



The Developments of Land Surveying Techniques and Equipment

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ABSTRACT

Civil surveying is considered to be one of the oldest arts practiced by man. It is vitally important to ensure the success of construction projects that scale from residential to commercial buildings to infrastructure. It is the basis for boundaries of land and has been necessary for the planning and designing construction and civil engineering projects. Understanding the history and background of such a field is essential for further development and improvement of methods and techniques. This study outlines the chronological development of civil surveying, tracing its origins in ancient times to the modern world of the 21st century. This study is intended to identify the developments of civil surveying not only as an art, but also as discipline and a profession.

Keywords: Civil engineering, surveying, civil survey, construction, development

Introduction

Civil engineering is a discipline as old as mankind itself since it is defined as the branch of engineering that deals with the science of the design and maintenance of roads, bridges, dams, and similar structures (Watson, 2023). A discipline that all civil engineers are familiar with is the discipline of civil surveying, which is an engineering application that involves assessing and recording details about an area of land. It is a discipline that has been practiced for over a millennium and can be traced back to the Egyptians. Civil surveying has a vast and deep history and is considered to be one of the oldest professions in the world.

Modern day land surveyors have developed the technology so much that with the use of Global Positioning Systems (GPS), they are able to accurately pinpoint a location on earth. However, in ancient times, this was not possible. However, this does not mean that ancient civilizations were unable to conduct land surveys. Instilling in ourselves a concrete foundation of such a vast and old discipline allows us to fully appreciate the technology of modern times. This paper aims to provide a chronological development of the civil surveying techniques and equipment used throughout time.

Significance of the Study

This study aims to explore the advancements in land surveying techniques and equipment which hold a lot of significance in various industries, including construction, urban planning, environmental management, and resource exploration. Analysis of civil surveying may allow professionals as well as newcomers in the field to more fully appreciate the progress made over the centuries while encouraging a deeper comprehension of the challenges faced by early practitioners. A sense of continuity and tradition within the profession shall be uplifted through this historical examination.

Furthermore, the study will conduct a thorough examination of the surveying procedures used across different points in history, while also investigating the instruments and methodologies that are employed by surveyors. Improvements in measurement precision over time will be analyzed along with their historical contexts, which will allow for a critical evaluation of past practices, leading to potential enhancements in contemporary surveying methodologies. Moreover, examining how ancient civilizations conducted land surveys without modern technology enables modern civil engineers to develop a profound appreciation for the ingenuity and resourcefulness of their predecessors, which may inspire a forward-thinking approach, encouraging civil engineers to apply historical lessons to refine and advance current surveying practices, ultimately driving innovation forward.

Scope and Limitations

Scope:

This study focuses on the chronological development of land surveying techniques and equipment from ancient times to the 21st century. It examines the historical roots of the practice, noting key milestones and innovations that provided the foundation for civil surveying today. This study aims to provide a comprehensive overview, touching upon major civilizations and their contributions to surveying practices.

Limitations:

Although, this study focuses on the development, and evolutionary journey of land surveying. It aims to provide a broad historical perspective, leaving room for more in-depth research on specific periods or regions. Furthermore, the study primarily focuses on the evolution of civil surveying as a discipline and its application in construction and civil engineering projects.

Definition of Terms

In this section, it outlines the technical concepts utilized across this investigation, elucidating the roles and objectives of each. These principles are extensively employed and carefully considered in delineating the advancements in land surveying techniques and equipment outlined in the following chapters.

Civil Engineering. This is the branch of engineering that concerns itself with the design, construction, and maintenance of infrastructure such as roads, bridges, dams, and other large structures.

Civil Surveying. Also known as "Land Surveying", this is an engineering application involving the assessment and recording of details about a specific area of land, crucial for the planning and design of construction and civil engineering projects.

Chronological Development. This refers to the sequential unfolding of events over time, tracing the historical progression and evolution of a particular subject.

Discipline. This term is used in the context of civil surveying, where a field of study and practice is characterized by a systematic approach to assessing and recording land details for engineering purposes.

Profession. A vocation or occupation that requires specialized knowledge, training, and skills, often regulated by a professional body or association. In the case of civil surveying, it refers to the organized and skilled practice of assessing and recording land details for engineering applications.

Topography. The term refers to the detailed and precise description of the physical features of a land area, including its elevation, terrain, and natural and artificial features. It aids in assessing the suitability of the land for various purposes, such as construction, by considering factors like slope, drainage, and potential obstacles.

Plot of Land Division. Also known as "Subdivision Development", This refers to the act of dividing a piece of land into sections, blocks, or lots, often relevant for construction projects or development. This is carried out in a systematic manner and is particularly relevant for construction projects, urban planning, or any form of land development.

