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BEYOND CONCRETE: THE POTENTIAL OF EXOSKELETON STRUCTURES IN BUILIDNG DESIGN

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ABSTRACT

Earlier, people used to build those structures using wood, stone, and concrete but with the advent of time, the techniques of building structures also changed. People continued to build concrete load-bearing structures until the mid-20th century but due to its harmful effects on the environment and human health, architects and designers started searching out for alternative ways.

Exoskeleton structures started gaining traction in the contemporary engineering and construction industries. The exoskeleton is a type of external structure that is found in many different animals, including insects, crustaceans, and molluscs. It is a hard, protective covering that is made up of a material that can withstand even the harsh of the environmental conditions. In the recent years, the buildings have evolved to use the same technique where the whole structure is supported externally. In the current state of exoskeleton design and development, there are many benefits to using exoskeleton structures over conventional structures. From increased seismic resistance to greater structural stability, exoskeleton structures offer numerous benefits in terms of strength, durability, and cost-effectiveness. Not only this, these exoskeleton structures are lighter in weight and easier to install than concrete structures. This makes them a more attractive option for construction projects that are in difficult-to-reach areas, as they can be more easily transported and assembled on site. In addition, exoskeleton structures are more resistant to corrosion and other environmental damage than the traditional structures.

In modern architecture, as structures evolved, materials did too. Concrete is one of the commonly used building materials. It has been used for centuries, and its development and evolution over time has enabled it to be used in a variety of applications. However, despite its versatility, concrete is not without its drawbacks. It can be expensive, and its production can have a detrimental effect on the environment. This recent concern about the negative environmental impact of concrete structures have led to a re-evaluation of the materials used in their construction. As such, many architects have sought alternative building materials to replace it. In particular, the use of exoskeleton structures made from alternative materials has been proposed as a more environmentally friendly alternative to traditional concrete structures.

In this paper, beneficial aspects of using exoskeleton structures over conventional structures are highlighted. This paper also examines the possible implications of this shift in the field of architecture. Various possible materials that can be used to construct exoskeleton structures, their environmental-friendly effects, and other advantages over traditional structures is explored. Evidences from various studies, surveys, and reports will be examined to support the argument.

CONCRETE

Concrete is a widely used composite building material that is made up of several components, each with a specific purpose in the overall mix. The main components of concrete are cement, water, and aggregates. When these ingredients are mixed, they form a paste that can be poured or moulded into a variety of shapes and sizes.

Cement is a fine powder made from a combination of limestone, clay, and other minerals that have been heated to high temperatures. It is the primary binding agent in the concrete and works to hold the mixture together. Water being an essential component of concrete, as it reacts with the cement to form a paste that binds the aggregates together. The amount of water used in the mix is crucial as too little can result in a weak and brittle concrete, while too much can lead to shrinkage and cracking. Aggregates are a mixture of sand, gravel, or crushed stone that are added to the mix to provide bulk and stability. They make up most of the volume of the concrete and work to strengthen the mixture. Other than the following components various other components such as admixtures to alter the properties of concrete, reinforcement to increase its strength and stability, pozzolans to increase the durability of the concrete, etc.

CONCRETE AS A BUILIDNG MATERIAL

One of the key benefits of concrete as a building material is its strength and durability. Concrete is capable of withstanding heavy loads and extreme weather conditions, making it an ideal choice for a wide range of construction projects be it bridges, dams, buildings, and roads. In addition, concrete is fire-resistant and has a long lifespan, which makes it a cost-effective option for many building applications. Another reason for its multi-purpose is its versatility. It can be formed into a variety of shapes and sizes to fit the specific needs of a project. Additionally, it can be coloured, stamped, or polished to create a wide range of decorative effects. Finally, concrete also has an appreciable number of thermal properties, which can make it ideal for use in buildings. It has a high thermal mass, which means it can absorb and store heat, helping to regulate temperature inside a building and reducing the need for additional heating and cooling systems.

While concrete is generally considered a safe and durable building material, there are several harmful effects associated with its use and the components that make it up. These includes environmental impact, health risks, water pollution, alkali-silica reaction, carbonation, etc.

The production of cement, which is a key component of concrete, is a major source of greenhouse gas emissions. The manufacturing process involves heating materials to very high temperatures, which releases large amounts of carbon dioxide into the atmosphere. In addition, mining for the materials used in concrete production can lead to soil erosion, habitat destruction, and other negative environmental impacts. Cement also contains various hazardous materials, such as silica, chromium, and cadmium, which can be harmful to human health. Exposure to these substances can lead to lung damage, cancer, and other serious health problems. Workers involved in the production or handling of cement and concrete are at particular risk of exposure.

