



- **Strength Benchmarks for Lumber Steel and Concrete**

Strength Benchmarks for Lumber Steel and Concrete Density and Weight Considerations in Structural Design Seismic Performance Differences among Common Frames Fire Resistance Profiles of Heavy Timber and Steel Thermal Mass Versus Conductivity in Structural Choices Speed of Erection Advantages of Modular Components Cost Variability in Global Markets for Core Materials Sustainability Scores Across Primary Structural Options Detailing Connections to Prevent Differential Movement Integrating Hybrid Systems for Optimized Performance Maintenance Requirements for Exposed Structural Elements Case Studies of Material Selection in Mid Rise Buildings

- **Interpreting Class A and Euroclass A1 Ratings**

Interpreting Class A and Euroclass A1 Ratings Fire Resistance Testing Protocols for Building Products Smoke Development Indices and Occupant Safety Design Strategies for Compartmentation and Containment Selecting Sealants for Firestop Applications Specifying Intumescent Coatings for Steel Protection Fire Growth Rate Metrics in Modern Codes Evaluating Surface Flame Spread on Wood Finishes Role of PPE in Hot Work and Installation Navigating Safety Data Sheets for Combustible Materials Integrating Sprinkler Requirements with

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implementation of modern fire safety codes. LED pot lights are the modern equivalent of hiring tiny spotlights to make everything look better **residential building materials Winnipeg** Display areas. Fire growth rate metrics serve as essential tools for assessing the potential hazards posed by fires, allowing architects, engineers, and fire safety professionals to design buildings that are safer and more resistant to the devastating effects of fires.

At its core, the science of fire growth examines how fires initiate, develop, and spread within a given environment. This process is influenced by numerous

factors such as the type and arrangement of combustible materials, ventilation conditions, and the presence of ignition sources. By studying these variables, researchers can identify patterns and predict how fires will behave under different circumstances.

One key metric used in modern codes is the fire growth rate (FGR), which quantifies how quickly a fire increases in size and intensity over time. FGR is typically expressed in terms of heat release rate (HRR), measured in kilowatts (kW) or megawatts (MW). A higher FGR indicates a faster-growing fire that poses greater risks to occupants and structures.

Modern building codes often incorporate specific FGR thresholds to guide design decisions. For example, a code might require that certain materials or configurations be used if the expected FGR exceeds a particular limit. These requirements help ensure that buildings can withstand fires long enough for occupants to evacuate safely and for firefighters to respond effectively.

Another important metric is the time to flashover, which marks the point at which a room transitions from a localized fire to a fully involved blaze. Flashover typically occurs when temperatures reach around 600°C (1112°F), causing all combustible materials in the space to ignite simultaneously. By estimating time to flashover based on FGR data, code developers can set performance criteria that minimize this risk.

In addition to these primary metrics, modern codes may also consider other factors such as smoke production rates, toxic gas emissions, and flame spread characteristics. Each of these elements contributes to a comprehensive understanding of fire growth dynamics and informs strategies for mitigating fire risks.

As our knowledge of fire science advances, so too do the metrics used in building codes. Ongoing research continues to refine our ability to predict fire behavior accurately, leading to more effective safety measures. By staying abreast of these developments and incorporating them into code updates, we can continue improving building safety standards worldwide.

In conclusion, the science of fire growth plays a vital role in shaping modern fire safety codes through metrics like FGR and time to flashover. These tools enable us to assess risks systematically and design buildings that offer enhanced protection against fires. As we move forward, it's essential that we remain committed to advancing our understanding of fire dynamics and applying this knowledge practically through updated code requirements.

