	AISI Cold-Formed Steel Design and section library		✓
23	Welding design code		✓
24	Composite beam design (including stud spacing) per AISC ASD and LRFD	✓	✓
25	Torsion design per Pub. T-117		✓
26	Transmission tower design code		✓
27	Design for Beams with Web Openings		✓
28	Check for Floor Vibrations due to Rhythmic Activities		✓

Both SAP2000 and STAAD.Pro have a list of different design codes they support. STAAD.Pro has specific size requirements regarding defining member dimensions, whereas SAP has no boundaries of such kind. STAAD.Pro doesn't carry out design for columns and piers where as SAP2000 does. But the design of columns by SAP2000 especially based on the Eurocode often raises questions in result validity. It seems that SAP2000 doesn't fully abide by the column code provisions stated in the Eurocode. For instance when considering accidental eccentricity 'ea'; Eurocode strictly commands the consideration of 'ea' at the bottom, mid axis and top of a vertical column member section. But the design feature in SAP2000 only checks 'ea' at the mid axis which probably leads to different output. In case of embedding design codes to their applications, American developed packages such as SAP2000 seem to give more attention to American design codes. It is wise to cautiously check Eurocode based SAP2000 design results especially for column members.

2.2.4 Output

Both software offer a number of output features for which the user can easily obtain the output result for a particular task he/she requires. Both are equipped with animation features which are very useful particularly in presentations. Relatively STAAD.Pro grant a more organized and integrated output format.

STAAD.Pro has a customizable and high quality report available. It can be a summary of pictures exactly as seen on screen or complete, fully detailed reports. Extracting data from the model such as the largest node displacement at a specific node becomes easy using an inbuilt Advanced Query, SQL tool. On the other hand SAP2000 has 3D perspective graphical displays of undeformed and deformed structural geometry with AVI file option for saving animated displays with animated stress contours and multiple windows simultaneously displaying different output parameters. The different output features are critically tabulated below.

Table 2.4 Output feature analysis of SAP2000 and STAAD.Pro

No.	Features	SAP2000	STAAD.Pro
	Output		
1	3Dperspective graphical displays of undeformed and deformed geometries	✓	✓
2	Static deformed shapes and mode shapes	✓	✓
3	Bending moment, shear force, axial force and deflection diagrams	✓	✓
4	Stress contours	✓	✓
5	Animation of deformed shapes, mode shapes and time history behavior	✓	✓
6	AVI file option for saving animated displays	✓	✓
7	Animated stress contours		✓
8	Multiple windows simultaneously displaying different output parameters	✓	✓
9	Instantaneous graphical details for specific objects with a right button click	✓	
10	Static and dynamic load combinations and envelopes	✓	✓
11	Virtual work plots of relative work in every element for any load with respect to any analysis case	✓	
12	User customizable output tables can be send to onscreen viewing, printer, text file, Microsoft excel workbook, and as HTML file	✓	✓

2.2.5 Import Export Utilities (communication between software)

Communication between software is one of the important criteria for the preference of a soft ware. Communication ability with many software allows the user to import and export data from or to a destination. The data exchange features of both software packages are comparatively tabulated below.

Table 2.5 Import export feature analysis of SAP2000 and STAAD.Pro

No.	Features	SAP2000	STAAD.Pro
	Import export utilities		
1	Interactive Database Editing for Model Creation/Editing	✓	✓
2	Import/Export Model to Access Database	✓	✓
3	Cut & Paste Portions of Model to Excel Spreadsheet for Editing	✓	✓
4	Import/Export Model to Excel Spreadsheet	✓	✓
5	Import/Export Model in CIS/2 STEP File Format	✓	✓
6	Import/Export Model to SAP2000 .s2k file	✓	✓
7	Steel Buildings Detailed in ProSteel 3D using an Import/Export link	✓	✓
8	Export Steel Models in the Steel Detailing Neutral File Format	✓	✓
9	Import/Export Model to Text file	✓	✓
10	Import/Export Model to STAAD file	✓	✓
11	Import/Export Model to Frameworks Plus file	✓	
12	Import/Export Model to AutoCAD DXF file	✓	✓
13	Data Exchange Using IFC Standard	✓	✓

SAP2000, owing to its longer age in the market, provides a better import export utility service with respect to interacting with other engineering software. SAP2000 has a better communication capacity with common application packages in our country such as SAFE (which is preferred for slab design) and ETABS (which is usually preferred for building design).

2.2.6 Special cases

Both software bear features that can carryout analysis for the following tasks.

Table 2.6 Special features analysis of SAP2000 and STAAD.Pro

No.	Features	SAP2000	STAAD.Pro
	Special Cases	✓	✓
1	Bridge structures	✓	✓
2	Pre-stressed members	✓	✓
3	Composite structures	✓	✓
4	Shear walls	✓	✓
5	Non-prismatic members	✓	✓
6	Cantilevers	✓	✓
7	Dome shaped structures	✓	✓
8	Shell shaped structures	✓	✓

2.2.7 General features

Whenever a user is faced with a new software, he/she would want to learn the software in the shortest possible time as simply as possible. The ease of learning of one software over the other can play a great role in preference of the person using it. Compared to other structural software such as RISA3D, RISA2D, ETABS and RAMFRAME; both SAP2000 and STAAD.Pro are labeled by users as ‘difficult to learn’ [19]. As SAP2000 stayed the longer in the business, it has shaped its product to the very preference of its users based on constructive comments and feedbacks. SAP2000 also offers a set of manuals available on the internet with online help features which highly easens the learning process.

It is obvious that whenever buying a product, cost plays a vital role. In software market the higher price doesn’t necessarily imply the higher quality. So we have to be careful when buying the product with our required specifications and qualities at affordable price. Regarding cost of the software on the market, SAP2000 is more expensive than STAAD.Pro. Owing to extensive marketing strategy by CSI, users give SAP2000 the upper hand in the cost Vs value quality regardless of higher product price.

The simplicity in use of software's interface is the greatest tool to attract users to use the software. Users prefer a user friendly environment, which would make him/her feel in control of the operations being performed. This has been proved to be a great factor in terms of user preferences over software usage. Although both software use similar user interface, STAAD.Pro offers an additional editor tool which gives an upper hand in terms of ease of use. Applying the editor tool the user can display and edit the analysis procedure and output results at any part of the analysis and design steps.

Whenever using software packages which perform structural analysis, in order for the user to accept the analysis results, the user has to develop a certain trust towards that software. Result reliability is a great factor in choosing certain software over another. Based on experience and marketing skills a software producer has to be able to develop a solid trust and confidence of the user for the results of analysis by the software. Because of a longer experience in the market and feed back from CSI's impressive reputation in the structure world, SAP2000 results are more acceptable and trusted than STAAD.Pro results [20].

2.3 Software Survey

1998 Structural Software Survey

A 1998 national survey of structural engineering professionals published by Modern Steel Construction magazine [19] provides a basis for comparing the major structural engineering software programs. For this survey, practicing structural engineers were asked to rate the programs they use on a scale from 1 to 8 in various categories, where 8 is the most positive. Following are the results of this survey for various categories: (These bar charts are all based on a start value of 4)

