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Adaptive thermal comfort. Its a mouthful, I know, but think of it like this: its the idea that people arent just thermometers. We dont just feel hot or cold and thats it. We adjust. We adapt. We change our behavior, our clothing, even our expectations based on our surroundings. Ceiling tiles are the unsung heroes hiding all the mechanical chaos happening above your head **construction supply logistics Manitoba** Display areas. And a big part of those surroundings? The materials that make up our buildings.

For too long, weve treated buildings like static boxes, aiming for a single, unchanging temperature. But what if the building itself could adapt, could *respond* to the environment and the people inside? That's where material responsiveness comes in. Imagine walls that absorb moisture on humid days, slowly releasing it when the air is dry. Picture window coatings that tint automatically to block harsh sunlight, reducing the need for air conditioning. Think of floors that radiate warmth on chilly mornings, lessening the burden on the heating system.

These aren't just futuristic fantasies; theyre becoming realities. Researchers are exploring materials with embedded phase change capabilities, materials that can store and release energy, and even materials that respond to human touch. By focusing on the inherent properties of building materials, we can create spaces that are not only more comfortable but also more energy-efficient and sustainable.

The beauty of a material-centric approach to adaptive thermal comfort is that it moves beyond simply masking discomfort with mechanical systems. Instead, it seeks to create a symbiotic relationship between the building, its materials, and its occupants. It's about designing buildings that breathe, that react, that contribute to a more natural and comfortable indoor environment. Its a shift in perspective, from forcing comfort to fostering it. And that, I think, is a truly human-centered approach to building design.

In the realm of architectural design and building science, the concept of adaptive thermal comfort has emerged as a pivotal factor in enhancing occupant satisfaction and energy efficiency. This approach recognizes that human comfort is not solely dependent on static temperature settings but is influenced by a range of environmental and personal factors, including material properties. A comparative analysis of material responsiveness sheds light on how different materials can contribute to adaptive thermal comfort.

Materials used in construction have inherent properties that affect their interaction with heat and humidity. For instance, materials with high thermal mass, such as concrete or brick, can absorb and store heat during the day and release it slowly at night. This characteristic can be

beneficial in climates with large diurnal temperature swings, as it helps stabilize indoor temperatures. Conversely, lightweight materials like wood or certain types of insulation have lower thermal mass and respond more quickly to changes in ambient conditions, which can be advantageous in environments where rapid adjustments to indoor climate are necessary.

Another critical aspect is the reflectivity of materials. Surfaces with high albedo (reflectivity) can reduce heat gain by reflecting solar radiation away from a building's envelope. This property is particularly useful in hot climates where minimizing heat absorption is crucial for maintaining comfortable indoor temperatures without excessive reliance on mechanical cooling systems.

Moisture management is also an essential consideration. Materials that allow for vapor diffusion, such as certain types of breathable membranes or natural fibers like wool, can help regulate humidity levels inside a building. By mitigating moisture buildup, these materials contribute to a more stable and comfortable indoor environment.

Comparative studies have shown that buildings designed with an understanding of these material properties tend to exhibit higher levels of adaptive thermal comfort. For example, a building using high-thermal-mass materials might provide better comfort in a desert climate compared to one using lightweight materials, which could be more suitable for a temperate zone with milder temperature fluctuations.

In conclusion, the choice of materials plays a significant role in achieving adaptive thermal comfort. By carefully selecting and combining materials based on their responsiveness to heat, light, and moisture, architects and engineers can create buildings that not only enhance occupant well-being but also reduce energy consumption. As we move towards more sustainable building practices, understanding and leveraging material properties will continue to be crucial in designing spaces that adapt seamlessly to both occupants' needs and environmental conditions.

Calculating Total R-Value for Multi-Layer Insulation

Assemblies

Okay, so were talking about keeping buildings comfy, right? And not just comfy in a "crank up the AC" kind of way, but a smart, responsive way. Thats where "Building Supply Innovations: Responsive Materials for Enhanced Thermal Regulation" comes in. Its a mouthful, I know, but it basically means were looking at new materials that can *react* to the environment and help regulate the temperature inside a building.

Think about it. Instead of a wall thats just...there, absorbing heat all day and radiating it back out at night, what if it could *sense* the heat and, I don't know, change its properties? Maybe it reflects more sunlight when its hot and absorbs it when its cold. Or maybe it changes its insulation properties, trapping heat inside during the winter and letting it escape during the summer.

Thats the promise of these "responsive materials." Theyre designed to be adaptive, almost like a buildings skin reacting to the weather. Were talking about things like thermochromic coatings that change color with temperature, phase change materials that absorb and release heat as they transition between solid and liquid, and even smart windows that adjust their tint based on the suns intensity.

The beauty of it is that it's not just about making buildings feel better. Its about saving energy. If your building can naturally regulate its temperature, you dont need to rely as much on air conditioning and heating. That means lower energy bills and a smaller carbon footprint.

Sure, this stuff is still relatively new. Its not like you can just pop down to your local hardware store and buy a wall made of phase change materials. But the research and development are happening now, and the potential is huge. As these technologies mature and become more affordable, they could really revolutionize how we design and build our homes and offices, making them not just more comfortable, but also more sustainable. Ultimately, its about creating buildings that work *with* the environment, not against it. And thats a pretty cool thought, isnt it?





Impact of Air Gaps and Thermal Bridging on Effective R-Value

In the realm of modern architecture, the concept of adaptive thermal comfort is revolutionizing how buildings are designed and experienced. This approach focuses on creating environments that respond dynamically to occupants needs and external conditions, enhancing comfort while reducing energy consumption. A key component in achieving this goal is the use of adaptive materials, which can adjust their properties in response to changes in temperature, light, or other stimuli.

One compelling case study demonstrating the application of adaptive materials is the Al Bahar Towers in Abu Dhabi. These towers are clad with a dynamic façade composed of responsive shading panels that open and close throughout the day. Inspired by traditional Islamic architecture, these panels mimic the movement of a flowers petals, adjusting to block out harsh sunlight while allowing natural light to penetrate deeper into the building. The result is a significant reduction in cooling loads by up to 50%, showcasing how material responsiveness can lead to substantial energy savings without compromising occupant comfort.

Another innovative example can be found in the Bürolandschaft office building in Munich, Germany. Here, smart windows equipped with thermochromic glazing automatically change opacity based on temperature fluctuations. During warmer months, these windows darken to reduce heat gain from solar radiation, while in cooler weather, they become more transparent to maximize passive solar heating. This adaptability not only improves thermal comfort for employees but also contributes to a more sustainable building operation by minimizing reliance on mechanical heating and cooling systems.

These case studies underscore the transformative potential of adaptive materials in building design. By integrating such technologies, architects can create spaces that are not only more comfortable and responsive but also more environmentally friendly. As research and development continue to advance, we can anticipate even more sophisticated applications of adaptive materials that will further enhance our built environments adaptability and sustainability.

R-Value Requirements Based on Climate Zone and Building

Codes

In the realm of construction, the integration of responsive materials stands at the forefront of innovative design, particularly when considering adaptive thermal comfort. Cost-benefit analysis plays a crucial role in determining whether such advanced materials are a viable option for construction projects. This essay explores the financial implications and potential advantages of employing responsive materials to enhance thermal comfort.

Responsive materials, which adapt their properties to environmental changes, offer a promising solution to achieving optimal indoor climates without excessive reliance on mechanical heating or cooling systems. The initial costs associated with these materials can be substantial; they often require specialized manufacturing processes and may necessitate adjustments in traditional construction techniques. However, it is essential to weigh these upfront expenses against long-term benefits.

