Sudan University of Science And Technology
College of Graduate Studies

The Industrialized building System in Sudan: The Challenges and the Way Forward

نظام المباني المصنعة في السودان: التحديات والطريق الي الامام

A Thesis Submitted to Civil Engineering in Fulfillment of the Requirements for the master in Civil Engineering (Constriction Engineering)

By

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August 2020

بسم الله الرحمن الرحيم

Sudan University of Science & Technology
College of Graduate Studies

جامعة السودان للعلوم والتكنولوجيا
كلية الدراسات العليا

كلية الدراسات العليا

Ref: SUST/ CGS/A11

Approval Page

(To be completed after the college council approval)

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الآية

قال تعالى :

{ يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ }

صدق الله العظيم

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DEDICATION

There are no words to express my gratitude and thanks to those who their love has been the major spiritual support in my life.

I will always appreciate all they have done to me, each and every individual who has been a source of support and encouragement and helped me to complete my research successfully.

I dedicate this research to: my father, my mother, my Brothers, my Sisters, and my friend Manahil Domi.

ACKNOWLEDGMENTS

A research like this is never the work of anyone alone. Contributions of many different people, in their different ways, I would like to take this opportunity to express my heartfelt gratitude to all those who helped me to make my research successful.

First and foremost, I have to thank my family for their generous support they provided me throughout my entire life and particularly through the process of pursuing the master degree.

I would like to sincerely thank my supervisor Dr. Eltahir Abu Elgassim Mohamed Elshaikh for this guidance and support throughout this study.

I owe a deep debt of gratitude to our university for giving me an opportunity to complete this work.

I would like also to thank and appreciate the members of the discussion committee for accepting this discussion.

I would like to thank my friends and Colleagues who have shared words of advice. Thank you for providing ideas, support, helpful suggestions and encouragement to finish this study.

Last but not least, deepest thanks go to all people who took part in making this research real.

Abstract

The aim of this research is to identify the challenges that faced implementation of Industrialized Building System in Sudan, knowing the extent of using this system in Sudan, as well as to determine the acceptance of this system in the construction industry in Sudan.

To implement the objectives of this research, five sector questionnaire was designed, six systems have been adopted (Precast concrete framing, panel and box systems, Steel formwork systems, Prefabricated timber framing systems, Steel framing systems, Block work systems). The questionnaire was distributed to 100 respondents, Results were analyzed using statistical analysis software (SPSS).

Several finding have been found firstly: there are many factors barrier in the application of Industrialized Building System in Sudan, such as Shortage in curriculum at universities about IBS, Lack of research and development to improve using local materials, Need specific machine in factory, Secondly: the systems that used now days in Sudan, Steel formwork systems, Steel framing systems, Block work systems. Thirdly: the best system, Block work systems, 3D panel construction system, precast concrete framing.

المستخلص

هدف هذا البحث الي معرفة التحديات التي تواجه تطبيق نظام المباني المصنعة في السودان، ولمعرفة مدي استخدام هذا النظام في السودان ، ولتحديد قبول هذا النظام في قطاع صناعة التشييد في السودان.

لتطبيق اهداف هذا البحث تم تصميم استبيان مكون من خمسة قطاعات، تم اعتماد ستة انظمه (نظام الخرسانة مسبقه الصب، نظام الفورمات الحديدية، نظام الفريم الخشبي الجاهز، نظام الفريم الحديدي الجاهز، نظام البناء بالبلوك الاسمنتي، نظام البناء بالالواح ثلاثية البعاد) . تم توزيع الاستبيان علي عدد 100 من المشاركين. تم تحليل النتائج باستخدام برنامج التحليل الإحصائي (SPSS).

تم التوصل الي عدة نتائج:اولا هناك عوائق في تطبيق نظام المباني الجاهزة في السودان مثل: نقص المناهج الدراسية في الجامعات والمعاهد عن نظام المباني الجاهزة (IBS)، نقص البحث والتطوير لتحسين استحدام المواد المحلية، تحتاج آلات مددة في المصنع. ثانيا: الانظمة المستخدمة حاليا السودان نظام الفورمات الحديدية، نظام الفريم الحديدي الجاهز،نظام البناء بالبلوك السمنتي. ثالثا: افضل نظام، نظام البناء بالبلوك السمنتي، نظام البناء بالاواح ثلاثية الابعاد، نظام الخرسانة مسبقة الصب.

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Chapter One

Introduction

1.1 General Introduction:

An Industrialized Building System (IBS) refers to a technique of construction whereby components are manufactured in a controlled environment - either onsite or offsite - placed and assembled into construction works.

Industrialized Building System (IBS) is a modern system of construction instead of the conventional system which takes times and cost also waste of building material, although it's used commonly in the world, but is still not widely used in Sudan.

IBS is the constriction system whereby most of the structural elements such as beams, columns, walls, slabs and other structural element in buildings are prepared in factories and assemble at constriction side in a short period of time being one of the prominent methods of constriction in this era.

IBS offers a few plus points such as increasing the productivity of structural components spit up the delivery times reducing the number of labor.

The term IBS is used in Malaysia, whereas it is also known as Pre-fabricated/Pre-fab Construction, Modern Method of Construction (MMC) and Off-site Construction in the rest of the world.

IBS benefits listed from the most beneficial to the least beneficial are: minimal wastage, cleaner environment, less site materials, reduction of site labor, controlled quality, faster project completion, neater and safer construction sites and lower total construction costs.

The benefits of prefabrication helped the Housing Ministries in various countries to fulfill the high demand for housing especially in United States, United Kingdom, Australia, Singapore, Hong Kong and Malaysia. [1]

1.2 Research Scope and Limitations:

Working on Industrialized Building System in Sudan is the issue of this research concentrated basically on six systems. The research covers the cost, the time, and the challenges that faced implementation this system by taking questionnaire as the way of assessment.

1.3 Research problem:

Nowadays, the construction industry in Sudan has been changed due to the current technology which increasing the level of quality and safety of the building. It is important to implement the Industrialized Building System (IBS), because of high demand from the clients in construction activities.

The construction industry in Sudan had faced so many problems in time, cost, and quality such as: the high cost of construction and building materials, also there is delaying in construction period, and Increasing of using foreign workers, moreover the quality of building materials is uncontrollable as result of that there is waste of building materials, in addition there is lack of research and inadequate knowledge of IBS, also on safety in construction site.

1.4 Research Importance:

This research looking for the challenges that faced implementation IBS in Sudan the main impact of Industrialized Building System on construction industry involving two an important parts time and cost, considering them as the factors that affect mostly, looking forward to find suitable system for decreasing the total cost and require time for executing the projects

1.5 Research Objectives:

1. To determining the challenges that faced the application of industrialized building system in Sudan.
2. To knowing the extent of using IBS system in Sudan.
3. To determine the level of IBS acceptance in constriction industry.

1.6 Research Assumptions

1. There are many Challenges that faced implementation IBS in Sudan.
2. The universities have a clear shortage of IBS curriculum.
3. Lack of manufacturer companies.
4. Application of the IBS system is based on awareness and good knowledge of the customer.

1.7 Research Methodology:

1.7.1 Theoretical study:

To illustrate the concepts and principles, relying on the sources of books and researches made in this field.

1.7.2 Applied Study:

Conduct a survey of the study society through a questionnaire to collect the necessary data then after we collect the data it will be analysis by using Statistical Analysis Program (SPSS).

1.8Area of study:

The area of study is Khartoum state.

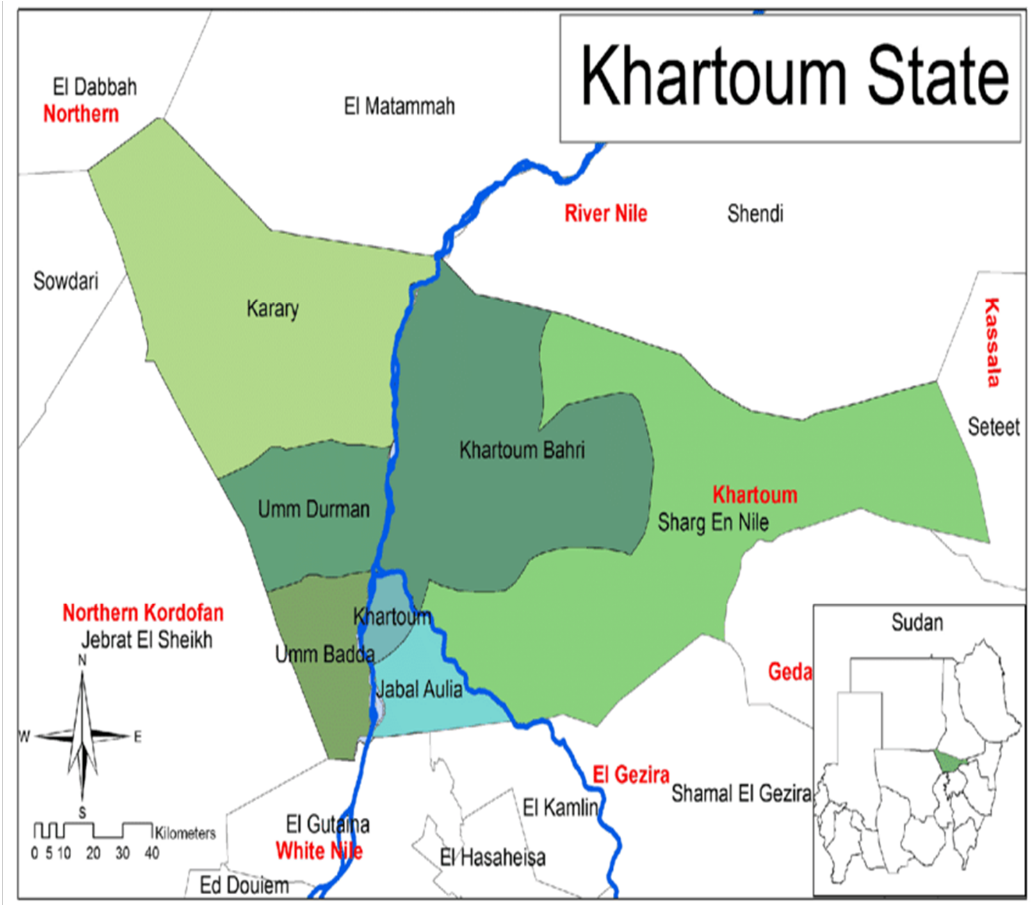


Figure (1) Map of Khartoum state

Chapter Two

Literature review and previous studies

2.1 Introduction:

Industrialized Building System (IBS) has proven that it can contribute many advantages in construction project. The Industrialized Building System (IBS) can reduce the number of unskilled and foreign workers on site. The presence of them can increase cost and wastage in construction industry. In addition, Industrialized Building System (IBS) can make the time period of construction progress become shorter and it can be finished before or on time. The quality of the structural works can be guaranteed because the size and the dimensions of the components had been specified through the design. The safe environment platform can be provided to the workers since the site is clean from the mess of construction tools, prevent the crowded environment that full with too many workers and prevent social problems among the workers. [2]

Therefore, the adoption of Industrialized Building System (IBS) can develop benefits in economic, social and environmental to the country. Since the unskilled labors become less, the dependency on foreign labor force can be reduced. Moreover, a great opportunity and a new job can be created since the industries are using the manufacturing component system.

2.2Definition of Industrialized Building System (IBS)

There are a few definitions for Industrialized Building System by researchers whom studied in this area:

In Malaysia, the Construction Industry Development Board (CIDB) defines IBS as a technique of construction whereby building components are manufactured at factories or off site, transported and then assembled into a structure with minimum work.

In Singapore, the term IBS refers to a construction system for all types of structures, including infrastructure. Whatever the definition, the root idea of IBS is the same, which is the manufacture of components for the construction of structures in a controlled environment [3]

Industrialized Building System (IBS) as a construction which is using prefabricated materials in construction which was manufactured and pre-assembled in factory then transported to the site to be fully assembled and erected.

The fabricated components are manufactured mechanically by using the machine or formworks in factory. [4]

2.3 Background:

After the Second World War, prefabrication of building was the best method to fulfill the housing demand. In Nigeria, the organized building practices dates back to the 1930s when the very few construction activities of significance in the country were handled by the Public Works Department (PWD) and the Royal Army Engineers which was later transformed into the Nigerian Army Engineers. Direct labor was the mode of construction project delivery at this time.

Construction contracting in Nigeria began in the 1940s with a few British and Italian companies coming into operation.

Nigeria's independence in 1960 brought an upward trend in construction activities and until the late sixties; most of the available construction organizations were over-stressed with contracts

Industrialized Building System in Malaysia begun in early 1960s when Ministry of Housing and Local Government of Malaysia visited several European countries and evaluate their housing development program. [5]

In the early 1970s, the US government explored several prefabrication building systems Among the largest prefabrication building system in the US is the manufactured house (MH) which is the second largest provider of housing units and consist about 20% of the total share of the housing market

In the early 1980s, similar action was also taken by the government of Singapore and Hong Kong to spread the use of prefabrication system which was widely used in the building of public housing [6]

2.4 The benefits of using IBS:

1. Results in high-quality products and minimum waste, due to a factory work environment that is easier to control.
2. Results in elimination of conventional timber props and an obvious decrease of supporting materials, through the use of complete assembly elements or prop system for the onsite casting process.
3. Results in a stronger and safer work platform, produced through a complete assembly element.
4. Results in faster completion, due to the introduction of prefabricated components to replace onsite fabrication.
5. Results in a safer, cleaner and more organized site, due to the reduction of construction waste, site workers and prefabricated construction materials.
6. Results in a cheaper total construction cost, resulting from the above factors.[7]

2.5 The barrier of IBS:

There are many problems faced in the implementation of IBS:

1. IBS is not favorable and popular among designers
2. Lack of understanding among designers, client and contractors
3. Slow adoption among contractors with the available systems and high degree of skills, mechanism, coordination and logistic for transportation and erection of the system.

4. The lest standardized and non-concurrent for joints, design, adaptation, chemistry of the components produced coupled with the poor quality and bad aesthetic outlook have make it much harder to promote it within the build communities especially contractors.
5. The chances of securing a continuous project from government worry the contractor in term of cash flow where the break event point after investing on IBS system.[8]

2.6 The type of IBS system:

The five commonly used IBS types are:

1. Precast concrete framing, panel and box systems
2. Steel formwork systems
3. Prefabricated timber framing systems
4. Steel framing systems
5. Block work systems

2.6.1 Precast concrete framing, panel and box systems:

Precast concrete consists of concrete (a mixture of cement, water, aggregates and admixtures) that is cast into a specific shape at a location other than its in-service position. The concrete is placed into a form, typically wood or steel, and cured before being stripped, usually the following day.

Precast concrete components can begin to be erected shortly after foundations are ready and can be installed quickly, often cutting weeks or months from the schedule

Because precast components are fabricated under factory-controlled condition at the plant, harsh winter weather does not impact the production schedule or product quality. [9]

2.6.1.1 The types of precast concrete:

1. **Wall panels:**

Which can include an inner layer of insulation, and be load supporting if desired, Wall panels are made in a considerable variety of shapes, depending on architectural requirements. [10]

Fig (2.1) Wall panels

2. **Spandrels:**

Which generally span between columns and are used with window systems in office buildings or in parking structures [10]

Fig (2.2) Spandrels

3. **Double tees:**

Named due to the two extending tees perpendicular to the flat horizontal deck these tees are often used for parking structures and buildings where long open spans are desired [10]

Fig (2.3) Double tees

4. **Hollow-core slabs**:

Which are long panels in which voids run the length of the pieces, reducing weight while maintaining structural strength [10]

Fig (2.4) Hollow-core slabs

5. **Columns and beams**:

Including columns and a variety of beam shapes [10]

Fig (2.5) Columns and beams

6. **Bridge components**:

For both substructure and superstructure designs including girders in a variety of shapes, box beams, and deck panels. [10]

Fig (2.6) Bridge components

2.6.2 Steel formwork systems:

2.6.2.1 Definition:

This system always be the popular choice and used intensively in the fast-track construction of skyscrapers. Recent development in this types system included the increased usage of light steel trusses. Steel is non-combustible material and improves fire safety and reduces amount of structural damages in the event of a fire happen. Example: Steel beam, columns, portal frames, roof trusses. Steel framing also consider as prefabricated system and it to be erected whereby welding at joints are conducted. This system cans faster the progress construction. [11]

Steel forms are stronger, durable and have long life and the reuses are more in number. Steel forms can be installed and dismantled with greater ease and speed. The quality of exposed concrete surface by using steel forms is good and such surfaces need no further treatment. Steel formwork does not absorb moisture from concrete. Steel formwork does not shrink or warp.

Steel formwork now becoming popular due to its long life, time and multiple times reuse, although it's costly but can be used for large number of projects, it gives very smooth finishes to concrete surface. In addition, it is suitable for circular or curved structures such as tanks, columns, chimneys, sewer, tunnel and retaining wall.

2.6.2.2 Requirements of good formwork

1. It should be strong enough to withstand all types of dead and live loads.
2. It should be rigidly constructed and efficiently propped and braced both horizontally and vertically, so as to retain its shape.
3. The joints in the formwork should be tight against leakage of cement grout.

4. Construction of formwork should permit removal of various parts in desired sequences without damage to the concrete.
5. The material of the formwork should be cheap, easily available and should be suitable for reuse.
6. The formwork should be set accurately to the desired line and levels should have plane surface.
7. It should be as light as possible.
8. The material of the formwork should not warp or get distorted when exposed to the elements.
9. It should rest on firm base.[12]

2.6.2.3 Types of formwork:

Types of concrete formwork construction depend on formwork material and type of structural element, also can be named based on the type of structural member construction Steel formwork is made of

1. Steel sheets
2. Angle Iron
3. Tee Iron

The types of form work based on Structural member:

2.6.2.3.1Wall Form work:

Wall formwork used for concreting of shears or wall in dams, wing walls, basement walls etc. [13]

Fig (2.7) Wall Form work

2.6.2.3.2 Beam Form work:

Beam is the most important member in framed structure it has prefabricated form work includes sheeting bottom and side sheeting panels. The individual parts of formwork are manufactured based on the beam size. For prefabrication of the sheeting parts, a table for fabrication must be manufactured on site. [13]

Fig (2.8) Beam Form work

2.6.2.3.3Foundation Form work:

Foundation formworks designed according to foundation type like footing combined footing, raft. Basically there is a difference in the design for individual foundations, and shuttering for strip foundations. The design of shuttering is dictated by the size, mainly by the height of the foundation. [13]

Fig (2.9) Foundation Form work

2.6.2.3.4 Column Formwork:

Formwork arrangement for column may differ on the basis of column outline like rectangular, circular, and hexagonal or any other shape. The sheeting of column shuttering is constructed according to the column dimensions. The panels are placed in a foot rim, anchored in soil with the help of bolts. [13]

Fig (2.10) Column Formwork

2.6.2.4 Functions:

Forms mold the concrete to desired size and shape and control its position and alignment. Formworks also act as a temporary structure that supports: its own weight + the freshly placed concrete + Construction live loads (material, human, logistic). Formwork is a classic temporary structure in a sense that: It can be erected quickly and it is highly loaded for a few hours during the concrete placement. Within a few days it is disassembled for future use like any other temporary structure. [14]

2.6.2.5 The advantages of steel formwork:

1. Steel shuttering is strong, durable and has longer life.
2. It gives very smooth finish to surface of member.
3. It is waterproof and minimizes the honeycombing effect.
4. It can be used more than 100 times.
5. Steel formwork can be installed & dismantled with greater ease.
6. Easy to disassemble

2.6.3 Prefabricated timber framing systems:

2.6.3.1 Introduction:

Increasingly, wood framing is also being used in commercial and industrial buildings. Wood frame buildings are economical to build, heat and cool, and provide maximum comfort to occupants

Framing system is one of the most common systems that used in the modern construction. It carries the loads through their beams and girders to column and to the ground. This system will form a skeletal structure to support the weight and the number of load carrying member. Their important function is the capacity to transfer heavy loads over large spans. Hence, this system usually will have used to build bridges, warehouse, parking loads, industrial building and so on. It does not enclose the space. Therefore, infill elements such as prefabricated panel or building the infill elements on-site or both need to be set up to complete the entire system. All this explanation of frame system has helped us to understand frame system better, which lead us to the topic of Prefabricated Timber framing. The term prefabricated leads many to think about complete structures built in a factory then transported to the site and set on a foundation. While this building method is becoming increasingly popular, there are other ways builders are using factory precision and efficiencies to create quality structures. [15]

These prefabricated timber framing can be used to form a structure of heavy timber jointed together with various joints, regularly and initially with lap jointing, and the later pegged mortise and ten on joints.[16]

Fig (2.11) Prefabricated timber framing systems

2.6.3.2 Advantages:

1. Building speed
2. Energy efficient house
3. Major manufacturing inside factory where working conditions are perfect
4. Easily processed on building site
5. Attractive price

2.6.4 Steel framing systems:

Steel frame is a building technique with a "skeleton frame" of vertical steel columns and horizontal I-beams, constructed in a rectangular grid to support the floors, roof and walls of a building which are all attached to the frame. The development of this technique made the construction of the skyscraper possible. [17]

Fig (2.12) Steel framing systems

There are different types and configurations of steel connections which are used to connect steel beams to columns in skeleton frame structure, for example, bolt connection and welded connections.

