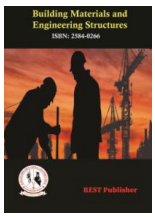
Building Materials and Engineering Structures

Vol: 1(1), March 2023

REST Publisher; ISSN: 2584-0266 (Online)

Website: https://restpublisher.com/journals/bmes/

DOI: http://doi.org/10.46632/bmes/1/1/2



Benefits of Building Information Modeling (BIM) Software Using IBM SPSS Statistics

Chinnasami Sivaji, M. Ramachandran, Vimala Saravanan, Sathiyaraj Chinnasamy

REST Labs, Kaveripattinam, Krishnagiri, Tamil Nadu, India.

*Corresponding Author Email: chinnasami@restlabs.in

Abstract. *Building Information Modelling software is commonly used in the architecture and construction industries for computer-aided design (CAD) and construction information modelling. These products include many tools and libraries that are especially aimed at architecture design, construction, and mechanical, electrical, and plumbing (MEP) modeling BIM software offers a process centered around models to create designs for buildings and infrastructure, and creates a digital representation of a facility's operational characteristics beyond construction drawings. Other products in this category can be used for various CAD purposes, but their main focus is on architectural design. To be included in the BIM category, a product must provide tools for 2D or 3D computer-aided design aimed at architectural design and construction. It should also include collaboration tools that allow multiple group members to work together. Additionally, it should provide performance data and analytical engines to improve building efficiency. For more information on CAD products, see our public objective CAD software type. For information on product and mechanical design software, see our product and machinery category. And for civil engineering design products, see our civil engineering design software category. In building design and BIM products, the top four influencing factors that favor user satisfaction are "sequence steps," "dynamic updating," "editing," and "preparation in doing business." These are predictable satisfaction attributes that are determined by the algorithm for users within this category. It creates detailed digital representations that integrate regulatory data and enables real-time collaboration on an open cloud platform.IBM SPSS Statistics is a software tool created by IBM that serves various purposes such as data management, advanced analytics, multivariate analytics, business intelligence, and criminal investigation. The software originated from the acquisition of SPA Inc. in 2009 and is currently known as IBM SPSS Statistics in its latest versions. In the context of the mentioned software, the Cronbach's alpha reliability result for the following applications: autocad, revit, sketchup, navisworks, archicad, aurora solar, autocad arch, and tekla structures, is recorded as 0.622. This value indicates a reliability level of 62%. Based on the findings from the literature review, this Cronbach's alpha value of 62% is considered for further analysis.*

Keywords: *building information modeling (BIM), design, SPSS statistics, and civil engineering design.*

1. INTRODUCTION

The geometric modeling of building performance, which is useful in managing construction projects. This can help in collecting data on the status of construction projects, and the success criteria of each criterion can be established through analysis. Cost reduction and control are some of the advantages that can be achieved through BIM. However, negative benefits are mainly related to the usability of BIM software.BIM is commonly employed as a catalyst for fostering innovation and enhancing productivity within the construction sector. While its adoption is becoming more prevalent in developed nations, its application in developing countries is infrequent due to various constraints associated with the socio-economic and technological environment of construction firms.The benefits offered by BIM are needed for research on its adoption. An investigation was carried out to assess the efficiency of Building Information Modeling (BIM) as a means of communication within a team, focusing on an offsite precast concrete facility for fabrication. Four information management systems were used in this study: During the course of the projects, information was tracked and presented visually through several platforms: email, a construction project extranet tool, an enterprise resource planning system, and a recently implemented Building Information Modeling (BIM) system. This allowed for effective monitoring of information flow as the projects advanced.As technology advances, the physical environment of the planet is deteriorating, and BIM is one of the recent ideas that have arrived in the construction industry. BIM is much more than CAD on steroids. Its origins are in CAD procedures, but one of

its features is that everyone in the industry shares information from a common site.BIM is a dependent network of policies, procedures, and interconnected technologies, Digital format is crucial for both building design and project data management throughout the entire life cycle of a structure. Collaborative design and modeling tools are increasingly being connected in BIM processes. However, implementing BIM is a complex endeavor, as it requires communication among various parties and functions. The complete design, construction, and management process of buildings require all necessary information to be represented in a digital format. BIM is a method for achieving, which replaces traditional ways of reflecting building information using computers to replicate two-dimensional drawings, perspectives, engineering calculations, measurements, management networks, and costs. However, the utopian model of an integrated BIM is rarely practically achieved. To communicate truthfully, convenience is very important, and BIM is usually virtual and consists of a collection of models. In these cases, interoperability between different BIMs is necessary. Although some standards for improvement are available, such as ISO 10303, or STEP "Product Model Data Standard for Exchange," these are not universally accepted. Problems with the interface between various federated BIMs include duplication and inconsistency of data and an increased probability of errors. Creating building models, communicating and analyzing processes, and facilitating machine-readable documents, tools, processes, and technologies for the planning, construction, and later digital operation of a building. BIM is a function described, not an object, and it is an expanding set of transformative skills, concepts, and tools in the field of AECO. [15].

FIGURE 1. Building Information Modelling (BIM) Software

2. MATERIALS & METHODS

Evaluation Preference: AutoCAD, Revit, SketchUp, Navisworks, Archicad, Aurora Solar, AutoCAD Arch, Tekla Structures.