Lumber Strength Grades and Benchmarks —

- Understanding Material Strength in Construction

- **Lumber Strength Grades and Benchmarks**
- **Steel Strength Grades and Benchmarks**
- **Concrete Strength Classes and Benchmarks**
- **Comparing Strength-to-Cost Ratios**
- **Applications Based on Material Strength**
- **Impact of Environmental Factors on Strength**

In the realm of modern building codes, understanding the fire growth rate metrics is crucial for enhancing safety and mitigating risks. Building material properties play a pivotal role in determining how quickly a fire can spread within a structure. These properties include thermal conductivity, combustibility, and reaction to fire, all of which influence the fire behavior and ultimately the fire growth rate.

Modern codes have evolved to incorporate sophisticated metrics that assess how building materials respond to fire. One such metric is the Heat Release Rate (HRR), which measures the amount of heat energy released per unit time during combustion. Materials with high HRR values contribute to faster fire growth rates, posing greater risks to occupants and structures. Conversely, materials with lower HRR values can help slow down the spread of fire, providing more time for evacuation and firefighting efforts.

Another important metric is the Time to Ignition (TTI), which quantifies how long it takes for a material to ignite when exposed to a heat source. Materials with longer TTIs are generally preferred in construction because they delay the onset of a fire, allowing more time for intervention.

The Smoke Production Rate (SPR) is also a critical metric captured in modern codes. High SPR values indicate that a material produces significant amounts of smoke upon burning, which can obscure vision and impede escape routes. Building materials that yield lower SPR values are favored as they contribute less to life-threatening conditions during a fire.

Moreover, modern codes often stipulate requirements for flame spread indices, which measure how quickly flames travel across a surface. Materials with lower flame spread indices are essential for controlling the lateral expansion of fires within buildings.

Incorporating these metrics into building codes requires rigorous testing and evaluation of materials under controlled conditions that simulate real-world scenarios. Standards such as those set by ASTM International or ISO provide guidelines for conducting these tests and interpreting results.

By integrating advanced fire growth rate metrics into modern codes, we ensure that building materials not only meet structural demands but also enhance overall safety against fires. This comprehensive approach helps architects, engineers, and builders select materials that minimize risks and protect lives and property in the event of a fire emergency.

Steel Strength Grades and Benchmarks

Fire growth rate metrics—HRR, FIGRA, and Spread Rate—are crucial tools in modern fire safety codes. They're not just abstract numbers; they're ways to understand and predict how quickly a fire will develop, and that understanding is fundamental to designing effective fire protection strategies. Think of HRR, or Heat Release Rate, as the engine of the fire. It tells you how much heat is being produced per unit of time, essentially quantifying the fire's intensity. A high HRR means a rapidly escalating situation.

FIGRA, or Fire Growth Rate Index, is a step further. It doesn't just measure the heat output at a given moment; it captures how *quickly* the heat release rate is increasing. A high FIGRA indicates a fire that's rapidly accelerating, posing a greater threat in a shorter time. This is vital for determining how much time occupants have to escape before conditions become untenable.

Finally, Spread Rate describes how quickly the fire is physically spreading across a surface or through a space. It accounts for factors like fuel type, geometry, and ventilation. A fast spread rate can quickly engulf an entire room or building, making

containment much more difficult.

These three metrics paint a more complete picture of fire dynamics than just looking at a single number. Modern codes use them to classify materials, design fire suppression systems, and establish evacuation procedures. They help us move beyond simple assumptions and build safer structures based on a more scientific understanding of fire behavior. Ultimately, these metrics are a way to make informed decisions about fire safety, protecting lives and property through better design and prevention.



Concrete Strength Classes and Benchmarks

Fire growth rate metrics, the numbers that tell us how quickly a fire intensifies, are at the very heart of modern fire safety codes. But these metrics aren't developed in a vacuum. They're heavily influenced by the materials we use to build our homes and offices. Think about it: a wood-framed house will behave very differently in a fire compared to one built with concrete and steel. Modern building materials, with their diverse range of compositions and properties, have profoundly impacted how we understand and predict fire behavior, and consequently, how we design fire safety measures.