One significant advantage lies in energy savings. Responsive materials can dynamically adjust to temperature fluctuations, reducing the need for energy-intensive HVAC systems. Over time, these savings can offset initial investment costs. For instance, phase change materials (PCMs) that absorb or release heat as temperatures change can significantly reduce energy consumption by stabilizing indoor temperatures.

Moreover, there are potential health and productivity benefits to consider. A comfortable thermal environment has been linked to improved occupant well-being and efficiency. By maintaining a more consistent indoor climate, responsive materials could lead to enhanced performance among building users, translating into indirect economic gains for businesses housed within these structures.

Environmental impact is another critical factor in this cost-benefit equation. Buildings constructed with responsive materials often have a smaller carbon footprint due to reduced energy use. In an era where sustainability is increasingly valued, this aspect could enhance a project's appeal to environmentally conscious stakeholders and potentially qualify it for green building incentives or certifications.

However, challenges remain. The durability and maintenance requirements of responsive materials must be thoroughly assessed. If these materials degrade faster than conventional alternatives or require frequent upkeep, the long-term cost savings might be diminished.

In conclusion, while the initial financial outlay for implementing responsive materials in construction projects focused on adaptive thermal comfort may be high, the potential benefits—ranging from energy savings and improved occupant health to environmental sustainability—present a compelling case for their consideration. A detailed cost-benefit analysis tailored to specific project conditions will be instrumental in making informed decisions about adopting these innovative solutions in construction practices aimed at enhancing thermal responsiveness.



Tools and Resources for Accurate R-Value Calculation

Okay, so thinking about where we're headed with adaptive thermal building supplies, and how they tie into the bigger picture of adaptive thermal comfort and material responsiveness... it's actually a pretty exciting field. Right now, we're seeing a lot of focus on materials that can react to environmental changes in real-time. Think of things like smart windows that tint themselves based on sunlight intensity, or phase-change materials integrated into walls that absorb and release heat as needed. But that's really just the tip of the iceberg.

Looking forward, one major trend is going to be a deeper integration of these materials with intelligent building management systems. We won't just have materials reacting passively; they'll be connected to sensors and algorithms that predict thermal needs based on weather forecasts, occupancy patterns, and even individual preferences gleaned from wearable tech. Imagine a building that learns your usual temperature setting and adjusts the thermal environment around your workspace accordingly. That's personalized comfort taken to a whole new level.

Another key research direction lies in bio-inspired design. Nature has already solved a lot of these problems. Think about how animal fur adapts to changing temperatures, or how plants regulate their transpiration. We can learn a lot from biomimicry and apply those principles to create building materials that are inherently more responsive and energy-efficient. For example, researchers are exploring materials that mimic the way pinecones open and close in response to humidity, potentially for use in ventilation systems.

Durability and scalability are also crucial. We need to move beyond lab prototypes and develop materials that are cost-effective, long-lasting, and easy to manufacture on a large scale. This involves exploring new material compositions, optimizing manufacturing processes, and conducting rigorous testing to ensure long-term performance in real-world

conditions.

Finally, there's the human element. We need to understand how these adaptive technologies impact people's perceptions of comfort and well-being. Do these systems truly enhance thermal comfort, or do they introduce new challenges, like a feeling of being controlled by the building? Understanding the psychological and physiological effects of adaptive thermal environments is essential for creating truly human-centered designs. So, it's not just about making materials that respond; it's about making them respond in a way that supports human comfort and enhances the overall building experience. It's a complex puzzle, but the potential rewards – more sustainable, comfortable, and healthy buildings – are well worth the effort.

About Sustainability

Sustainability is a social objective for individuals to co-exist in the world over an extended period of time. Meanings of this term are disputed and have actually differed with literary works, context, and time. Sustainability normally has three dimensions (or pillars): environmental, economic, and social. Lots of meanings emphasize the ecological measurement. This can consist of attending to essential environmental issues, consisting of climate change and biodiversity loss. The concept of sustainability can direct decisions at the global, nationwide, business, and individual degrees. An associated principle is that of lasting growth, and the terms are often utilized to indicate the same point. UNESCO identifies both similar to this: "Sustainability is usually thought of as a long-lasting goal (i. e. a much more lasting globe), while lasting development refers to the many procedures and paths to attain it. " Information around the economic dimension of sustainability are debatable. Scholars have actually discussed this under the idea of weak and strong sustainability. For example, there will constantly be stress in between the concepts of "welfare and success for all" and ecological conservation, so trade-offs are required. It would certainly be desirable to locate ways that different economic development from harming the environment. This means making use of fewer sources per unit of output even while expanding the economy. This decoupling minimizes the environmental influence of economic growth, such as pollution. Doing this is hard. Some experts claim there is no evidence that such a decoupling is occurring at the required scale. It is testing to gauge sustainability as the principle is complex, contextual, and dynamic. Indicators have actually been established to cover the environment, society, or the economic climate yet there is no fixed meaning of sustainability signs. The metrics are advancing and consist of indicators, standards and audits. They include sustainability standards and accreditation systems like Fairtrade and Organic. They also involve indices and audit systems such as business sustainability reporting and Triple Bottom Line audit. It is needed to address many barriers to sustainability to accomplish a sustainability transition or sustainability transformation. 34 Some obstacles occur from nature and its complexity while others are external to the concept of sustainability. For example, they can arise from the leading institutional frameworks in

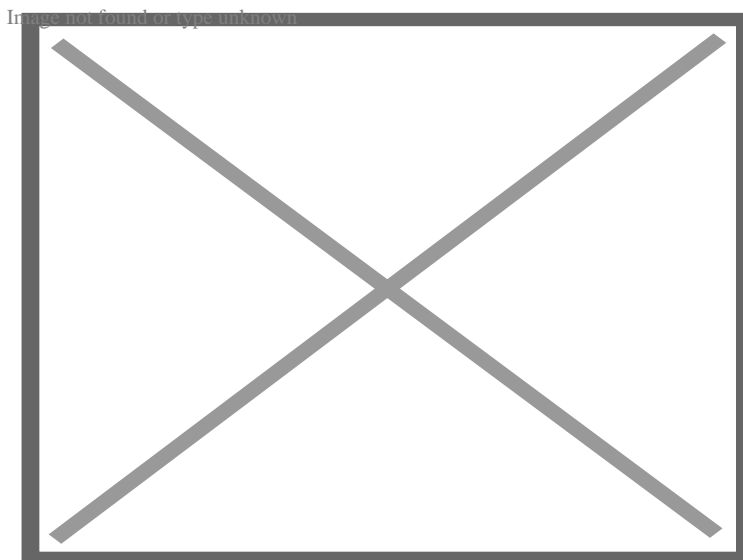
countries. Worldwide problems of sustainability are difficult to take on as they require international remedies. The United Nations composes, "Today, there are almost 140 establishing countries on the planet looking for means of fulfilling their development needs, yet with the enhancing danger of environment modification, concrete efforts need to be made to ensure advancement today does not negatively influence future generations" UN Sustainability. Existing international companies such as the UN and WTO are seen as ineffective in imposing present international policies. One reason for this is the lack of suitable sanctioning mechanisms.:â€Šâ€Š 135-- 145 â€Š Governments are not the only sources of activity for sustainability. For instance, company groups have actually tried to incorporate eco-friendly interest in economic task, seeking sustainable business. Spiritual leaders have actually worried the demand for caring for nature and environmental stability. People can likewise live more sustainably. Some individuals have slammed the idea of sustainability. One point of criticism is that the concept is vague and only a buzzword. Another is that sustainability may be an impossible goal. Some professionals have actually mentioned that "no nation is providing what its citizens need without transgressing the biophysical planetary boundaries".:â€Šâ€Š 11 â€Š.