3.1. AutoCAD: AutoCAD, developed by Autodesk and launched in December 1982, is a commercial computer-aided design (CAD) and drafting software. Originally designed for microcomputers with internal graphics controllers, it was initially released as a desktop application. Prior to AutoCAD's introduction, most CAD programs operated on mainframe or minicomputers, with individual CAD operators working on separate graphics terminals. Although AutoCAD now offers 3D modeling capabilities, its primary use remains focused on 2D drawings. While there are other CAD software options like Fusion 360, Inventor, and SolidWorks 3D that are preferred for modeling purposes, AutoCAD has evolved to be accessible as both a mobile and web application.

3.2. Revit: Autodesk Revit is a comprehensive software application designed to cater to the needs of various professionals in the architectural, landscaping, structural engineering, mechanical, electrical, and plumbing (MEP) engineering fields, as well as designers and construction contractors. It originated as "Charles River," a product developed by a company established in 1997. However, it underwent a name change to Revit Technology Corporation in 2000 and later became part of Autodesk after being acquired by the company in

2002.This software empowers users to create 3D models of buildings, structures, and their components, allowing for detailed design and visualization. Furthermore, it facilitates 2D drafting to annotate the model effectively. The software takes a database approach to building information modeling, collecting information about components and building models. Revit is a 4D architecture information modeling application that supports various stages of building lifecycle planning, monitoring, and maintenance, from concept to construction and even demolition."

3.3. Sketch Up: Sketch Up is a software application designed for desktop use and offers a variety of subscription-based products. It serves as a versatile tool for various design purposes, such as architecture, interior design, industrial and manufacturing design, landscape architecture, and the creation of 3D models for civil and mechanical drawings. It is a computer-aided design (CAD) program that is also used in engineering, drama, film, and video game development. Currently owned by Trimble Inc., Sketch Up is a web-based application that offers a free version as well as three paid subscriptions Sketch Up offers three versions of its software, namely Sketch Up Shop, Sketch Up Pro, and Sketch Up Studio, each offering a range of enhanced features. The software includes a drawing layout function and various surface styles within different style optionsas well as rendering. It can also be used with Google Earth to help place samples.

3.4. Navisworks: Navisworks, formerly referred to as JetStream, is a software application designed for Microsoft Windows, specializing in 3D design review. It finds significant application in industries like construction, aiding in the comprehensive assessment of 3D design packages such as Autodesk Revit, AutoCAD, and MicroStation. Users can effectively open and link 3D models in Navisworks, granting them the capability to navigate these models in real-time using the WASD keys, and make comments or use redlining and overview instruments, including measurement tools. Users can also use plugins for interference detection, 4D timing simulation, optical rendering, and outputs such as PDFs. Please review the set of plugins available and updates to the package."

3.5. Archicad: Archicad stands out as the most efficient and user-friendly BIM software available due to its robust built-in features and intuitive interface. It excels in various aspects, including designing, visualizing, documenting, and delivering projects of any scale. By using Archicad, architects can prioritize their design creativity, unburdened by technical complexities."

3.6. Aurora Solar:An aurora (plural: auroras or aurorae), usually seen in polar regions and also called the northern or southern lights, is a natural phenomenon in the Earth's atmosphere that creates a visual display of light. This phenomenon is most commonly observed in high-latitude regions such as the Arctic and Antarctic. Aurora displays can take the form of curtains covering the sky, rays, loops or dynamic flickering patterns of lights. Auroras are a result of solar wind-induced disturbances in the magnetosphere. Major disruptions occur due to coronal holes and coronal mass ejections, which improve the speed of the solar wind. These disturbances cause changes in the paths of charged particles in the magnetosphere, which are mainly electrons and protons. These particles collide with atmospheric elements in the upper atmosphere (thermosphere/exosphere), resulting in ionization and excitement that produce a complex light show of varied colors. Auroras occur within two polar regions and take the form of bands, the location and intensity of which depend on the amount of acceleration provided to the precipitated particles.

3.7. AutoCAD Arch:"Let's cut straight to the chase. It's not possible to get Autocad 2023 without paying. However, the software is available for free in the form of a trial, a free one-year education license, or a limited version that can save you money on versioning. Autocad Architecture is Autodesk's flagship product, and it's the version of Autocad designed for architectural work, containing appropriate tools and functions. Architectural objects are interconnected and have a relationship with one another, communicating wisely with each other. For example, a window contains and is related to the wall."

3.8. Tekla Structures: In the construction industry, Tekla Structures is used for steel and concrete details, for pre-cast and cast-in-situ applications. This program enables users to generate and oversee 3D models of concrete or steel constructions, covering the entire process from conceptualization to the production of detailed shop drawings. The system operates with automation, streamlining the overall workflowand different structures and localized contexts are available. Tekla Structures is capable of supporting multiple models at once, but it is known to be relatively expensive to learn and use fully, considering its complexity. In the BIM market, Tekla Structures competes with other software such as Autodesk Revit, ArchiCAD, and Digital Project, among others. It is compliant with Industry Foundation Classes (IFC). Tekla Structures covers a wide range of modeling scopes, including steel, cast-in-place (CIP) concrete, and reinforcing bars. Its features also include framing for steel and light-gauge structures. In 2004, Xsteel was rebranded as Tekla Structures and significant additional functionality was added. Tekla Structures is often used in conjunction with Autodesk Revit, with structure designs created in Tekla being exported to Revit using DWG/DXF formats.