Concrete production results in the release of pollutants, such as heavy metals and chemicals, into nearby water sources. This can have negative impacts on aquatic life and make water unsafe for human consumption. One of the potential issues with concrete is the alkali-silica reaction, which occurs when the cement reacts with certain types of aggregates. This can lead to cracking and weakening of the concrete over time. Over time, concrete can become carbonated as carbon dioxide in the atmosphere reacts with the material. This can lead to a reduction in the alkalinity of the concrete, which can cause corrosion of any steel reinforcement present and ultimately weaken the structure.

Overall, while the components of concrete are essential for its strength and durability, their production and use can have negative environmental and health impacts. It is important to consider these effects and seek out more sustainable alternatives where possible.

WHY CONCRETE!

Concrete is an incredibly popular building material, and for good reason. It is strong, durable, and versatile, making it ideal for use in a wide range of construction projects. However, despite its many benefits, concrete also has some harmful effects that cannot be ignored.

Despite of many harmful effects, concrete remains a popular building material for several reasons. The popularity of concrete as a building material can be attributed to its strength, durability, versatility, cost-effectiveness, and sustainability. One is the lack of viable alternatives that can provide the same level of strength, durability, and versatility as concrete. While there are some concerns associated with its use, ongoing efforts develop more sustainably and eco-friendly alternatives to traditional concrete are helping to mitigate these issues.

In addition, many builders and architects are taking steps to minimize the negative environmental impacts of concrete. For example, buildings can be designed to maximise energy efficiency and reduce water usage, and construction techniques can be optimized to minimise waste and maximize the use of recycled materials.

In conclusion, concrete is a popular building material due to its many advantages, including strength, durability, versatility, and cost-effectiveness. However, it is important to recognize and address the harmful effects of concrete production and use. By continuing to innovate and develop more sustainable alternatives, we can ensure that concrete remains a viable and responsible choice for construction projects for years to come.

EXOSKELETON STRUCTURE

An exoskeleton structure is a form that surrounds and supports the outside of a building or structure, rather than relying on internal supports like traditional buildings. While concrete is a popular choice for exoskeleton structures, there are a variety of other material that can be used to achieve similar results.

Exoskeleton structures are a type of building design where the building's outer skin or shell is used as the primary structural support system, rather than relying on internal columns, beams, or other traditional support structures. This creates an open, column-free interior space that can be used for a variety of purposes, such as office or residential space.

One of the benefits of exoskeleton structures is their flexibility in terms of design. The outer shell can be customised to suit the needs of the building's occupants and the surrounding environment. For example, the shell can be designed with sun shading features to reduce the heat gain in hot climates, or with openings to allow for natural ventilation in temperate climates.

Exoskeleton structures are also a popular choice for sustainable building design. Because the outer shell serves as the primary structural support, there is less need for internal support structures, which can reduce the amount of material required for construction. Additionally, the open interior spaces created by exoskeleton structures can be more easily adapted to changing needs and uses over time, reducing the need for demolition and reconstruction.

IF NOT CONCRETE, THEN WHAT?

One alternative material for exoskeleton structures is steel. Steel is strong, durable, and lightweight, making it ideal choice for high-rise buildings or other structures that require a lot of supports. It can be easily fabricated and customised to fit a wide range of design requirements, making it a versatile choice for architects and engineers. Another material that can be used for exoskeleton structures is timber, timber is a

renewable resource that is gaining popularity in sustainable building design. It is also lightweight, strong, and durable, making it a practical choice for exoskeleton structures. Additionally, timber can be easily prefabricated off-site, reducing construction time and costs. Aluminium is another material that can be used for exoskeleton structures. It is lightweight, corrosion-resistant, and can be easily formed and fabricated. Additionally, aluminium is highly recyclable, making it an eco-friendly choice for sustainable building projects. Fibre-reinforced polymers (FRP) are another alternative material that can be used for exoskeleton structures. FRP is a composite material that is made from fibres, such as carbon or fiberglass, and a polymer matrix. It is strong, lightweight, and can be easily moulded into complex shapes, making it an ideal choice for unique and innovative designs.

In addition to these materials, there are a variety of other innovative materials that can be used for exoskeleton structures. These include natural materials like bamboo or hemp, as well as synthetic materials like carbon nanotubes or aerogels.

In conclusion, while concrete is a popular choice for exoskeleton structures, there are a variety of alternative materials that can be used to achieve similar results. These materials offer unique advantages, including strength, durability, and sustainability.

EXOSKELETON STRUCTURES V/S CONVENTIONAL STRUCTURES

Exoskeleton structures and conventional structures are two different approaches to building design and construction. While both have their advantages and disadvantages, there are certain factors that may make one option preferable than the other in certain situations.