2.6.4.1 The common steel structures in use:

1. Roof trusses for factories, cinema halls, auditoriums etc.
2. Trussed bents, crane girders, column etc.
3. Roof trusses and column to cover platforms in railway station
4. Single layer or double layer domes for auditoriums, exhibition halls, indoor stadiums
5. Plat girder and truss bridges for railway and roads
6. Transmission towers for microwave and electric power
7. Water tanks
8. Chimneys

2.6.4.2 Advantage of steel structures:

The advantage of steel over other material for construction is:

1. It has high strength per unit mass, hence even for large structures, the size of steel structural element is small, saving peace in construction and improving aesthetic view
2. It has assured quality and high durability
3. Speed of construction in another important advantage of steel contracture
4. Steel structures can be strengthened at any later time, if necessary
5. By using bolted connection, steel structures can be easily dismantled and transported to other site quickly
6. If joints are taken care, it is the best water and gas resistant structure
7. Material is reusable. [18]

2. 6.4.3Types of steel members:

Individual element or components are selected to properly support and transmit loads throughout the structure.

Steel member are selected from among the standard rolled shapes adopted by American Institute of steel construction also given by American Society of Testing Materials (ASTM) A6 Specification.

1. Wide flange shape
2. American standard beam
3. American standard channel
4. Angle
5. Structural tee
6. Pipe section
7. Structural tubing
8. Bars
9. Plates [19]

2.6.5 Block work systems:

2.6.5.1 General:

Block work is construction with concrete or cement blocks that are larger than a standard clay or concrete brick. To make them lighter and easier to work with they have a hollow core that also improves their insulation capacity. Including interlocking concrete masonry units and lightweight concrete blocks.

They are available in a variety of densities to suit different applications. Their convenience and cost effectiveness have made them a popular alternative to clay bricks although they require an additional finish for reasons of aesthetics and water resistance. They are often used to build internal partition walls and retaining walls. [20]

Block work in IBS system is interlocking concrete block that are a way to build a strong wall without mortar. Interlocking block walls don't require a footing, but some styles require you to set the first course in a trench to hold the bottom of the wall in place. [21]

Fig (2.13) Block work systems

2.6.5.2 Materials:

Used the block is made up of a mixture of powdered Portland cement, water, sand, and gravel. The concrete mixture has a higher percentage of sand and a lower percentage of gravel and water than the concrete mixtures .This is based on the construction general information. This produces a dry and hard block that maintains its shape. The block also could contain various chemicals or admixtures to decrease curing time, increase strength or improve workability.

2.6.5.3 Some of product of block work system:

1. Hollow block
2. Dense concrete block
3. Foundation block
4. Lightweight block
5. Glass block
6. Unfired clay block
7. Hemp block
8. Masonry block

2.6.5.4 The main advantage is:

1. Masonry block
2. Labor saving
3. . Easier fixing
4. Lower density
5. Higher thermal insulation properties
6. Provides a suitable key for a plaster and cement rendering.

2.7 Other Term Used to Describe IBS:

Many different terms are used to describe industrialized construction and prefabrication. Pre-assembly, prefabrication, Modern Method of Construction (MMC), Offsite Manufacturing (OSM), Offsite Production (OSP) and Offsite Construction (OSC) are terms in common use at various times in the literatures. The IBS term is used interchangeable with other terms like offsite construction, prefabrication, offsite manufacturing, Modern Method of Construction (MMC) industrialized building and industrialized construction. Those concepts are often use interchangeably when describing the characteristics of industrialized construction. They are however, distinct. The terminologies provide a rich historical account of the development of the concept. Nonetheless, regardless of the terms, the idea is the same which refers to manufacture of structure components for the construction of buildings in a control environment rather than doing on site. Modern Method of Construction (MMC) is a term adopted in the United Kingdom as a collective description for both offsite based construction technologies and innovative onsite technologies. [22]

2.8 IBS in Sudan:

Reducing the cost of housing construction is required for helping the increasing number of immigrants whom come from countryside consistently to urban area, towns and cities.

Owning a house in the largest cities in Sudan is something too difficult because of the high cost of construction, which is not commensurate with the level of income, so this requires great efforts to reduce the cost of construction to assist citizens for owning a house taking Khartoum as example.

There are other types of Industrialized Building System, none of the six systems we taken in this research usable in Sudan and they are:

2.8.1 The Construction of agricultural waste technology:

It is not commonly use, even though the materials are available but there was one factory which is closed because of the unsuitable rate of humidity in Sudan.

2.8.2 3D panel construction system:

3D panel is a spatial structure consisting of a expanded polystyrene plate (usually called core), both sides of which are fixed welded wire fabrics made of high strength wire. The welded mesh fabric connected piercing polystyrene with truss of steel wire, welded to the welded fabric at an angle. It gives a rigidity spatial structure, and simultaneously prevents polystyrene core shifting. 3D panel is a versatile structural element designed for floors, walls, partitions, roof, and stairs. [23]

This system consists of polystyrene foam in panels with different thicknesses and densities, depending on the type of buildings that shaded and need to be treated to isolate heat, humidity and sound. Foam polystyrene is non-toxic and chemically inactive in addition to a network of galvanized wire 3 mm diameter which was soldered together with electricity by the side of the polystyrene plates with the nets connected with each other on both sides and then the whiteness of the facades in two stages the first stage spraying with a special machine and white to form plates Walls and ceiling.

Fig (2.14) 3D panel

There are different products thickness of three-dimensional panels, depending on the type of building and the number of floors to be implemented panels which are:

1. Signal panels
2. Double panels
3. Sheet panels
4. stairs panels

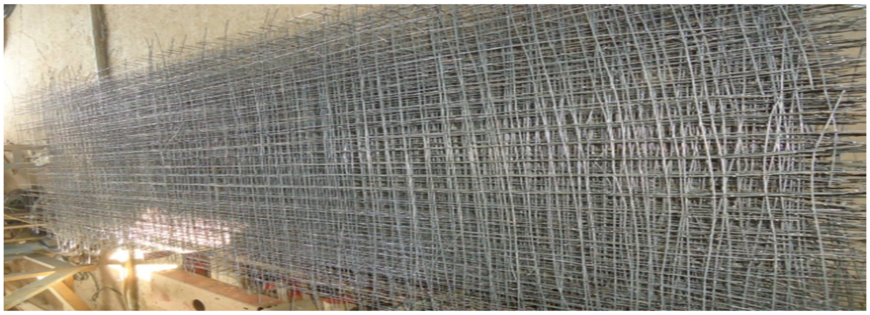
There is another type of 3D panel by using galvanized wire 3 mm diameter which was soldered together with electricity as in fig (2.14) they put the wires in the Truss machine in order to make the Joints, after that they put the Joints in the assembly machine to welded it together by self-welding which make it much stronger, and bring The panels which are the final shape, then they put this panels in the form that needed either it Signal panels, stairs panels, or any shape the need in order to cast it with concrete, but after visiting the 3D panel factory the researcher found that the manufacture panels did not mold in the factory they transport it to the sites and mold them because of the high cost of transportation if the panel molded in the factory.

The weirs

trust machine

Joints

assembly machine



The panels

Fig (2.14) 3D panel construction system

2.8.2.1 Advantages of 3D panel construction:

1. Good insulation for heat, humidity and sound
2. Easy transport, movement and assembly
3. Good resistance to earthquakes and hurricanes
4. It does not need to be installed into skilled workers
5. Light weight does not require skilled workers
6. It gives extra value by increasing the area of the wall because the wall thickness is 10 cm
7. Is not affected by natural erosion factors and has no negative impact on the environment

2.8.2.2 Defects:

1. High initial cost
2. High transportation cost
3. Assembly process is expensive

2.8.3 Technical Prefabricated building:

There are some companies in Sudan for this kind of building such as:

- AL ACADABE in Khartoum bahri
- PRECON in Khartoum
- TAHADEEL in Khartoum bahri

We will take here one company as example **(PRECON)**

Their products are manufactured according to all climate conditions with their heavy duty main frame, compact wall units and special rain water drainage system. Precon which has an ISO 9001:2000 Quality Management System always uses high quality materials for its products. Precon products can be used for permanent accommodation and Office units for years.

Precon Sudan for prefabricated building technology come as result partnership with global brand Karmod

Karmod with its technological expertise and industry has commenced production in Sudan since 2007 using the latest technological facilities for the new branch Precon located in Khartoum.

With modern manufacturing technology, Precon produces long lasting structures among which the following can be mentioned: containers, office containers, containers houses, prefabricated office, prefabricated side building, prefabricated houses, school and hospital structure and many others solution.

The company implemented many projects in many important fields that contribute by indirect way to help the economy of Sudan such as projects of petroleum, mining, agriculture, and infrastructure projects. [24]

Fig (2.15) Technical Prefabricated building

2.8.4 Comparisons study:

A comparative study of the cost of constructing the basic components of an average two-story house model by calculating the cost of constructing for traditional and modern building techniques in Sudan by using:-

1. Construction technology with load bearing
2. Reinforced concrete technology
3. 3D panel technology
4. Construction of agricultural waste technology

The research found that the least cost among the alternatives is the joint structure between the agricultural waste and the walls of the three-dimensional board building, while the most expensive are the concrete buildings with the ceramic and concrete deposits and the walls of the retaining walls

The use of some modern technology such as walls and ceilings in traditional buildings leads to lower costs. [26]

2.8.5 Feasibility study about precast concrete:

Involved a sample project consisting of 8 blocks was considered assuming that it would be constructed using precast concrete elements product by the proposed factory. The cost of such project was compared with that of a similar project that is constructed using in situ in forced concrete. The study showed that the used of precast concrete resulted in considerable saving range from (30% to 37%) in the requirement concrete and almost half (44% to 50%) of the reinforcing bars required quality. It was also evident from the cost analysis exercise that the cost of producing slab is lessened by about USD13/m2 when precast concrete is used instead of the traditional in situ concrete. [37

Chapter Three

Research methodology

3.1 Introduction:

This chapter comprehends the Research methodology and design adopted for achieving the objectives of the study, organized into the fourth sections. The first section includes a description of the research design applied in this study. The second section contains the description of the study survey while the third section includes the Questionnaire, population and sample of the study, the method and procedures used for data collection. The fourth section explains a description of measures, highlighting a discussion about the procedure of analyzing the data of this study. The following figure explain the methodology

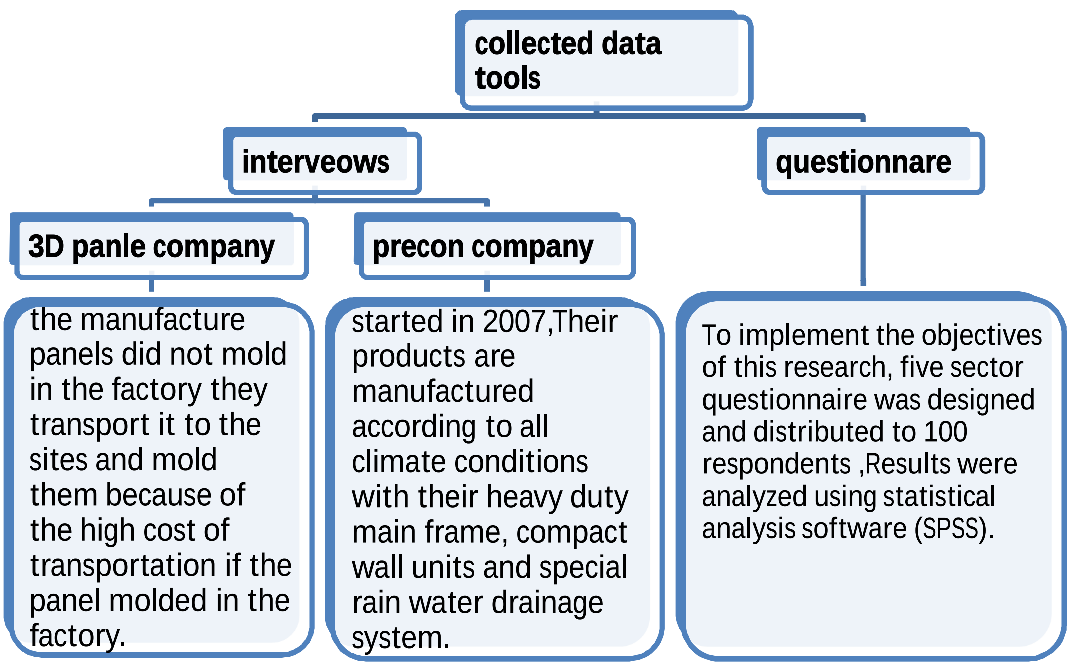


Fig (3.1) the methodology

3.2 Survey study:

As a result of visiting some sites the researcher found that there are a lot of buildings that used steel framing system lead to the fact that this system used widely in Sudan.

According to the survey that has been done by the researcher, more than 70% of factories built by using steel framing system, also the two biggest malls (AFRAA , AL WAHA) also AL FATH tower and so many others buildings spatially the biggest one. [28]

Fig (3.2) steel framing

In addition, there is another kind of building use light steel, it used when we need to add another floor and the building cannot accept more heavy load

In such cases using light steel as a frame and secspanda as the wall with mortar of cement is the way of building. [29]

Fig (3.3) light steel framing

3.3 Questionnaire:

The questionnaire is one of the most prominent tools used in scientific research. It is the researcher's way to obtain data and information regarding the study vocabulary, whether the research is in survey or in part. The questionnaire is mostly used to identify the trends of the study sample and to discover important information that the researcher needs to carry out scientific research

In this research some part of the questionnaire was designed according to the similar research done in the same filed which is the industrialized building system the challenges and the way forward [27]

3.3.1 Design questionnaire:

The questionnaire is a method that includes a set of questions or sentences so that it can collect information about the problem of the study and examine its hypotheses. It is formulated in clear terms and easy words.

The questionnaire process requires the following main steps:

1. Determine the subject of the study in general as well as the sub-topics
2. Formulate a set of questions about each subtopic
3. Conducting a pilot test on the questionnaire by presenting it to the experienced people to know their opinions on the questionnaire paragraphs and their suitability for use
4. After the initial answers, the questionnaire will be modified in the light of the notes and printed in final form

3.3.2 Contents of the Questionnaire:

The questionnaire is divided into five sections

➢ The first sector contain (instructions) to help respondents to understand the term that used in study in order to answer the question correctly to achieve the aim of study also, to now general information about the respondents such as Scientific qualification, , type of work, The field, characteristics such as: Years of experience, size of work , etc.

- The second sector consist of a set of question about the challenges that face IBS implementation in Sudan to find out what are the most challenge can prevent uses IBS in Sudan
- The third sector under name of “ What are the systems that using now a days in Sudan” the research consist of six system the and this is one of objective‘s research
- The fourth sector under name of “what the best systems” to identify the best system the can use in Sudan
- The fifth sector under name of “which system affected on decreasing the cost in Sudan” this sector This sector has been divided into three denomination: (less than 50) % , (50-80)% , (above 80)%

3.3.3 Population and Sample:

In statistics, a population is the entire pool from which a statistical sample is drawn. A population may refer to an entire group of people.

Unlike a sample, when carrying out statistical analysis on a population, there are no standard errors to report that is, because such errors inform analysts using a sample how far their estimate may deviate from the true population value. But since you are working with the true population you already know the true value.

The researcher focus on populations of (Owner contractors, consultants, Project manager), as presented in the Contractors union classification and Council of Organization of Consultant. This listing included (70) contractors and (65) consultants in Khartoum [28] .The size of the sample required from each population was determined on the basis of statistical principles for this type of exploratory research. For such research, sample size was determined as follows:

$$n0 = (p*q)/ V2 \quad (1)$$

$$n = n0 / [1+ (n0 / N)] \quad (2)$$

Where:

n0: First estimate of sample size, P: The proportion of the characteristic being

Measured in the target population, q: Complement of „p" or 1-p, V: The Maximum standard error allowed, N: The population size, n: The sample size.

To maximize n, p is set at 0.5. The target populations N are 70 and 60 for contractors and consultants respectively. To account for more error in qualitative answers of this questionnaire, maximum standard error V is set at 10% or 0.1. Substituting in Equations 1 and 2 above, minimum required sample is calculated to be 50 and 45 for contractors and consultants respectively. This means that the minimum sample size for each population is 50 and 45. The respondents were grouped into four major groups namely Chapter Three Data collection 54 contractor, consultant, owner and projects managers. The returns from the four groups are tabulated in table (1) below which shows the response rate. Out of 145 targeted responses, only 100 (68.96%) of them completed and returned the questionnaire.

100 questionnaires from 45 contractors, 20 consultants, 5 owners and 30 projects managers were received.

Table (3.1): Questionnaire distribution and return rate

Participant category	Questionnaires sent (Sample size)	Response	Response rate (%)
Contractors	55	45	81.82
Consultants	35	20	57.14
Owners	10	5	50
Project managers	45	30	66.66
Total	145	100	68.96

3.4 Data Analysis:

After the data was collected it was organized and analyzed. For the analysis questions, a computer programmed called Statistical Package for Social Sciences (SPSS) was used. Data was analyzed by using descriptive statistics. Frequency tables were drawn and from these the data was presented in bar diagrams.

3.4.1 Importance Index:

Then Importance index for each factor was calculated according to the equations (3), (4) and (5) [28]

Importance Index= $(Wi\ x\ Xi)/N$ **(3)**

Where:

Wi: the weight is assigned to the option of factor; Xi: the number of respondents who selected the option of factor; N: the total number of respondents.

- Importance index for section (two), (four), (five) calculated by the following equation:

Importance Index = 5(x5) +4(x4) +3(x3) +2(x2) + 1 (x1) / (N) (4)

- Importance index for section three calculated by the following equation:

$$\textbf{Importance Index} = 4(x4) + 3(x3) + 2(x2) + 1\,(x1)\,/\,(N) \qquad (5)$$

3.4.2 Reliability:

Reliability is the degree of consistency with which an instrument measures the attribute it is designed to measure

Reliability is a way of assessing the quality of the measurement procedure used to collect data in a dissertation. In order for the results from a study to be considered valid, the measurement procedure must first be reliable.