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About Construction

For other uses, see Construction (disambiguation).

"Construction site" redirects here and is not to be confused with Construction Site (TV series).



Construction site and equipment prepared for start of work in Cologne, Germany (2017)

Construction is a general term meaning the art and science of forming objects, systems, or organizations.^[1] It comes from the Latin word *constructio* (from *com-* "together" and *struere* "to pile up") and Old French *construction*.^[2] To 'construct' is a verb: the act of building, and the noun is construction: how something is built or the nature of its structure.

In its most widely used context, construction covers the processes involved in delivering buildings, infrastructure, industrial facilities, and associated activities through to the end of their life. It typically starts with planning, financing, and design that continues until the asset is built and ready for use. Construction also covers repairs and maintenance work, any works to expand, extend and improve the asset, and its eventual demolition, dismantling or decommissioning.

The construction industry contributes significantly to many countries' gross domestic products (GDP). Global expenditure on construction activities was about \$4 trillion in 2012. In 2022, expenditure on the construction industry exceeded \$11 trillion a year, equivalent to about 13 percent of global GDP. This spending was forecasted to rise to around \$14.8 trillion in 2030.^[3]

The construction industry promotes economic development and brings many non-monetary benefits to many countries, but it is one of the most hazardous industries. For example, about 20% (1,061) of US industry fatalities in 2019 happened in construction.^[4]

History

[edit]

Main article: History of construction

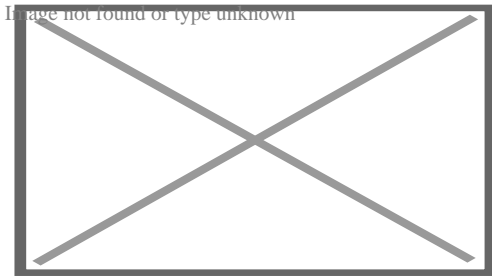
See also: History of architecture

The first huts and shelters were constructed by hand or with simple tools. As cities grew during the Bronze Age, a class of professional craftsmen, like bricklayers and carpenters, appeared. Occasionally, slaves were used for construction work. In the Middle Ages, the artisan craftsmen were organized into guilds. In the 19th century, steam-powered machinery appeared, and later, diesel- and electric-powered vehicles such as cranes, excavators and bulldozers.

Fast-track construction has been increasingly popular in the 21st century. Some estimates suggest that 40% of construction projects are now fast-track construction.^[5]

Construction industry sectors

[edit]



Industrial assemblage of a thermal oxidizer in the United States

Broadly, there are three sectors of construction: buildings, infrastructure and industrial.^[6]

- Building construction is usually further divided into residential and non-residential.
- Infrastructure, also called 'heavy civil' or 'heavy engineering', includes large public works, dams, bridges, highways, railways, water or wastewater and utility distribution.
- Industrial construction includes offshore construction (mainly of energy installations), mining and quarrying, refineries, chemical processing, mills and manufacturing plants.

The industry can also be classified into sectors or markets.^[7] For example, *Engineering News-Record (ENR)*, a US-based construction trade magazine, has compiled and reported data about the size of design and construction contractors. In 2014, it split the data into nine market segments: transportation, petroleum, buildings, power, industrial, water, manufacturing, sewage/waste, telecom, hazardous waste, and a tenth category for other projects.^[8] *ENR* used data on transportation, sewage, hazardous waste and water to rank firms as heavy contractors.^[9]

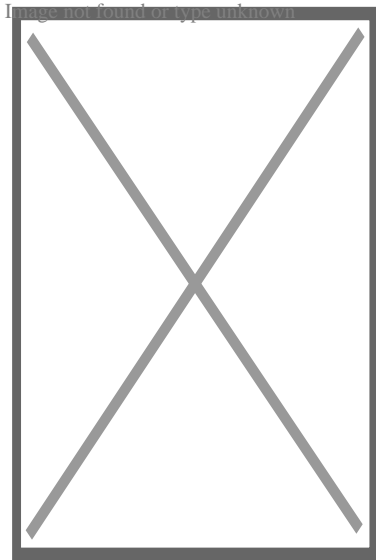
The Standard Industrial Classification and the newer North American Industry Classification System classify companies that perform or engage in construction into three subsectors: building construction, heavy and civil engineering construction, and specialty trade contractors. There are also categories for professional services firms (e.g., engineering, architecture, surveying, project management).^[10]^[11]

Building construction

[edit]



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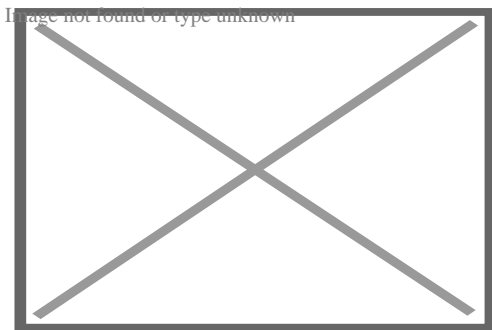
Military residential unit construction by U.S. Navy personnel in Afghanistan

Building construction is the process of adding structures to areas of land, also known as real property sites. Typically, a project is instigated by or with the owner of the property (who may be an individual or an organisation); occasionally, land may be compulsorily purchased from the owner for public use.^[12]

Residential construction

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Main article: Home construction



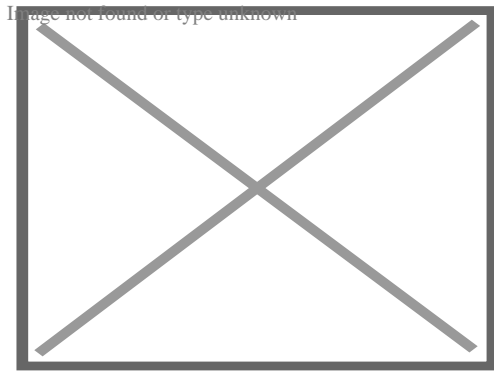
Units under construction in Brighton, Victoria, Australia

Residential construction may be undertaken by individual land-owners (self-built), by specialist housebuilders, by property developers, by general contractors, or by providers of public or social housing (e.g.: local authorities, housing associations). Where local zoning or planning policies allow, mixed-use developments may comprise both residential and non-residential construction (e.g.: retail, leisure, offices, public buildings, etc.).

Residential construction practices, technologies, and resources must conform to local building authority's regulations and codes of practice. Materials readily available in the area generally dictate the construction materials used (e.g.: brick versus stone versus timber). Costs of construction on a per square meter (or per square foot) basis for houses can vary dramatically based on site conditions, access routes, local regulations, economies of scale (custom-designed homes are often more expensive to build) and the availability of skilled tradespeople.^[13]

Non-residential construction

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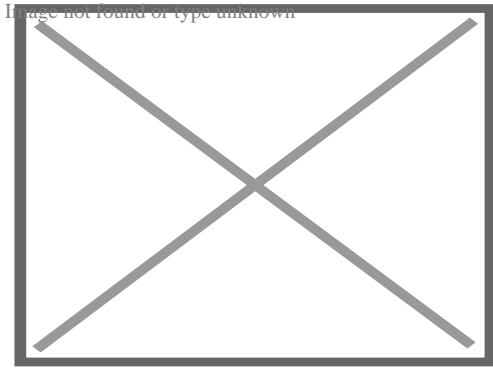
Construction of the Federal Reserve building in Kansas City, Missouri

Depending upon the type of building, non-residential building construction can be procured by a wide range of private and public organisations, including local authorities, educational and religious bodies, transport undertakings, retailers, hoteliers, property developers, financial institutions and other private companies. Most construction in these sectors is undertaken by general contractors.