Methods: SPSS Statistics is a statistical software package developed by IBM to handle various tasks, including data management, advanced analytics, multivariate analytics, business intelligence, and criminal investigation. The software was initially created by IBM and later acquired by spa Inc. in 2009. The most recent versions are

branded as IBM SPSS Statistics. SPSS, short for "Statistical Package for the Social Sciences," comprises a set of software tools for manipulating, analyzing, and presenting data, commonly used in different fields.SPSS offers multiple formats for data handling and supports various add-on modules that can be purchased to enhance its capabilities for data entry, statistical analysis, and reporting. The primary application within SPSS is known as SPSS Base. Among the add-on modules, SPSS Advanced Models and the SPSS Regression Model are particularly essential for statistical analysis, in our viewpoint. Moreover, there are independent programs available from IBM that integrate with SPSS.The software has versions compatible with Windows (98, 2000, ME, NT, and XP), with Windows 2000 supporting SPSS version 11.0.1. Although newer versions of SPSS are likely to be released in the future, the SPSS instructions provided in this book are expected to remain applicable to the outlined studies.

3. RESULT AND DISCUSSION

TABLE 1. Reliability Statistics

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.622	.626	8

Table 1 displays the results of Cronbach's Alpha Reliability. The model's overall Cronbach's Alpha value is .622, suggesting a reliability of 62%. Based on the findings from the literature review, this model with a Cronbach's Alpha of 62% can be deemed suitable for further analysis.

TABLE 2. Reliability Statistic individual

	Cronbach's Alpha if Item Deleted
AutoCAD	0.524
Revit	0.592
SketchUp	0.578
Navisworks	0.571
Archicad	0.522
Aurora Solar	0.621
AutoCAD Arch	0.577
Tekla Structures	0.698

Table 2 Shows the Reliability Statistic individual parameter Cronbach's Alpha Reliability results AutoCAD0.524, Revit0.592, SketchUp0.578, Navisworks0.571, Archicad0.522, Aurora Solar0.621, AutoCAD Arch0.577, Tekla Structures0.698

TABLE 3. Descriptive Statistics

Descriptive Statistics												
	N	**Range**	**Minimum**	**Maximum**	**Mean**		**Std. Deviation**	**Variance**	**Skewness**		**Kurtosis**	
	Statistic	**Statistic**	**Statistic**	**Statistic**	**Statistic**	**Std. Error**	**Statistic**	**Statistic**	**Statistic**	**Std. Error**	**Statistic**	**Std. Error**
AutoCAD	96	4	1	5	3.28	.117	1.149	1.320	-.489	.246	-.121	.488
Revit	96	4	1	5	3.19	.128	1.251	1.564	.065	.246	-.991	.488
SketchUp	96	4	1	5	3.29	.129	1.264	1.598	-.156	.246	-.955	.488
Navisworks	96	4	1	5	3.27	.114	1.119	1.252	-.327	.246	-.271	.488
Archicad	96	4	1	5	3.48	.147	1.444	2.084	-.311	.246	-1.359	.488
Aurora Solar	96	4	1	5	3.31	.138	1.348	1.817	.014	.246	-1.332	.488
AutoCAD Arch	96	4	1	5	3.10	.131	1.285	1.652	-.107	.246	-.926	.488
Tekla Structures	96	4	1	5	3.71	.128	1.256	1.577	-.535	.246	-.979	.488
Valid N (listwise)	96											

Table 3 displays the descriptive statistics for the analysis, including N (sample size), range, minimum, maximum, mean, standard deviation, variance, skewness, and kurtosis. The software tools utilized in the analysis are AutoCAD, Revit, SketchUp, Navisworks, Archicad, Aurora Solar, AutoCAD Arch, and Tekla Structure.

TABLE 4. Frequency Statistics

Statistics									
		Auto CAD	Revit	SketchUp	Navisworks	Archicad	Aurora Solar	AutoCAD Arch	Tekla Structures
N	Valid	96	96	96	96	96	96	96	96
	Missing	36	36	36	36	36	36	36	36
Median		3.00	3.00	3.00	3.00	4.00	3.00	3.00	4.00
Mode		3	3	3	3	5	5	3	5
Percentiles	25	3.00	2.00	2.00	3.00	2.00	2.00	2.00	3.00
	50	3.00	3.00	3.00	3.00	4.00	3.00	3.00	4.00
	75	4.00	4.00	4.00	4.00	5.00	5.00	4.00	5.00

Table 4 displays the frequency statistics for various software programs, including AutoCAD, Revit, SketchUp, Navisworks, Archicad, Aurora Solar, AutoCAD Arch, and Tekla Structures. The statistics include the number of valid occurrences (30), the count of missing values (1), the median value (3.00), and the mode value (3).