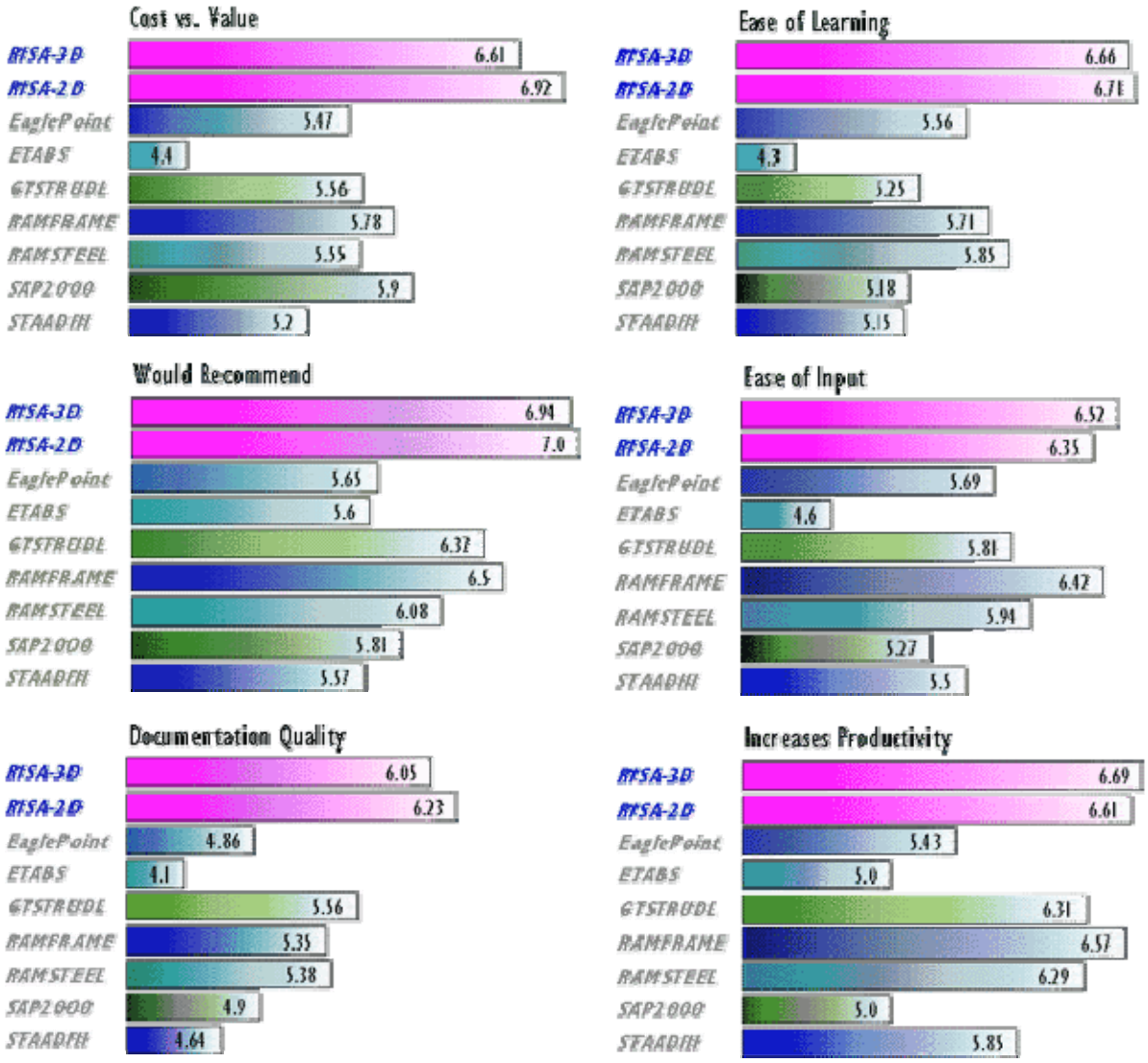

Fig 2.1 1998 Structural software survey

1996 Structural Software Survey

Modern Steel Construction magazine's annual structural software survey (Jan. '96 issue) provides an unbiased comparison of the major structural engineering programs. These comparisons are the result of a national survey of practicing structural engineers, who were asked to rate the structural software they use on a scale of 1 to 10, where 1 is the most negative and 10 is the most positive.

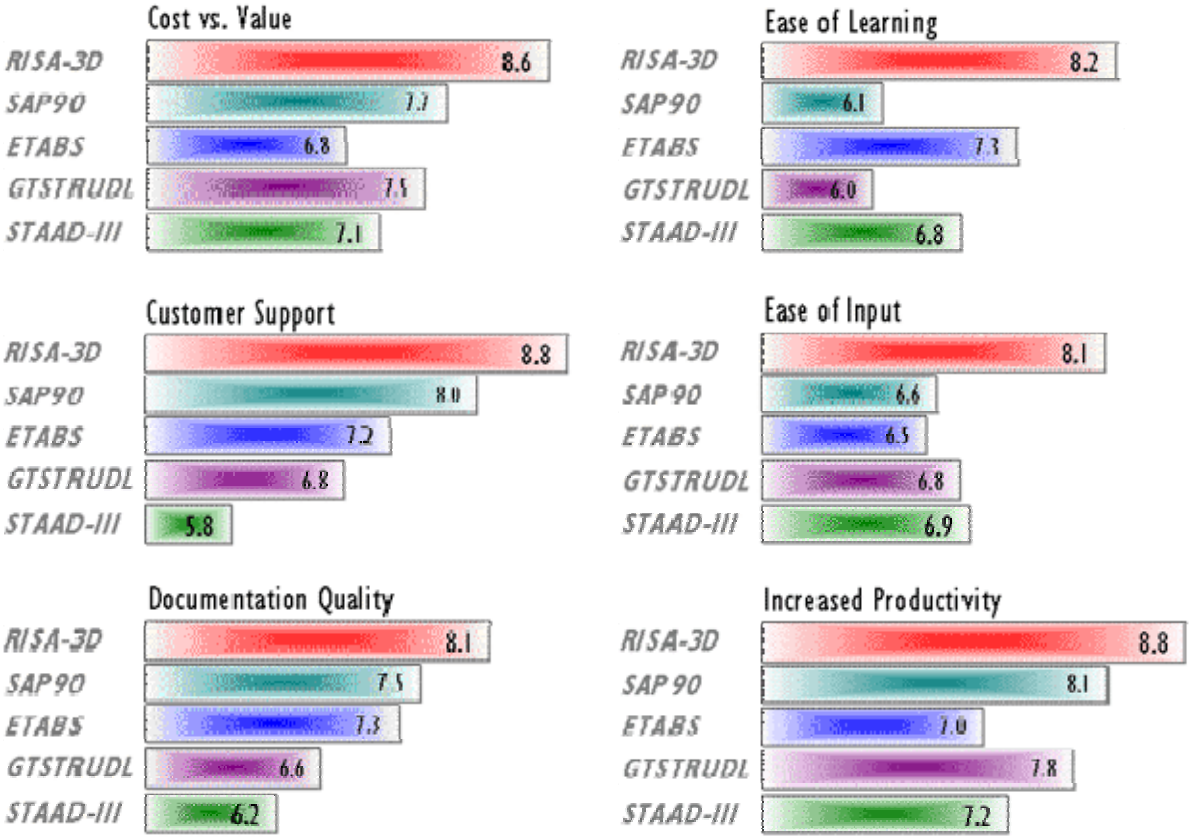

Fig 2.2 1996 Structural software survey

Each January and July, Modern Steel Construction presents a round-up of structural engineering software. The next table shows the result of a survey mailed to 1,000 MSC readers asking about their structural engineering software use and preferences. Respondents were encouraged to fill out a separate form for each program they use.