Property Upgrades. The term refers to the enhancements or modifications made to a piece of land, such as adding structures, parks, pools, or expanding driveways. This plays a vital role in property upgrades by providing accurate measurements and information about the existing land.

Planning Standards. This refers to the adherence to building codes and town plans when designing and constructing on a piece of land. It is essential for ensuring that construction plans align with planning standards, such as, building codes, zoning regulations, and other legal requirements, contributing to the approval and successful execution of construction projects.

Renovation/Demolition. Renovation involves making improvements or modifications to existing structures, while demolition is the process of tearing down structures. Both processes require a comprehensive land survey to assess feasibility and potential impacts.

Art of Surveying. This refers to the historical and contemporary practices involved in accurately mapping land, considering both the scientific and artistic aspects of the discipline. This involves the expression of the landscape through maps and drawings which adds depth to the understanding of the land and its features.

Rope Stretchers. Rope stretchers were early surveyors in ancient Egypt who used calibrated ropes or cords for measuring larger distances. Their methods laid the foundation for subsequent surveying practices, showcasing the resourcefulness and innovation of ancient surveyors.

Triangulation. The term refers to a surveying method using angle measurements and triangles to determine precise points on a map. It is a fundamental surveying technique that allows for precise mapping and measurement over large areas.

Gunter's Chains. Traditional surveying tools, originally used in the 18th century, comprising a 66-foot metal chain with 100 links.

Geomatics. A term used in the late 20th century to redefine land surveying; later replaced by the term "geospatial."

Linear Measurement. Measuring distances on land, historically done using tools like Gunter's chains and later updated to steel bands.

Computers in Surveying. The integration of computers in surveying processes, leading to increased accuracy, efficiency, and data processing capabilities.

Remote Sensing. Using technology like cameras from balloons, airplanes, or satellites to gather data about land from a distance.

Building Information Modeling (BIM). A modern surveying application involving the creation of digital representations of physical structures for better planning and management.

Structural Theory. Understanding the principles governing the stability and strength of structures, crucial for designing durable and safe buildings.

Efficiency. The ability to accomplish a task with minimal wasted resources, time, or effort; often linked to advancements in surveying technology.

Analysis

Significance of land surveying

The significance of land surveying may vary depending on the type of surveying to be applied. The study is about the significance of surveying in general. The following are significant to the comprehensive understanding of the topography, information gathering, plot of land division, property upgrades, planning standards, and renovation/demolition.

A comprehensive understanding of the topography means that there is a need for a thorough investigation of the property before purchasing or potentially constructing the plan. Through surveying, the engineers will be able to investigate the property by detecting the soil. It is vital in detecting whether the location has potential structural issues like being flood prone. A detailed land survey and representing it through creating plot representations will help prevent such issues from occurring.

Information gathering could be plot size determination is one way for landowners to obtain information about the land. The information could be how much land they own through accurate dimensions. This is especially helpful for defining where the estate ends. The plan for constructing a project will then be considered. It is not only useful for estates but also for better communication before construction. The information/data gathered are utilized for planning how to build on the site (Indovance, 2021).

The plot of land division can be applicable if the landowner wants to build a subdivision/project that requires the division of land. It could be through blocks/lots. Land surveying makes it possible to identify the measurements of how the land will be divided.

Property upgrades are possible especially when landowners want to improve something or make something new for the location. An example would be adding a pool, adding fences, creating a park somewhere within the land owned, or maybe expanding driveways. A land survey determines the dimensions and parts of land that can be upgraded or not.

Planning standards means adhering to building codes and town plans. A plan will only be a plan and not be constructed if it goes against the building codes. A professional land survey is essential in having a proposal approved.

Renovation or demolition may happen in the future. That's why the land survey is important for determining the feasibility of it. This gives the landowners and the surveyors a more comprehensive view of the property's attributes (Indovance, 2021). When renovating/demolishing a location, the surveyors should always consider the parts that will be affected like areas that are not part of the owner's property. Through surveying, it is possible to locate and pinpoint existing structures not to be demolished.

Land Surveying as an art

Over the course of a few centuries, land surveying has significantly evolved. The historical practices of surveyors who once meticulously placed chains to accurately map the land has played a crucial role in the advancements of modern surveying practices and principles for precise mapping and measurement (Milton, 2014).

The historical records showcase the crude yet ingenious approach of the early surveyors, who not only marked and measured the land but also played a key role in articulating the artistic nature of mapping (Redmond, 2019). Furthermore, the artistic representation of surveying in preserving historical events cannot be neglected. In the period where photography was limited or even nonexistent, expressive documentation through surveying was used to capture the life of the surveyor as well as the land they are mapping.