Histogram

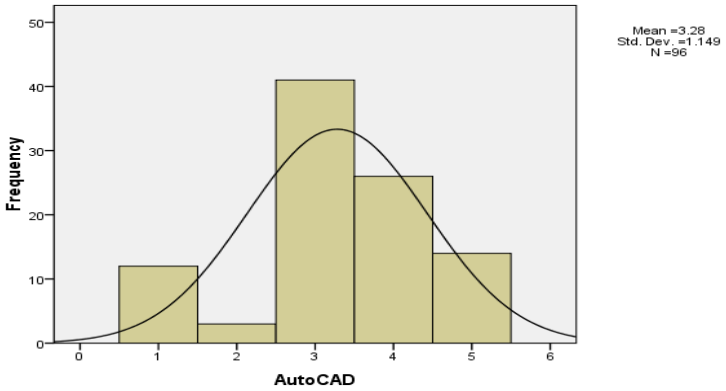


FIGURE 2. AutoCAD

The histogram in Figure 2 illustrates the distribution of responses for AutoCAD. It is evident that the data is slightly left-skewed, primarily because a larger number of respondents selected the value 3 for AutoCAD. With the exception of the value 1, all other values fall within the normal curve, indicating that the model significantly follows a normal distribution.

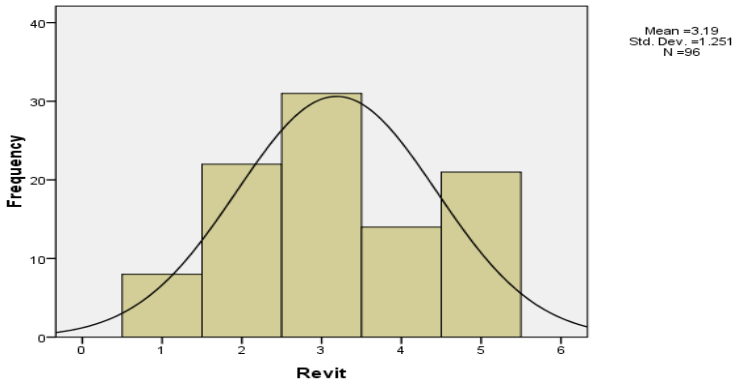


FIGURE 3. Revit

The histogram in Figure 3 depicts the distribution of responses for Revit. It is evident that the data exhibit a slight left-skew, primarily because a higher number of respondents chose the value 3 for Revit. All values, except for 2, fall within the range under the normal curve, indicating that the model closely adheres to a normal distribution.

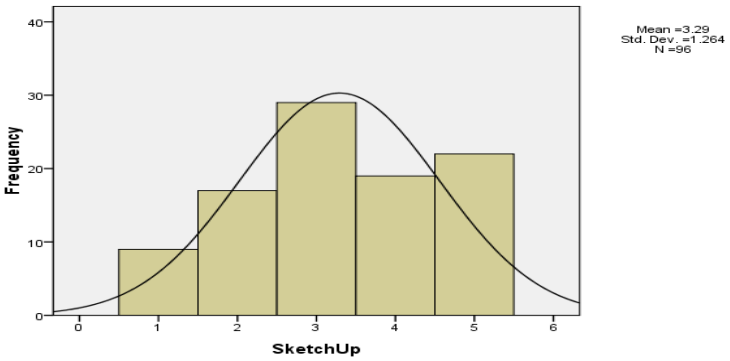


FIGURE 4. SketchUp

The histogram plot in Figure 4 illustrates the distribution of responses for SketchUp. It is evident that the data exhibit a slight right skew, which is mainly influenced by a higher number of respondents selecting the value 3 for SketchUp. However, all other values, with the exception of 2, are distributed within the bounds of a normal curve. This indicates that the model closely adheres to a normal distribution, demonstrating its significant conformity to this particular pattern.

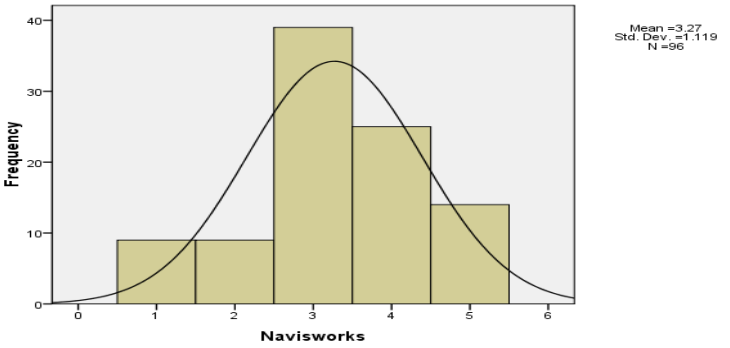


FIGURE 5. Navisworks

According to Figure 5, the histogram plot represents data related to Navis works. The graph indicates that the data is slightly left-skewed, as a greater number of respondents chose the value 3 for Navis works. However, it's worth noting that, except for the value 1, all other values fall under the normal curve. This suggests that the model is largely following a normal distribution.