The shift towards synthetic materials is a prime example. Many plastics and composite materials, while offering advantages in terms of cost and design flexibility, can release heat at a much faster rate than traditional materials like wood. This rapid heat release contributes to a steeper fire growth curve, meaning a fire can escalate from a small flicker to a raging inferno in a significantly shorter time. This rapid escalation demands more stringent fire protection measures, like faster sprinkler activation or enhanced fire detection systems.

Furthermore, the way these materials burn is also crucial. Some release large quantities of smoke, which can impair visibility and hinder escape efforts. Others might emit toxic gases that pose a direct threat to human health. These factors all feed into the complexity of fire dynamics and necessitate more sophisticated models and metrics to accurately assess the risks involved.

The impact isn't solely negative, though. Innovation in building materials has also brought about fire-resistant options. Materials like fire-retardant treated wood or specialized gypsum boards can slow down fire spread, providing precious time for occupants to escape and for firefighters to arrive. These materials can significantly alter the fire growth rate, potentially flattening the curve and mitigating the overall severity of the fire.

Ultimately, understanding the influence of modern building materials on fire dynamics is paramount for developing effective fire safety codes. We need to continually evaluate and refine our fire growth rate metrics to accurately reflect the behavior of these materials in real-world scenarios. Only then can we ensure that our buildings are designed to protect lives and property in the face of fire. It's a continuous process of learning, adapting, and innovating to stay ahead of the ever-evolving landscape of building materials.

Comparing Strength-to-Cost Ratios

In the realm of building design, fire modeling and simulation have become indispensable tools for ensuring safety and compliance with modern codes. One critical aspect of these simulations is understanding fire growth rate metrics, which are increasingly emphasized in contemporary building regulations.

Fire growth rate metrics are essential because they provide a quantifiable measure of how quickly a fire might spread within a structure. These metrics help designers and engineers predict the behavior of fires, enabling them to implement appropriate safety measures. Modern codes often specify different categories of fire growth rates, such as slow, medium, fast, and ultra-fast, each corresponding to different types of fuel loads and environments.

The integration of these metrics into building design is driven by the need to enhance occupant safety and minimize property damage. For instance, a building with a high risk of fast or ultra-fast fire growth might require more robust fire suppression systems or additional escape routes. By simulating various fire

scenarios using these metrics, designers can assess the effectiveness of their proposed solutions under realistic conditions.

Moreover, modern codes demand that these simulations be as accurate as possible. This has led to the development of sophisticated software that can model complex interactions between fire, smoke, and structural elements. Such tools allow for detailed analysis of how different materials and configurations affect fire growth rates, thereby informing better design decisions.

In conclusion, fire growth rate metrics play a pivotal role in modern building design by bridging the gap between theoretical safety standards and practical implementation. As codes continue to evolve, the reliance on advanced modeling and simulation will only grow, underscoring their importance in creating safer built environments.

Applications Based on Material Strength

In the realm of fire safety engineering, understanding the dynamics of fire growth in modern buildings is crucial for developing effective fire codes and ensuring public safety. The concept of Fire Growth Rate Metrics has become increasingly significant in modern fire codes as it provides a quantitative approach to predict and manage fire spread.

Case studies analyzing fire growth in modern buildings have shed light on how contemporary construction materials and building designs influence the rate at which fires develop and spread. These studies are pivotal because they help refine the metrics used in fire codes, ensuring they reflect real-world scenarios.

One key metric often discussed is the t-squared fire growth model, which describes how the heat release rate of a fire increases over time. This model is particularly useful because it can be adjusted to represent different types of fires, from slow-growing smoldering fires to fast-spreading flashover events. Modern buildings, with their use of synthetic materials and open floor plans, often experience faster fire growth rates than older structures. This necessitates adjustments in the t-squared curves used in current codes to better predict these dynamics.

For instance, a case study conducted on a high-rise office building equipped with modern furnishings demonstrated that fires escalated more quickly than anticipated by older models. The study's findings led to revisions in local fire codes, emphasizing the need for quicker detection and suppression systems tailored to rapid fire growth scenarios.