Exoskeleton structures offer greater flexibility in design compared to conventional concrete structures. The outer shell can be customised to suit the needs of the building's occupants and the surrounding environments. This allows for greater creativity and innovation in design.

Exoskeleton structures are a more sustainable option compared to conventional concrete structures. The reduced need for internal support structures can reduce the amount of material required for construction. Additionally, the open interior spaces created by exoskeleton structures can be more easily adapted to changing needs and uses over time, reducing the need for demolition and reconstruction. Because the outer shell serves as the primary structural support system, there is less need for internal support structures in exoskeleton structures. This can reduce the amount of material required for construction, leading to cost savings and a reduced environmental impact.

Exoskeleton structures can provide improved natural lighting and views compared to conventional concrete structures. The open interior spaces created by exoskeleton structures can allow more natural light to penetrate the building, reducing the need for artificial lighting. Additionally, the outer shell can be designed

to provide greater views of the surrounding environment. They also offer greater resilience to extreme weather events and seismic activity. The outer shell can be designed to withstand a variety of environmental factors, such as wind, rain, and temperature fluctuations.

Last but not the least, exoskeleton structures also offer improved aesthetics compared to conventional concrete structures. The outer shell can be designed to create a unique and visually striking appearance, enhancing the building's overall aesthetics appeal. Overall, exoskeleton structures offer a range of benefits over conventional concrete structures, making them a popular choice for sustainable and innovative building design.

Moreover, exoskeleton structures can also offer significant cost savings compared to traditional concrete structures. By reducing the need for internal support structures, exoskeleton structures can reduce the amount of material required for construction, which can lead to lower costs for materials and labour. Additionally, exoskeleton structures can be built more quickly than traditional concrete structures, which can also reduce construction costs.

Another benefit of exoskeleton structures is their improved sustainability. The reduced material requirements and increased natural lighting and views can lead to a more environmentally friendly building. Additionally, the use of sustainable materials in the construction of exoskeleton structures can further enhance their sustainability. Overall, exoskeleton structures can provide a more sustainably and environmentally friendly building option than traditional concrete structures.

Ultimately, exoskeleton structures offer a range of benefits over conventional concrete structures, including sustainability, greater resilience to extreme weather events and seismic activity, and potential cost savings. As such, exoskeleton structures are becoming an increasingly popular choice for innovative and sustainable building design.

However, there are also some drawbacks to this approach. One of the primary drawbacks of exoskeleton structures is their durability over time. While the outer shell can be designed to withstand a variety of environmental factors, such as wind, rain, and temperature fluctuations, there is still the potential for wear and tear over time. Additionally, if the outer shell is damages, it can be more difficult to repair or replace than internal support structures.

On the other hand, conventional concrete structures have been the go-to-choice for building construction for decades. There are known for their durability, strength, and fire resistance. They can also be more cost-effective than exoskeleton structures, especially for smaller scale projects.

However, conventional concrete structures also have their drawbacks. One of the biggest issues is their environmental impact. Concrete production is a major contributor to carbon emissions, and the use of concrete in construction can contribute to the depletion of natural resources. Additionally, conventional

concrete structures can be less flexible in terms of design, as they often require internal support structures that can limit the layout and use of the interior space.

Ultimately, the choice between an exoskeleton structure and a conventional concrete structure will depend on the specific will depend on the specific needs and goals of the projects. For larger-scale projects where sustainability and flexibility in design are priorities, an exoskeleton structure may be the preferable option. However, for smaller-scale projects where cost and durability are the primary concerns, a conventional concrete structure may be a better choice.

WHY ARE EXOSKELETON STURCTURES NOT SO POPULAR IN INDIA?

Exoskeleton structures are a relatively new form of construction, and their popularity varies from country to country. While exoskeleton structures are gaining popularity in many parts of the world, they are not yet widely used in India.

One reason for the limited use of exoskeleton structures in India may be the relatively high cost of construction. The use of innovative and sustainable building materials and techniques can be more expensive than traditional methods, and this may make exoskeleton structures less feasible in a country where cost considerations are often a primary concern.

Another reason may be a lack of awareness and education about exoskeleton structures among architects, engineers, and builders in India. Many construction professionals may be unfamiliar with the benefits and potential of exoskeleton structures, and this may make them less likely to adopt this form of construction.

Finally, India's climate and building regulations may also play a role in the limited use of exoskeleton structures. Building codes and regulations may not yet be fully adapted to accommodate the unique design requirements of exoskeleton structures.

Overall, while exoskeleton structures offer many benefits over conventional concrete structures, their use in India is limited due to range of factors, including cost, education, and awareness, and building regulations. However, as sustainability and innovation become increasingly important considerations in the construction industry, it is possible that exoskeleton structures may become more widely adopted in India in the future.

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