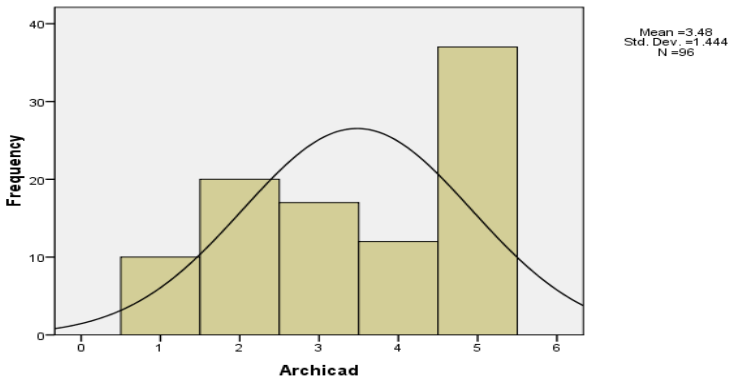


FIGURE 6. ArchiCAD

The histogram in Figure 6 displays the data distribution for Archicad. It is evident that the data exhibits a slight right skewness, primarily caused by a higher number of respondents selecting the value 5 for Archicad. With the exception of the value 2, all other data points fall within the range of the normal curve, indicating that the model significantly adheres to a normal distribution.

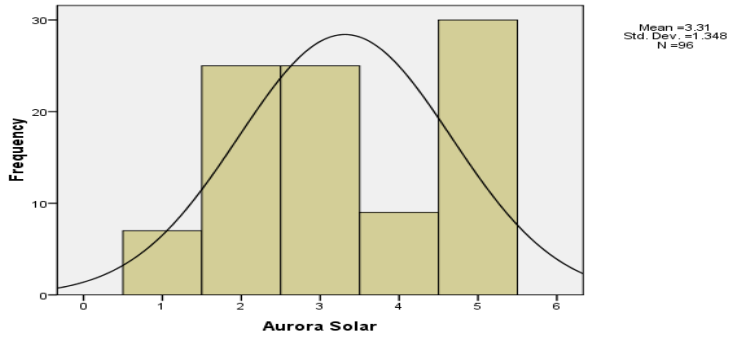


FIGURE 7. Aurora Solar

The histogram plot in Figure 7 illustrates the distribution of responses for the Aurora Solar. It is evident from the figure that the data exhibits a slight left skew, mainly attributed to a higher number of respondents selecting the value 5 for the Aurora Solar. With the exception of the value 2, all other data points fall within the range of a normal curve, indicating that the model significantly follows a normal distribution.

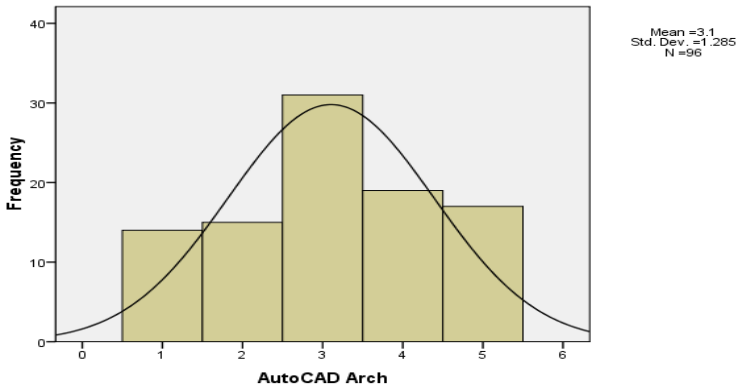


FIGURE 8. AutoCAD Arch

The histogram in Figure 8 illustrates the data distribution of the AutoCAD Arch responses. It is evident that the data is slightly left-skewed, indicating that a higher number of respondents chose the value 3 for the AutoCAD Arch. With the exception of the value 1, all other values are clustered under the normal curve. This observation suggests that the model is significantly following a normal distribution.

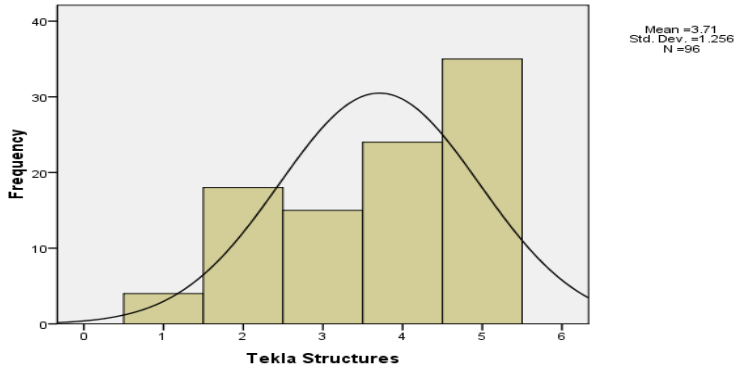


FIGURE 9. Tekla Structures

The histogram in Figure 9 illustrates the data distribution of Tekla Structures. It is evident from the plot that the data exhibits a slight left skewness. This skewness is primarily caused by a higher number of respondents choosing the value 5 for Tekla Structures. With the exception of the value 2, all other values are clustered below the normal curve, indicating that the model closely adheres to a normal distribution.