STRUCTURAL ENGINEERING SOFTWARE SURVEY

Results are from 1 to 8, with 8 being the top score	Ease of learning	Ease of Installation	Documentation	Customer Support	Ease of Data Input	Tabulated Results	GUI	Graphical Output	Expectations	Accuracy-Basic	Accuracy-Complex	Productivity	Value	Recommendation	# of respondents
AISC for AutoCAD	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	5.00	5.00	5.00	6.00	7.00	1
Algor SAP	3.80	5.60	3.40	4.80	3.80	4.60	4.40	4.20	5.20	6.00	5.80	4.80	3.80	3.20	5
BRASS (Wyoming DOT)	6.00	4.00	5.00	5.00	5.00	6.00	5.00	6.00	6.00	7.00	5.00	6.00	5.00	5.00	1
SJI (Floor Vibration)	6.00	7.40	4.80	2.40	6.60	3.80	6.80	4.00	6.40	5.60	4.80	6.20	6.40	5.00	5
CONXPRT	5.75	6.75	4.25	5.00	5.75	5.00	7.25	7.25	5.75	7.00	5.75	7.00	5.75	6.00	4
DESCON	5.66	5.66	5.00	5.00	6.00	5.66	6.00	6.00	5.66	5.66	5.66	5.33	4.66	5.33	3
Descon Brace	2.00	2.00	1.00	2.00	2.00	2.00	1.00	1.00	1.00	2.00	2.00	1.00	1.00	1.00	1
DESCUS	6.00	6.00	4.50	6.50	6.00	5.00	6.50	5.00	7.00	7.00	6.50	7.00	6.50	7.50	2
DetailCAD	7.00	7.00	6.00	8.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	8.00	8.00	8.00	1
Eagle Point Software	5.56	6.26	4.86	6.04	5.69	4.56	5.91	5.52	5.69	6.56	5.00	5.43	5.47	5.65	23
Enercalc	6.31	6.50	5.50	5.43	5.87	5.62	6.43	6.06	5.68	5.81	4.50	6.12	5.75	6.00	16
ETABS	4.30	4.00	4.10	6.10	4.60	4.70	5.10	5.00	4.20	5.70	5.60	5.00	4.40	5.60	10
FloorVib	5.00	7.00	3.00	4.00	4.00	0.00	7.00	0.00	5.00	6.00	6.00	4.00	5.00	5.00	1
FrameMAC	7.50	7.50	5.50	2.50	7.50	7.50	7.50	7.50	7.50	7.00	1.50	7.50	7.50	7.50	2
FrameWorks Plus	6.00	7.00	5.00	3.00	7.00	6.00	5.00	7.00	7.00	8.00	7.00	7.00	7.00	7.00	1
GT STRUDL	5.25	5.31	5.56	5.62	5.81	4.87	6.00	5.81	6.43	7.37	6.75	6.31	5.56	6.37	16
IMAGES-3D	4.00	4.00	4.00	5.00	6.00	4.00	6.00	5.00	5.00	6.00	6.00	3.00	3.00	3.00	1
LARSA for Windows	6.20	7.60	5.20	6.60	6.80	6.80	7.40	7.60	6.20	7.60	7.40	6.20	6.20	6.80	5
MDX Software	5.33	4.33	4.33	4.00	7.00	0.00	5.33	0.00	5.66	3.66	3.00	5.66	4.33	5.66	3
MERLIN DASH	5.12	4.87	4.62	5.50	5.37	5.12	5.25	5.37	5.50	5.50	5.25	6.00	5.25	5.37	8
Multiframe (Macintosh)	7.16	7.66	6.00	5.16	7.33	7.50	7.16	7.33	7.50	7.66	6.33	6.83	7.16	7.66	6
QuickBEAM	7.33	7.66	7.66	5.00	7.66	5.00	7.66	5.00	7.33	7.66	7.66	5.00	8.00	7.66	3
QuickConnect	5.66	5.00	6.00	5.00	6.00	5.66	6.00	5.66	5.00	6.00	5.33	6.00	5.33	5.66	3
RAMFRAME	5.71	6.28	5.35	6.85	6.42	6.07	6.28	6.57	6.42	6.85	5.71	6.57	5.78	6.50	14
RAMSBEAM	6.86	6.47	6.13	6.08	6.73	6.60	6.47	6.60	6.69	6.86	5.82	6.47	6.60	6.65	23
RAMSTEEL	5.85	5.76	5.38	5.23	5.94	5.82	5.82	5.76	5.82	6.32	5.44	6.29	5.55	6.08	34
RISA-2D	6.71	6.56	6.23	5.51	6.35	5.97	6.53	6.51	6.43	6.92	5.17	6.61	6.92	7.00	39
RISA-3D	6.66	6.25	6.05	6.11	6.52	5.88	6.41	6.72	6.58	6.86	6.05	6.69	6.61	6.94	36
RobotV6	6.00	5.00	5.00	5.00	5.00	6.00	5.00	5.00	5.00	6.00	6.00	6.00	6.00	6.00	1
S-FRAME/S-STEEL	8.00	8.00	7.00	8.00	8.00	7.00	7.00	7.00	8.00	8.00	8.00	7.00	8.00	8.00	1
SACS	5.50	6.00	4.50	6.50	7.00	6.00	7.00	6.00	7.00	7.00	7.00	7.00	5.00	5.50	2
SAP2000	5.18	6.72	4.90	5.90	5.27	5.81	6.36	6.90	5.09	7.18	5.81	5.00	5.90	5.81	11
SAP90	4.62	5.62	4.50	3.62	4.62	2.50	5.25	4.75	5.00	6.25	6.00	5.00	5.00	4.62	8
SDI Floor	5.00	6.00	6.00	5.00	5.00	6.00	7.00	6.00	6.00	7.00	7.00	7.00	6.00	6.00	1
SIMON Systems	6.33	4.66	6.33	3.66	6.00	2.00	6.00	2.33	4.00	7.00	7.00	7.00	7.00	6.66	3
SODA	8.00	8.00	6.00	7.00	8.00	8.00	8.00	6.00	8.00	8.00	7.00	8.00	8.00	8.00	1
STAAD-III	5.15	6.03	4.64	4.55	5.50	5.35	6.05	6.14	5.83	6.45	5.78	5.85	5.20	5.57	110
StruCAD*3D	5.50	6.50	4.75	6.00	5.50	6.00	6.50	6.50	5.25	6.75	5.75	4.75	4.00	5.75	4
Structural Analysis, Inc.	4.00	8.00	4.00	1.00	3.00	1.00	7.00	1.00	5.00	8.00	8.00	7.00	8.00	6.00	1
VisualAnalysis/VisualDesign	7.16	7.00	5.50	6.33	6.50	6.83	6.50	7.00	6.16	6.16	3.83	6.50	6.00	6.16	6
WEBOPEN	6.00	6.66	5.00	4.66	6.33	3.66	6.00	3.66	5.66	6.33	6.00	5.00	6.00	6.00	3
WinSTRUDL	6.00	7.00	3.00	4.00	5.00	2.00	6.00	6.00	6.00	7.00	5.00	7.00	6.00	7.00	1

Fig 2.3 Software survey by MSC

2.4 Comments from International Users about SAP2000 and STAAD.Pro

The comments below are provided by several software users and were acquired from an interactive engineering website. Selected few comments discussing about our target software are presented here.

- **Qshake** (Structural) 23 May 05 9:52

The use of codes to design is subjective and usually those software companies have programmers deciding the gray issues. Of course, the argument will be made that the programs are checked; and they are. But are they checked against the problems we face day to day? I don't think so. When's the last time we were asked to do something right out of a textbook? As a structural program, STAAD is mediocre, SAP and GTSTRUDL are much better and, of course, more costly.

- **Mark10** (Structural) 23 May 05 17:23

I agree with your view about the reliability of software not created by the user. But, STAAD claims that 75% of engineering firms are using their software, which seems very impressive. Also, when looking at structural job openings, most firms are looking for a STAAD background. As a young engineer without a lot of FEA background, the decision becomes a little difficult.

- **Carl** (Structural) 23 May 05 18:06

Those numbers are impressive yet consider that at a time when the cost of complex structural analysis software was out of reach for 90% of the firms STAAD comes along and produces a mediocre product for an astounding low price - quite a bargain. I myself am a former STAAD user and my company still has a license for the software although we are moving toward SAP as a bread-and-butter program. We also have licenses for GTSTRUDL, SAP, COSMOS and a number of other more specific structural analysis programs. It's been our experience that for complex analysis we just couldn't rely on STAAD.

- **Riz** (Structural) 24 May 05 3:23

STAAD is doing well with us here. Initially, it had an air of not being user….. But it gets okay with time. I would still vote for it.

- **Arnie** (Visitor) 9 Jul 05 12:18

I have used STAAD since 95 and I've had enough, way too many bugs and dodgy answers. I've turned to Robot, the most user- friendly I've seen especially for slabs and stuff. I have just received the latest version and it has Pushover analysis in it which is a bit of a bonus. If you like programming your own postprocessing environments our other stuff then Robot has its own Windows Object Model so yu can directly program into/from Robot in VBasic/C++ etc.

2.5 Conclusion

In this thesis it is viewed that both SAP2000 and STAAD.Pro are efficient structural software. Both have helped revolutionize the system of analysis and design of structures. They have played a great role in eradicating the very tedious analysis and design procedure by hand, with very high precision as well.

The purpose of this thesis is not to draw a general conclusion of which software is better than which, but a suggestion according to a predefined criteria as to when a user shall use either of the software. From the criteria set to evaluate the software a clear picture can be drawn for what purpose certain software shall be used. The main difference in the application of the software can be noticed from the past chapters as; SAP2000 doesn't have a feature for designing continuum structural elements such as slabs, shells, and shear wall. The exclusion of such important feature in SAP2000 is probably a market strategy of CSI (producer of SAP2000) as to make users buy other CSI products which specialize in those areas such as SAFE. Through long years of experience on the market, both software packages have integrated user comments in order to polish the software functionality to a better precision and applicability. Thus precision of results for simpler structures is very similar in case of both software.

I want to stress on the point that the new trend of application of software in our country should be oriented to the right direction before it is too late. The structural software should be used by users with intense background knowledge of the basic engineering principles behind the software and those who are familiar with the assumptions made and limitation of the software. In addition to that a habit of reading instructions and manuals of engineering software shall also develop.

CHAPTER THREE - PIRATED SOFTWARE

3.1 General

Within the last decade there has been a massive growth in the use of microcomputers in private and public institutions. Paralleling the growth in microcomputer use has been the growth in software piracy. Defined as the illegal duplication of commercially available software in order to avoid fees or the unauthorized copying of an organization's own internally developed software, software piracy has become recognized as a major problem for the software industry and for business. It has been estimated that software piracy results in between two and ten illegal copies made for ever legitimate copy sold. Coupled with intense price competition in the software industry, software piracy threatens the survival of a number of firms in the industry.

When software is pirated, consumers, software developers, and resellers are harmed. Software piracy increases the risk consumer's computers will be corrupted by defective software and infected with viruses. Those who provide defective and illegal software do not tend to provide sales and technical support. Pirated software usually has inadequate documentation, which prevents consumers from enjoying the full benefits of the software package. In addition, consumers are unable to take advantage of technical support and product upgrades, which are typically available to legitimate registered users of the software.

Developers lose revenue from pirated software, from current products as well as from future programs. When software is sold most developers invest a portion of the revenue into future development and better software packages. When software is pirated, software developers lose revenue from the sale of their products, which hinders development of new software and stifles the growth of the software company.