As random error increases, reliability decreases [30] provided a commonly accepted rule of thumb for describing internal consistency using Cronbach's alpha is as follows:

Table (3.2): Cronbach‘s consistency alpha [28]

Cronbach‘s Coefficient Alpha	Internal Consistency Remarks
$\alpha \geq 0.9$	Excellent
$0.7 \leq \alpha < 0.9$	good
$0.6 \leq \alpha < 0.7$	Acceptable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

Reliability test was carried out to determine whether the questionnaire was capable of yielding similar scores if the respondents have used it twice. The test was conducted using SPSS version 21.0. The determined Cronbach‘s alpha coefficient value for questionnaire was 0.883 as shown in table 3. 3. This value indicates that the questionnaire items form a scale that has reasonable internal consistency reliability. Impliedly, the survey instrument used was good reliable and acceptable and that an agreement exists between construction industry participants.

Table (3.3): Results of Cranach's consistency alpha

Questionnaire Section	Number of Items	Cronbach's Alpha
General information	8	0.787
the challenges	36	0.787
the systems that using now a days in Sudan	6	0.970
what the best systems	6	0.876
Witch system affected on decreasing	6	0.145
Combination	62	.883

3.4.3 Correlation Coefficient (R^2):

Correlation coefficient (sometimes called the regression coefficient) is the act of the linear correlation between two variables x and y, between +1 and -1 for sale inclusive. R^2 = 1 indicates a perfect linear correlation and linear regression perfect, R_2 =0 is no correlation and R= -1 total negative correlation. Table 3.14 states the accuracy of the correlation coefficient in measures by determination R^2 . [28]

Table (3. 4): Measure of correlation accuracy by R^2 [28]

R^2 Values	Accuracy
<0.25	Not good
0.25-0.55	Relatively good
0.56-0.75	Good
>0.75	Very good

Chapter Four

Results Analysis and Discussion

4.1 Introduction:

This chapter reviews the results and analysis of the data, discusses the data analysis and findings from 100 questionnaires completed by engineers, consultants, contractors.

4.2 Questionnaire Analysis and Discussion

This chapter presents the findings of this study, which were obtained from the various analyses. The chapter starts with the respondent's profile, the challenges that face IBS implementation in Sudan, What are the systems that using now days in Sudan, the best systems, and which system affected on decreasing the cost in Sudan

4.2.1 Sample Configuration

(1) Participants Work Area:

The configuration of the participants was as presented in table (4.1) and figure (4.1), 8% of the respondents were working as owner, 57% were contractors and 35% were consultative

Table (4.1): Participants work area:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Owner	8	8%	8%	8%
	contractor	57	57%	57%	65%
	consultative	35	35%	35%	100%
	Total	100	100.0%	100.0%	

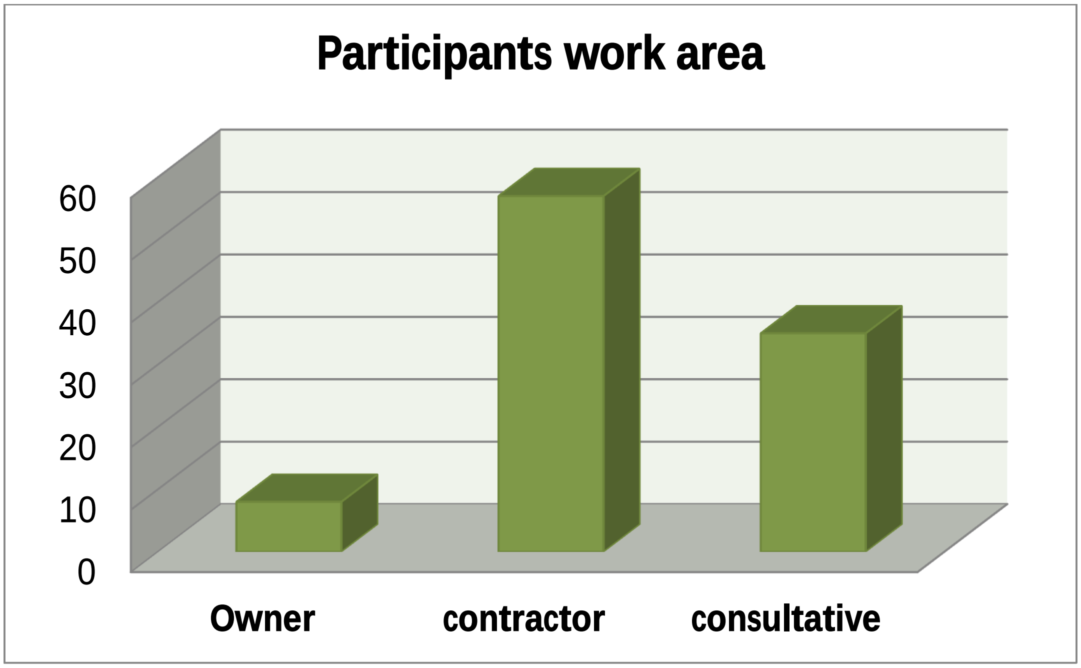


Figure (4.1): Participants work area

(2) Participants Academic Qualification:

The academic qualifications of the overall participants were as presented in table (4.2) and figure (4.2). The highest percentages of participants 42% have bachelor degree while 36% earned diploma degree, 17% Master and 5% PhD. This gives indication that the sample covers participants with a wide range of qualification

Table (4.2): Participants' academic qualification:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	diploma	36	36%	36%	36%
	Bachelor	42	42%	42%	78%
	Master	17	17%	17%	95%
	PHD	5	5%	5%	100%
	Total	100	100%	100%	

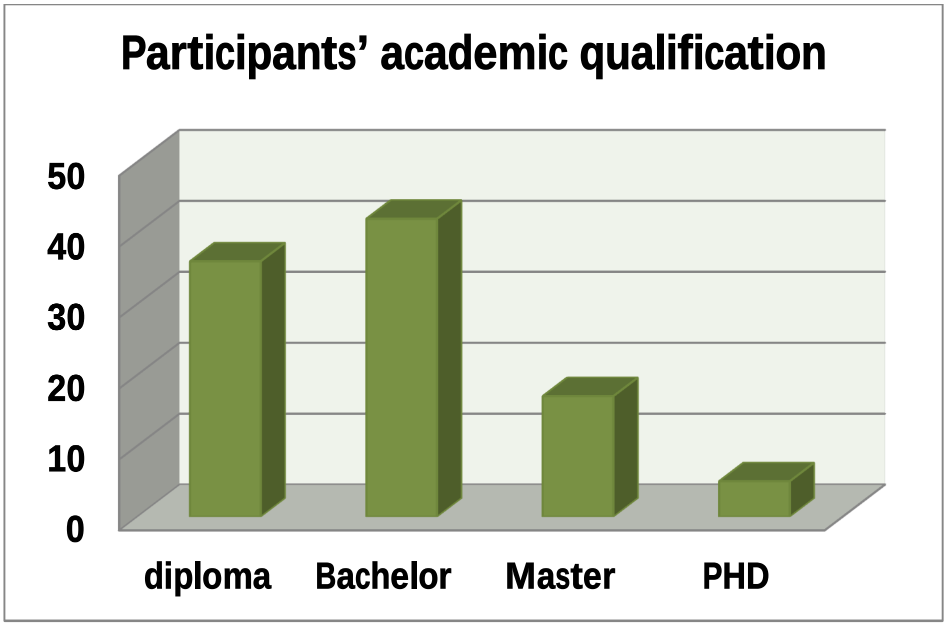


Figure (4.2): Participants academic qualification

(3) Participants' work Sector:

Regarding the work area, the results showed that 54 % classify themselves as were private sector, while 46% organizations as public sector organizations shown in table (4.3) and figure (4.3)

Table (4.3): participants work sector

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Private sector	54	54%	45%	54%
	Gov. sector	46	46%	40 %	100%
	Total	100	100%	100 %	

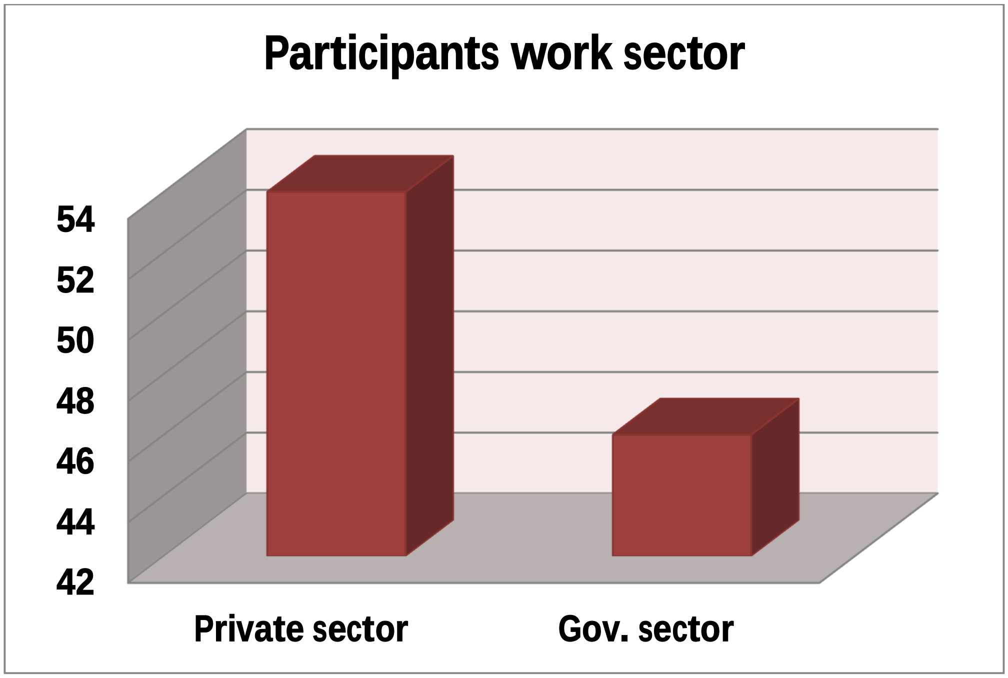


Figure (4.3): Participants work sector

(4) Participants Specialization:

When asked participants to specify their area of specialization, 69% were recorded as civil engineers while 29% were architects, and 31% other as shown in table (4.4) and figure (4.4)

Table (4.4): Participants' specialization

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Civil	69	69%	69%	69%
	architect	31	31%	31%	100%
	Total	100	100%	100%	

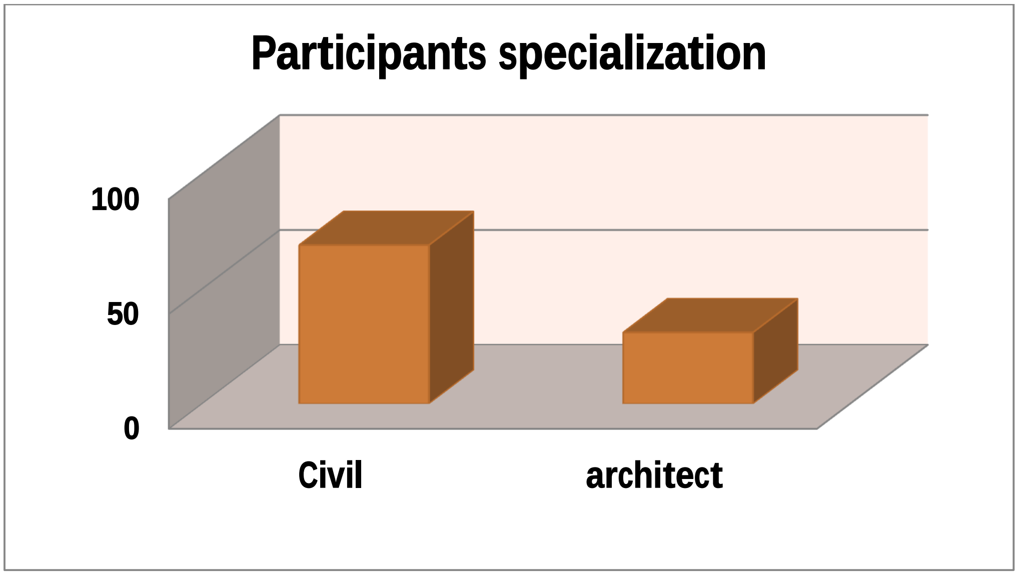


Figure (4. 4): Participants specialization

(5) **Participants Experience**

To evaluate the respondent's experience, 34% admitted to be working in the field less than 5 years, 26% were working for (5 – 10) years, 30 % for (11-15) years, 8% were working for (16 – 20) years and 2% for more than 20 years. This confirms that (66%) of participants have been working for at least10 years which imply a good experience to give a reasonable consent. (Refer to table 4.5 and figure 4.5).

Table (4.5): Years of experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 5	34	34%	34%	34%
	5-10	26	26%	26%	60%
	11-15	30	30%	30%	90%
	16-20	8	8%	8%	98%
	More than 20	2	2%	2%	100%
	Total	100	99%	100%	

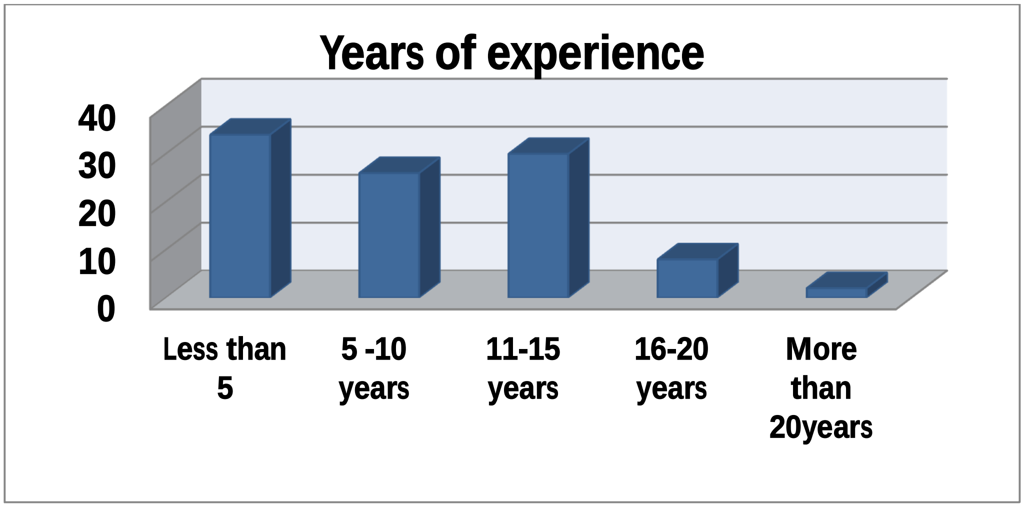


Figure (4. 5): Years of experience

(6) Number of annual projects

The respondents given 5 options to choose from their feedback, we found that with 35% confirmed in less than 5 projects, while 10% said (5-10) projects, 29 % said (11-15) projects, and 21 % said for (16-20) and 5% said more than 15 projects. As shown in table (4.6) and figure (4.6)

Table (4.6): Number of annual projects

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 5	35	35%	35%	35%
	5-10	10	10%	10%	45%
	11-15	29	29%	29%	74%
	16-20	21	21%	21%	95%
	More than 20	5	5%	5%	100%
	Total	100	99%	100%	

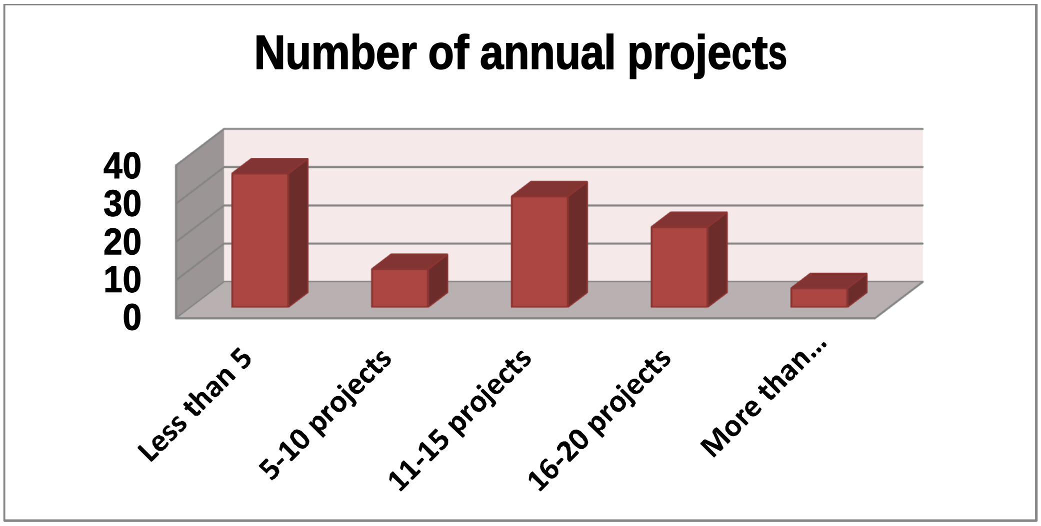


Figure (4. 6): Number of annual projects

4.2.2 The challenges that faced IBS implementation

This sector consists of the challenges that faced implementation IBS, respondents were asked to give their opinion ranking the occurrence of each of the highlighted 36 challenges. The results are collected and presented in table (4.6), and figure (4.6)

- First challenge: (Shortage in curriculum at universities about IBS) 87% of the respondents confirmed this occurs Strongly Agree, 12 % Agree, 1 % sometimes, 0% strongly disagree and 0% disagree, and the importance index is 4.86, this result confirms that the all respondents agree there is Shortage in curriculum at universities about IBS.
- Second challenge: (Architects are unfamiliar to IBS projects designing)) 15% of the respondents confirmed this occurs Strongly Agree, 19 % Agree, 34 % sometimes, 22% strongly disagree and 10% disagree, and the importance index is 3.07, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Third challenge: (weakness in engineers' experience to IBS projects designing) 19% of the respondents confirmed this occurs Strongly Agree, 15 % Agree, 36 % sometimes, 21% strongly disagree and 9% disagree, and

the importance index is 3.14, this result confirms that the majority of the respondents consider occurring this challenge frequently.

- Fourth challenge: (Shortage of contractors' experience to handle IBS projects) 69% of the respondents confirmed this occurs Strongly Agree, 26 % Agree, 3 % sometimes, 2% strongly disagree and 0% disagree, and the importance index is 4.62, this result confirms that the majority of the respondents consider occurring this challenge frequently.

- Fifth challenge: (Lack of experience among workers in working on IBS projects) 50% of the respondents confirmed this occurs Strongly Agree, 38% Agree,10 % sometimes, 2% strongly disagree and 0% disagree, and the importance index is 4.36, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Sixth challenge: (Lack of experience to handle software systems (CAD system) 8% of the respondents confirmed this occurs Strongly Agree, 10% Agree,16 % sometimes, 30% strongly disagree and 35% disagree, and the importance index is 2.23, this result confirms that the more than 50%of the respondents are not agree with this challenge.
- Seventh challenge: (Lack of scientific information about the economic benefits of IBS) 74% of the respondents confirmed this occurs Strongly Agree, 20% Agree,5 % sometimes, 1% strongly disagree and 0% disagree, and the importance index is 4.67, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Eighth challenge: (Lack of research and development to improve using local materials) 86% of the respondents confirmed this occurs Strongly Agree, 10% Agree,2 % sometimes, 1% strongly disagree and 0% disagree, and the importance index is 4.78, this result confirms that the majority of the respondents consider occurring this challenge frequently.