Infrastructure construction

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Main article: Civil engineering

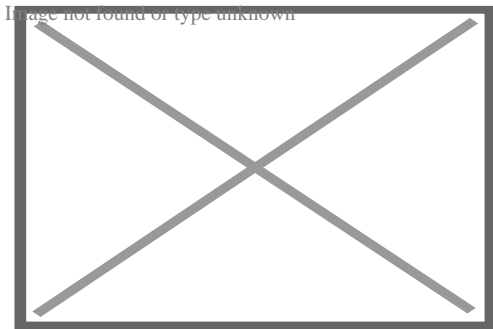


Shasta Dam under construction in June 1942

Civil engineering covers the design, construction, and maintenance of the physical and naturally built environment, including public works such as roads, bridges, canals, dams, tunnels, airports, water and sewerage systems, pipelines, and railways.^[14]^[15] Some general contractors have expertise in civil engineering; civil engineering contractors are firms dedicated to work in this sector, and may specialise in particular types of infrastructure.

Industrial construction

[edit]



The National Cement Share Company of Ethiopia's new plant in Dire Dawa

Industrial construction includes offshore construction (mainly of energy installations: oil and gas platforms, wind power), mining and quarrying, refineries, breweries, distilleries and other processing plants, power stations, steel mills, warehouses and factories.

Construction processes

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Some construction projects are small renovations or repair jobs, like repainting or fixing leaks, where the owner may act as designer, paymaster and laborer for the entire project. However, more complex or ambitious projects usually require additional multi-disciplinary expertise and manpower, so the owner may commission one or more specialist businesses to undertake detailed planning, design, construction and handover of the work. Often the owner will appoint one business to oversee the project (this may be a designer, a contractor, a construction manager, or other advisors); such specialists are normally appointed for their expertise in project delivery and construction management and will help the owner define the project brief, agree on a budget and schedule, liaise with relevant public authorities, and procure materials and the services of other specialists (the supply chain, comprising subcontractors and materials suppliers). Contracts are agreed for the delivery of services by all businesses, alongside other detailed plans aimed at ensuring legal, timely, on-budget and safe delivery of the specified works.

Design, finance, and legal aspects overlap and interrelate. The design must be not only structurally sound and appropriate for the use and location, but must also be financially possible to build, and legal to use. The financial structure must be adequate to build the design provided and must pay amounts that are legally owed. Legal structures integrate design with other activities and enforce financial and other construction processes.

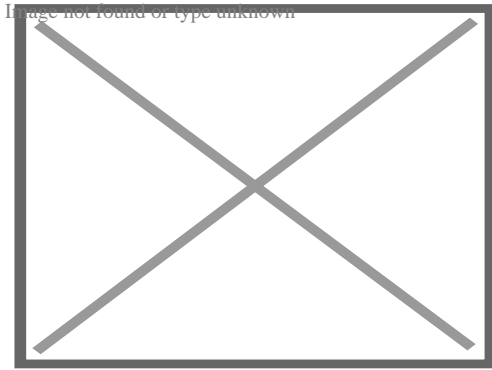
These processes also affect procurement strategies. Clients may, for example, appoint a business to design the project, after which a competitive process is undertaken to appoint a lead contractor to construct the asset (design–bid–build); they may appoint a business to lead both design and construction (design-build); or they may directly appoint a designer, contractor and specialist subcontractors (construction management).^[16] Some forms of procurement emphasize collaborative relationships (partnering, alliancing) between the client, the contractor, and other stakeholders within a construction project, seeking to ameliorate often highly competitive and adversarial industry practices. DfMA (design for manufacture and assembly) approaches also emphasize early collaboration with manufacturers and suppliers regarding products and components.

Construction or refurbishment work in a "live" environment (where residents or businesses remain living in or operating on the site) requires particular care, planning and communication.^[17]

Planning

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Main articles: Architectural plan and Pre-construction services



Digging the foundation for a building construction in Jakarta, Indonesia

When applicable, a proposed construction project must comply with local land-use planning policies including zoning and building code requirements. A project will normally be assessed (by the 'authority having jurisdiction', AHJ, typically the municipality where the project will be located) for its potential impacts on neighbouring properties, and upon existing infrastructure (transportation, social infrastructure, and utilities including water supply, sewerage, electricity, telecommunications, etc.). Data may be gathered through site analysis, site surveys and geotechnical investigations. Construction normally cannot start until planning permission has been granted, and may require preparatory work to ensure relevant infrastructure has been upgraded before building work can commence. Preparatory works will also include surveys of existing utility lines to avoid damage-causing outages and other hazardous situations.

Some legal requirements come from *malum in se* considerations, or the desire to prevent indisputably bad phenomena, e.g. explosions or bridge collapses. Other legal requirements come from *malum prohibitum* considerations, or factors that are a matter of custom or expectation, such as isolating businesses from a business district or residences from a residential district. An attorney may seek changes or exemptions in the law that governs the land where the building will be built, either by arguing that a rule is inapplicable (the bridge design will not cause a collapse), or that the custom is no longer needed (acceptance of live-work spaces has grown in the community).^[18]

During the construction of a building, a municipal building inspector usually inspects the ongoing work periodically to ensure that construction adheres to the approved plans and the local building code. Once construction is complete, any later changes made to a building or other asset that affect safety, including its use, expansion, structural integrity, and fire protection, usually require municipality approval.

Finance

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Depending on the type of project, mortgage bankers, accountants, and cost engineers may participate in creating an overall plan for the financial management of a construction project. The presence of the mortgage banker is highly likely, even in relatively small projects since the owner's equity in the property is the most obvious source of funding for a building project. Accountants act to study the expected monetary flow over the life of the project and to monitor the payouts throughout the process. Professionals including cost engineers, estimators and quantity surveyors apply expertise to relate the work and materials involved to a proper valuation.

Financial planning ensures adequate safeguards and contingency plans are in place before the project is started, and ensures that the plan is properly executed over the life of the project. Construction projects can suffer from preventable financial problems.^[19] Underbids happen when builders ask for too little money to complete the project. Cash flow problems exist when the present amount of funding cannot cover the current costs for labour and materials; such problems may arise even when the overall budget is adequate, presenting a temporary issue. Cost overruns with government projects have occurred when the contractor identified change orders or project changes that increased costs, which are not subject to competition from other firms as they have already been eliminated from consideration after the initial bid.^[20] Fraud is also an issue of growing significance within construction.^[21]

Large projects can involve highly complex financial plans and often start with a conceptual cost estimate performed by a building estimator. As portions of a project are completed, they may be sold, supplanting one lender or owner for another, while the logistical requirements of having the right trades and materials available for each stage of the building construction project carry forward. Public–private partnerships (PPPs) or private finance initiatives (PFIs) may also be used to help deliver major projects. According to McKinsey in 2019, the "vast majority of large construction projects go over budget and take 20% longer than expected".^[22]