Software piracy has become recognized as a major problem for the software industry and for business. There is substantial evidence that many individuals do not perceive software piracy to be an ethical problem. The software protection strategy of software developer and the inherent risk to end user in using pirated software are two major factors that affect a user’s decision on whether to purchase or to pirate a software product.

3.2 Software Copy Protection

Basically no company reveals its copy protection logic and algorithm for obvious security reasons. Each developer may use specific copy protection routines particular to the application software. But the most common and widely applied copy protection systems are discussed below.

3.2.1 The Key diskette system

This system has been effectively applied in the past years. The system provides a special diskette that would carry a special code for proper functioning of the software package [4]. In earlier versions of this system copies of the application package could be made on other computers and the copies worked as long as the key diskette was made available. But the earlier versions of the system only work on the first computer on which the license transfer has been made from the key diskette. It is possible to make the license files on the key diskette to be copy protected so as to make them not operational if copied. This system has been very effective and large number of vendors used it. But as the floppy diskette era began to fade away the applicability of this system followed suite. Very limited numbers of modern computers come with floppy devices making the 'key diskette' system un-functional. In our country ' Concepts Data Systems', the developers of the Amharic alphabet word processing software, ' Power Geez', used the key diskette protection system for many years.

3.2.2 Hard ware Lock system

A hardware lock is a small device that is usually attached to the universal serial port or the printer port of the computer to control the legitimacy of a software product. The hardware lock is programmed to check and approve if the product in use is licensed or not. It is even possible to embed one or more subroutines and procedures that are required for proper operation of the product. Some software modules can be programmed into the hard ware lock which provide the right subroutines if the product is legitimate. But it is important to cautiously note here that if any form of tampering with the application package by removing copy protection has been attempted, the developers can easily revert to wrongly programmed modules which might lead to catastrophic results [4]. The dangers of these kinds of scenario are more stressed in engineering software

packages where wrong software output may directly be linked to human life loss. An example of engineering software which uses this system is ‘SofiStik’. This German developed finite element analysis software requires a hard ware lock called code meter to operate.

3.2.3 Limited Number of Installation System

In this system an end user is provided only with the number of copies in parallel with the number of purchased license. Once the “license counter” has detected that all purchased licenses have been used the application software can not be installed. Moreover the software is locked not to be illegally copied from the computer on which installation was made from the original media.

3.2.4 License for limited time

This system allows the user to access the full functions of the software for a limited duration. This approach is quite different from demo versions as in case of demo versions some features are deliberately deactivated and the user is expected to get a preview of the software not the full taste. The user is able to renew the license when the license duration expires. The earlier versions of this system used the clock of the machine to measure the duration of the license. But as readjusting the machine clocks became commonplace to hackers developers were forced to embed an independent internal clock modified to the software package.

3.2.5 License activation system

In this copy protection system the software activation code is provided by the developer based on hardware related data [4]. This approach enables the user to first install the software package then contact the developer for specific activation code as per the particular central processing unit (CPU) data for a particular machine. This system is becoming more popular owing to the e commerce age we are in. Thanks to internet a user can simply download the software and get the activation code from the developer paying by credit card online. The method enables a user to acquire a legitimate product without moving from his work station within two to three hours time. Nowadays giant engineering software developers such as CSI and RISA efficiently apply this system.

3.3 Software “Cracking”

Despite the fact that software developers invest a fortune on software copy protection, ‘hackers’ somehow manage to find a way to break in the protection systems. So far there is no absolute software protection system. Although the protection systems are more and more sophisticated, the hackers seem to always be one step ahead. As one local software cracker put it “Difficulty never implies impossibility”. Some of the common software “cracking” methods are discussed below.

3.3.1 License Copying

This method has served as one of the basic software cracking means for quite a while. Software developers usually put the licensing module in different package than the main software application package. So successful copying or imaging of the license module will make way to the availability of the un-tampered main application package. Famous cracking tools such as Copy Write™ and Soft Sect™ have successfully carried out these tasks in the past [4]. But in recent practices the use of these methods has rapidly declined owing to the fact that software developers started embedding additional license subroutines in the main application package. In such cases copying the separate license module won’t be enough to get the full software functionality. Especially the introduction of the hard lock embedded routines has made the method more unreachable and even dangerous.

3.3.2 Tampering with License codes

This system is a more evolved method than previous ones. In this case small programs are written so as to deactivate the licensing module of the software, to generate license codes or to tamper the legitimacy checking operation of the application. Programs which use this method such as terminate and stay resident (TSR) even fool hard ware lock subroutines in making it assume that a legitimate user is accessing the program [4]. They also illegally generate key codes that unlock trial versions and making the package look like a licensed product.

3.3.3 Reverse Engineering

Reverse engineering (RE) is the process of discovering the technological principles of a device, object or system through analysis of its structure, function and operation. It often involves taking something (e.g., a mechanical device, electronic component, or software program) apart and analyzing its workings in detail to be used in maintenance, or to try to make a new device or program that does the same thing without copying anything from the original. As computer-aided design has become more popular, reverse engineering has become a viable method to create a 3D virtual model of an existing physical part for use in 3D CAD.

The basic concept of this method in relation with software application has been around for more than 15 years: yet its recent user friendly tools have made it evolve to become the most common and effective software cracking method. Reverse engineering tools such as IDA™ have the ability to generate source codes of executable files making a number of commercial software highly vulnerable. Once a hacker successfully generates the source code he can basically modify several features of the program. Some hackers change logos of the original developer's to their own, some embed viruses in them so as to make their own anti viruses available to the market and some even put their advertisements in the package after they crack it. In a recent encounter a hacker managed to sell several copies of cracked "Power Geez" software under a different name and logo.

3.4 Survey on Software Piracy

A recent research [26] suggests that companies that rely on unlicensed software are more likely to experience system failures and lose customer data. According to the research, mid-sized firms - those with more than 24 PCs and fewer than 500 - were 43 percent more likely to have had a critical system failure in relation to using unlicensed software packages.

Those businesses were also 28 percent more likely to lose customer data and 73 percent more likely to lose their own data than firms exclusively using licensed software.
The Harrison Group reached those conclusions after interviewing IT professionals and businesspeople at nearly 1,600 companies in the US, the UK, China and Brazil [24]. Of the

companies included in the survey, Harrison Group labeled 690, or 43.7 percent, as using fully-licensed software; 890, or 56.3 percent, ran some unlicensed software.

According to another survey [27] carried out by business software alliance, a group of software developers which was completed by independent firm IDC, more than one-third of all software installed on personal computers is pirated. 35 percent of installed software was pirated in 2007, down one percent from 2006. However, the survey found that losses from software increased, from $29 to $33 billion [28]. These losses have a profound economic impact in countries around the world.

Software piracy waxes and wanes from country to country, according to the survey. Also high up in piracy activity are Latin American countries, with piracy estimated at 63 percent, accounting for losses of $1.3 billion in the region. In the Asia/Pacific region, the piracy rate was 53 percent, with $7.5 billion in losses. In the Middle Easter and Africa, the 56 percent piracy rate was responsible for losses of more than $1 billion. Legitimate software companies in Western Europe and North America fared better. With a piracy rate of 36 percent in Western Europe, the region saw $9.6 billion in losses. In North America, losses totaled $7.2 billion, while the piracy rate was just 23 percent. It has to be noted here that the volume of software usage by developed nations is much greater than developing nations.

IDC said that much of the reason why losses from software piracy increased were due to a falling U.S. dollar and six-percent growth in the PC industry. The survey found that piracy in 37 countries decreased, while another 34 increased. 16 countries saw the same level of piracy year over year. In 24 of the 87 countries studied, piracy rates eclipsed 75 percent. Of the top five countries, three of them were in Asia, with Vietnam having the highest at 92 percent. Piracy is still most prevalent in countries and regions where the software market is growing as personal computing becomes more integral to work and daily life.

In developing countries like Ethiopia, although a proper survey on software piracy has not been carried out, we can surely say that a very high majority of commercial software in use are pirated. Even the so called professional world of the country has very low awareness over the whole software piracy matter.

3.5 Benefits of Using Genuine Software

3.5.1 Technical help facility

It is not unusual that technical questions and difficulties come along using engineering software. Users may be faced with a range of difficulties while operating the software. So who better to solve such problems than the developers themselves? It is essential for many businesses to have access to help desk. Otherwise a user won't be able to fully utilize the functionality of the software. Our country's practice of asking one another instead of getting professional help can simply be labeled as a blind man leading anther blind man.

3.5.2 Full instructions and manuals

The price of pirated software may be cheap but they usually miss out on elements that make genuine software easier to use and more complete in application. Genuine software offers all the required documentation for utilizing software features at full capacity. The wrong tradition of operating software without reading instructions and manuals has to be turned to the right direction.