- Ninth challenge: (Delay in deliver IBS components at required time) 12% of the respondents confirmed this occurs Strongly Agree, 16% Agree,43 % sometimes, 27% strongly disagree and 2% disagree, and the importance index is 3.09, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Tenth challenge: (Designing change needing during site work) 6% of the respondents confirmed this occurs Strongly Agree, 21% Agree,59 % sometimes, 11% strongly disagree and 3% disagree, and the importance index is 3.16, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Eleventh challenge: (Delay in making decisions) 12% of the respondents confirmed this occurs Strongly Agree, 21% Agree,61 % sometimes, 6% strongly disagree and 0% disagree, and the importance index is 3.39, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Twelfth challenge: (High initial cost to establish a factory)) 69% of the respondents confirmed this occurs Strongly Agree, 24% Agree,7 % sometimes, 0% strongly disagree and 0% disagree, and the importance index is 4.62, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Thirteenth challenge: (Need more money to import specific materials) 48% of the respondents confirmed this occurs Strongly Agree, 46% Agree,3 % sometimes, 3% strongly disagree and 0% disagree, and the importance index is 4.39, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Fourteenth challenge: (Need more money to import specific equipment) 45% of the respondents confirmed this occurs Strongly Agree, 46% Agree,6 % sometimes, 3% strongly disagree and 0% disagree, and the importance

index is 4.33, this result confirms that the majority of the respondents consider occurring this challenge frequently.

- Fifteenth challenge: (High transportation cost) 41% of the respondents confirmed this occurs Strongly Agree, 52% Agree, 5 % sometimes, 1% strongly disagree and 1% disagree, and the importance index is 4.31, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Sixteenth challenge: (Need more money to employ skilled Workers) 23% of the respondents confirmed this occurs Strongly Agree, 66% Agree, 9 % sometimes, 2% strongly disagree and 0% disagree, and the importance index is 4.1, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Seventeenth challenge: (Swing of markets demands) 9% of the respondents confirmed this occurs Strongly Agree, 14% Agree, 66 % sometimes, 9% strongly disagree and 2% disagree, and the importance index is 4.19, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Eighteenth challenge: (Using expensive finishing materials in design) 7% of the respondents confirmed this occurs Strongly Agree, 13% Agree, 51 % sometimes, 24% strongly disagree and 3% disagree, and the importance index is 2.91, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Nineteenth challenge: (Delay in payment from clients) 8% of the respondents confirmed this occurs Strongly Agree, 33% Agree, 52% sometimes, 5% strongly disagree and 2% disagree, and the importance index is 3.4, this result confirms that the majority of the respondents consider occurring this challenge frequently.

- Twentieth challenge: (Production process is slower than real need at site) 22% of the respondents confirmed this occurs Strongly Agree, 40% Agree, 29% sometimes, 5% strongly disagree and 4% disagree, and the importance index is 3.71, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Twenty-one challenge: (Need specific machine in factory) 84% of the respondents confirmed this occurs Strongly Agree, 11% Agree, 3% sometimes, 2% strongly disagree and 0% disagree, and the importance index is 4.77, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Twenty- tow challenge: (Need specific machine in factory) 75% of the respondents confirmed this occurs Strongly Agree, 22% Agree, 2% sometimes, 1% strongly disagree and 0% disagree, and the importance index is 4.71, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Twenty-three challenge: (Lack of manufacturer) 81% of the respondents confirmed this occurs Strongly Agree, 9% Agree, 4% sometimes, 5% strongly disagree and 1% disagree, and the importance index is 4.64, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Twenty-fourth challenge: (Leakage in IBS components after assembling)) 5% of the respondents confirmed this occurs Strongly Agree, 16% Agree, 32% sometimes, 40% strongly disagree and 6% disagree, and the importance index is 2.71, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Twenty-fifth challenge (Shortage in special machines to assemble IBS components) 18% of the respondents confirmed this occurs Strongly Agree, 67% Agree, 14% sometimes, 1% strongly disagree and 1% disagree, and

the importance index is 4.03, this result confirms that the majority of the respondents consider occurring this challenge frequently.

- Twenty-sixth challenge: (Shortage in specialist workers to assemble IBS components) 19% of the respondents confirmed this occurs Strongly Agree, 73% Agree, 6% sometimes, 1% strongly disagree and 1% disagree, and the importance index is 4.08, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Twenty-seventh challenge: (Inability of IBS components to repair) 18% of the respondents confirmed this occurs Strongly Agree, 33% Agree, 46% sometimes, 3% strongly disagree and 1% disagree, and the importance index is 3.66, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Twenty-eighth challenge: (Assembly process is expensive) 45% of the respondents confirmed this occurs Strongly Agree, 44% Agree, 5% sometimes, 4% strongly disagree and 2% disagree, and the importance index is 2.26, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Twenty-ninth challenge: (Storage area is exposed to environmental effects) 35% of the respondents confirmed this occurs Strongly Agree, 49% Agree, 12% sometimes, 3% strongly disagree and 1% disagree, and the importance index is 4.14, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Thirty challenge: (Long distance between factory and site) 10% of the respondents confirmed this occurs Strongly Agree, 28% Agree, 54% sometimes, 6% strongly disagree and 2% disagree, and the importance index is 3.38, this result confirms that the majority of the respondents consider occurring this challenge frequently.

- Thirty-one challenge: (Difficulty to reach to construction site) 6% of the respondents confirmed this occurs Strongly Agree, 7% Agree, 76% sometimes, 7% strongly disagree and 4% disagree, and the importance index is 3.04, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Thirty-tow challenge: (Difficult site topography) 5% of the respondents confirmed this occurs Strongly Agree, 5% Agree, 79% sometimes, 6% strongly disagree and 4% disagree, and the importance index is 2.98, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Thirty-three challenge: (Joints are inadequate to our environment) 9% of the respondents confirmed this occurs Strongly Agree, 10% Agree, 57% sometimes, 19% strongly disagree and 1% disagree, and the importance index is 2.95, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Thirty-fourth challenge: (Transportation process has difficulties to transport big components from factory to construction site) 16% of the respondents confirmed this occurs Strongly Agree, 52% Agree, 27% sometimes, 1% strongly disagree and 3% disagree, and the importance index is 3.74, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Thirty-fifth challenge: (Customers do not accept new systems) 77% of the respondents confirmed this occurs Strongly Agree, 17% Agree, 4% sometimes, 1% strongly disagree and 0% disagree, and the importance index is 4.67, this result confirms that the majority of the respondents consider occurring this challenge frequently.
- Thirty-sixth challenge: (Application of the IBS system is based on awareness and good knowledge of the customer) 87% of the respondents

confirmed this occurs Strongly Agree, 6% Agree, 4% sometimes, 1% strongly disagree and 0% disagree, and the importance index is 4.73, this result confirms that the majority of the respondents consider occurring this challenge frequently.

Table (4.7) the challenges that faced IBS implementation

Factor Description	Strongly Agree	Agree	Sometimes	Strongly Disagree	Disagree	Importance Index
Shortage in curriculum at universities about IBS	87	12	1	0	0	4.86
	87%	12%	1%	0%	0%	
Architects are unfamiliar to IBS projects designing	15	19	34	22	10	3.07
	15%	19%	34%	22%	10%	
weakness in engineers' experience to IBS projects designing	19	15	36	21	9	3.14
	19%	15%	36%	21%	9%	
Shortage of contractors' experience to handle IBS projects	69	26	3	2	0	4.62
	69%	26%	3%	2%	0%	
Lack of experience among workers in working on IBS projects	50	38	10	2	0	4.36
	50%	38%	10%	2%	0%	
Lack of experience to handle software systems (CAD system)	8	10	16	30	35	2.23
	8%	10%	16%	30%	35%	
Lack of scientific	74	20	5	1	0	4.67

information about the economic benefits of IBS	74%	20%	5%	1%	0%	
Lack of research and development to improve using local materials	86	10	2	1	0	4.78
	86%	10%	2%	1%	0%	
Delay in deliver IBS components at required time	12	16	43	27	2	3.09
	12%	16%	43%	27%	2%	
Designing change needing during site work	6	21	59	11	3	3.16
	6%	21%	59%	11%	3%	
Delay in making decisions	12	21	61	6	0	3.39
	12%	21%	61%	6%	0%	
High initial cost to establish a factory	69	24	7	0	0	4.62
	69%	24%	7%	0%	0%	
Need more money to import specific materials	48	46	3	3	0	4.39
	48%	46%	3%	3%	0%	
Need more money to import specific equipment	45	46	6	3	0	4.33
	45%	46%	6%	3%	0%	
High transportation cost	41	52	5	1	1	4.31
	41%	52%	5%	1%	1%	
Need more money to employ skilled	23	66	9	2	0	4.1
	23%	66%	9%	2%	0%	

Workers						
Swing of markets demands	9	14	66	9	2	3.19
	9%	14%	66%	9%	2%	
Using expensive finishing materials in design	7	13	51	24	3	2.91
	7%	13%	51%	24%	3%	
Delay in payment from clients	8	33	52	5	2	3.4
	8%	33%	52%	5%	2%	
Production process is slower than real need at site	22	40	29	5	4	3.71
	22%	40%	29%	5%	4%	
Need specific machine in factory	84	11	3	2	0	4.77
	84%	11%	3%	2%	0%	
Need to skilled craftsmen in a factory	75	22	2	1	0	4.71
	75%	22%	2%	1%	0%	
Lack of manufacturer	81	9	4	5	1	4.64
	81%	9%	4%	5%	1%	
Leakage in IBS components after assembling	5	16	32	40	6	2.71
	5%	16%	32%	40%	6%	
Shortage in special machines to assemble IBS components	18	67	14	1	1	4.03
	18%	67%	14%	1%	1%	
Shortage in specialist workers to assemble IBS	19	73	6	1	1	4.08
	19%	73%	6%	1%	1%	

components						
Inability of IBS components to repair	18	33	46	3	0	3.66
	18%	33%	46%	3%	0%	
Assembly process is expensive	45	44	5	4	2	4.26
	45%	44%	5%	4%	2%	
Storage area is exposed to environmental effects	35	49	12	3	1	4.14
	35%	49%	12%	3%	1%	
Long distance between factory and site	10	28	54	6	2	3.38
	10%	28%	54%	6%	2%	
Difficulty to reach to construction site	6	7	76	7	4	3.04
	6%	7%	76%	7%	4%	
Difficult site topography	5	5	79	6	4	2.98
	5%	5%	79%	6%	4%	
Joints are inadequate to our environment	9	10	57	19	1	2.95
	9%	10%	57%	19%	1%	
Transportation process has difficulties to transport big components from factory to construction site	16	52	27	1	3	3.74
	16%	52%	27%	1%	3%	
Customers do not accept	77	17	4	1	0	4.67

new systems	77%	17%	4%	1%	0%	
Application of the IBS system is based on awareness and good knowledge of the customer	87	6	4	1	0	4.73
	87%	6%	4%	1%	0%	

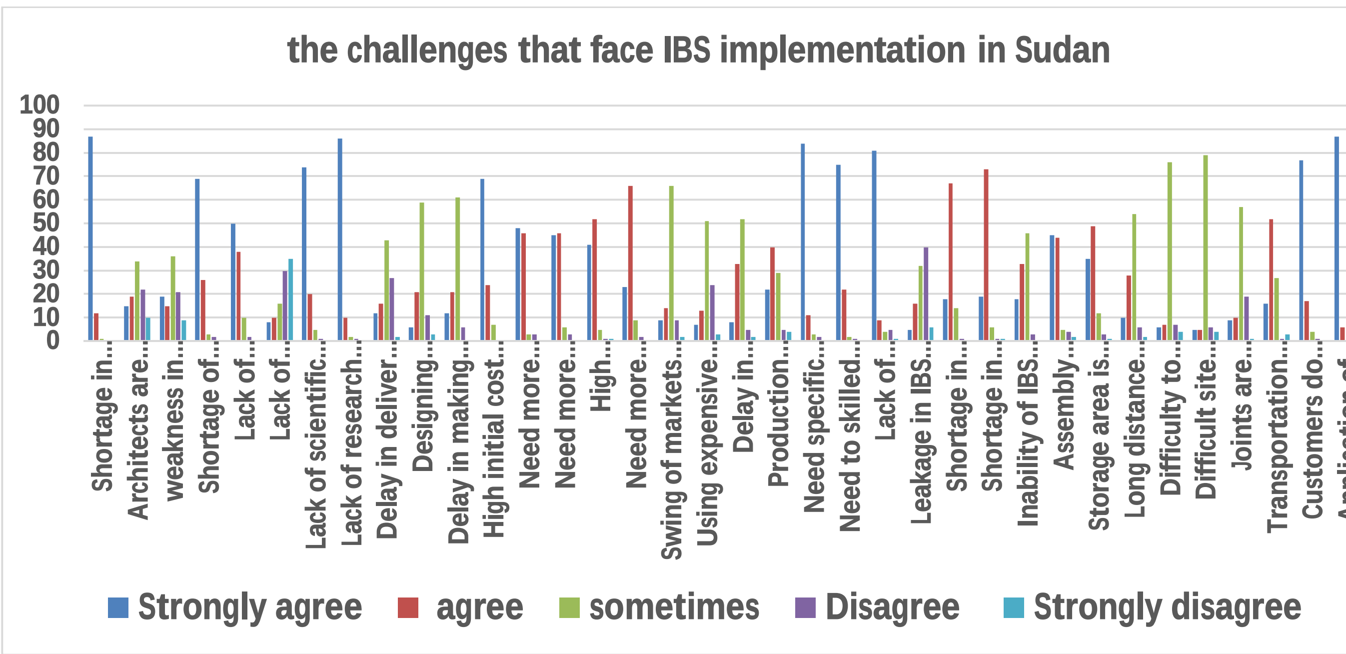


Figure (4.7) the challenges that face IBS implementation in Sudan

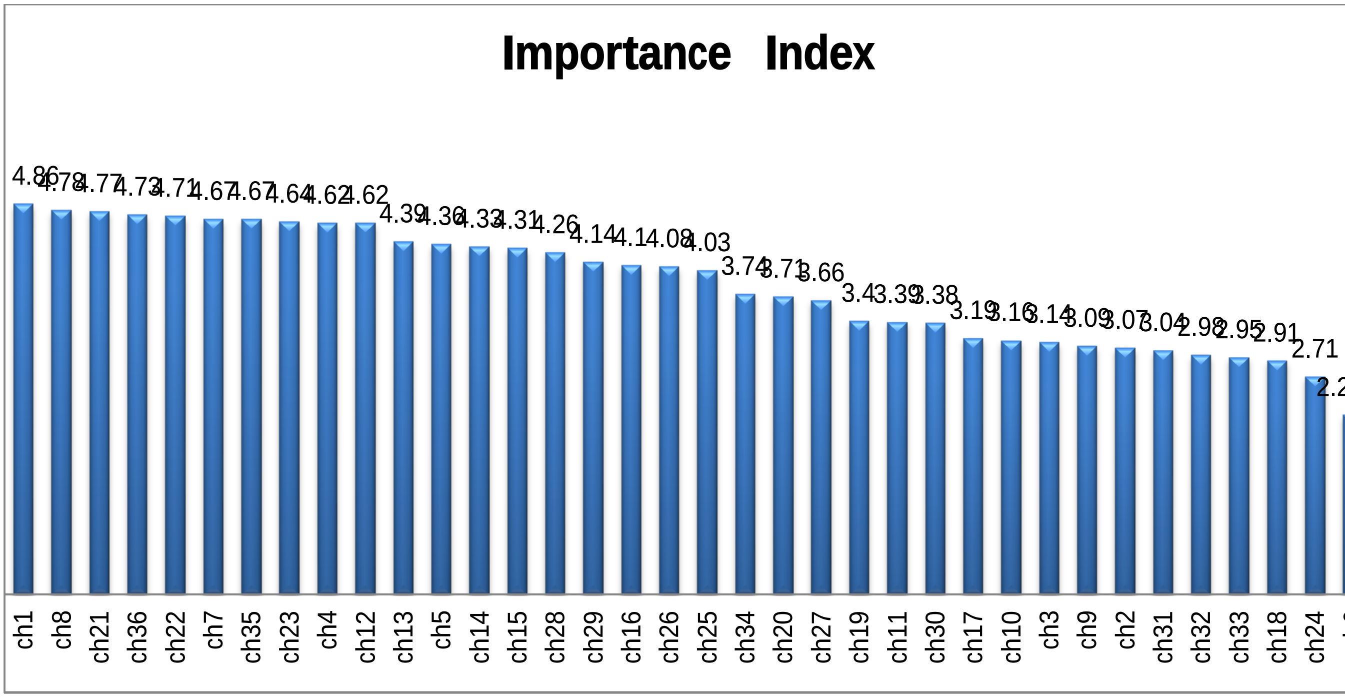


Figure (4.8) the important index

4.2.3 The Systems that using now days in Sudan:

In this sector the respondents were asked to give their opinion about the system that used now days in Sudan, it consist six systems in a form of (usable, semi usable, unusable). The results are collected and presented in table (4.8), and figure (4.9)

- First system: (Precast concrete framing, panel and box systems) 15% the respondents considered this system are usable, while 40% see is semi usable, and 45% see its unusable. The importance index is 1.7. about 15% only see that this system are usable, that means the Precast concrete framing, panel and box systems is not usable in Sudan at this time.
- Second system: (Steel formwork systems) 50% the respondents considered this system are usable, while 30% see is semi usable, and 20% see its unusable. The importance index is 2.3. , this result confirms that the majority of the respondents consider this system is usable.

- Third system: (Prefabricated timber framing systems) 20% the respondents considered this system are usable, while 30% see is semi usable, and 50% see its unusable. The importance index is 1.7.this result confirms that the respondents consider this system is usable. about 20% only see that this system are usable, that means the Prefabricated timber framing systems is not usable in Sudan at this time.
- Fourth system: (Steel framing systems) 39% the respondents considered this system are usable, while 31% see is semi usable, and 30% see it's unusable. The importance index is 2.09.this result confirms that the majority of the respondents consider this system is usable in Sudan.
- Fifth system: (Block work systems) 15% the respondents considered this system are usable, while 50% see is semi usable, and 35% see it's unusable. The importance index is 1.8.this result confirms that the majority of the respondents consider this system is usable in Sudan.
- Six system: (3D panel construction system) 19% the respondents considered this system are usable, while 31% see is semi usable, and 50% see it's unusable. The importance index is 1.39.this result confirms that the half of the respondents consider this system is usable in Sudan, and the half of them are not.