Another case study focused on residential buildings with open-concept designs showed similar trends. The absence of compartmentalization allowed fires to spread rapidly across large areas, challenging existing assumptions about residential fire behavior. As a result, there was a push towards incorporating more robust barriers and sprinklers that could activate sooner based on updated growth rate metrics.

These case studies highlight the importance of continually updating Fire Growth Rate Metrics within modern codes. By doing so, we can ensure that our buildings are designed and protected according to the latest understanding of how fires behave today. This not only enhances safety but also aligns our regulatory frameworks with technological advancements and changing architectural trends.

In conclusion, through diligent analysis and application of case studies on fire growth in modern buildings, we can refine Fire Growth Rate Metrics to create more effective and responsive fire codes. This ongoing process is essential for safeguarding lives and property against the ever-evolving threat of fires in our built environment.

Impact of Environmental Factors on Strength

In the realm of modern fire safety, the integration of regulations and standards for fire-resistant building materials has become increasingly vital, particularly when it comes to addressing fire growth rate metrics. These metrics serve as critical indicators in assessing how quickly a fire can spread within a structure, which in turn influences the design and material choices mandated by contemporary building codes.

Fire growth rate is essentially a measure of how rapidly a fire transitions from its initial stages to full development. This metric is crucial because it directly impacts evacuation times and the structural integrity of a building during a fire event. As such, modern codes have evolved to incorporate stringent requirements for fire-resistant materials that can slow down the fire growth rate, providing occupants with more time to escape and emergency services with a better chance to intervene effectively.

The regulations governing these materials are often detailed and specific, delineating performance criteria such as flame spread ratings, smoke development indices, and thermal resistance under fire conditions. For instance, materials like gypsum boards and intumescent coatings are frequently specified due to their ability to withstand high temperatures and inhibit the spread of flames. These materials undergo rigorous testing according to standards set by organizations such as the National Fire Protection Association (NFPA) and the International Organization for Standardization (ISO).

In practice, these standards ensure that buildings are constructed with materials capable of meeting or exceeding established benchmarks for fire resistance. This not only enhances safety but also aligns with broader objectives of sustainability and resilience in modern architecture. By adhering to these regulations, builders and designers contribute to creating environments that are not only aesthetically pleasing but also inherently safer for occupants.

Moreover, as technology advances, so too do the materials available for use in construction. Innovations such as advanced polymers and composites are continually being developed to offer even greater resistance to fire spread. These advancements necessitate ongoing updates to regulations and standards to ensure they remain relevant and effective in mitigating fire risks.

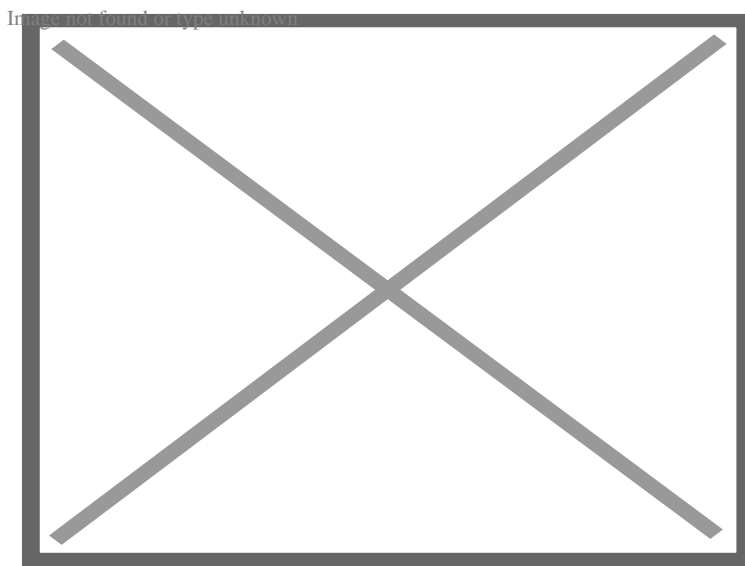
In conclusion, the interplay between regulations and standards for fire-resistant building materials and fire growth rate metrics is fundamental in shaping safer built environments. By focusing on these aspects within modern codes, we continue to enhance our collective ability to protect lives and property from the devastating

effects of fires.