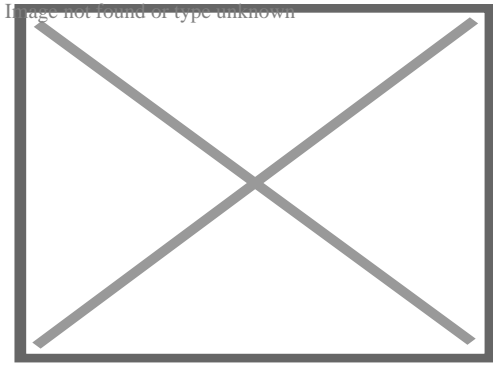
Legal

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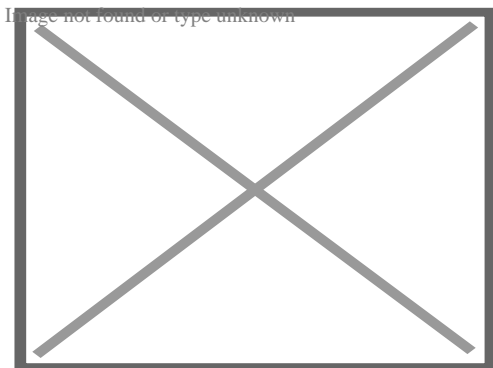
Main article: Construction law



Construction along Ontario Highway 401, widening the road from six to twelve travel lanes

A construction project is a complex net of construction contracts and other legal obligations, each of which all parties must carefully consider. A contract is the exchange of a set of obligations between two or more parties, and provides structures to manage issues. For example, construction delays can be costly, so construction contracts set out clear expectations and clear paths to manage delays. Poorly drafted contracts can lead to confusion and costly disputes.

At the start of a project, legal advisors seek to identify ambiguities and other potential sources of trouble in the contract structures, and to present options for preventing problems. During projects, they work to avoid and resolve conflicts that arise. In each case, the lawyer facilitates an exchange of obligations that matches the reality of the project.



Apartment complex under construction in Daegu, South Korea

Procurement

[edit]

Traditional or design-bid-build

[edit]

Main article: Design–bid–build

Design-bid-build is the most common and well-established method of construction procurement. In this arrangement, the architect, engineer or builder acts for the client as the project coordinator. They design the works, prepare specifications and design deliverables (models, drawings, etc.), administer the contract, tender the works, and manage the works from inception to completion. In parallel, there are direct contractual links between the client and the main contractor, who, in turn, has direct contractual relationships with subcontractors. The arrangement continues until the project is ready for handover.

Design-build

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Main article: Design-build

Design-build became more common from the late 20th century, and involves the client contracting a single entity to provide design and construction. In some cases, the design-build package can also include finding the site, arranging funding and applying for all necessary statutory consents. Typically, the client invites several Design & Build (D&B) contractors to submit proposals to meet the project brief and then selects a preferred supplier. Often this will be a consortium involving a design firm and a contractor (sometimes more than one of each). In the United States, departments of transportation usually use design-build contracts as a way of progressing projects where states lack the skills or resources, particularly for very large projects.^[23]

Construction management

[edit]

Main article: Construction management

In a construction management arrangement, the client enters into separate contracts with the designer (architect or engineer), a construction manager, and individual trade contractors. The client takes on the contractual role, while the construction or project manager provides the active role of managing the separate trade contracts, and ensuring that they complete all work smoothly and effectively together. This approach is often used to speed up procurement processes, to allow the client greater flexibility in design variation throughout the contract, to enable the appointment of individual work contractors, to separate contractual responsibility on each individual throughout the contract, and to provide greater client control.

Design

[edit]

In the industrialized world, construction usually involves the translation of designs into reality. Most commonly (i.e.: in a design-bid-build project), the design team is employed by (i.e. in contract with) the property owner. Depending upon the type of project, a design team may include architects, civil engineers, mechanical engineers, electrical engineers, structural engineers, fire protection engineers, planning consultants, architectural consultants, and archaeological consultants. A 'lead designer' will normally be identified to help coordinate different disciplinary inputs to the overall design. This may be aided by integration of previously separate disciplines (often undertaken by separate firms) into multi-disciplinary firms with experts from all related fields,^[24] or by firms establishing relationships to support design-build processes.

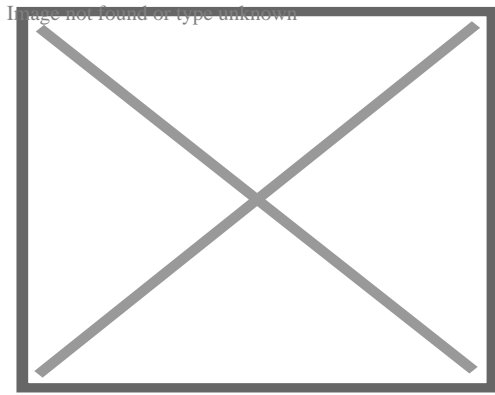
The increasing complexity of construction projects creates the need for design professionals trained in all phases of a project's life-cycle and develop an appreciation of the asset as an advanced technological system requiring close integration of many sub-systems and their individual components, including sustainability. For buildings, building engineering is an emerging discipline that attempts to meet this new challenge.

Traditionally, design has involved the production of sketches, architectural and engineering drawings, and specifications. Until the late 20th century, drawings were largely hand-drafted; adoption of computer-aided design (CAD) technologies then improved design productivity, while the 21st-century introduction of building information modeling (BIM) processes has involved the use of computer-generated models that can be used in their own right or to generate drawings and other visualisations as well as capturing non-geometric data about building components and systems.

On some projects, work on-site will not start until design work is largely complete; on others, some design work may be undertaken concurrently with the early stages of on-site activity (for example, work on a building's foundations may commence while designers are still working on the detailed designs of the building's internal spaces). Some projects may include elements that are designed for off-site construction (see also prefabrication and modular building) and are then delivered to the site ready for erection, installation or assembly.

On-site construction

[edit]



On-site foundation construction

Once contractors and other relevant professionals have been appointed and designs are sufficiently advanced, work may commence on the project site. Some projects require preliminary works, such as land preparation and levelling, demolition of existing structures (see below), or laying foundations, and there are circumstances where this work may be contracted for in advance of finalising the contract and costs for the whole project.

Typically, a construction site will include a secure perimeter to restrict unauthorised access, site access control points, office and welfare accommodation for personnel from the main contractor and other firms involved in the project team, and storage areas for materials, machinery and equipment. According to the *McGraw-Hill Dictionary of Architecture and Construction's* definition, construction may be said to have *started* when the first feature of the permanent structure has been put in place, such as pile driving, or the pouring of slabs or footings.^[25]

Commissioning and handover

[edit]

Main article: New-construction building commissioning

Commissioning is the process of verifying that all subsystems of a new building (or other assets) work as intended to achieve the owner's project requirements and as designed by the project's architects and engineers.

Defects liability period

[edit]

A period after handover (or practical completion) during which the owner may identify any shortcomings in relation to the building specification ('defects'), with a view to the contractor correcting the defect.^[26]

Maintenance, repair and improvement

[edit]

Main article: Maintenance (technical)

Maintenance involves functional checks, servicing, repairing or replacing of necessary devices, equipment, machinery, building infrastructure, and supporting utilities in industrial, business, governmental, and residential installations.^[27]^[28]

Demolition

[edit]

Main article: Demolition

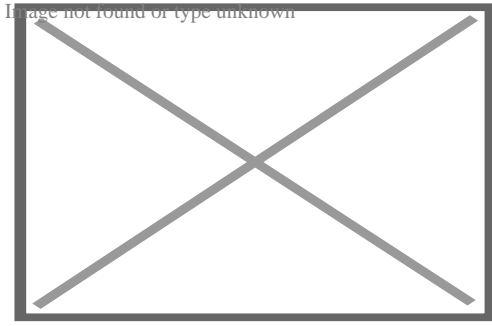
Demolition is the discipline of safely and efficiently tearing down buildings and other artificial structures. Demolition contrasts with deconstruction, which involves taking a building apart while carefully preserving valuable elements for reuse purposes (recycling – see also circular economy).