Table (4.8) the Systems that using now days in Sudan

Items	Usable	Semi usable	Unusable	Importance Index
Precast concrete framing, panel and box systems	15	40	45	1.7
	15 %	40%	45%	
Steel formwork systems	50	30	20	2.3
	50 %	30%	20%	
Prefabricated timber	20	30	50	1.7

framing systems	20 %	30%	50%	
Steel framing systems	39	31	30	2.09
	39 %	31%	30%	
Block work systems	15	50	35	1.8
	15 %	50%	35%	
3D panel construction system	19	31	50	1.69
	19 %	31%	50%	

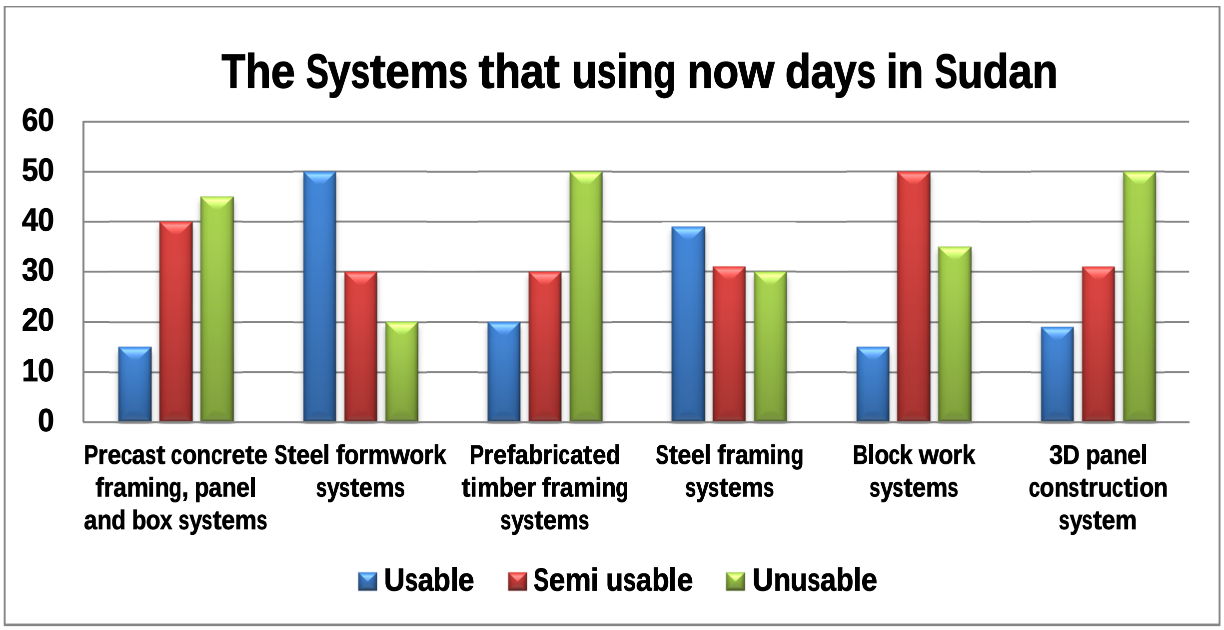


Figure (4.9) the Systems that using now days in Sudan

4.2.3.1 Precast concrete framing, panel and box systems

The respondents were asked to give their opinion about the system that used now days in Sudan. About this system 15% of them see that is usable, while 40% see its semi usable, and 45% see is unusable. It’s clear that this system is not widely use in Sudan show in table (4. 9) and figure (4.10).

Table (4.9) Precast concrete framing, panel and box systems (system use)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Usable	15	15%	15%	15%
	mi usable	40	40%	40%	55%
	Unusable	45	45%	45%	100%
	Total	100	100%	100%	

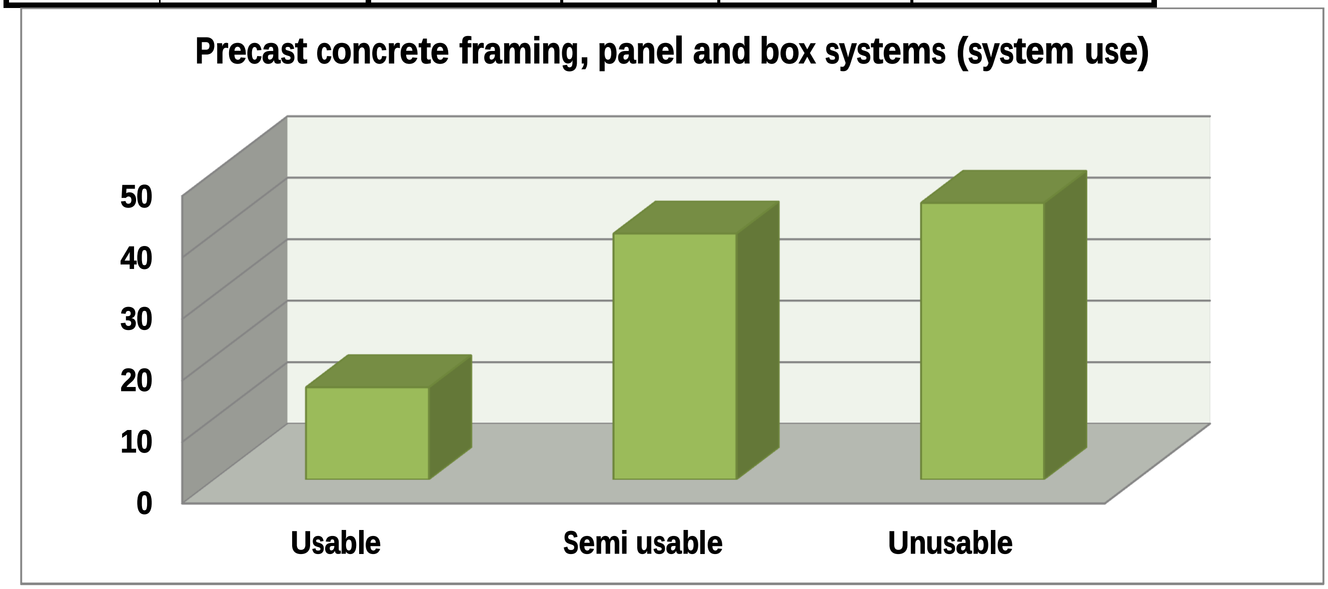


Figure (4.10) Precast concrete framing, panel and box systems (system use)

4.2.3.2 Steel formwork systems

The respondents were asked to give their opinion about the system that used now days in Sudan. About this system 50% of them see that is usable, while 30% see its semi usable, and 20% see is unusable, it's clear that this system is widely use in Sudan as show in table (4.10) and figure (4.11).

Table (4.10) Steel formwork systems (system use)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Usable	50	50%	50%	50%
	emi usable	30	30%	30%	80%
	Unusable	20	20%	20%	100%
	Total	100	100 %	100%	

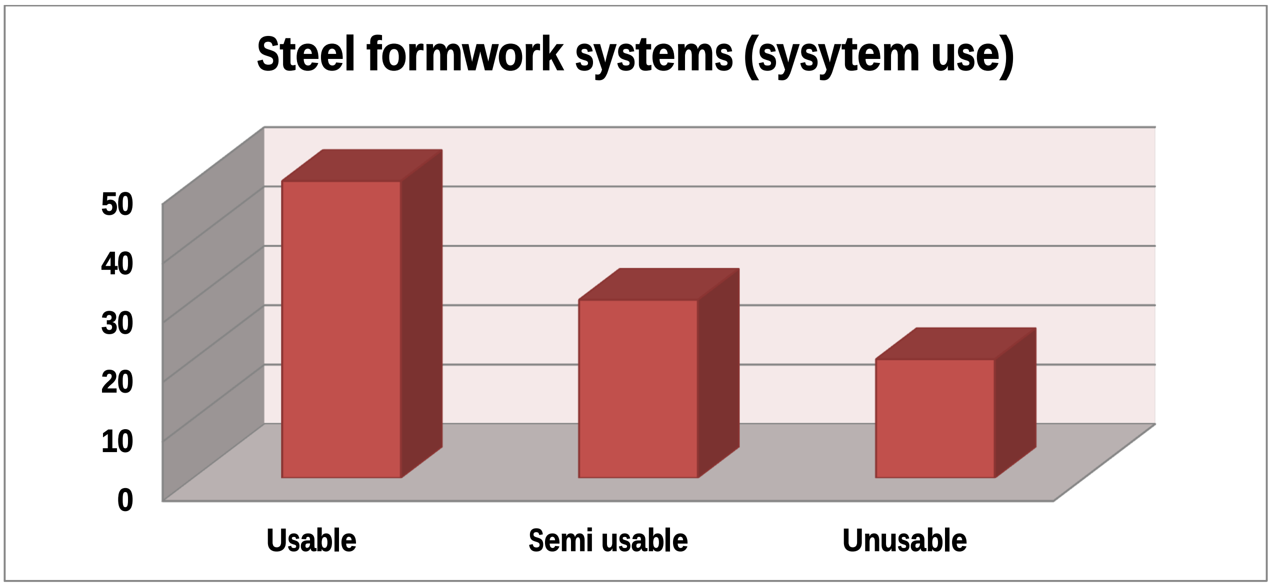


Figure (4.11) Steel formwork systems (system use)

4.2.3.3 Prefabricated timber framing systems

The respondents were asked to give their opinion about the system that used now days in Sudan. About this system 20% of them see that is usable, while 30% see its semi usable, and 50% see is unusable, it's clear that this system is not widely use in Sudan as show in table (4.11) and figure (4.12).

Table (4.11) Prefabricated timber framing systems (system use)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Usable	20	20%	20%	20%
	Semi usable	30	30%	30%	50%
	Unusable	50	50%	50%	100%
	Total	100	100%	100%	

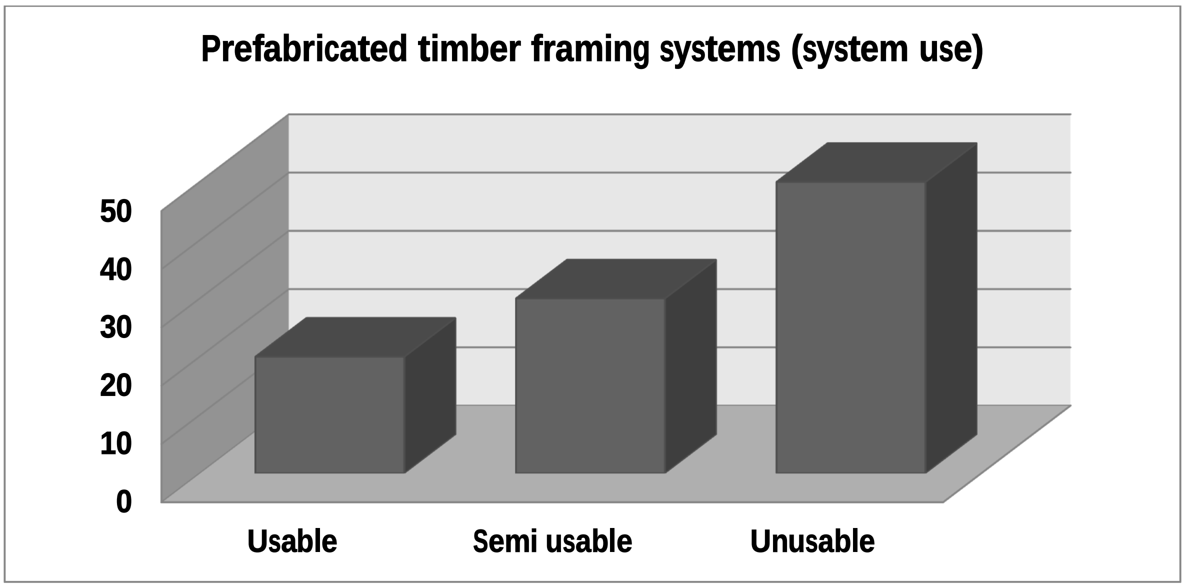


Figure (4.12) Prefabricated timber framing systems (system use)

4.2.3.4 Steel framing systems

The respondents were asked to give their opinion about the system that used now days in Sudan. About this system 39% of them see that is usable, while 31% see its semi usable, and 30% see is unusable, it's clear that this system is widely use in Sudan as show in table (4.12) and figure (4.13).

Table (4.12) Steel framing systems (system use)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Usable	39	39%	39%	39%
	Semi usable	31	31%	31%	70%
	Unusable	30	30%	30%	100%
	Total	100	100%	100%	

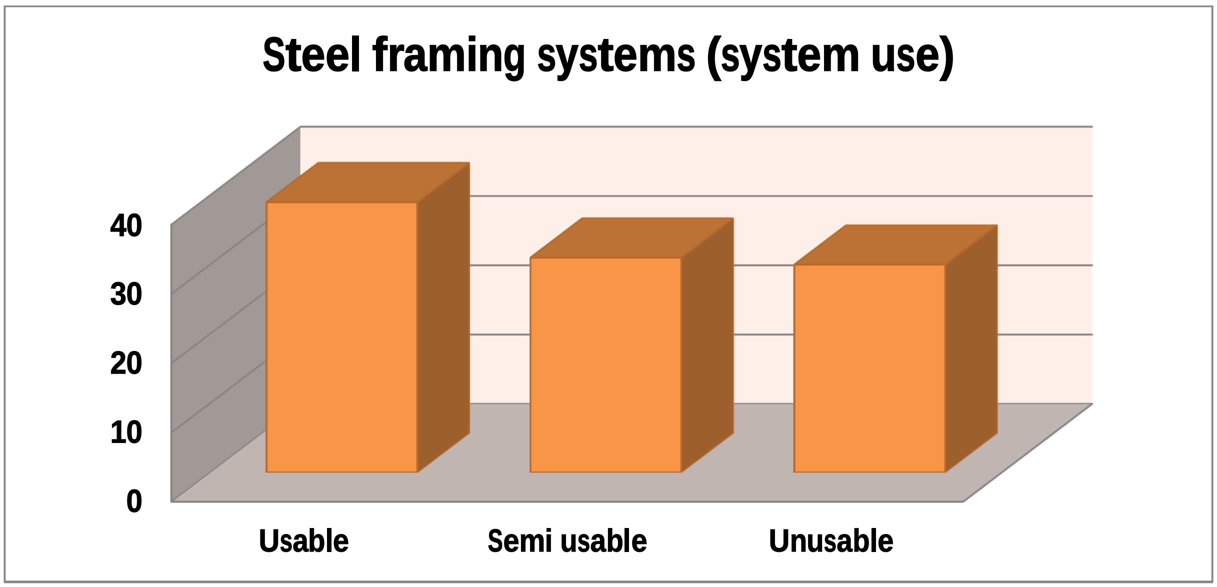


Figure (4.13) Steel framing systems (system use)

4.2.3.5 Block work systems

The respondents were asked to give their opinion about the system that used now days in Sudan. About this system 15% of them see that is usable, while 50% see its semi usable, and 35% see is unusable, it's clear that this system is not widely use in Sudan as show in table (4.13) and figure (4.14).

Table (4.13) Block work systems (system use)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Usable	15	15%	15%	15%
	ni usable	50	50%	50%	65%
	Unusable	35	35%	35%	100%
	Total	100	100%	100%	

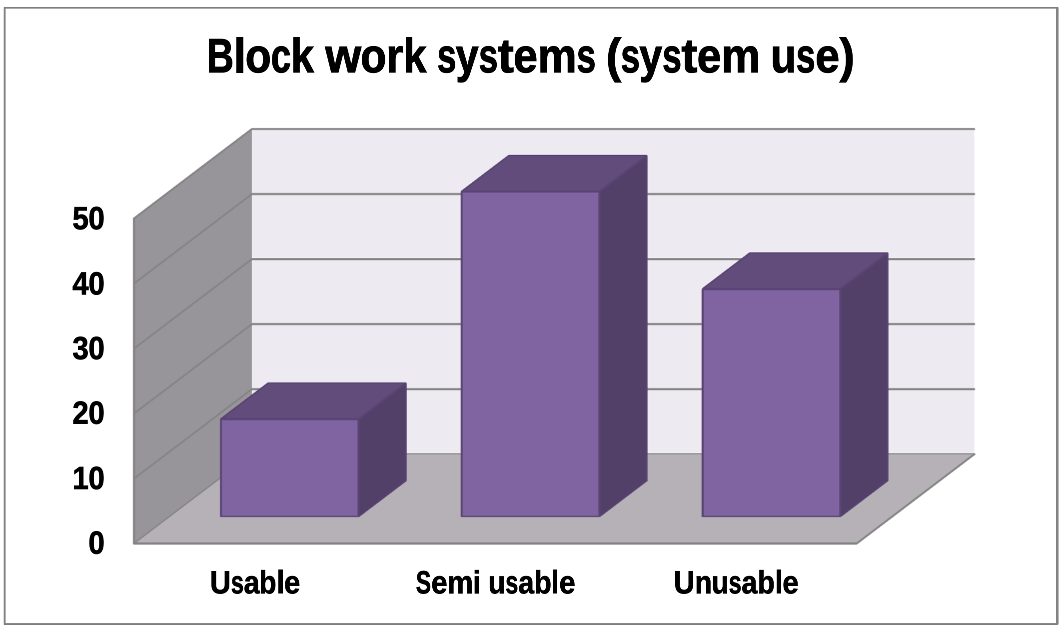


Figure (4.14) Block work systems (system use)

4.2.3.6 3D panel construction system

The respondents were asked to give their opinion about the system that used now days in Sudan. About this system 19% of them see that is usable, while 31% see its semi usable, and 50% see is unusable, it's clear that this system is not widely use in Sudan as show in table (4.14) and figure (4.15).

Table (4.14) 3D panel construction system (system use)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Usable	19	19%	19%	19%
	Semi usable	31	31%	31%	50%
	Unusable	50	50%	50%	100%
	Total	100	100%	100%	

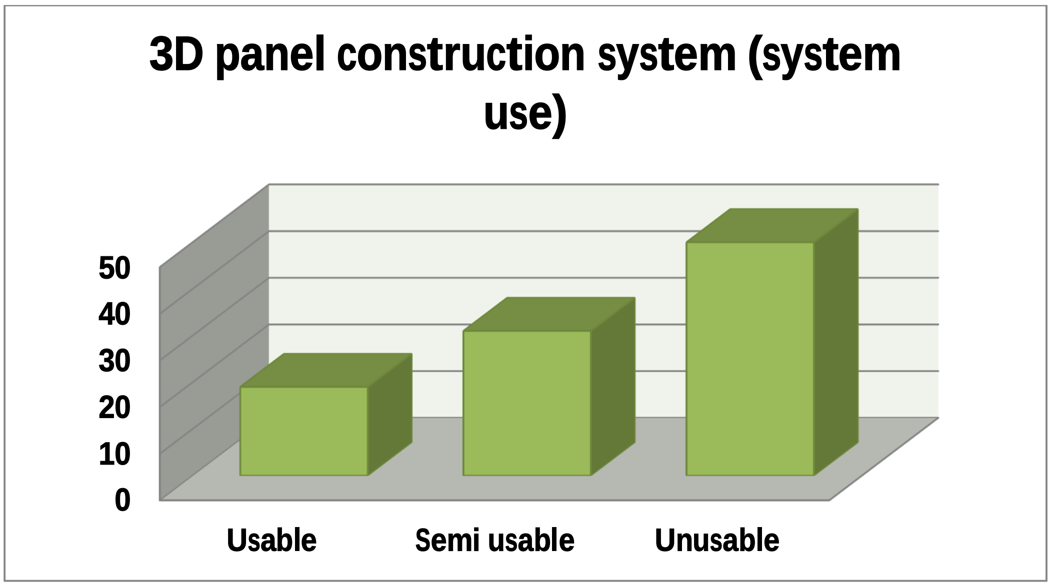


Figure (4.15) 3D panel construction system (system use)

4.2.4 The best systems:

In this sector the respondents were asked to give their opinion about what are the best system, it consist six systems in a form of (Excellent, Good, And Poor). The results are collected and presented in table (4.15), and figure (4.16)

- First system: (Precast concrete framing, panel and box systems) 30% the respondents considered this system is excellent, while 30% see is good, and 40% see its poor. The importance index is 1.9. About 60% between excellent and good, that means the precast concrete framing, panel and box systems is a good system.