David Thompson, an early Canadian surveyor and explorer, is one such prominent figure in the field of surveying. A 5-meter bronze sculpture of him was attributed to his efforts and serves as a testament to the historical roots and significance of land surveying. Through his efforts, a large map of the entire Northwest of Canada was established. This carefully detailed mapping of the area was later revised to be of a different scale. The findings of his surveying journey were later compiled, with much of the area's terrain being detailed in his records (hbcheritage, n.d.).

In summary, the art of surveying has proved to be an invaluable tool in providing us with a comprehensive understanding of historical and contemporary facets of the mapped land. The multifaceted nature of surveying has helped shape our understanding of the historic and artistic landscape around us as well as aid in the development of new methods and techniques in the profession.

Discovery of Land Surveying in Ancient Egypt

The practice of surveying is assumed to have its origin in ancient Egypt, around 2700 B.C. it played an important role in the construction of structures such as the Great Pyramid of Khufu found at Giza. The ancient Egyptians employed the use of various basic surveying tools such as plumb bobs which provided the ability to have a true vertical line. This tool is integral to sighting, leveling instruments, and measuring vertical distances. The plumb bob was considered a "workhorse" tool by the Egyptians since it was not only employed in surveying works but also in other fields such as astronomy, navigation, and building. (Rowan Edu, n.d.)

The Nile delta is known to have annual floods, which deeply affects the system of land ownership due to land markers being either destroyed or buried. Due to this, surveying has become a great tool in re-establishing such markers, this makes one of the first surveyors to have its origin in ancient Egypt. These early surveyors, known as “rope stretchers”, employed the use of calibrated ropes or cords with knots at certain intervals, which was used for measuring larger distances. (DRMP Inc, 2019)

The ancient Egyptians demonstrated remarkable skills in math and geometry. Despite the lack of knowledge about the Pythagoras Theorem, they were able to create right angles using their knotted rope or cord, even employing the 3-4-5 Triangle method. (DT Online, 2021)

These basic yet effective practices employed by the ancient Egyptians played a crucial role in the construction of the pyramids, the Great Pyramid at Giza being a prime example of astronomical precision. The Great Pyramids being 230.3-meter square, with a discrepancy of a mere 30cm between the west and north sides showcases the meticulous alignment of the pyramids (DT Online, 2021). This amazing feat underscores the proficiency of the ancient Egyptians in surveying techniques, making light of their enduring impact on architecture and engineering.

Land Surveying in the early centuries

In ancient China, during the Qin dynasty, the first magnetic compass was made. This instrument plays a pivotal role in modern surveying works. It was initially used by Chinese fortune tellers and eventually evolved into a navigational instrument which was first used by Zheng He in the 15th century. (CourthouseDirect, 2018)

During the eighteenth-century, Europeans employed triangulation, a method relying on angle measurements, for surveying the creation of networks facilitating precise point positioning within a country (ICSM, n.d.). Additionally, it was in the early 1800s that land surveying was formally recognized as a profession. The rapid growth due to the industrial revolution led to an increased demand for accurate land measurements which coincided with the growth of cities, development of roads as well as railways (CourthouseDirect, 2018). It was also in the 18th and 19th century that an increasing interest in surveying led to its rapid advancements due to the drive to procure accurate maps and establish national boundaries.

The British colonization of Australia and New Zealand involved a great deal of survey work in opening up the land for settlers. The surveying methods involved included Gunter’s chains, measuring wheels, circumferentors, Kater’s compass, as well as pacing of approximate measurements which was sufficient for the time. A clear emphasis on marking and staking claim to the land, which involved less precise measurement and direction accuracy. This method allowed for a pragmatic surveying process, ensuring that the land was available to settlers despite the limitations of the period. (Hallmann 1994, 2.3)

Early surveyors in the United States during the 1800s made use of the compass and chains. The chain used is a 66-foot metal chain that comprises 100 links, each being 7.92 inches. Other tools such as rods or poles were also used which correspond to 16.5 feet each. Despite their lack of precision, the methods and tools of this time were sufficient for the period. Overtime this basic equipment became obsolete and was later replaced by the transit and steel tape. These new set of instruments proved to have greater accuracy compared to its predecessors. (Geodetic Survey Ltd, n.d.)