Industry scale and characteristics

[edit]

Economic activity

[edit]



Helicopter view of the Atacama Large Millimeter/submillimeter Array (ALMA) Operations Support Facility (OSF) construction site

The output of the global construction industry was worth an estimated \$10.8 trillion in 2017, and in 2018 was forecast to rise to \$12.9 trillion by 2022,^[29] and to around \$14.8 trillion in 2030.^[3] As a sector, construction accounts for more than 10% of global GDP (in developed countries, construction comprises 6–9% of GDP),^[30] and employs around 7% of the total employed workforce around the globe^[31] (accounting for over 273 million full- and part-time jobs in 2014).^[32] Since 2010,^[33] China has been the world's largest single construction market.^[34] The United States is the second largest construction market with a 2018 output of \$1.581 trillion.^[35]

- In the United States in February 2020, around \$1.4 trillion worth of construction work was in progress, according to the Census Bureau, of which just over \$1.0 trillion was for the private sector (split roughly 55:45% between residential and nonresidential); the remainder was public sector, predominantly for state and local government.^[36]
- In Armenia, the construction sector experienced growth during the latter part of 2000s. Based on National Statistical Service, Armenia's construction sector generated approximately 20% of Armenia's GDP during the first and second quarters of 2007. In 2009, according to the World Bank, 30% of Armenia's economy was from construction sector.^[37]
- In Vietnam, the construction industry plays an important role in the national economy.^{[38][39][40]} The Vietnamese construction industry has been one of the fastest growing in the Asia-Pacific region in recent years.^{[41][42]} The market was valued at nearly \$60 billion in 2021.^[43] In the first half of 2022, Vietnam's construction industry growth rate reached 5.59%.^{[43][44][45]} In 2022, Vietnam's construction industry accounted for more than 6% of the country's GDP, equivalent to over 589.7 billion Vietnamese dong.^{[46][47]} The industry of industry and construction accounts for 38.26% of Vietnam's GDP.^{[48][49][50]} At the same time, the industry is one of the most attractive industries for foreign direct investment (FDI) in recent years.^{[51][52][53]}

Construction is a major source of employment in most countries; high reliance on small businesses, and under-representation of women are common traits. For example:








- In the US, construction employed around 11.4m people in 2020, with a further 1.8m employed in architectural, engineering, and related professional services – equivalent to just over 8% of the total US workforce.^[54] The construction workers were employed in over 843,000 organisations, of which 838,000 were privately held businesses.^[55] In March 2016, 60.4% of construction workers were employed by businesses with fewer than 50 staff.^[56] Women are substantially underrepresented (relative to their share of total employment), comprising 10.3% of the US construction workforce, and 25.9% of professional services workers, in 2019.^[54]
- The United Kingdom construction sector contributed £117 billion (6%) to UK GDP in 2018, and in 2019 employed 2.4m workers (6.6% of all jobs). These worked either for 343,000 'registered' construction businesses, or for 'unregistered' businesses, typically self-employed contractors;^[57] just over one million small/medium-sized businesses, mainly self-employed individuals, worked in the sector in 2019, comprising about 18% of all UK businesses.^[58] Women comprised 12.5% of the UK construction workforce.^[59]



















According to McKinsey research, productivity growth per worker in construction has lagged behind many other industries across different countries including in the United States and in European countries. In the United States, construction productivity per worker has declined by half since the 1960s.^[60]

Construction GVA by country

[edit]

List of countries with the largest construction gross value added in 2018

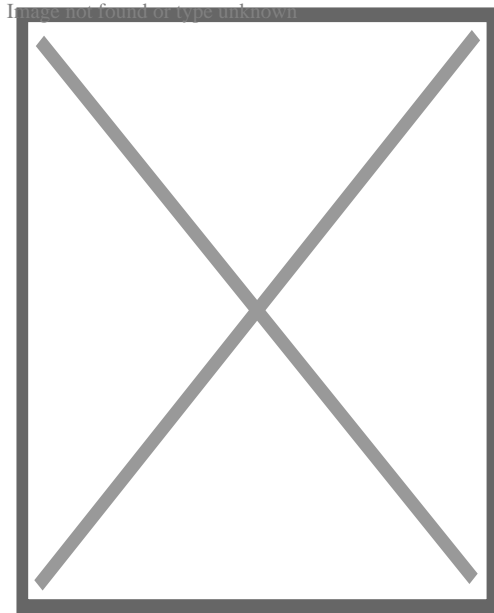
Economy	Construction GVA in 2018 (billions in USD)
(01)  China <small>Image not found or type unknown</small>	934.2
(02)  United States <small>Image not found or type unknown</small>	839.1
(03)  Japan <small>Image not found or type unknown</small>	275.5
(04)  India <small>Image not found or type unknown</small>	201.2
(05)  Germany <small>Image not found or type unknown</small>	180.5
(06)  United Kingdom <small>Image not found or type unknown</small>	154.7
(07)  France <small>Image not found or type unknown</small>	138.7

- (08)  **Canada** not found or type unknown 125.4
- (09)  **Russia** not found or type unknown 121.2
- (10)  **Australia** not found or type unknown 111.8
- (11)  **Indonesia** not found or type unknown 109.7
- (12)  **South Korea** not found or type unknown 93.0
- (13)  **Brazil** not found or type unknown 92.6
- (14)  **Mexico** not found or type unknown 89.0
- (15)  **Spain** not found or type unknown 80.0
- (16)  **Italy** not found or type unknown 78.9
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- (18)  **Saudi Arabia** not found or type unknown 40.2
- (19)  **Netherlands** not found or type unknown 39.5
- (20)  **Poland** not found or type unknown 39.4
- (21)  **Switzerland** not found or type unknown 36.3
- (22)  **United Arab Emirates** not found or type unknown 34.5
- (23)  **Sweden** not found or type unknown 33.3
- (24)  **Austria** not found or type unknown 27.2
- (25)  **Qatar** not found or type unknown 27.0

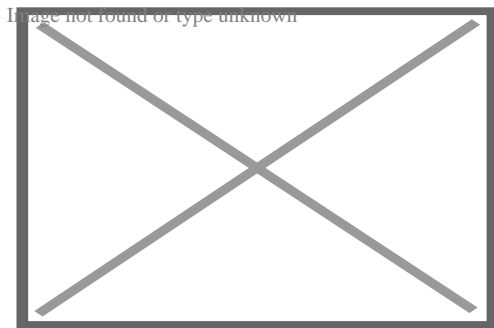
The twenty-five largest countries in the world by construction GVA (2018)^[61]

Employment

[edit]



Ironworkers erecting the steel frame of a new building at Massachusetts General Hospital in Boston



A truck operator at Al Gamil, the largest construction company in Djibouti

Some workers may be engaged in manual labour^[62] as unskilled or semi-skilled workers; they may be skilled tradespeople; or they may be supervisory or managerial personnel. Under safety legislation in the United Kingdom, for example, construction workers are defined as people "who work for or under the control of a contractor on a construction site";^[63] in Canada, this can include people whose work includes ensuring conformance with building codes and regulations, and those who supervise other workers.^[64]