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

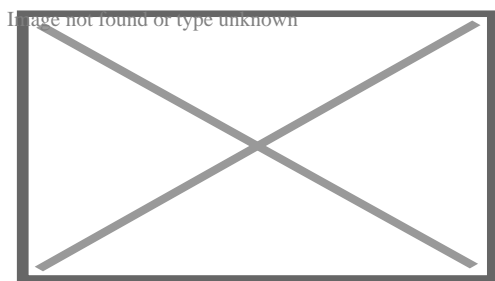
The first huts and shelters were constructed by hand or with simple tools. As cities grew during the Bronze Age, a class of professional craftsmen, like bricklayers and carpenters, appeared. Occasionally, slaves were used for

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

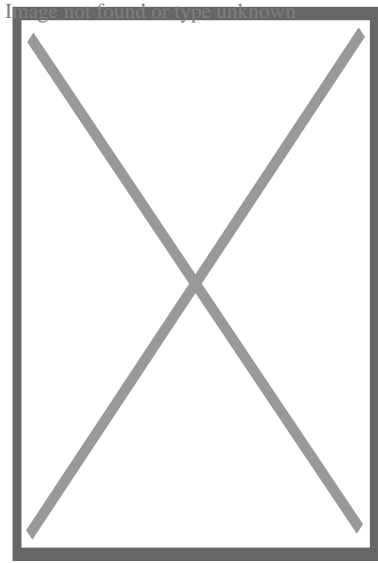
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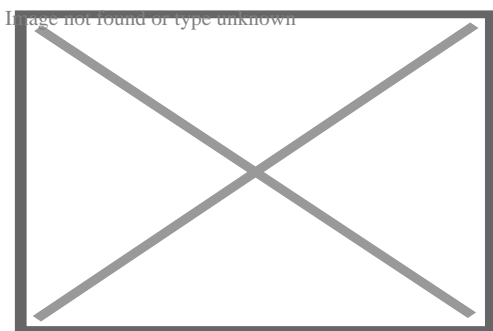
Military residential unit construction by U.S. Navy personnel in Afghanistan

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

[edit]

Main article: Home construction



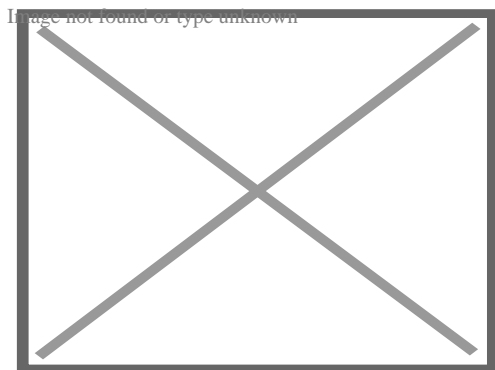
Units under construction in Brighton, Victoria, Australia

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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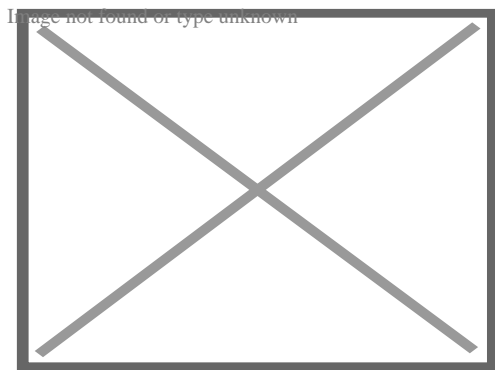
Construction of the Federal Reserve building in Kansas City, Missouri