- Second system: (Steel formwork systems) 30% the respondents considered this system is excellent, while 20% see is good, and 50% see its poor. The importance index is 1.8. About 50% between excellent and good, 50% say is poor.
- Third system: (Prefabricated timber framing systems) 25% the respondents considered this system is excellent, while 30% see is good, and 45% see its poor. The importance index is 1.8. About 55% between excellent and good, 50% say is poor.
- Fourth system: (Steel framing systems) 20% the respondents considered this system is excellent, while 30% see is good, and 50% see its poor. The importance index is 1.7. About 50% between excellent and good, 50% say is poor.
- Fifth system: (Block work systems) 49% the respondents considered this system is excellent, while 44% see is good, and 6% see its poor. The importance index is 2.41. About 93% between excellent and good, that means the Block work systems is an excellent system.
- Six system: (3D panel construction system)) 48% the respondents considered this system is excellent, while 40% see is good, and 11% see its poor. The importance index is 2.35. About 88% between excellent and good, that means the panel construction system is an excellent system.

- **Table (4.15) the best systems**

Items	Excellent	Good	Poor	Importance Index
Precast concrete			40	1.9

framing, panel and box systems	30	30		
	30%	30%	40%	
Steel formwork systems	30	20	50	1.8
	30%	20%	50%	
Prefabricated timber framing systems	25	30	45	1.8
	25%	30%	45%	
Steel framing systems	20	30	50	1.7
	20%	30%	50%	
Block work systems	49	44	6	2.41
	49%	44%	6%	
3D panel construction system	48	40	11	2.35
	48%	40%	11%	

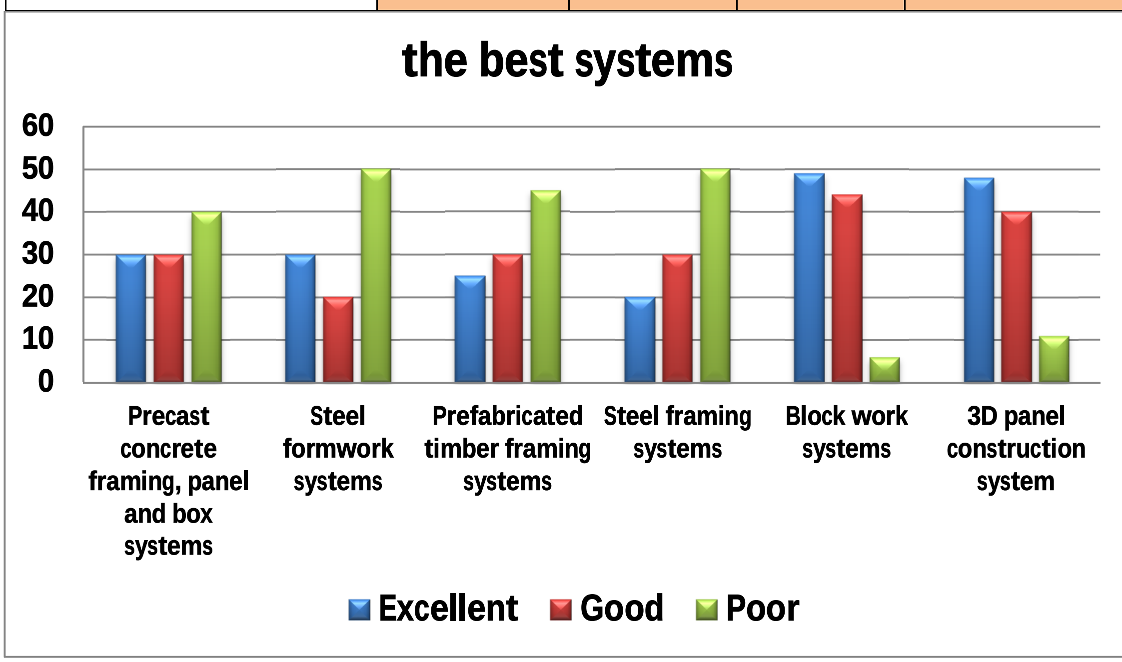


Figure (4.16) the best systems

4.2.4.1 Precast concrete framing, panel and box systems

The respondents were asked to give their opinion about the best system. In this system 30% of them see that is Excellent, while 30% see its good, and 40% see is Poor, as show in table (4.16) and figure (4.17)

Table (4.16) **Precast concrete framing, panel and box systems (best system)**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Excellent	30	30%	30%	30%
	Good	30	30%	30%	60%
	Poor	40	40%	40%	100%
	Total	100	100%	100%	

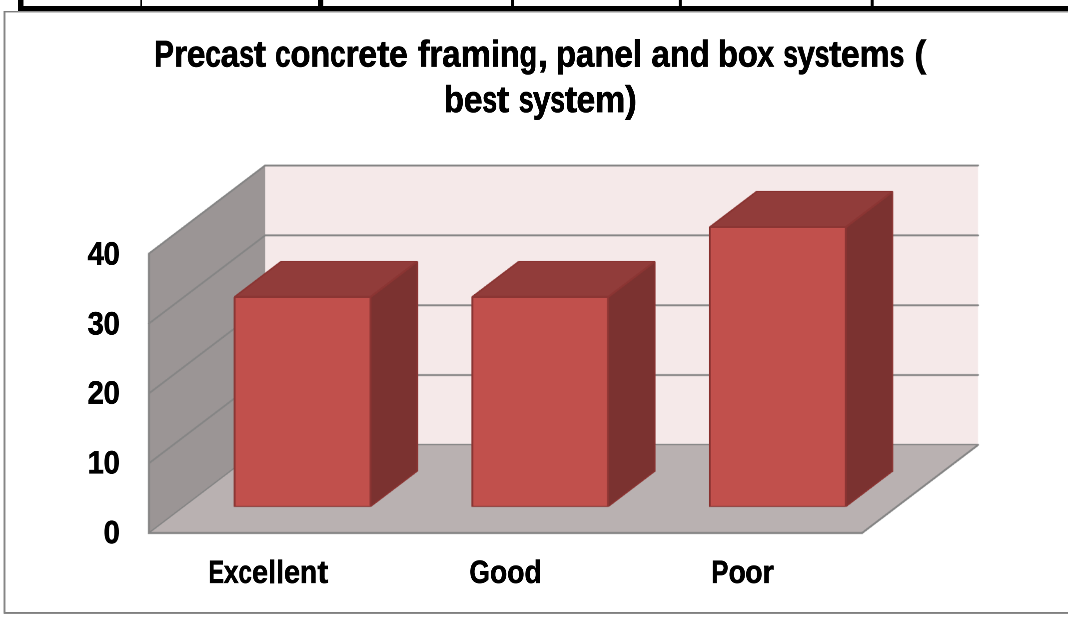


Figure (4.17) Precast concrete framing, panel and box systems (best system)

4.2.4.2 Steel formwork systems:

The respondents were asked to give their opinion about the best system. In this system 30% of them see that is Excellent, while 20% see its good, and 50% see is Poor, as show in table (4.17) and figure (4.18)

Table (4.17) Steel formwork systems (best system)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Excellent	30	30%	30%	30%
	Good	20	20%	20%	50%
	Poor	50	50%	50%	100%
	Total	100	100%	100%	

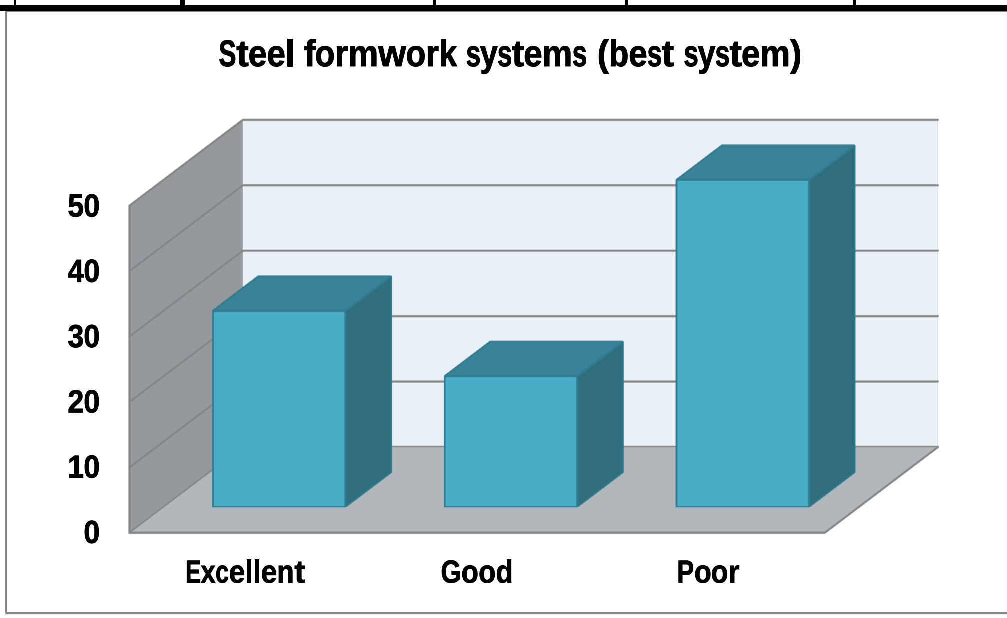


Figure (4.18) Steel formwork systems (best system)

4.2.4.3 Prefabricated timber framing systems

The respondents were asked to give their opinion about the best system. In this system 25% of them see that is Excellent, while 30% see its good, and 45% see is Poor, as show in table (4.18) and figure (4.19).

Table (4.18) Prefabricated timber framing systems (best system)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Excellent	25	25%	25%	25%
	Good	30	30%	30%	55%
	Poor	45	45%	45%	100%
	Total	100	100%	100%	

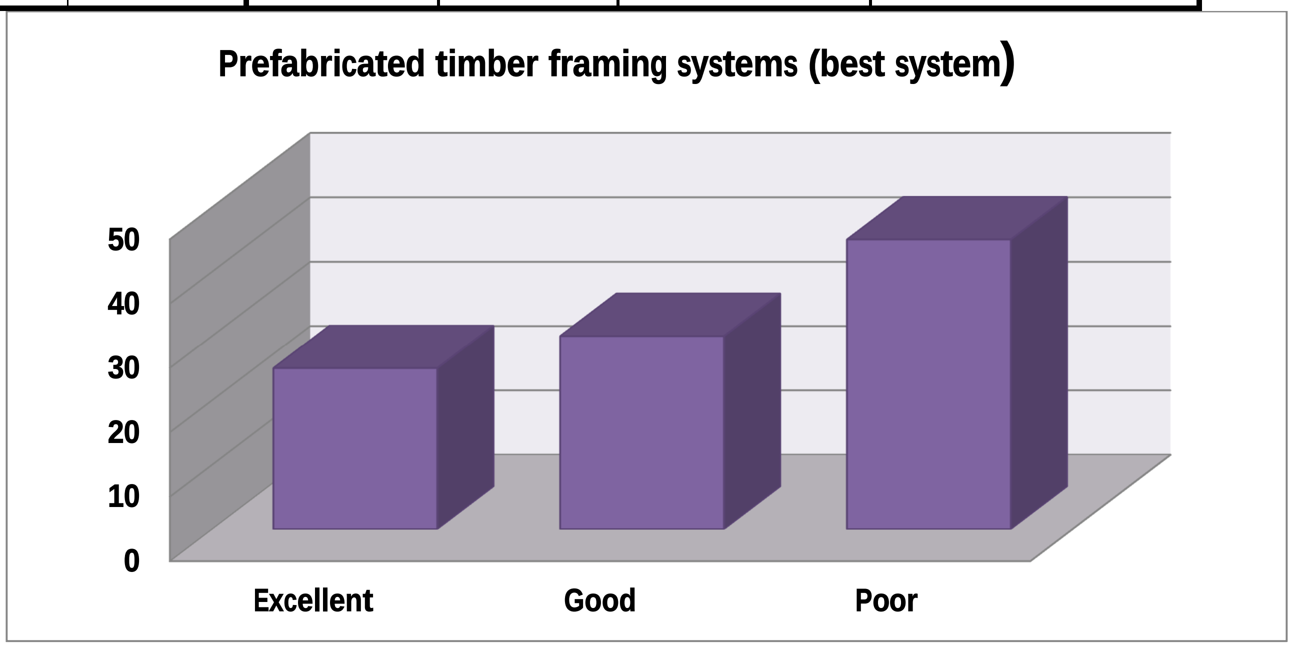


Figure (4.19) Prefabricated timber framing systems (best system)

4.2.4.4 Steel framing systems

The respondents were asked to give their opinion about the best system. In this system 20% of them see that is Excellent, while 30% see its good, and 50% see is Poor, as show in table (4.19) and figure (4.20).

Table (4.19) Steel framing systems (best system)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Excellent	20	20%	20%	20%
	Good	30	30%	30%	50%
	Poor	50	50%	50%	100%
	Total	100	100%	100%	

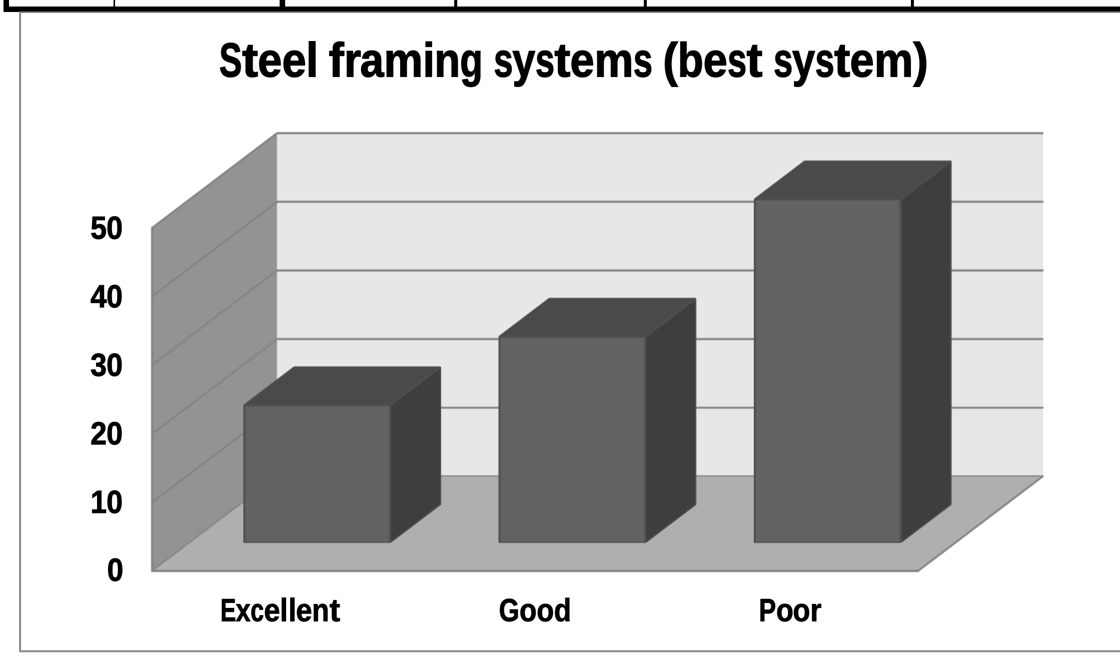


Figure (4.20) Steel framing systems (best system)

4.2.4.5 Block work systems:

The respondents were asked to give their opinion about the best system. In this system 49% of them see that is Excellent, while 44% see its good, and 6% see is Poor, as show in table (4.20) and figure (4.21).

Table (4.20) Block work systems (best system)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Excellent	49	49%	49.5%	49.5%
	Good	44	44%	44.4%	93.9%
	Poor	6	6%	6.1%	100%
	Total	99	99%	100.0	

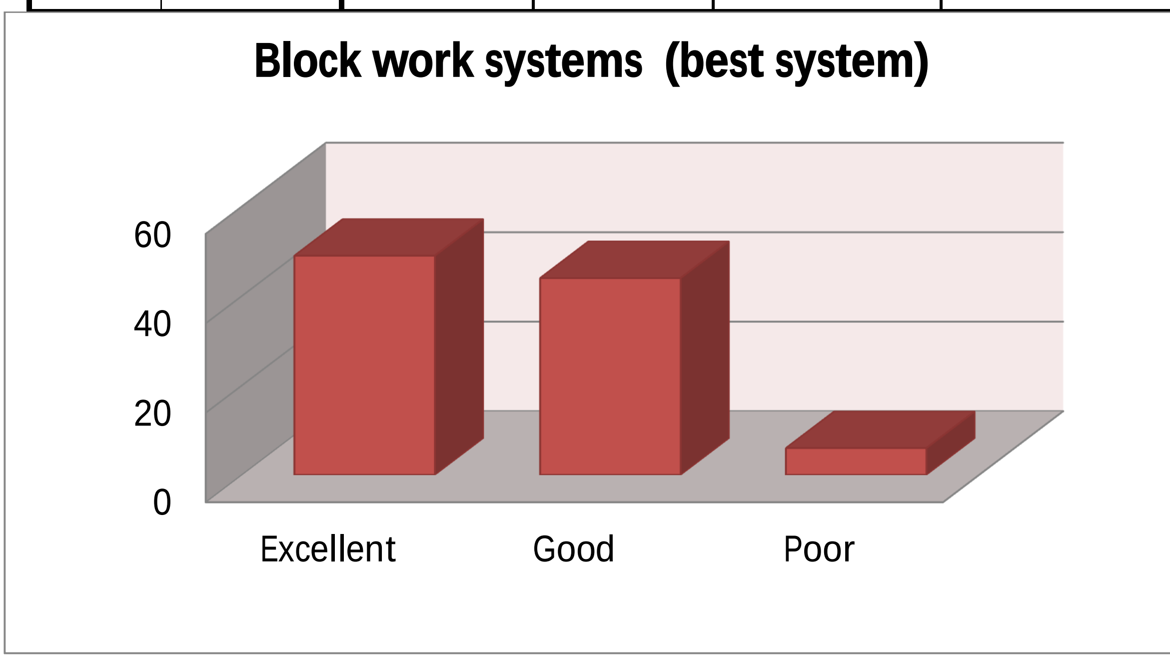


Figure (4.21) Block work systems (best system)

4.2.4.6 3D panel construction system

The respondents were asked to give their opinion about the best system. In this system 48% of them see that is Excellent, while 40% see its good, and 11% see is Poor, as show in table (4.21) and figure (4.22).