Development of Land surveying in modern times

Recently, many tools and techniques have been developed or improved upon for the acquisition of survey data with high accuracy, flexibility, simplicity, and cost-effectiveness. Improvements and new tools in modern times have been created for land surveying, remote sensing, hydrographic surveying, map-data processing, and data communication. (Surveying and Land Information Science, Vol. 71, No. 1, 2011, pp. 1-9)

Using grounded theory methodology, the research identified related issues for the profession. The first turned into the perception that land surveying, as a profession, had a bad public reputation and was seen only solely for the field aspect of the work. It was apparent that the poor public image was linked to a poor self-image by the surveyors themselves. Attempts were made to change that reputation by adopting a new term “geomatics”, in the late 20th century when the change was made it did not deliver the anticipated improvements on the craft, and dissatisfaction with the term was identified in all of the jurisdictions visited. In the meantime, the term “geospatial” was the more favored term, via means of stealth, references to geomatics. (Brian J Coutts 2017)

Land surveying from the air was the first challenge for traditional ground-based land surveyors (Staiger, 2009). The invention of human flight via balloons, airplanes and helicopters changed the world of data gathering around the world. When combined with the development of cameras, it enables surveyors the ability with the help of individuals with expertise in some of the fields of photography, to interpret photos of the land taken from the stable/static balloon platforms or that from a moving aircraft. (Kilford, 1970).

Linear measurement by terrestrial methods was using the updated version of Gunter’s chain, the steel band, which has been used by land surveyors up until the second half of the 20th century. The conversion from chains and links to meters occurred on 1 January 1973 in New Zealand and the steel bands were then updated to metric lengths as the world adopted the metric system. (Hemi, 2014)

Computers. Punch cards were then replaced through the late 1970s and early 1980s by magnetic strips carrying “programmed” instructions, which simplified the process. Continued advances in miniaturization made large desktop computers obsolete over time, since calculators increased in power and capacity, plus the reduction in size and in price further cements its place. As advanced software continues to develop and the power of hand-held calculators continues to improve, complex mathematical problems that once took days of painstaking work with the use of natural trigonometric functions

and logarithmic tables could be completed with accuracy and confidence in minutes which eventually became seconds. The ability to carry out complex calculations in small computers has continued to expand up until it has reached the maximum capacity for micro tech. Advancements in the storage, recording and presentation of the information extracted from the data. (Brian J Coutts 2017)

Combining all the technologies in the modern era produces completely new ways of working, new applications or new disciplines. These are not necessarily areas of application that are owned exclusively by the land surveying profession. These include laser scanning, building information modeling (BIM) and remote sensing etc. (Brian J Coutts 2017).

The economic role of the primeval layouts (plats) for a new development area has always been a conscious act of physical planning. The foundational layouts of a city or country in the “new world” had been historically the paintings of a surveyor, and the influences of that have been lasting. Typically following a grid iron pattern, with roots in historical history, the format of the surveyor is usually not aesthetically appealing. But the art of land surveying persists and continues to develop into modern times and even gained new tools for the craft thanks to advancement in technology. (Prof Stephen N.G. Davies, 2020)

Conclusion

To culminate, Land Surveying, also known as civil surveying, is one of the prospects in helping us shape our modern architectures and boundaries. A statement to human ingenuity that helped in the formation of the society we live in today. Furthermore, impacts of this “technology” is very prominent in today’s society especially in cases such as; defining world borders, creation of modern day buildings be it residential, highrises or skyscrapers. Formation of cities, provinces, and roads. Positioning of military bases, airports, docks. And even helped in the increasing structural stability and lifespan of architectural and Civil engineering works.

Additionally, Civil surveying helped us in redefining what’s possible. As it has been a great factor in planning assessment and even gave us data on which engineers use in creating, redefining, and showing possible solutions and alternatives to problems regarding cost, and convenience. In addition to that, civil surveying also paved a way in creating more structurally equal and pleasing designs making a more creative outlook into the world.

Lastly, improvements in this sort of technology have proven useful and helped advance our growth in efficiency and a better design. It gave engineers data which proved helpful in building more systematic transportation routes, in reacting to factors such as disasters, climate change, natural calamities. And also paved a way in understanding structural theory. Air resistance, and ground movement making modern structures more durable, safe, environmentally friendly, energy efficient, and cost effective.

Recommendations

Future researchers that are interested in this topic should first be focusing on giving a more timely and detailed explanation regarding the advancement of this technology in regards with the time and history. Focusing more on giving meaning, transitions to new discovery such as how this technology led to further development in a certain branch of criterion and how they all divulged into different parts and branches of the same technology in the later stages of development.

Furthermore, the focus on showing the advancement with the use of instrumentation, materials, gear, researches, and professions in regards with civil surveying could also help in knowing what shaped this branch of engineering into what we know today. May it be trend, necessity, or even entertainment.

Lastly, future researchers should focus on the leading purpose of the need to discover such art, the focus on understanding and divulging the methods and tools that are used during the phases of land surveying through history showing the process of making factual and accurate information with the ancient technology at the specific time period.

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