TABLE5. Correlations

Correlations								
	AutoCAD	**Revit**	**SketchUp**	**Navisworks**	**Archicad**	**Aurora Solar**	**AutoCAD Arch**	**Tekla Structures**
AutoCAD	1	.358**	.399**	.431**	.362**	.208*	.393**	-0.11
Revit	.358**	1	.285**	0.196	.387**	-0.091	0.138	-0.085
SketchUp	.399**	.285**	1	.494**	.326**	-0.073	0.124	-0.151
Navisworks	.431**	0.196	.494**	1	0.199	0.125	0.178	-0.115
Archicad	.362**	.387**	.326**	0.199	1	.317**	.313**	-0.05
Aurora Solar	.208*	-0.091	-0.073	0.125	.317**	1	.242*	0.079
AutoCAD Arch	.393**	0.138	0.124	0.178	.313**	.242*	1	-0.033
Tekla Structures	-0.11	-0.085	-0.151	-0.115	-0.05	0.079	-0.033	1
**. Correlation is significant at the 0.01 level (2-tailed).								
*. Correlation is significant at the 0.05 level (2-tailed).								

Table 5 displays the correlations between motivation parameters for various software applications. Among these, AutoCAD for Navisworks exhibits the strongest correlation, while Tekla Structures demonstrates the weakest correlation. Moving on, Revit for ArchiCAD shows the highest correlation, with Aurora Solar having the lowest correlation. Similarly, SketchUp for Navisworks exhibits the highest correlation, whereas Tekla Structures once again shows the lowest correlation. Additionally, when considering Navisworks for SketchUp, the highest correlation is observed, and the lowest correlation is found with Tekla Structures. Similarly, ArchiCAD for Revit demonstrates the highest correlation, with Tekla Structures showing the lowest correlation. Lastly, Aurora Solar for ArchiCAD displays the highest correlation, while Revit exhibits the lowest correlation. Furthermore, Autocad Arch for Autocad itself exhibits the highest correlation, with Tekla Structures having the lowest correlation. Finally, Tekla Structures for Aurora Solar demonstrates the highest correlation, and Sketchup displays the lowest correlation.

TABLE 6. Factor Analysis

Communalities		
	Initial	Extraction
AutoCAD	1.000	.610
Revit	1.000	.391
SketchUp	1.000	.624
Navisworks	1.000	.462
Archicad	1.000	.525
Aurora Solar	1.000	.680
AutoCAD Arch	1.000	.466
Tekla Structures	1.000	.220
Extraction Method: Principal Component Analysis.		

4. CONCLUSION

Building information modeling (BIM) there are various tools and technologies and physics of places and functional properties digital representations creating and managing supported by related agreements is a process. Building Information Models (BIMs) are computer files that primarily exist in proprietary formats and may contain proprietary data. These files can be extracted, exchanged, or shared over a network, facilitating structured decision-making in property-related matters. BIM software is utilized by individuals, businesses, and government agencies for various applications, including building design and infrastructure planning such as water, waste, electricity, gas, communication networks, roads, railways, bridges, ports, and tunnels various physical infrastructures like planning, designing, constructing operations, and maintenance. BIM the concept dates back to the 1970s in development, but it is only in the early 2000s as an accepted term changed. Development of standards and adoption of BIM different in different countries has progressed rapidly; in 2007 the United Kingdom created the year standards are international standards based on ISO 19650 created, January launched in 2019. Architecture, engineering, and very much in the field of construction (AEC). Promising latest one of the developments is building information modeling (BIM). With BIM technology, accurate virtualization of the building the model is constructed digitally. As a building information model this model, called planning, design, construction, and the operation of the facility can be used. Possible design, construction, or what in a simulated environment to identify operational issues to visualize what is to be built it is architects, engineers and helps constructors. BIM is a newcomer within AEC and reflects the paradigm, it's an in-one project shareholder shares encourage integration. In this thesis, the AEC current of BIM for industry trends, benefits, potential risks and future challenges are discussed. Findings from this study AEC career coaches are their BIM technology in projects considering implementation provide useful information. Architecture, engineering, and the construction industry (AEC) long to reduce project cost over time, to increase productivity and quality, and project delivery time also looking for techniques to reduce. Building information modeling (BIM) this ability to achieve

objectives provides BIM is a virtual construction project in context simulates. With BIM technology, called building information model accurate virtualization of the building the model is constructed digitally. Done then, these model functions and maintenance can be used for purposes a building information model geometry, spatial relations, geography information, size of building components and characteristics, cost estimates, material inventories, and project classifies the table. The entire building life cycle a sample can be used to demonstrate. As a result, goods dimensions and shared properties can be extracted immediately. Objectives of work are easy and queues are full facilities or within a group of facilities that can be displayed on a relative scale. Drawings, purchase details, submission process, and like other specifications construction documents easily can be interconnected. All design team owners of members, architects, engineers, contractors, subcontractors, and suppliers are more precise enables efficient collaboration all in one virtual model features, fields, and settings as a virtual process involving BIM can be viewed. Traditional using processes as the model is being developed, the panel members scheme specifications and according to design changes constantly refining their parts fixing is planned before being physically grounded the model is as accurate as possible ensures presence. BIM stands for not just software; it is a process and software. BIM is three-dimensional intelligence in addition to using models, workflow and project delivery are significant in processes it also means making changes. BIM is a newcomer within AEC and reflects the paradigm, it's an in-one project shareholder shares encourage integration. In the past, they as enemy's high performance among considered players and promotes harmony has power. BIM is of integrated project delivery that supports the concept, it is people, systems, and business structures and coordinating procedures an innovative project delivery approach, which is waste reduce and project life at all stages of the cycle improves performance.