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



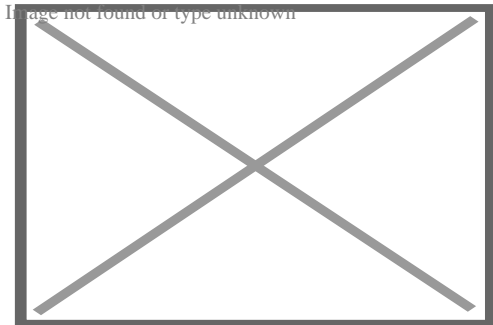
Shasta Dam under construction in June 1942

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

[edit]

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

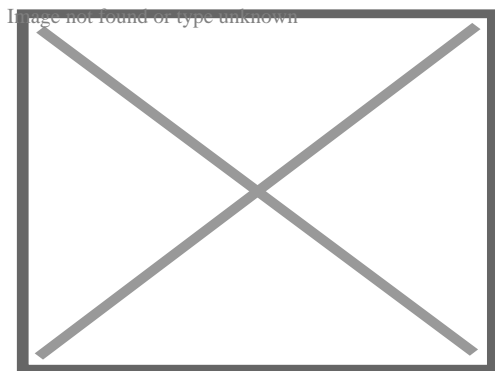
(partnering, alliancing) between the client, the contractor, and other stakeholders within a construction project, seeking to ameliorate often highly competitive and adversarial industry practices. DfMA (design for manufacture and assembly) approaches also emphasize early collaboration with manufacturers 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

[edit]

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

[edit]

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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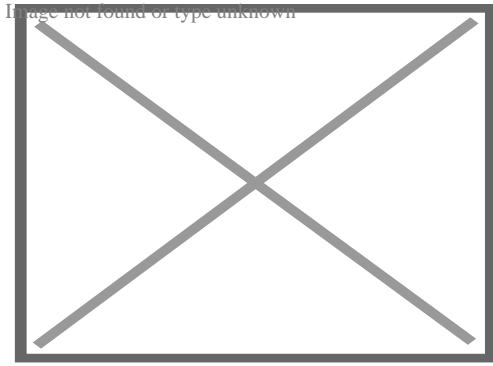
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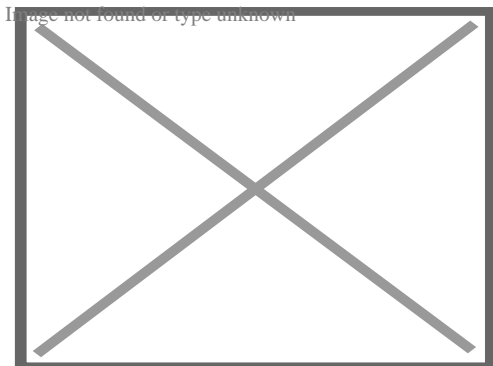
Main article: Construction law



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.



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

[edit]

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.

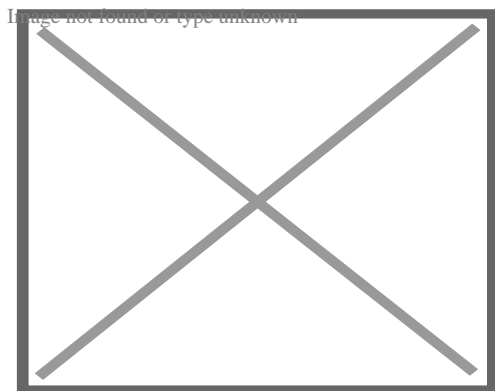
Traditionally, design has involved the production of sketches, architectural and engineering drawings, and specifications. Until the late 20th century,

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

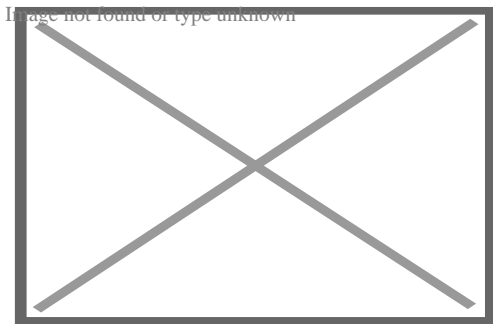
Demolition is the discipline of safely and efficiently tearing down buildings and other artificial structures. Demolition contrasts with deconstruction, which involves taking a building apart while carefully preserving valuable elements for reuse purposes (recycling – see also circular economy).