Table (4.21) 3D panel construction system (best system)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Excellent	48	48%	48.5%	48.5%
	Good	40	40%	40.4%	88.9%
	Poor	11	11%	11.1%	100%
	Total	99	99%	100%	

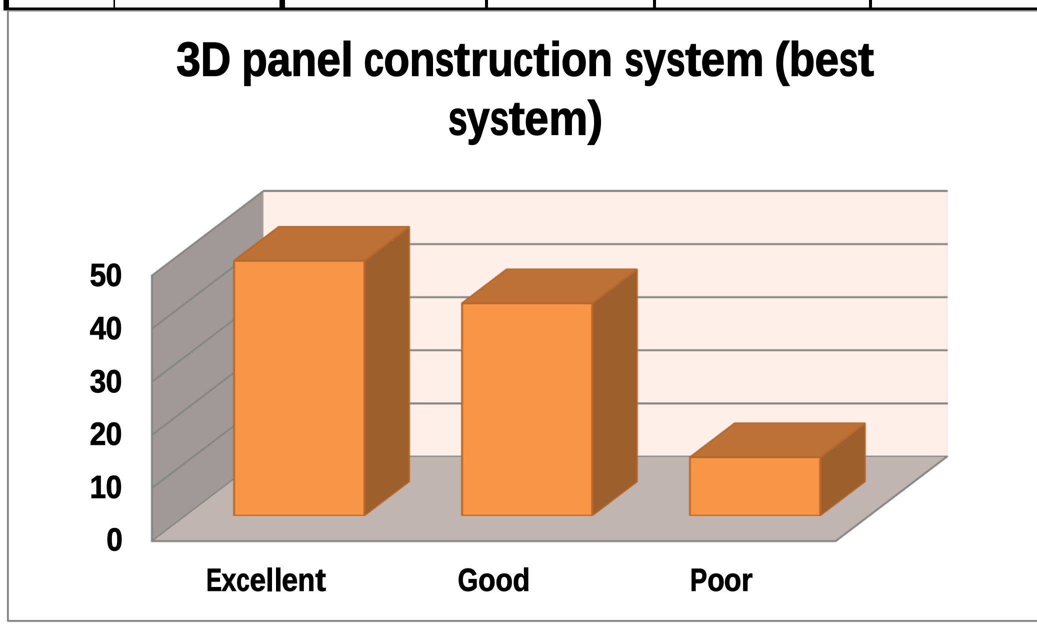


Figure (4.22) 3D panel construction system (best system)

4.2.5 The system that affected on decreasing the cost in Sudan?

In this sector the respondents were asked to give their opinion about which system affected on decreasing the cost in Sudan? It consist six systems in a form of (Less than 50%, 50-80%, above 80%). The results are collected and presented in table (4.22), and figure (4.23)

- First system: (Precast concrete framing, panel and box systems) 39% the respondents considered this system is (Less than 50%), while 41% see is (50-80%), and 20% see it's (Above 80%). The importance index is 2.19.
- Second system: (Steel formwork systems) 50% the respondents considered this system is (Less than 50%), while 0% see is (50-80%), and 50% see it's (Above 80%). The importance index is 2.00
- Third system: (Prefabricated timber framing systems) 98% the respondents considered this system is (Less than 50%), while 2% see is (50-80%), and 0% see it's (Above 80%). The importance index is 2.98
- Fourth system: (Steel framing systems) 60% the respondents considered this system is (Less than 50%), while 40% see is (50-80%), and 0% see it's (Above 80%). The importance index is 2.6.
- Fifth system: (Block work systems) 40% the respondents considered this system is (Less than 50%), while 60% see is (50-80%), and 0% see it's (Above 80%). The importance index is 2.4
- Six system: (3D panel construction system) 65% the respondents considered this system is (Less than 50%), while 35% see is (50-80%), and 0% see it's (Above 80%). The importance index is 2.

Table (4.22) the system affected on decreasing the cost in Sudan?

Items	Less than 50%	50-80%	Above 80%	importance Index
Precast concrete framing, panel and box systems	39	41	20	2.19
	39%	41%	20%	
Steel formwork systems	50	0	50	2
	50%	0%	50%	
Prefabricated timber	98	2	0.0	2.98

framing systems	98%	2%	0%	
Steel framing systems	60	40	0.0	2.6
	60%	40%	0%	
Block work systems	40	60	0.0	2.4
	40%	60%	0%	
3D panel construction system	65	35	0.0	2.65
	65%	35%	0%	

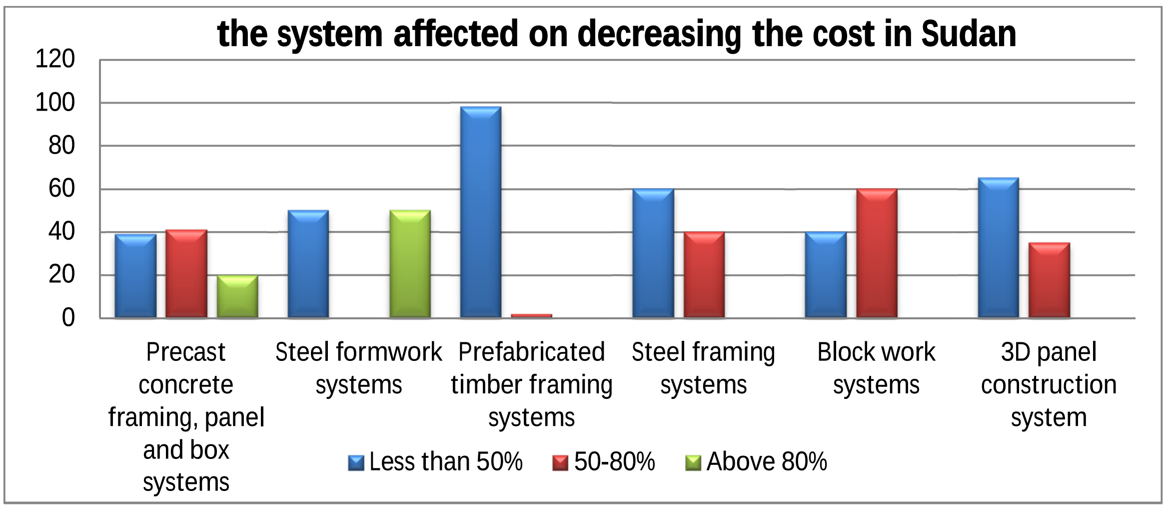


Figure (4.23) which system affected on decreasing the cost in Sudan

4.2.5.1 Precast concrete framing, panel and box systems:

The respondents were asked to give their opinion about the system that affected on decreasing the cost in Sudan. In this system 39% of them see this system affect (Less than 50%), while 41% see this system affect (50-80%), and 20% see this system affect (Above 80%), as show in table (4.23) and figure (4.24).

Table (4.23) Precast concrete framing, panel and box systems (decreasing cost)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 50%	39	39%	39%	39%
	50-80%	41	41%	41%	80%
	Above 80%	20	20%	20%	100%
	Total	100	100%	100%	

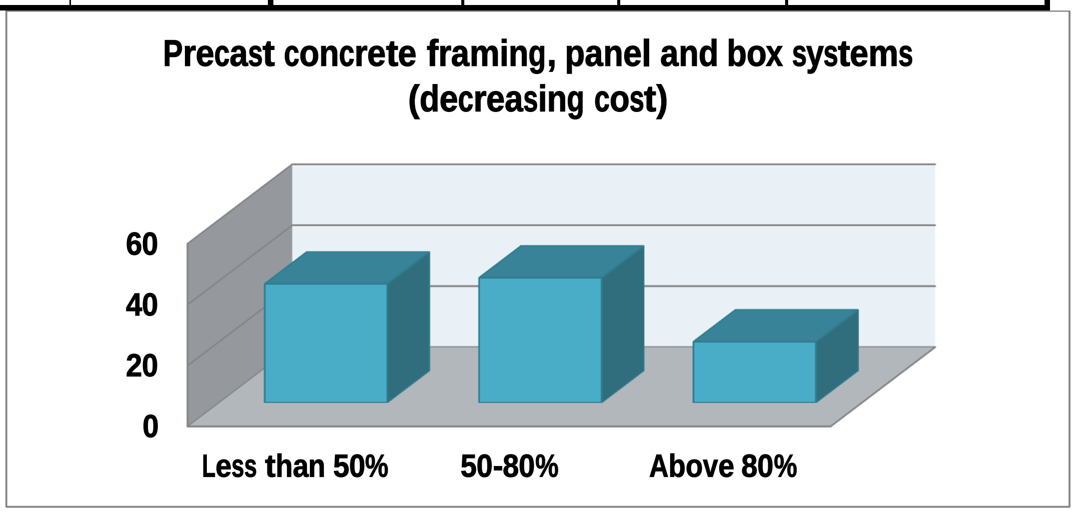


Figure (4.24) Precast concrete framing, panel and box systems (decreasing cost)

4.2.4.2 Steel formwork systems

The respondents were asked to give their opinion about the system that affected on decreasing the cost in Sudan. In this system 50% of them see this system affect (Less than 50%), while no one see this system affect (50-80%), and 50% see this system affect (Above 80%), as show in table (4.24) and figure (4.25).

Table (4.24) Steel formwork systems (decreasing cost)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 50%	50	50%	50%	50%
	50-80%	0	0	0	
	Above 80%	50	50%	50%	100%
	Total	100	100%	100%	

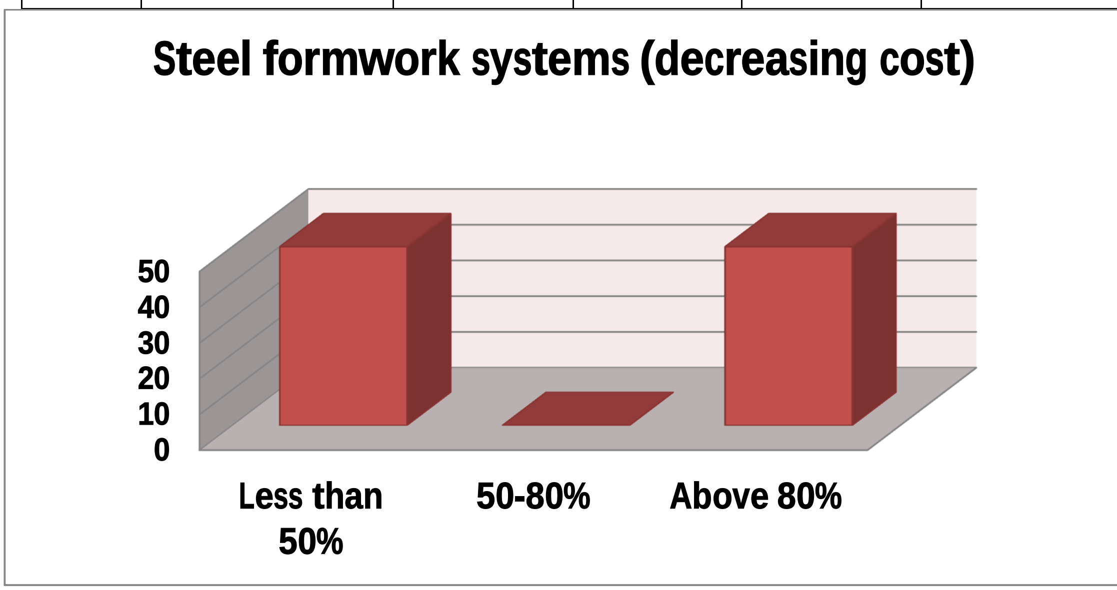


Figure (4.25) Steel formwork system (decreasing cost)

4.2.4.3 Prefabricated timber framing systems

The respondents were asked to give their opinion about the system that affected on decreasing the cost in Sudan. In this system 98% of them see this system affect (Less than 50%), while 2% see this system affect (50-80%), and no one see this system affect (Above 80%), as show in table (4.24) and figure (4.26).

Table (4.25) Prefabricated timber framing systems (decreasing cost)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 50%	98	98%	98%	1%
	50-80%	2	2%	2%	100%
	Above 80%	0	0.0	0.0	
	Total	100	100%	100%	

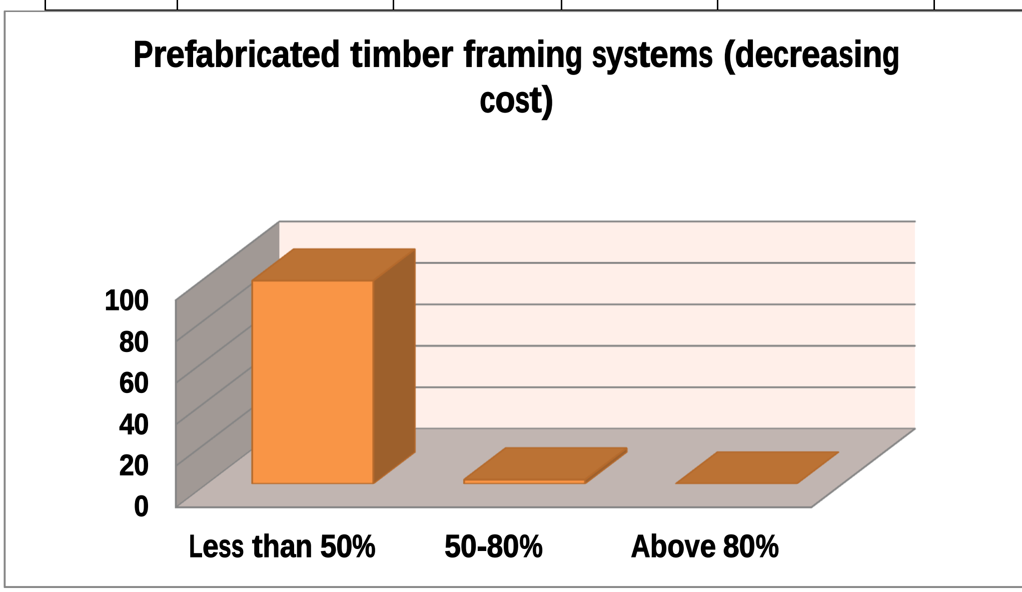


Figure (4.26) Prefabricated timber framing systems (decreasing cost)

4.2.4.4 Steel framing systems

The respondents were asked to give their opinion about the system that affected on decreasing the cost in Sudan. In this system 60% of them see this system affect (Less than 50%), while 40% see this system affect (50-80%), and no one see this system affect (Above 80%), as show in table (4.26) and figure (4.27).

Table (4.26) Steel framing systems (decreasing cost)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 50%	60	60%	60%	60%
	50-80%	40	40%	40%	100%
	Above 80%	0	0.0	0.0	
	total	100	100%	100%	

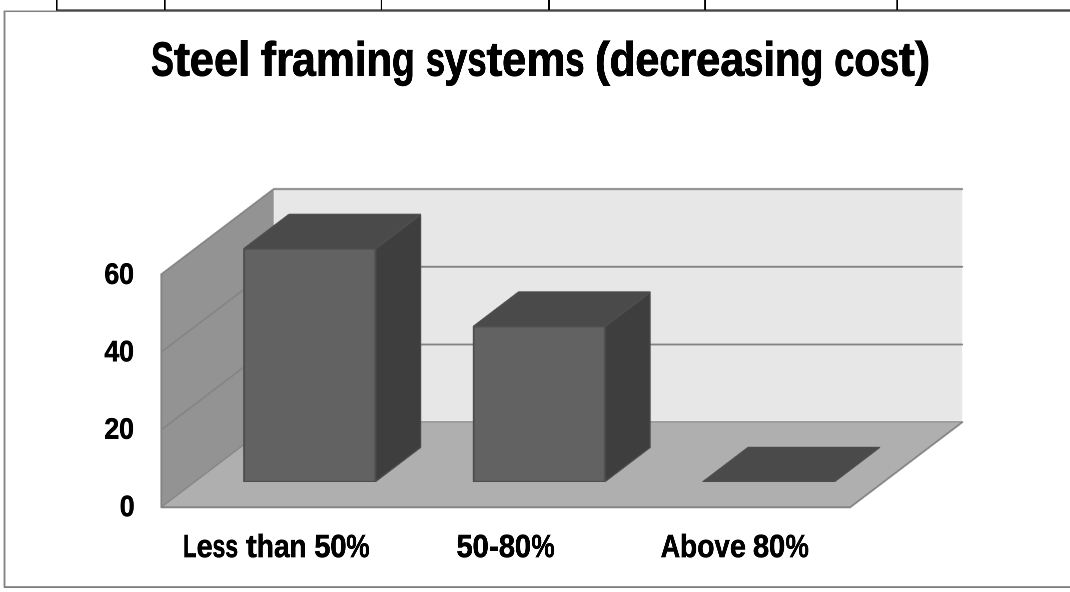


Figure (4.27) Steel framing systems (decreasing cost)

4.2.4.5 Block work systems

The respondents were asked to give their opinion about the system that affected on decreasing the cost in Sudan. In this system 40% of them see this system affect (Less than 50%), while 60% see this system affect (50-80%), and no one see this system affect (Above 80%), as show in table (4.27) and figure (4.28).

Table (4.27) Block work systems (decreasing cost)

		Frequency	Percent	Valid Percent	umulative Percent
Valid	Less than 50%	40	40%	40%	40%
	50-80%	60	60%	60%	100%
	Above 80%	0	0.0	0.0	
	Total	100	100%	100%	

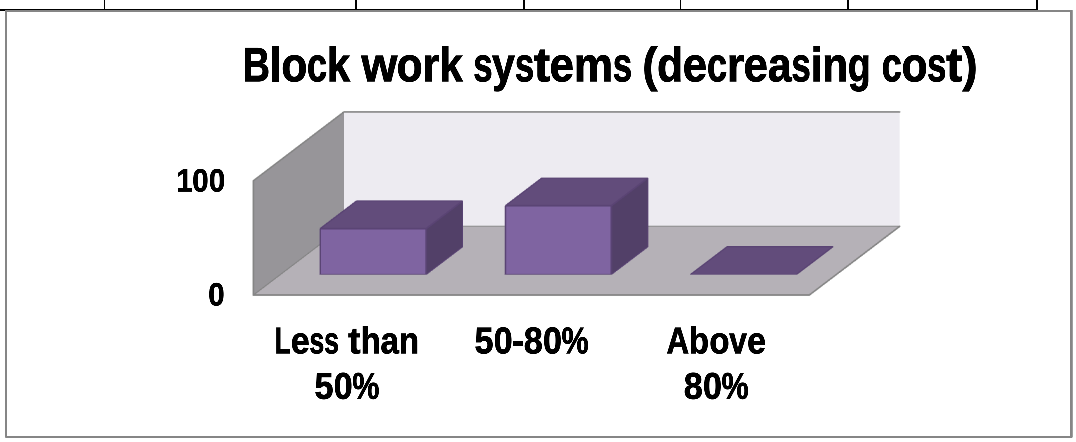


Figure (4.28) Block work systems (decreasing cost)

4.2.4.6 3D panel construction system

The respondents were asked to give their opinion about the system that affected on decreasing the cost in Sudan. In this system 65% of them see this system affect (Less than 50%), while 35% see this system affect (50-80%), and no one see this system affect (Above 80%), as show in table (4.28) and figure (4.29)

Table (4.28) 3D panel construction system (decreasing cost)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 50%	65	65%	65%	65%
	50-80%	35	35%	35%	100%
	Above 80%	0	0.0	0.0	
	Total	100	100%	100%	

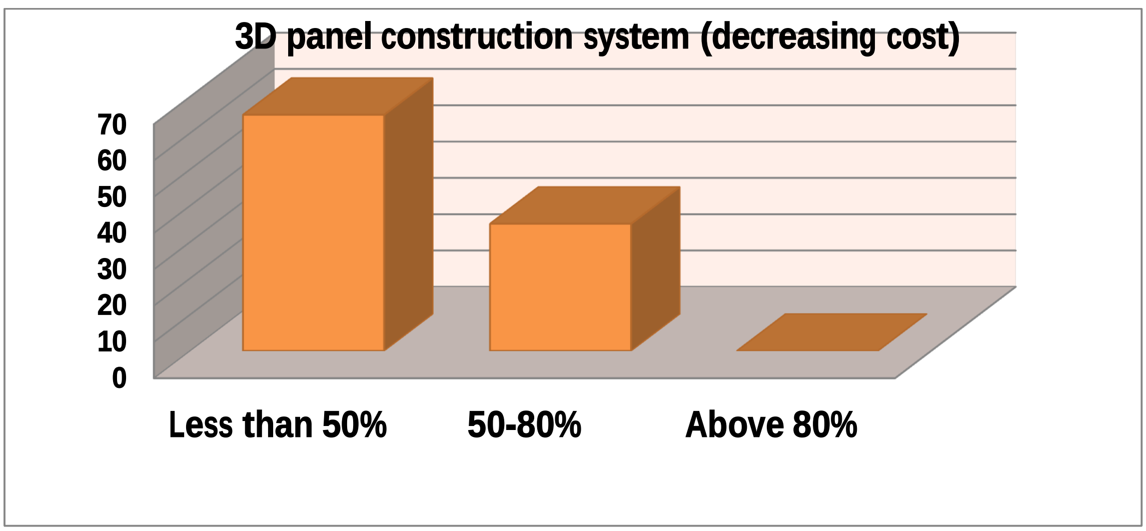


Figure (4.29) 3D panel construction system (decreasing cost)

Chapter five

Conclusion and Recommendations

5.1 Conclusion:

The aim of this study was: To determining the challenges that faced the application of industrialized building system in Sudan, to find out if there are using of IBS in Sudan, and what types we have, in addition to determine the level of IBS acceptance in construction industry.