Laborers comprise a large grouping in most national construction industries. In the United States, for example, in May 2023, the construction sector employed just over 7.9 million people, of whom 859,000 were laborers, while 3.7 million were construction trades workers (including 603,000 carpenters, 559,000 electricians, 385,000 plumbers, and 321,000 equipment operators).^[65] Like most business sectors, there is also substantial white-collar employment in construction - out of 7.9 million US construction sector workers, 681,000 were recorded by the United States Department of Labor in May 2023 as in 'office and administrative support occupations', 620,000 in 'management occupations' and 480,000 in 'business and financial operations occupations'.^[65]

Large-scale construction requires collaboration across multiple disciplines. A project manager normally manages the budget on the job, and a construction manager, design engineer, construction engineer or architect supervises it. Those involved with the design and execution must consider zoning requirements and legal issues, environmental impact of the project, scheduling, budgeting and bidding, construction site safety, availability and transportation of building materials, logistics, and inconvenience to the public, including those caused by construction delays.

Some models and policy-making organisations promote the engagement of local labour in construction projects as a means of tackling social exclusion and addressing skill shortages. In the UK, the Joseph Rowntree Foundation reported in 2000 on 25 projects which had aimed to offer training and employment opportunities for locally based school leavers and unemployed people.^[66] The Foundation published "a good practice resource book" in this regard at the same time.^[67] Use of local labour and local materials were specified for the construction of the Danish Storebaelt bridge, but there were legal issues which were challenged in court and addressed by the European Court of Justice in 1993. The court held that a contract condition requiring use of local labour and local materials was incompatible with EU treaty principles.^[68] Later UK guidance noted that social and employment clauses, where used, must be compatible with relevant EU regulation.^[69] Employment of local labour was identified as one of several social issues which could potentially be incorporated in a sustainable procurement approach, although the interdepartmental *Sustainable Procurement Group* recognised that "there is far less scope to incorporate [such] social issues in public procurement than is the case with environmental issues".^[70]

There are many routes to the different careers within the construction industry. There are three main tiers of construction workers based on educational background and training, which vary by country:

Unskilled and semi-skilled workers

[edit]

Unskilled and semi-skilled workers provide general site labor, often have few or no construction qualifications, and may receive basic site training.

Skilled tradespeople

[edit]

See also: List of construction trades

Skilled tradespeople have typically served apprenticeships (sometimes in labor unions) or received technical training; this group also includes on-site managers who possess extensive knowledge and experience in their craft or profession. Skilled manual occupations include carpenters, electricians, plumbers, ironworkers, heavy equipment operators and masons, as well as those involved in project management. In the UK these require further education qualifications, often in vocational subject areas, undertaken either directly after completing compulsory education or through "on the job" apprenticeships.^[71]

Professional, technical or managerial personnel

[edit]

Professional, technical and managerial personnel often have higher education qualifications, usually graduate degrees, and are trained to design and manage construction processes. These roles require more training as they demand greater technical knowledge, and involve more legal responsibility. Example roles (and qualification routes) include:

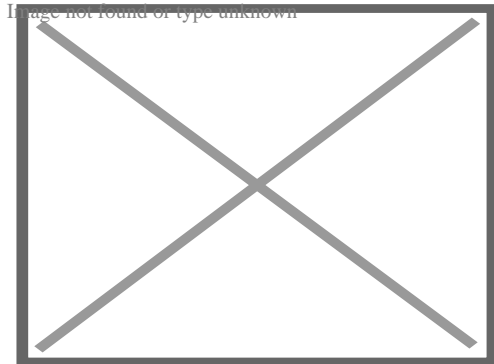
- Architect – Will usually have studied architecture to degree level, and then undertaken further study and gained professional experience. In many countries, the title of "architect" is protected by law, strictly limiting its use to qualified people.
- Civil engineer – Typically holds a degree in a related subject and may only be eligible for membership of a professional institution (such as the UK's ICE) following completion of additional training and experience. In some jurisdictions, a new university graduate must hold a master's degree to become chartered,^[a] and persons with bachelor's degrees may become Incorporated Engineers.
- Building services engineer – May also be referred to as an "M&E" or "mechanical, electrical, and plumbing (MEP) engineer" and typically holds a degree in mechanical or electrical engineering.^[a]
- Project manager – Typically holds a 4-year or greater higher education qualification, but are often also qualified in another field such as architecture, civil engineering or quantity surveying.
- Structural engineer – Typically holds a bachelor's or master's degree in structural engineering.^[a]

- Quantity surveyor – Typically holds a bachelor's degree in quantity surveying. UK chartered status is gained from the Royal Institution of Chartered Surveyors.

Safety

[edit]

See also: Construction site safety



At-risk workers without appropriate safety equipment

Construction is one of the most dangerous occupations in the world, incurring more occupational fatalities than any other sector in both the United States and in the European Union.^{[4][72]} In the US in 2019, 1,061, or about 20%, of worker fatalities in private industry occurred in construction.^[4] In 2017, more than a third of US construction fatalities (366 out of 971 total fatalities) were the result of falls;^[73] in the UK, half of the average 36 fatalities per annum over a five-year period to 2021 were attributed to falls from height.^[74] Proper safety equipment such as harnesses, hard hats and guardrails and procedures such as securing ladders and inspecting scaffolding can curtail the risk of occupational injuries in the construction industry.^[75] Other major causes of fatalities in the construction industry include electrocution, transportation accidents, and trench cave-ins.^[76]

Other safety risks for workers in construction include hearing loss due to high noise exposure, musculoskeletal injury, chemical exposure, and high levels of stress.^[77] Besides that, the high turnover of workers in construction industry imposes a huge challenge of accomplishing the restructuring of work practices in individual workplaces or with individual workers.^[citation needed] Construction has been identified by the National Institute for Occupational Safety and Health (NIOSH) as a priority industry sector in the National Occupational Research Agenda (NORA) to identify and provide intervention strategies regarding occupational health and safety issues.^{[78][79]} A study conducted in 2022 found “significant effect of air pollution exposure on construction-related injuries and fatalities”, especially with the exposure of nitrogen dioxide.^[80]

Sustainability

[edit]

Main article: Sustainability in construction

Sustainability is an aspect of "green building", defined by the United States Environmental Protection Agency (EPA) as "the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction."^[81]

Decarbonising construction

[edit]

The construction industry may require transformation at pace and at scale if it is to successfully contribute to achieving the target set out in The Paris Agreement of limiting global temperature rise to 1.5C above industrial levels.^[82]^[83] The World Green Building Council has stated the buildings and infrastructure around the world can reach 40% less embodied carbon emissions but that this can only be achieved through urgent transformation.^[84]^[85]

Conclusions from industry leaders have suggested that the net zero transformation is likely to be challenging for the construction industry, but it does present an opportunity. Action is demanded from governments, standards bodies, the construction sector, and the engineering profession to meet the decarbonising targets.^[86]

In 2021, the National Engineering Policy Centre published its report *Decarbonising Construction: Building a new net zero industry*,^[86] which outlined key areas to decarbonise the construction sector and the wider built environment. This report set out around 20 different recommendations to transform and decarbonise the construction sector, including recommendations for engineers, the construction industry and decision makers, plus outlined six-overarching 'system levers' where action taken now will result in rapid decarbonisation of the construction sector.^[86] These levels are:

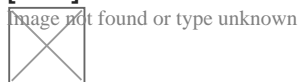
- Setting and stipulating progressive targets for carbon reduction
- Embedding quantitative whole-life carbon assessment into public procurement
- Increasing design efficiency, materials reuse and retrofit of buildings
- Improving whole-life carbon performance

- Improving skills for net zero
- Adopting a joined up, systems approach to decarbonisation across the construction sector and with other sectors

Progress is being made internationally to decarbonise the sector including improvements to sustainable procurement practice such as the CO2 performance ladder in the Netherlands and the Danish Partnership for Green Public Procurement.^{[87][88]} There are also now demonstrations of applying the principles of circular economy practices in practice such as Circl, ABN AMRO's sustainable pavilion and the Brighton Waste House.^{[89][90][91]}

See also

[edit]



Look up **construction** in Wiktionary, the free dictionary.