REFERENCES

[1]. Bryde, David, Martí Broquetas, and Jürgen Marc Volm. "The project benefits of building information modelling

[2]. Kumar, Ashish, Ketan Rathor, Snehit Vaddi, Devanshi Patel, Preethi Vanjarapu, and Manichandra Maddi. "ECG Based Early Heart Attack Prediction Using Neural Networks." In *2022 3rd International Conference on Electronics and Sustainable Communication Systems (ICESC)*, pp. 1080-1083. IEEE, 2022.

[3]. Bui, Nam, Christoph Merschbrock, and Bjørn Erik Munkvold. "A review of Building Information Modelling for construction in developing countries." Procedia Engineering 164 (2016): 487-494.

[4]. Succar, Bilal. "Building information modelling framework: A research and delivery foundation for industry stakeholders." Automation in construction 18, no. 3 (2009): 357-375.

[5]. Rathor, Ketan, Sushant Lenka, Kartik A. Pandya, B. S. Gokulakrishna, Susheel Sriram Ananthan, and Zoheib Tufail Khan. "A Detailed View on industrial Safety and Health Analytics using Machine Learning Hybrid Ensemble Techniques." In *2022 International Conference on Edge Computing and Applications (ICECAA)*, pp. 1166-1169. IEEE, 2022.

[6]. Demian, Peter, and David Walters. "The advantages of information management through building information modelling." Construction management and economics 32, no. 12 (2014): 1153-1165.

[7]. Wong, Kam-din, and Qing Fan. "Building information modelling (BIM) for sustainable building design." Facilities 31, no. 3/4 (2013): 138-157.

[8]. Sukumaran, C., D. Selvam, M. Sankar, V. Parthiban, and C. Sugumar. "Application of Artificial Intelligence and Machine Learning to Predict Basketball Match Outcomes: A Systematic Review." *Computer Integrated Manufacturing Systems* 28, no. 11 (2022): 998-1009.

[9]. Crotty, Ray. The impact of building information modelling: transforming construction. Routledge, 2013.

[10]. Steel, Jim, Robin Drogemuller, and Bianca Toth. "Model interoperability in building information modelling." Software & Systems Modeling 11 (2012): 99-109.

[11]. Manjunath, C. R., Ketan Rathor, Nandini Kulkarni, Prashant Pandurang Patil, Manoj S. Patil, and Jasdeep Singh. "Cloud Based DDOS Attack Detection Using Machine Learning Architectures: Understanding the Potential for Scientific Applications." *International Journal of Intelligent Systems and Applications in Engineering* 10, no. 2s (2022): 268-271.

[12]. Howard, Rob, and Bo-Christer Björk. "Building information modelling–Experts' views on standardisation and industry deployment." Advanced engineering informatics 22, no. 2 (2008): 271-280.

[13]. McAdam, Brodie. "Building information modelling: the UK legal context." International Journal of Law in the Built Environment 2, no. 3 (2010): 246-259.

[14]. Rathor, Ketan, Anshul Mandawat, Kartik A. Pandya, Bhanu Teja, Falak Khan, and Zoheib Tufail Khan. "Management of Shipment Content using Novel Practices of Supply Chain Management and Big Data Analytics." In *2022 International Conference on Augmented Intelligence and Sustainable Systems (ICAISS)*, pp. 884-887. IEEE, 2022.

[15]. Shou, Wenchi, Jun Wang, Xiangyu Wang, and Heap Yih Chong. "A comparative review of building information modelling implementation in building and infrastructure industries." Archives of computational methods in engineering 22 (2015): 291-308.

[16]. Krishna, S. Rama, Ketan Rathor, Jarabala Ranga, Anita Soni, D. Srinivas, and Anil Kumar. "Artificial Intelligence Integrated with Big Data Analytics for Enhanced Marketing." In *2023 International Conference on Inventive Computation Technologies (ICICT)*, pp. 1073-1077. IEEE, 2023.

[17]. Sukumaran, C., M. Ramachandran, Chinnasami Sivaji, and Manjula Selvam. "Ranking of Product in E-store using WASPAS method." *REST Journal on Banking, Accounting and Business* 1, no. 1 (2022): 1-9.

[18]. Sukumaran, C., B. Karpagavalli, R. Hariharan, and V. Parthiban. "Preclusive Strategies of Obesity to Lead a Healthy Life-A Reviewl." *Pharmaceutical Sciences and Research* 1, no. 1 (2022): 42-45.

[19]. Succar, Bilal. "Building information modelling maturity matrix." In Handbook of research on building information modeling and construction informatics: Concepts and technologies, pp. 65-103. IGI Global, 2010.

[20]. B. Uthira Kumar, D. S. Robinson Smart, M. Ramachandran, Vimala Saravanan, "Influence of Chemical Treatment of Natural Fibre using Shape Memory Alloy for Aeronautics", /Journal on Electronic and Automation Engineering, 2(2), June 2023, 11-19.

[21]. Bruno, Silvana, Mariella De Fino, and Fabio Fatiguso. "Historic Building Information Modelling: performance assessment for diagnosis-aided information modelling and management." Automation in Construction 86 (2018): 256-276.