3.5.3 Access to upgrade and update

The reality of the world of software is that nothing stays the same for particularly long. Products are constantly improved and kinks sifted out. Unfortunately, with a pirated version or knockoff, that continuum hits the brakes, leaving a product that's never going to get better or more efficient. With a bona fide product, however, elements such as upgrades, plug-ins and other ongoing improvements are the norm. Buying genuine software means that you know all available upgrades and documentation will be made available to you in the future.

3.5.4 Unnecessary risk to computers

Counterfeit software, much of it untested and unprotected, may be infected with bugs and viruses that could damage hard drive and even cripple an entire network. Even working programs could have defects leading to malfunctions of a system [25].

3.5.5 Illegality

In most countries, companies whose employees are found to be using illegal software can be liable for damages, fines and even jail time, according to the Business Software Alliance. In the United States, the fines can run as high as $150,000 for each illegal copy. Since Ethiopia is not yet a member of World Trade organization (WTO), developers lack the jurisdiction to cross borders of Ethiopia and sue illegal copy sellers and users. Although the Ethiopian government has passed a copy right law [29], the implementation yet needs proper attention.

3.5.6 Company image

In competitive market environment company image is a very important element of business strategy. It seems irony to find companies advocating genuine and honest work principles using pirated software products. Companies have to live what they preach if they are to be taken seriously. Using legitimate product surely adds class and a sense of professionalism to a company’s image, which directly translates to attracting more important projects and clients even at international level. It may seem a stretch, but using cheap software can say pretty much the same thing about a business, both within and without.

3.5.7 Ethically correct

Anything illegal never exists in a vacuum. Using pirated or illegal software is no exception. Recent studies estimate that even a modest reduction of global software piracy could add more than one million new jobs, boost economic growth by hundreds of billions and generate billions in taxes to bolster sagging economies worldwide.

One of the best ways to protect a business from the dangers of illegal software is to get to know the topic better. For instance, know what "illegal" means — it may surprise some, but that can mean using perfectly genuine software on more computers than a business is licensed to support. Developing a relationship with a reliable partner or vendor can also help in coming to understand the specifics of licensing, product certification and other elements of genuine software. A user has to enjoy the security of doing the right thing that ensures peace of mind.

3.6 Questionnaire

In order to measure the nature of engineering software application and software piracy in Ethiopia, a questionnaire has been distributed among several engineering firms here in Addis. From selected 20 firms only six firms responded to the questionnaire (see Annex). From this small survey I came across practicing engineers with deep concern over the software piracy problem and those who never even heard of the term ‘software piracy’.

The overall survey shows that very few engineering firms use licensed software products as the majority declined to fill out the questionnaire assumableley to avoid confrontations for using pirated engineering software products. And of those very few still a very small fraction dare to renew their license. Many claim that the cost of licensing is overpriced relative to the terrible low fee offered in the country for the consulting industry. Most welcomed the idea of a discount group purchase deal while some were skeptical about it by stating that the use of uniform software packages may affect competitive advantage. All agree that the practice of structural design is deteriorating in contrary to the software advancement. Some argue that the rapidly evolving user friendly nature of the new product interfaces give false confidence for those with inadequate know-how.

By principle a user of the software must be aware of the engineering principles behind the application as well as its limitations, yet many admit that they spent little effort in training their engineers for particular software applications. Some suggested that the government shall intervene by introducing strict policies discouraging the use of illegal software packages. All in all the current software application practice doesn’t seem to head to the right direction any time soon unless crucial measures are taken.

The responses of the six engineering firms who willingly filled out the prepared questionnaire are summarized in the following table.

No.		Afro European Engineering	MH Engineering Plc.	GTZ Int.	Sublime Engineers	Zias Design Int.	Remhai Engineers
1	Firms who originally purchased licensed software product	✓	✓	✓	**X**	✓	**X**
2	Firms who plan to renew their software licenses when it expires	✓	**X**	✓	**X**	**X**	**X**
3	Firms with experience of using pirated software products	**X**	✓	✓	✓	✓	✓
4	Firms who encountered technical problems when using pirated products	-	✓	✓	✓	✓	✓
5	Firms who claim the software license to be over priced for the local market	✓	✓	✓	✓	✓	✓
6	Firms who welcome hypothetical developer's group discount offer	**X**	✓	✓	**X**	✓	✓

Table 3.1 Summary of responses to questionnaire

N.B ✓ Agree, X disagree, - Neutral

3.7 Test Models

In this section selected structural models are tested for analysis results. The models are run on a licensed version of SAP2000 V-12 and a pirated version of SAP2000 V-12. The selected models are descriptively stated below.

Model 1

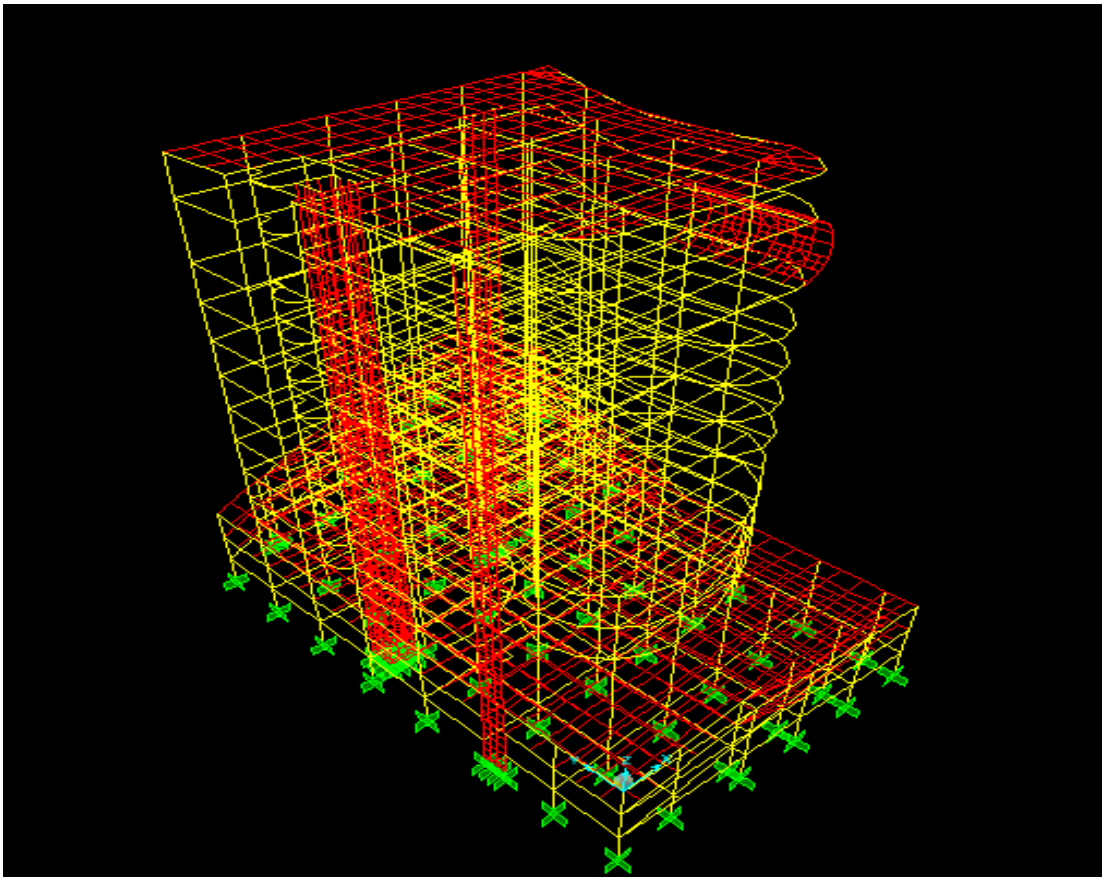

Fig 3.1 Model for G+ 12 irregular frame system with shear wall subjected to gravity and lateral loads