- Agile construction – Management system in the construction industry
- Building material – Material which is used for construction purposes
- Civil engineering – Engineering discipline focused on physical infrastructure
- Commissioning (construction) – Process to ensure that all building systems perform according to the "Design Intent"
- Environmental impact of concrete
- Impervious surface – Artificial structures such as pavements covered with water-tight materials
- Index of construction articles
- Land degradation – Gradual destruction of land
- List of tallest structures
- List of tallest structures built before the 20th century
- Modern methods of construction
- Outline of construction – Overview of and topical guide to construction
- Real estate development – Process that creates or renovates new or existing spaces
- Structural robustness – Ability of a structure to withstand physical strain
- Umarell – Bolognese slang term

icon

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Architecture portal

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Engineering portal

Notes

[edit]

- [^] **a b c** In the UK, the Chartered Engineer qualification is controlled by the Engineering Council, and is often achieved through membership of the relevant professional institution (ICE, CIBSE, IStructE, etc).

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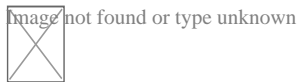
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Construction

Types

- Home construction
- Offshore construction
- Underground construction
 - Tunnel construction

History

- Architecture
- Construction
- Structural engineering
- Timeline of architecture
- Water supply and sanitation

Professions

- Architect
- Building engineer
- Building estimator
- Building officials
- Chartered Building Surveyor
- Civil engineer
- Civil estimator
- Clerk of works
- Project manager
- Quantity surveyor
- Site manager
- Structural engineer
- Superintendent
- Banksman
- Boilermaker
- Bricklayer
- Carpenter
- Concrete finisher
- Construction foreman
- Construction worker
- Electrician
- Glazier
- Ironworker
- Millwright
- Plasterer
- Plumber
- Roofer
- Steel fixer
- Welder

Trades workers (List)

	<ul style="list-style-type: none"> ○ American Institute of Constructors (AIC) ○ American Society of Civil Engineers (ASCE) ○ Asbestos Testing and Consultancy Association (ATAC) ○ Associated General Contractors of America (AGC) ○ Association of Plumbing and Heating Contractors (APHC) ○ Build UK ○ Construction History Society ○ Chartered Institution of Civil Engineering Surveyors (CICES) ○ Chartered Institute of Plumbing and Heating Engineering (CIPHE) ○ Civil Engineering Contractors Association (CECA) ○ The Concrete Society ○ Construction Management Association of America (CMAA) ○ Construction Specifications Institute (CSI)
Organizations	<ul style="list-style-type: none"> ○ FIDIC ○ Home Builders Federation (HBF) ○ Lighting Association ○ National Association of Home Builders (NAHB) ○ National Association of Women in Construction (NAWIC) ○ National Fire Protection Association (NFPA) ○ National Kitchen & Bath Association (NKBA) ○ National Railroad Construction and Maintenance Association (NRC) ○ National Tile Contractors Association (NTCA) ○ Railway Tie Association (RTA) ○ Royal Institution of Chartered Surveyors (RICS) ○ Scottish Building Federation (SBF) ○ Society of Construction Arbitrators
By country	<ul style="list-style-type: none"> ○ India ○ Iran ○ Japan ○ Romania ○ Turkey ○ United Kingdom ○ United States
Regulation	<ul style="list-style-type: none"> ○ Building code ○ Construction law ○ Site safety ○ Zoning

- Style
 - List
 - Industrial architecture
 - British
- Architecture**
 - Indigenous architecture
 - Interior architecture
 - Landscape architecture
 - Vernacular architecture
 - Architectural engineering
 - Building services engineering
 - Civil engineering
 - Coastal engineering
 - Construction engineering
 - Structural engineering
- Engineering**
 - Earthquake engineering
 - Environmental engineering
 - Geotechnical engineering
 - List
- Methods**
 - Earthbag construction
 - Modern methods of construction
 - Monocrete construction
 - Slip forming

Other topics

- Building material
 - List of building materials
 - Millwork
- Construction bidding
- Construction delay
- Construction equipment theft
- Construction loan
- Construction management
- Construction waste
- Demolition
- Design–build
- Design–bid–build
- DfMA
- Heavy equipment
- Interior design
- Lists of buildings and structures
- Megaproject
- Megastructure
- Plasterwork
 - Damp
 - Proofing
 - Parge coat
 - Roughcast
 - Harling
- Real estate development
- Stonemasonry
- Sustainability in construction
- Unfinished building
- Urban design
- Urban planning

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Construction industry by country

- Canada
- India
- Iran
- Japan
- Hong Kong SAR
- Romania
- United Kingdom
- United States

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Tallest buildings and structures

- By category

- By region**
- Africa
 - Asia
 - Indian subcontinent
 - Southeast
 - Europe
 - Balkans
 - Baltic states
 - Scandinavia
 - Oceania
 - Southern Hemisphere
 - The Americas
 - North America
 - Central America
 - Latin America
 - South America
 - Afghanistan
 - Albania
 - Algeria
 - Argentina
 - Australia
 - Austria
 - Azerbaijan
 - Bangladesh
 - Bolivia
 - Bosnia and Herzegovina
 - Brazil
 - Bulgaria
 - Cambodia
 - Canada
 - Chile
 - China (Hong Kong, Macau)
 - Colombia
 - Croatia
 - Cyprus
 - Czech Republic
 - Denmark
 - Ecuador
 - Egypt
 - Estonia
 - Finland
 - France
 - Georgia
 - Germany
 - Greece
 - Iceland
 - India
 - Indonesia
 - Iran

By region

- Africa
- Asia
 - Indian subcontinent
 - West Asia
- Europe
 - former Soviet Union
- The Americas
 - South America

- Afghanistan
- Albania
- Algeria
- Armenia
- Australia
- Austria
- Bahrain
- Belgium
- Bulgaria
- Canada
- China
- Czech Republic
- Denmark
- Egypt
- Estonia
- Finland
- France
- Germany
- Greece
- Hungary
- Iceland
- India
- Indonesia
- Iran
- Ireland
- Italy

By country

- Japan
- Kosovo
- Luxembourg
- Myanmar
- Netherlands
- New Zealand
- Norway
- Philippines
- Poland
- Portugal
- Romania
- Saudi Arabia
- Serbia
- Slovakia

**Structures
of any type
(History)**

Related topics

- Air traffic obstacle
- Antenna height considerations
- Architectural engineering
- Construction
- Fires
- Groundscraper
- Guyed mast
- Height restriction laws
- Skyscraper
 - Early skyscrapers
 - Skyscraper Index
- Storey
- Tower block
- Vanity height

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