The following conclusions were drawn from the results of the analysis carried out in the study"

1.The most ten important challenge that faced implementation IBS in Sudan: (1) Shortage in curriculum at universities about IBS, (2) Lack of research and development to improve using local materials, (3) Need specific machine in factory, (4) Application of the IBS system is based on awareness and good knowledge of the customer, (5) Need to skilled craftsmen in a factory, (6) Customers do not accept new systems, (7) Lack of scientific information about the economic benefits of IBS, (8) Lack of manufacturer, (9) Shortage of contractors' experience to handle IBS projects, (10) High initial cost to establish a factory

2. the Systems that using now days in Sudan: (1) Steel formwork systems, (2) Steel framing systems, (3) Block work systems, (4) Precast concrete framing, panel and box systems., (5) 3D panel construction system (6), Prefabricated timber framing systems

3. The best system: (1) Block work systems, (2) 3D panel construction system, (3) Precast concrete framing, panel and box systems, (4) Steel formwork systems, (5) Prefabricated timber framing systems, (6) Steel framing systems.

4. About the research assumptions: (1) There are many Challenges that faced implementation IBS in Sudan, we asked about 36 question we mention the most ten important challenge that faced implementation IBS in Sudan up, (2) Shortage in curriculum at universities about IBS, we found 87% of the respondent are strongly agree, 12% are agree, (3) Lack of manufacturer , 81% were strongly agree, 9% were agree, (4) Application of the IBS system is based on awareness and good knowledge of the customer, 87% were strongly agree, 6% were agree

5.2 Recommendations:

- General suggestion:

1. Make workshops about IBS system for the contractor in order to know how they handle these systems.
2. Courage the investors to establish factories for the components of IBS
3. Recognize method to expand the use of Industrialized Building System (IBS) in Sudan
4. Add curriculum at universities about IBS.

- Suggestions for Future Research:

  Further studies obviously need to be much more broadly based; the better to aid generalization, but in this study some suggestions have been made that can be more fully explored. For instance:

1. Research comparison between all this systems to know the actual cost of each systems and the best system with the minimum cost.
2. Study each system individually.
3. Compromise IBS system with conventional systems.

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APPENDIX A

Tables of Statistical Analysis

1. The challenges that faced IBS implementation

Table (1.1) Descriptive statistics of the challenges that faced IBS implementation

Challenge NO	N	Mean	Std. Deviation	Chi Square	result
Challenge1	100	1.14	.377	131.42	Significant
Challenge 2	100	2.93	1.191	16.300	Significant
Challenge 3	100	2.86	1.215	20.2	Significant
Challenge 4	100	1.38	.648	118	Significant
Challenge 5	100	1.64	.746	61.92	Significant
Challenge 6	100	3.75	1.264	29.55	Significant
Challenge 7	100	1.33	.620	136.08	Significant
Challenge 8	100	1.17	.496	204.07	Significant
Challenge 9	100	2.91	.996	49.1	Significant
Challenge 10	100	2.84	.813	104.4	Significant
Challenge 11	100	2.61	.777	73.68	Significant

Challenge 12	100	1.38	.616	61.58	Significant
Challenge 13	100	1.61	.695	77.52	Significant
Challenge 14	100	1.67	.726	67.44	Significant
Challenge 15	100	1.69	.706	67.44	Significant
Challenge 16	100	1.92	.706	120.6	Significant
Challenge 17	100	2.81	.800	98.8	Significant
Challenge 18	100	3.03	.890	135.9	Significant
Challenge 19	100	2.60	.791	75.673	Significant
Challenge 20	100	2.29	.998	94.3	Significant
Challenge 21	100	1.23	.601	187.6	Significant
Challenge 22	100	1.29	.556	144.56	Significant
Challenge 23	100	1.36	.859	234.2	Significant
Challenge 24	100	3.26	.975	49.5353	Significant
Challenge 25	100	1.99	.643	100.4	Significant
Challenge 26	100	1.92	.617	182.969	Significant
Challenge 27	100	2.34	.807	41.52	Significant
Challenge 28	100	1.74	.883	100.3	Significant
Challenge 29	100	1.86	.817	89	Significant
Challenge 30	100	2.62	.826	92	Significant
Challenge 31	100	2.96	.737	196.3	Significant

Challenge 32	100	2.99	.692	221.35	Significant
Challenge 33	100	2.93	.849	101.5	Significant
Challenge 34	100	2.22	.840	87.818	Significant
Challenge 35	100	1.29	.643	152.91	Significant
Challenge 36	100	1.17	.538	213.10	Significant

2. The Systems that using now days in Sudan:

Table (2.1) the Systems that using now days in Sudan

Items	Usable	Semi usable	Unu sable	Import ance Index
Precast concrete framing, panel and box systems	15	40	45	2.3
	15%	40%	45%	
Steel formwork systems	50	30	20	1.7
	50%	30%	20%	
Prefabricated timber framing systems	20	30	50	2.3
	20%	30%	50%	
Steel framing systems	39	31	30	1.9
	39%	31%	30%	
Block work systems	15	50	35	2.2
	15%	50%	35%	
3D panel construction	19	31	50	2.31

system	19%	31%	50%	

Table (2.2) Descriptive statistics of the Systems that using now days in Sudan

Items	Usable	Semi usable	Unusable	Importance Index
Precast concrete framing, panel and box systems	15	40	45	2.3
	15%	40%	45%	
Steel formwork systems	50	30	20	1.7
	50%	30%	20%	
Prefabricated timber framing systems	20	30	50	2.3
	20%	30%	50%	
Steel framing systems	39	31	30	1.9
	39%	31%	30%	
Block work systems	15	50	35	2.2
	15%	50%	35%	
3D panel construction system	19	31	50	2.31
	19%	31%	50%	

3. The best systems:

Table (3.1) the best systems

Items	Excellent	Good	Poor	Importance Index
Precast concrete framing, panel and box systems	30	30	40	2.1
	30%	30%	40%	
Steel formwork systems	30	20	50	2.2
	30%	20%	50%	
Prefabricated timber framing systems	25	30	45	2.2
	25%	30%	45%	
Steel framing systems	20	30	50	2.2
	20%	30%	50%	
Block work systems	49	44	6	1.55
	49%	44%	6%	
3D panel construction system	48	40	11	1.61
	48%	40%	11%	

Table (3.2) Descriptive statistics of the best Systems:

Items	Mean	Std. Deviation	Chi Square	result

Precast concrete framing, panel and box systems	2.30	.718	15.50	significant
Steel formwork systems	1.70	.785	14.0	significant
Prefabricated timber framing systems	2.30	.785	14.0	significant
Steel framing systems	1.91	.830	1.46	Not significant
Block work systems	2.20	.682	18.5	significant
3D panel construction system	2.31	.775	14.66	significant

4. The system affected on decreasing the cost in Sudan?

Table (4.1) which system affected on decreasing the cost in Sudan?

Items	Less than 50%	50-80%	Above 80 %	importance Index
Precast concrete framing, panel and	39	41	20	1.81
	39%	41%	20%	

box systems				
Steel formwork systems	50	0	50	2
	50%	0%	50%	
Prefabricated timber framing systems	98	2	0.0	1.02
	98%	2%	0%	
Steel framing systems	60	40	0.0	1.4
	60%	40%	0%	
Block work systems	40	60	0.0	1.6
	40%	60%	0%	
3D panel construction system	65	35	0.0	1.35
	65%	35%	0%	

Table (3.2) Descriptive statistics of the system affected on decreasing the cost in Sudan

Items	Mean	Std. Deviation	Chi Square	Result
Precast concrete framing, panel	1.81	.748	8.06	significant

and box systems				
Steel formwork systems	2.00	1.005	74.36	Significant
Prefabricated timber framing systems	3.00	.000	96.040	Significant
Steel framing systems	1.80	.985	4.000	Significant
Block work systems	2.20	.985	4.000	Significant
3D panel construction system	1.70	.959	9.000	Significant

APPENDIX B

Questionnaire in English Version

Questionnaire about the Industrialized building System in Sudan: Challenges and the Way Forward

Directions:

- An Industrialized Building System **(IBS)** refers to a technique of construction whereby components are manufactured in a controlled environment at factories then transported and assembled into construction works with minimum work
- The objective of the study is to find out if there are using of IBS in Sudan, and what types we have, the Challenges that facing IBS implementation, determine the level of IBS acceptance in the construction industry and the impact of these systems on cost reduction.
- Thank you for filling out this questionnaire to contribute to the achievement of the objectives of this study in the hope that the benefit to all.
- The information to be used will be used for scientific research purposes only.

Thank you very much،،،

For any question or comments, please call me on the mobile (0966203066)

- **Sector 1 (General Questions):**

1. Name………………………………………………… (Optional)

2. The name of the company ………………………………. (Optional)

3. Scientific qualification									
diploma		Bachelor		Master	PHD		Other(specify)		
4. Category of work									
Owner		contractor		consultative		Other (specify)			
5. Type of business									
Private sector		Gov. sector		Other (specify)					
6. The field									
Civil		architect		Other (specify)					
7. Years of experience									
Less than 5		5-10		11-15		16-20		More than 20	
8. Average of annual income (Million Sudanese Pounds)									
Less than 5		5-10		11-50		51-100		More than 100	
9. The number of annual executive projects									
Less than 5		5-10		11-15		16-20		More than 20	

<u>Sector 2:</u> In your opinion, what are the challenges that face IBS implementation in Sudan?

Please indicate (√) the answer that represents your point of view accurately

NO	Phrase	Strongly Agree	Agree	Sometimes	Disagree Strongly	Disagree
1	Shortage in curriculum at universities about IBS					
2	Architects are unfamiliar to IBS projects designing					
3	weakness in engineers' experience to IBS projects designing					
4	Shortage of contractors' experience to handle IBS projects					
5	Lack of experience among workers in working on IBS projects					
6	Lack of experience to handle software systems (CAD system)					
7	Lack of scientific information about the economic benefits of IBS					
8	Lack of research and development to improve using local materials					
9	Delay in deliver IBS components at required time					
10	Designing change needing during site work					
11	Delay in making decisions					
12	High initial cost to establish a factory					

NO	Phrase	Strongly Agree	Agree	Sometimes	Disagree Strongly	Disagree
13	Need more money to import specific Materials					
14	Need more money to import specific equipment					
15	High transportation cost					
16	Need more money to employ skilled Workers					
17	Swing of markets demands					
18	Using expensive finishing materials in Design					
19	Delay in payment from clients					
20	Production process is slower than real need at site					
21	Need specific machine in factory					
22	Need to skilled craftsmen in a factory					
23	Lack of manufacturer					
24	Leakage in IBS components after Assembling					
25	Shortage in special machines to assemble IBS components					
26	Shortage in specialist workers to assemble IBS components					
27	Inability of IBS components to repair					

NO	Phrase	Strongly Agree	Agree	Sometimes	Disagree Strongly	Disagree
28	Assembly process is expensive					
29	Storage area is exposed to environmental effects					
30	Long distance between factory and site					
31	Difficulty to reach to construction site					
32	Difficult site topography					
33	Joints are inadequate to our environment					
34	Transportation process has difficulties to transport big components from factory to construction site					
35	Customers do not accept new systems					
36	Application of the IBS system is based on awareness and good knowledge of the customer					

<u>Sector 3:</u> What are the systems that using now a days in Sudan?

Please indicate (√) the answer that represents your point of view accurately

NO	System	Usable	Semi usable	Unusable
1	Precast concrete framing, panel and box systems			
2	Steel formwork systems			
3	Prefabricated timber framing systems			
4	Steel framing systems			
5	Block work systems			
6	3D panel construction system			

<u>Sector 4:</u> In your opinion, what the best systems?

Please indicate (√) the answer that represents your point of view accurately

NO	System	Excellent	Good	Poor
1	Precast concrete framing, panel and box systems			
2	Steel formwork systems			
3	Prefabricated timber framing systems			
4	Steel framing systems			
5	Block work systems			
6	3D panel construction system			

<u>Sector 5:</u> In your opinion, to what extent this system affected on decreasing the cost in Sudan?

Please indicate (√) the answer that represents your point of view accurately

NO	System	Less than 50%	50-80%	Above 80%
1	Precast concrete framing, panel and box systems			
2	Steel formwork systems			
3	Prefabricated timber framing systems			
4	Steel framing systems			
5	Block work systems			
6	3D panel construction system			

APPENDIX C
Questionnaire in Arabic Version

بسم الله الرحمن الرحيم

جامعه السودان للعلوم والتكنلوجيا

كلية الدراسات العليا – هندسة مدنية

إستبيان حول : نظام المباني المصنعة في السودان: التحديات والطريق الي الامام

موجهات :

- نظام المباني المصنعة the Industrialized Building System(IBS) يشير إلى تقنية البناء الحديثة حيث يتم تصنيع المكونات في بيئة مضبوطة في المصانع ثم نقلها وتجميعها في مواقعالبناء
- تهدف الدراسة الي معرفة ما إذا كان هناك استخدام لنظام (IBS) في السودان ، ما هي الأنواع الموجودة ، التحديات التي تواجه تطبيق نظام (IBS)، لتحديد مستوى قبول (IBS)في صناعة التشييد وايضا تاثير هذة الانظمة علي تقليل التكلفة.
- تكرمكم بملء هذا الاستبيان يسهم في تحقيق اهداف هذه الدراسة آملين في أن تعم الفائدة للجميع.
- المعلومات التي سترد ستستخدم لاغراض البحث العلمي فقط

لكم مني خالص الشكر والتقدير،،،

لأي استفساراو إبداء أي ملاحظة أرجوالاتصال علي الجوال (0966203066)

القطاع الاول : (اسئلة عامة)

1. الاسم (اختياري): ....

2. اسم المؤسسة او الشركة (اختياري): ....

المؤهل العلمي									
دبلوم		بكالريوس		ماجتسير		دكتوراه		أخري (حدد)	
طبيعة العمل									
مالك		مقاول		إستشاري		أخري (حدد)			
نوع العمل									
قطاع خاص		قطاع عام		أخري (حدد)					
التخصص									
مدني		معماري		أخري (حدد)					
سنوات الخبرة العملية									
أقل من 5		10-5		15-11		20-16		أكثر من 20	
متوسط حجم العمل السنوي (مليون جية سوداني)									
أقل من 5		10-5		50-11		100-51		أكثر من 100	
عدد المشاريع التي تقومون بتنفيذها سنويا									
أقل من 5		10-5		15-11		20-16		أكثر من 20	

<u>القطاع الثاني</u>: (من وجهة نظرك)ماهي التحديات التي تواجه تطبيق نظام (IBS) في السودان

فضلا أشر بعلامة (√) علي الإجابة التي تمثل وجهة تظرك بدقة

الرقم	العبارة	اوافق بشدة	اوافق	أحيانا	لا اوافق	لا أوافق بشدة
1	نقص في المناهج الدراسية في الجامعات والمعاهد عن نظام المباني الجاهزة (IBS)					
2	المهندسون المعماريون ليسوا على دراية بتصميم مشاريع الـ IBS					
3	ضعف في خبرة المهندسين لتصميم مشاريع IBS					
4	نقص خبرة المقاولين في التعامل مع مشاريع IBS					
5	عدم وجود الخبرة لدي العمال في تنفيذ مشاريع IBS					
6	عدم وجود خبرة للتعامل مع أنظمة البرمجيات (نظام CAD)					
7	عدم وجود معلومات علمية حول الفوائد الاقتصادية لل IBS					
8	نقص البحث والتطوير لتحسين استخدام المواد المحلية					
9	التأخير في تسليم مكونات IBS في الوقت المحدد					
10	تحتاج إلى تغيير تصميم المشروع بعد بدء العمل في الموقع					
11	تأخير في اتخاذ القرارات					
12	تكلفة أولية عالية لإنشاء مصنع					
13	الحاجة الى الكثير من المال لاستيراد مواد محددة					
14	الحاجة الى الكثير من المال لاستيراد معدات محددة					
15	تكلفة النقل عالية					

الرقم	العبارة	اوافق بشدة	اوافق	أحيانا	لا اوافق	لا أوافق بشدة
16	الحاجة إلى الكثيرمن المال لتوظيف عمال مهرة					
17	تغيير طلبات الاسواق					
18	استخدام مواد التشطيب باهظة الثمن في التصميم					
19	تأخير في الدفع من العملاء					
20	عملية الإنتاج أبطأ من الحاجة الحقيقية في الموقع					
21	تحتاج الات محددة في المصنع					
22	تحتاج إلى الحرفيين المهرة في المصنع					
23	عدم وجود الشركة المصنعة					
24	تسريب في مكونات IBS بعد التجميع					
25	نقص في الآلات الخاصة لتجميع مكونات الـ IBS					
26	نقص في العاملين المتخصصين لتجميع مكونات الـ IBS					
27	عدم القدرة علي تصليح مكونات IBS					
28	العملية التجميعية مكلفة					
29	تتعرض منطقة التخزين للتأثيرات البيئية					
30	المسافة الطويلة بين المصنع والموقع					
31	صعوبة في الوصول إلى موقع البناء					
32	صعوبة الطبيعة الجغرافيةللمواقع					

الرقم	العبارة	اوافق بشدة	اوافق	أحيانا	لا اوافق	لا أوافق بشدة
33	الوصلات غير ملائمةلبيئة السودان					
34	تواجه عملية النقل صعوبات في نقل المكونات الكبيرة من المصنع إلى موقع البناء					
35	لايوجد قبول لدي الزبائن للانظمة الجديدة					
36	تطبيق نظام IBS يتم بناء على الوعي والمعرفة الجيدة للعميل					

القطاع الثالث:ماهي الانظمة المستخدمة حاليا في السودان

فضلا أشر بعلامة (√) علي الإجابة التي تمثل وجهة تظرك بدقة

الرقم	الانظمة	غير مستخدمة	مستخدمه احيانا	مستخدمة بكثرة
1	نظام الخرسانة مسبقه الصب			
2	نظام الفرم الحديدية			
3	نظام الفريم الخشبي الجاهز			
4	نظام الفريم الحديدي الجاهز			
5	نظام البناء بالبلوك الاسمنتي			
6	نظام البناء بالالواح ثلاثية البعاد			

القطاع الرابع:من وجهة نظرك ماهو افضل نظام ؟

فضلا أشر بعلامة (√) علي الإجابة التي تمثل وجهة نظرك بدقة

الرقم	الانظمة	ممتاز	جيد	ضعيف
1	نظام الخرسانة مسبقه الصب			
2	نظام الفرم الحديدية			
3	نظام الفريم الخشبي الجاهز			
4	نظام الفريم الحديدي الجاهز			
5	نظام البناء بالبلوك الاسمنتي			
6	نظام البناء بالالواح ثلاثية البعاد			

القطاع الخامس:من وجهة نظرك ماهو مدي تاثير هذة الانظمة علي تقليل التكلفة في السودان ؟

فضلا أشر بعلامة (√) علي الإجابة التي تمثل وجهة نظرك بدقة

الرقم	الانظمة	اقل من 50%	50%-80%	اكثر من80%
1	نظام الخرسانة مسبقه الصب			
2	نظام الفرم الحديدية			
3	نظام الفريم الخشبي الجاهز			
4	نظام الفريم الحديدي الجاهز			
5	نظام البناء بالبلوك الاسمنتي			
6	نظام البناء بالالواح ثلاثية البعاد			