Model 2

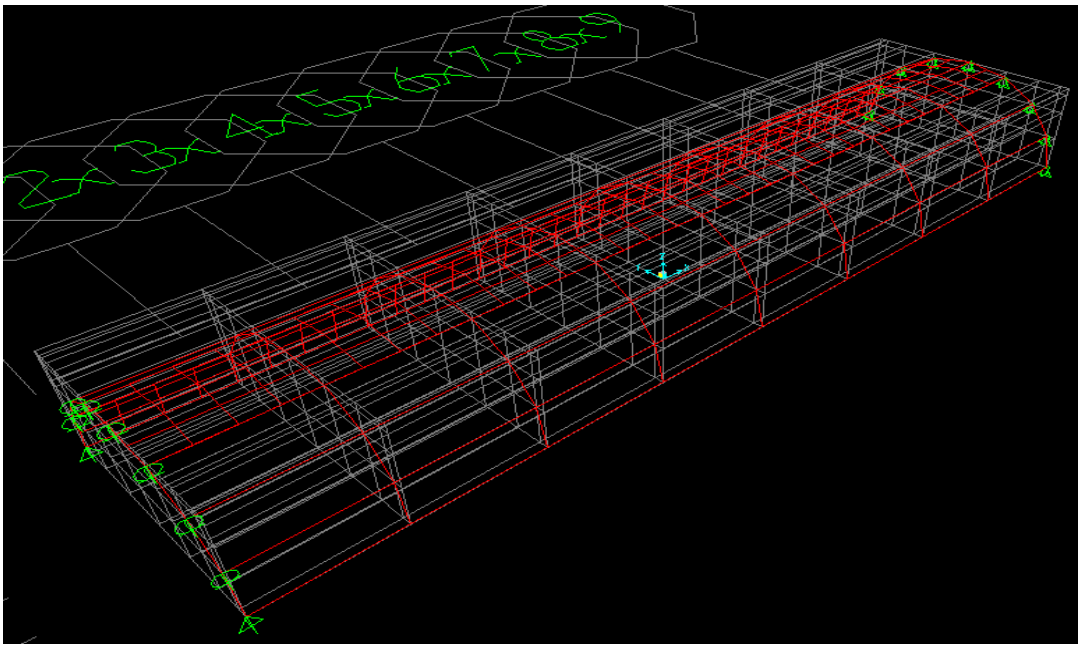

Fig 3.2 Model for Shell barrel structure subjected to gravity and lateral loads

Model 3

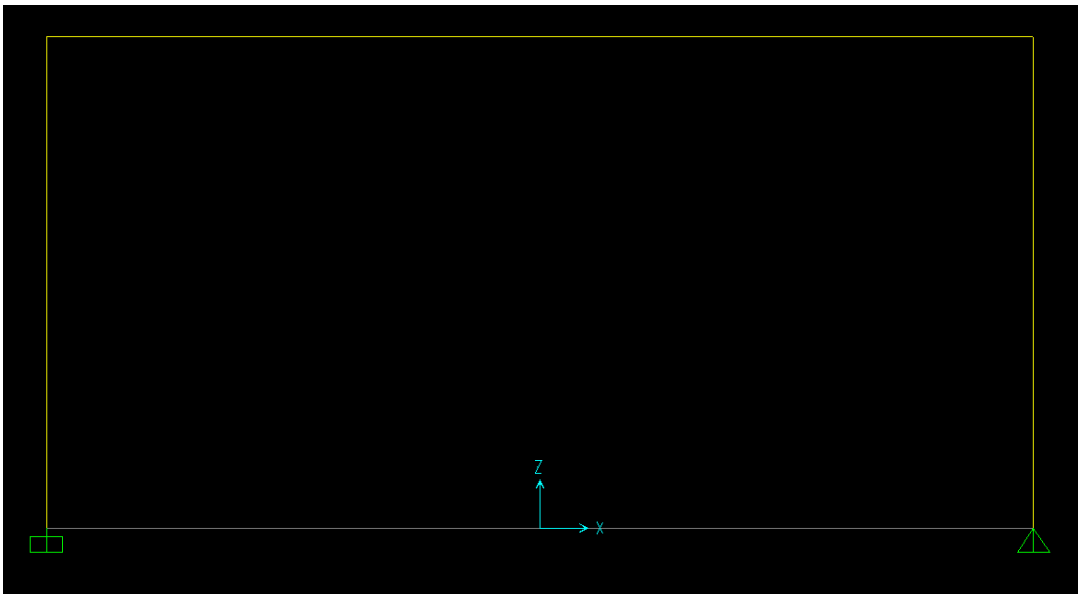

Fig 3.3 Model for Simple 2D portal frame with three members subjected to concentrated lateral

Model 4

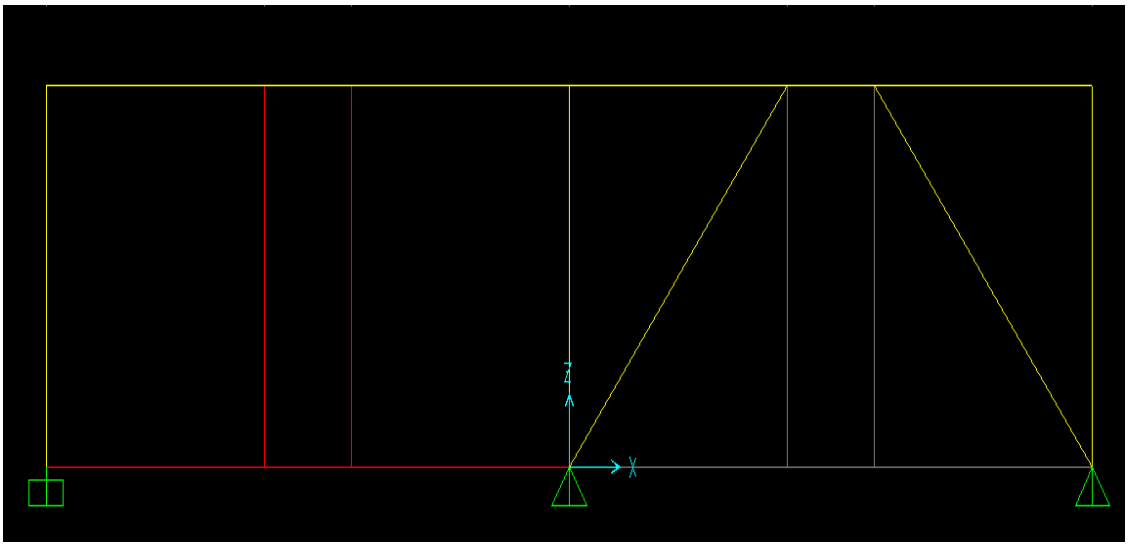

Fig 3.4 Model for Eccentrically braced 2D frame with wall system subjected to concentrated lateral

- The output of the analysis results with percentage difference between the two versions are tabulated as follows. The results are rounded to 2 decimal places.

(Licensed SAP2000 V-12)						(Pirated SAP2000 V-12)						Percentage Difference (%)					
P	V2	V3	T	M2	M3	P	V2	V3	T	M2	M3	P	V2	V3	T	M2	M3
KN	KN	KN	KN-m	KN-m	KN-m	KN	KN	KN	KN-m	KN-m	KN-m	%	%	%	%	%	%
0.00	123.33	0.00	1.68	0.00	64.56	0.00	123.33	0.00	1.68	0.00	64.56	0.00	0.00	0.00	0.00	0.00	0.00
0.00	56.18	0.00	1.68	0.00	52.12	0.00	56.18	0.00	1.68	0.00	52.12	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.97	0.00	1.68	0.00	81.51	0.00	10.97	0.00	1.68	0.00	81.51	0.00	0.00	0.00	0.00	0.00	0.00
0.00	78.12	0.00	1.68	0.00	23.60	0.00	78.12	0.00	1.68	0.00	23.60	0.00	0.00	0.00	0.00	0.00	0.00
0.00	145.27	0.00	1.68	0.00	121.61	0.00	145.27	0.00	1.68	0.00	121.61	0.00	0.00	0.00	0.00	0.00	0.00
0.00	123.33	0.00	1.68	0.00	64.56	0.00	123.33	0.00	1.68	0.00	64.56	0.00	0.00	0.00	0.00	0.00	0.00
0.00	56.18	0.00	1.68	0.00	52.12	0.00	56.18	0.00	1.68	0.00	52.12	0.00	0.00	0.00	0.00	0.00	0.00
0.00	10.97	0.00	1.68	0.00	81.51	0.00	10.97	0.00	1.68	0.00	81.51	0.00	0.00	0.00	0.00	0.00	0.00
0.00	78.12	0.00	1.68	0.00	23.60	0.00	78.12	0.00	1.68	0.00	23.60	0.00	0.00	0.00	0.00	0.00	0.00
0.00	145.27	0.00	1.68	0.00	121.61	0.00	145.27	0.00	1.68	0.00	121.61	0.00	0.00	0.00	0.00	0.00	0.00
0.00	72.26	0.00	9.09	0.00	135.66	0.00	72.27	0.00	9.09	0.00	135.67	0.00	0.01	0.00	0.00	0.00	0.01
0.00	68.25	0.00	9.09	0.00	123.72	0.00	68.25	0.00	9.09	0.00	123.72	0.00	0.00	0.00	0.00	0.00	0.00
0.00	64.23	0.00	9.09	0.00	112.46	0.00	64.23	0.00	9.09	0.00	112.46	0.00	0.00	0.00	0.00	0.00	0.00
0.00	60.21	0.00	9.09	0.00	101.88	0.00	60.21	0.00	9.09	0.00	101.88	0.00	0.00	0.00	0.00	0.00	0.00
0.00	56.19	0.00	9.09	0.00	91.99	0.00	56.19	0.00	9.09	0.00	91.99	0.00	0.00	0.00	0.00	0.00	0.00
0.00	72.26	0.00	9.09	0.00	135.66	0.00	72.27	0.00	9.09	0.00	135.67	0.00	0.01	0.00	0.00	0.00	0.01
0.00	68.25	0.00	9.09	0.00	123.72	0.00	68.25	0.00	9.09	0.00	123.72	0.00	0.00	0.00	0.00	0.00	0.00
0.00	64.23	0.00	9.09	0.00	112.46	0.00	64.23	0.00	9.09	0.00	112.46	0.00	0.00	0.00	0.00	0.00	0.00
0.00	60.21	0.00	9.09	0.00	101.88	0.00	60.21	0.00	9.09	0.00	101.88	0.00	0.00	0.00	0.00	0.00	0.00
0.00	56.19	0.00	9.09	0.00	91.99	0.00	56.19	0.00	9.09	0.00	91.99	0.00	0.00	0.00	0.00	0.00	0.00
19.61	13.99	0.07	0.69	0.23	18.35	19.61	13.99	0.07	0.69	0.23	18.35	0.00	0.00	0.00	0.00	0.00	0.00
19.61	0.14	0.07	0.69	0.03	9.33	19.61	0.14	0.07	0.69	0.03	9.33	0.00	0.00	0.00	0.00	0.00	0.00
19.61	7.20	0.07	0.69	0.17	2.00	19.61	7.20	0.07	0.69	0.17	2.00	0.00	0.00	0.00	0.00	0.00	0.00
19.61	14.26	0.07	0.69	0.30	19.44	19.61	14.26	0.07	0.69	0.30	19.44	0.00	0.00	0.00	0.00	0.00	0.00
19.61	13.99	0.07	0.69	0.23	18.35	19.61	13.99	0.07	0.69	0.23	18.35	0.00	0.00	0.00	0.00	0.00	0.00
														Max % Diff.	**0.01**		