[22]. Sukumaran, C., and P. J. Sebastian. "Effect of Inclusive Games and Physical Exercises on Selected Physical Variables among the Intellectually Challenged Children." *Annals of the Romanian Society for Cell Biology* 26, no. 01 (2022): 1442-1450.

[23]. Chaudhari, Rakesh, and Asha Ingle. "Finite element analysis of dissimilar metal weld of SA335 P11 and SA312 TP304 formed by transition grading technique." *Materials Today: Proceedings* 5, no. 2 (2018): 7972-7980.

[24]. Gandhi, Mohd Asif, Vusal Karimli Maharram, G. Raja, S. P. Sellapaandi, Ketan Rathor, and Kamlesh Singh. "A Novel Method for Exploring the Store Sales Forecasting using Fuzzy Pruning LS-SVM Approach." In *2023 2nd International Conference on Edge Computing and Applications (ICECAA)*, pp. 537-543. IEEE, 2023.

[25]. Khan, Imran, S. P. Maniraj, K. Santosh Reddy, V. Balaji, K. Kalaivani, and Mukesh Singh. "Congenital Heart Disease Prediction based on Hybrid Approach of CNN-GRU-AM." In *2023 7th International Conference on Intelligent Computing and Control Systems (ICICCS)*, pp. 613-618. IEEE, 2023.

[26]. Sukumaran, C., and P. J. Sebastian. "Effect of Inclusive Games and Physical Exercises on Selected Physical Variables among the Intellectually Challenged Children." *Annals of the Romanian Society for Cell Biology* 26, no. 01 (2022): 1442-1450.

[27]. Reddy, K. Santosh, V. KAVITHA, and VL NARAYANA. "Slow Increasing Functions and their Applications to some Problems in Number Theory." *ARPN Journal of Engineering and Applied Sciences* 8, no. 7 (2015): 33-44.

[28]. Sacks, Rafael, Mark Girolami, and Ioannis Brilakis. "Building information modelling, artificial intelligence and construction tech." Developments in the Built Environment 4 (2020): 100011.

[29]. Rathor, Ketan, Jaspreet Kaur, Ullal Akshatha Nayak, S. Kaliappan, Ramya Maranan, and V. Kalpana. "Technological Evaluation and Software Bug Training using Genetic Algorithm and Time Convolution Neural Network (GA-TCN)." In *2023 Second International Conference on Augmented Intelligence and Sustainable Systems (ICAISS)*, pp. 7-12. IEEE, 2023.

[30]. Manjula Selvam, M. Ramachandran, Vimala Saravanan, "Performance Comparison of Optical Wireless Communication Using Gray Relational Analysis", Journal on Applied and Chemical Physics, 1(1), December 2022, 22-30.

[31]. Arayici, Yusuf. "Towards building information modelling for existing structures." Structural Survey (2008).

[32]. Rathor, Ketan, Keyur Patil, Mandiga Sahasra Sai Tarun, Shashwat Nikam, Devanshi Patel, and Sasanapuri Ranjit. "A Novel and Efficient Method to Detect the Face Coverings to Ensurethe Safety using Comparison Analysis." In *2022 International Conference on Edge Computing and Applications (ICECAA)*, pp. 1664-1667. IEEE, 2022.

[33]. Reddy, K. Santosh, V. KAVITHA, and VL NARAYANA. "Slow Increasing Functions and their Applications to some Problems in Number Theory." *ARPN Journal of Engineering and Applied Sciences* 8, no. 7 (2015): 33-44.

[34]. Patil, Niteen, M. R. Patil, Rakesh Chaudhari, and Praveen Kumar Loharkar. "Investigation on the Machining of Inconel-718 Using EDM." In *Recent Advances in Smart Manufacturing and Materials: Select Proceedings of ICEM 2020*, pp. 129-136. Springer Singapore, 2021.

[35]. Chaudhari, Rakesh, Asha Ingle, and Kanak Kalita. "Experimental Investigation of Correlation of Grain Size and Mechanical Properties in 304 Stainless Steel." *Materials Focus* 5, no. 5 (2016): 440-445.

[36]. Naryana, V. Lakshmi, S. P. Kishore, and K. Santosh Reddy. "An Adaptive Design For Discrete Responses Of Patients In Clinical Trials."

[37]. Sukumaran, C., M. Ramachandran, Vimala Saravanan, and Sathiyaraj Chinnasamy. "An Empirical Study of Brand Marketing Using TOPSIS MCDM Method." *REST Journal on Banking, Accounting and Business* 1, no. 1 (2022): 10-18.

[38]. Krishna Kumar TP, M. Ramachandran, Kurinjimalar Ramu, "Understanding a Recent Trends in Block Chain Technology", Recent trends in Management and Commerce Vol: 1(1), 2020: 87-91

[39]. Reddy, K. Santosh, and M. Rangamma. "Functions of Fast Increase which appears in some Limits and Formulae." *Telematique* (2022): 4978-4986.

[40]. REDDY, K. SANTOSH, and M. RANGAMMA. "ON SOME FUNCTIONS OF FAST INCREASE."

[41]. J. Joseva, 1D. S. Robinson Smart 2Chandrasekar Raja, 2M. Ramachandran, "Recent Developments in the Field of Thermal Barrier Coatings Solutions for Structural Repair ", Journal on Applied and Chemical Physics, 2(1), March 2023, 31-39.