Table 3.2 Analysis results for G+ 12 irregular frame system with shear wall

	(Licenced SAP2000 V-12)			(Pirated SAP2000 V-12)			Percentage Difference (%)		
ShellType	**FMax**	**MMax**	**VMax**	**FMax**	**MMax**	**VMax**	**FMax**	**MMax**	**VMax**
Text	KN/m	KN-m/m	KN/m	KN/m	KN-m/m	KN/m	%	%	%
Shell-Thin	743.74	16.50	54.35	743.74	16.50	54.35	0.00	0.00	0.00
Shell-Thin	707.55	55.46	54.12	707.55	55.46	54.12	0.00	0.00	0.00
Shell-Thin	301.58	34.55	4.74	301.58	34.55	4.74	0.00	0.00	0.00
Shell-Thin	368.41	30.00	6.84	368.41	30.00	6.84	0.00	0.00	0.00
Shell-Thin	482.66	8.17	141.35	482.66	8.17	141.35	0.00	0.00	0.00
Shell-Thin	443.48	127.90	141.75	443.48	127.90	141.75	0.00	0.00	0.00
Shell-Thin	293.80	79.23	44.87	293.80	79.23	44.87	0.00	0.00	0.00
Shell-Thin	336.49	35.17	43.58	336.49	35.17	43.58	0.00	0.00	0.00
Shell-Thin	269.97	1.49	209.79	269.97	1.49	209.79	0.00	0.00	0.00
Shell-Thin	289.80	185.08	211.16	289.80	185.08	211.16	0.00	0.00	0.00
Shell-Thin	179.43	115.66	72.76	179.43	115.66	72.76	0.00	0.00	0.00
Shell-Thin	151.77	37.72	68.68	151.77	37.72	68.68	0.00	0.00	0.00
Shell-Thin	156.41	38.35	70.22	156.41	38.35	70.22	0.00	0.00	0.00
Shell-Thin	186.73	116.53	73.73	186.73	116.53	73.73	0.00	0.00	0.00
Shell-Thin	292.19	182.30	204.20	292.19	182.30	204.20	0.00	0.00	0.00
Shell-Thin	322.22	38.23	48.56	322.22	38.23	48.56	0.00	0.00	0.00
Shell-Thin	280.80	80.76	46.93	280.80	80.76	46.93	0.00	0.00	0.00
Shell-Thin	458.14	134.37	154.24	458.14	134.37	154.24	0.00	0.00	0.00
Shell-Thin	496.71	7.07	154.74	496.71	7.07	154.74	0.00	0.00	0.00
Shell-Thin	1673.89	39.83	41.54	1673.89	39.83	41.54	0.00	0.00	0.00
Shell-Thin	1645.50	73.91	35.65	1645.50	73.91	35.65	0.00	0.00	0.00
Shell-Thin	611.36	55.08	2.08	611.36	55.08	2.08	0.00	0.00	0.00
Shell-Thin	649.26	56.37	21.42	649.26	56.37	21.42	0.00	0.00	0.00
Shell-Thin	745.07	87.67	95.58	745.07	87.67	95.58	0.00	0.00	0.00
Shell-Thin	697.83	183.79	93.35	697.83	183.79	93.35	0.00	0.00	0.00
Shell-Thin	77.44	147.33	23.67	77.44	147.33	23.67	0.00	0.00	0.00
Shell-Thin	158.43	123.71	31.33	158.43	123.71	31.33	0.00	0.00	0.00
							Max % Difference	**0.00**	

Table 3.3 Analysis results for Shell barrel structure subjected to gravity and lateral loads

(Licensed SAP2000 V-12)						(Pirated SAP2000 V-12)						Percentage Difference (%)					
P	V2	V3	T	M2	M3	P	V2	V3	T	M2	M3	P	V2	V3	T	M2	M3
KN	KN	KN	KN-m	KN-m	KN-m	KN	KN	KN	KN-m	KN-m	KN-m	%	%	%	%	%	%
0.57	7.41	0.00	0.00	0.00	15.01	0.57	7.41	0.00	0.00	0.00	15.01	0.00	0.00	0.00	0.00	0.00	0.00
0.20	7.41	0.00	0.00	0.00	3.90	0.20	7.41	0.00	0.00	0.00	3.90	0.00	0.00	0.00	0.00	0.00	0.00
0.96	7.41	0.00	0.00	0.00	7.20	0.96	7.41	0.00	0.00	0.00	7.20	0.00	0.00	0.00	0.00	0.00	0.00
5.57	2.59	0.00	0.00	0.00	0.00	5.57	2.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.80	2.59	0.00	0.00	0.00	3.89	4.80	2.59	0.00	0.00	0.00	3.89	0.00	0.00	0.00	0.00	0.00	0.00
4.03	2.59	0.00	0.00	0.00	7.78	4.03	2.59	0.00	0.00	0.00	7.78	0.00	0.00	0.00	0.00	0.00	0.00
2.59	0.96	0.00	0.00	0.00	7.20	2.59	0.96	0.00	0.00	0.00	7.20	0.00	0.00	0.00	0.00	0.00	0.00
2.59	1.22	0.00	0.00	0.00	6.66	2.59	1.22	0.00	0.00	0.00	6.66	0.00	0.00	0.00	0.00	0.00	0.00
2.59	1.47	0.00	0.00	0.00	5.99	2.59	1.48	0.00	0.00	0.00	5.99	0.00	0.68	0.00	0.00	0.00	0.00
2.59	1.73	0.00	0.00	0.00	5.18	2.59	1.73	0.00	0.00	0.00	5.18	0.00	0.00	0.00	0.00	0.00	0.00
2.59	1.99	0.00	0.00	0.00	4.26	2.59	1.99	0.00	0.00	0.00	4.26	0.00	0.00	0.00	0.00	0.00	0.00
2.59	2.24	0.00	0.00	0.00	3.20	2.59	2.24	0.00	0.00	0.00	3.20	0.00	0.00	0.00	0.00	0.00	0.00
2.59	2.50	0.00	0.00	0.00	2.01	2.59	2.50	0.00	0.00	0.00	2.01	0.00	0.00	0.00	0.00	0.00	0.00
2.59	2.75	0.00	0.00	0.00	0.70	2.59	2.75	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00
2.59	3.01	0.00	0.00	0.00	0.74	2.59	3.01	0.00	0.00	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00
2.59	3.27	0.00	0.00	0.00	2.31	2.59	3.27	0.00	0.00	0.00	2.31	0.00	0.00	0.00	0.00	0.00	0.00
2.59	3.52	0.00	0.00	0.00	4.01	2.59	3.52	0.00	0.00	0.00	4.01	0.00	0.00	0.00	0.00	0.00	0.00
2.59	3.78	0.00	0.00	0.00	5.83	2.59	3.78	0.00	0.00	0.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00
2.59	4.03	0.00	0.00	0.00	7.78	2.59	4.03	0.00	0.00	0.00	7.78	0.00	0.00	0.00	0.00	0.00	0.00
												Max % Diff.	0.68				

Table 3.4 Analysis results for simple 2D portal frame subjected to lateral load

(Licensed SAP2000 V-12)						(Pirated SAP2000 V-12)						Percentage Difference (%)					
P	V2	V3	T	M2	M3	P	V2	V3	T	M2	M3	P	V2	V3	T	M2	M3
KN	KN	KN	KN-m	KN-m	KN-m	KN	KN	KN	KN-m	KN-m	KN-m	%	%	%	%	%	%
7.78	0.08	0.00	0.00	0.00	0.00	7.78	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.01	0.08	0.00	0.00	0.00	0.12	7.01	0.08	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00
6.24	0.08	0.00	0.00	0.00	0.23	6.24	0.08	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00
8.33	0.10	0.00	0.00	0.00	0.09	8.33	0.10	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00
7.56	0.10	0.00	0.00	0.00	0.05	7.56	0.10	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
6.79	0.10	0.00	0.00	0.00	0.20	6.79	0.10	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
2.32	0.21	0.00	0.00	0.00	0.35	2.32	0.21	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00
1.55	0.21	0.00	0.00	0.00	0.03	1.56	0.21	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
0.79	0.21	0.00	0.00	0.00	0.29	0.79	0.21	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00
2.07	0.72	0.00	0.00	0.00	0.09	2.07	0.72	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00
2.07	0.47	0.00	0.00	0.00	0.20	2.07	0.47	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
2.07	0.21	0.00	0.00	0.00	0.37	2.07	0.21	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00
2.07	0.05	0.00	0.00	0.00	0.41	2.07	0.05	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00
2.07	0.30	0.00	0.00	0.00	0.33	2.07	0.30	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00
2.07	0.56	0.00	0.00	0.00	0.11	2.07	0.56	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
7.64	0.27	0.00	0.00	0.00	0.68	7.64	0.27	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00
7.64	0.01	0.00	0.00	0.00	0.61	7.64	0.01	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00
7.64	0.25	0.00	0.00	0.00	0.67	7.64	0.25	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00
1.47	0.54	0.00	0.00	0.00	0.07	1.47	0.54	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
1.47	0.29	0.00	0.00	0.00	0.27	1.47	0.29	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00
1.47	0.03	0.00	0.00	0.00	0.35	1.47	0.03	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00
1.47	0.23	0.00	0.00	0.00	0.30	1.47	0.23	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00
1.47	0.48	0.00	0.00	0.00	0.13	1.47	0.48	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00
1.47	0.74	0.00	0.00	0.00	0.18	1.47	0.74	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00
												Max % Diff.	0.00				

Table 3.5 Analysis results for eccentrically braced 2D frame with wall system subjected to lateral load

3.8 Conclusion

Software piracy is a deep rooted problem in all likelihood to attack especially countries with frail economy and weak copy right laws. The advancing technology of software cracking – one form of software piracy- has been catalyzed by the boom of the internet era. No matter how much money a software developer invests on copy protection systems, it hasn't been possible to prevent hackers from breaking in security systems. Although an overnight solution is not viable, addressing issues of the problem shall at least start soon.

There is a very precarious concept in our country that software results are perfect and binding. But this is not the actual case. Let alone pirated software, software developers clearly state that they are not liable for any damage associated with the use of even original software. The full context of CSI's disclaimer as copied from the SAP2000 manual is as follows.

"DISCLAIMER
CONSIDERABLE TIME, EFFORT AND EXPENSE HAVE GONE INTO THE DEVELOPMENT OF THE SOFTWARE, AND IT HAS BEEN THOROUGHLY TESTED AND USED. HOWEVER, EXCEPT AS OTHERWISE SPECIFICALLY PROVIDED HEREIN, NO WARRANTY IS MADE ON ITS ACCURACY OR RELIABILITY. IT IS THE RESPONSIBILITY OF THE ENGINEER TO VERIFY THE RESULTS OBTAINED FROM THE SOFTWARE. IN THE EVENT THE SOFTWARE IS FOUND TO BE DEFECTIVE, CSI'S ONLY OBLIGATION IS TO REMEDY THE DEFECT. CSI WILL IN NO EVENT HAVE OBLIGATIONS OR LIABILITIES FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES ASSOCIATED WITH THE USE OF THE SOFTWARE. NO OTHER WARRANTY IS MADE."

Moreover an important matter which needs to be noted here is the significant difference in software crack quality. Based on the copy protection system and the method the software has been cracked, some cracked versions function better than other cracked versions. Since hackers who perform engineering software cracking are usually programmers who have no hint about the engineering applications of the packages, they lack the knowhow to test the result validity of cracked products incase additional subroutines are added to falsify results by the developer as one means of copy protection. Cracked software products in our country usually come from India and

China according to Ato Messay Zegeye, managing director of Concept Data Systems. The common practice is that once a certain cracked version of a program is introduced to the market, it will immediately be multiplied in hundreds of copies and gets distributed. Other cracked product of the same version will not have a chance to enter the market as the market will already be saturated. For example once a software importer knows a single cracked copy of SAP2000 V14 has entered the market he will not dare to order a different cracked version as he knows by the time his version reaches here the market will already be saturated. This can easily be demonstrated by evaluating different SAP2000 versions. The 'dll' files in the patch usually give hints as to whether the cracked version is in good quality or not. For instance the maximum percentage difference of the four tested models in this thesis is less than 1%, which is relatively small. This might suggest that the pirated version of SAP2000 V-12 used for this example is a good cracked product. But this by no means shall encourage the use of cracked packages.

Although some cracks might be better than others, in a case where the software developers themselves don't give guarantee for exact result outputs, tampering with those systems by way of cracking simply adds result unreliability.

CHAPTER FOUR – CONCLUSION AND RECOMMENDATIONS

Out of numerous powerful genera-use structural software packages, SAP2000 and STAAD.Pro are popularly available in the local consulting industry. It's very essential to note that general engineering software application needs sufficient background engineering knowhow. Therefore full feature analysis of software would highly assist a user in understanding what to expect and how to apply that particular package to a practical engineering problem. Regarding software piracy several reasons have been stated in the past chapter stressing the urgency in using licensed software products. Although the four structural models prepared to check result validity of "cracked" packages in the past chapter constitute of a variety of structural groups, they might not be sufficient in drawing general conclusions in accepting or rejecting results from pirated versions. The following recommendations can be stated from this Master's thesis.

- Engineering software users should properly study manuals of software before use in order to utilize full power of software application.
- Engineering software packages are there to assist not to substitute the engineer. Engineers should never fully rely on software outputs. Hand calculations to verify results and have positive engineering feel is always mandatory.
- Software users should be well aware of the basic engineering principles of the software as well as the engineering assumptions and limitations of the software.
- Users should be well acquainted with accessing multiple features of engineering software in relative to one another. This will enable the user to know which software to use for a specific task.
- The use of pirated software is wrong and unethical. It also undoubtedly increases result unreliability. Even the only advantage of using pirated product, that is its assistance in getting accustomed to software features, doesn't make it right to use them.
- Software piracy highly discourages international as well as local software developers. Hugh some of time and money invested on copy protection could have been used in research and study in order to enhance and refine the software package.

- Hypothetically if situations arise where using cracked software becomes utterly unavoidable it is vital to know about the crack quality of the pirated product in use.

- Local engineering consulting firms shall be encourages to develop the habit of using legitimate software products. At least government design approval authorities have the responsibility to engage engineers with intense background knowledge of engineering principles who can properly understand and work with licensed engineering software packages.

- Instead of simply criticizing the practice from the other side of the bridge we have the duty to help government shape up policies regarding engineering applications. As engineers we carry the professional responsibility to verify results even from legitimate software packages, with basic engineering principles. The Ethiopian association of Civil engineers (EACE) and the Ethiopian Consultants Association can play major roles by applying strategic thinking in redirecting the wrong practice of engineering software application in our country to the right path before it is too late.

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ANNEX

I would once again like to pass my gratitude to the six engineering firms who took their valuable time to fill out the prepared questionnaire (attached following this page) and to broadly discuss their experience around structural software application in relation to pirated packages. The following points are noted from the discussions.

- Some encountered different analysis outputs for the same model run on pirated SAP2000 V.8 on different machines
- Some came across too many unrealistic warning messages when running analysis for bigger models using pirated SAP2000 V.9
- Some found it difficult to assign slabs as diaphragms for storeys higher than 10 using pirated SAP2000 V.10
- Some faced the problem of unwillingly running P-Δ analysis every time they command analysis on SAP2000 V.9 which caused unnecessary delay in the computational process
- Many claim that pirated versions get stuck and some features suddenly fail to operate especially on Windows Vista operating system
- Some came across output mix-ups while using pirated SAP2000 V.8 where shear force diagrams were drawn for bending moment results and vise versa

DECLARATION

I, the undersigned declare that this thesis is my work and that all sources of material used for this thesis have been duly acknowledged.

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