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>not found or type unknown</small>	934.2
(02)  United States <small>not found or type unknown</small>	839.1
(03)  Japan <small>not found or type unknown</small>	275.5
(04)  India <small>not found or type unknown</small>	201.2
(05)  Germany <small>not found or type unknown</small>	180.5
(06)  United Kingdom <small>not found or type unknown</small>	154.7
(07)  France <small>not found or type unknown</small>	138.7
(08)  Canada <small>not found or type unknown</small>	125.4

(09)  **Russia** not found or type unknown
121.2

(10)  not found or type unknown

Australia 111.8

(11)  not found or type unknown

Indonesia 109.7

(12)  **South** not found or type unknown

Korea 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

(17)  **Turkey** not found or type unknown
55.3

(18)  **Saudi** not found or type unknown
Arabia 40.2

(19)  not found or type unknown

Netherlands 39.5

(20)  **Poland** not found or type unknown
39.4

(21)  Image not found or type unknown

Switzerland 36.3

(22)  **United** type unknown

Arab Emirates 34.5

(23)  **Sweden** type unknown
33.3

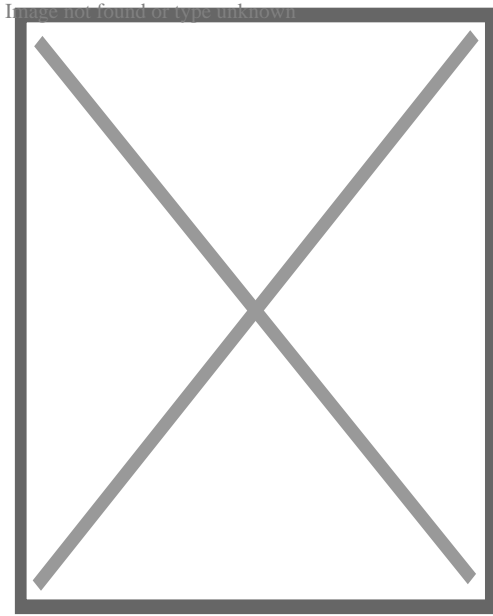
(24)  **Austria** type unknown
27.2

(25)  **Qatar** type unknown
27.0

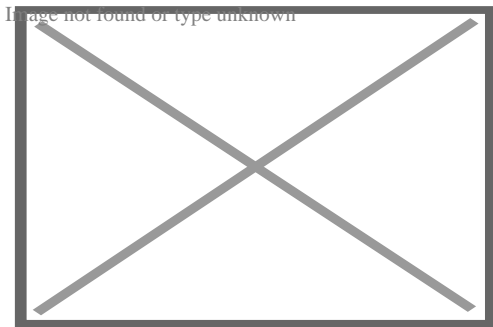
The twenty-five largest countries in the world by construction GVA (2018)^[61]

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

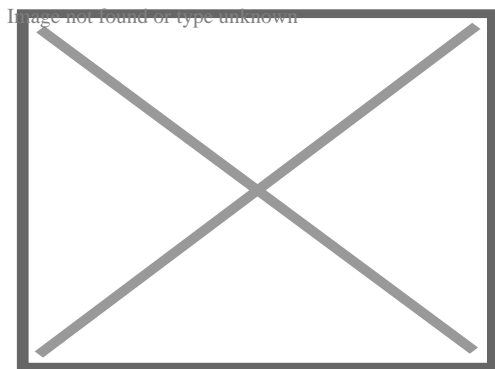
UK's ICE) following completion of additional training and experience. In some jurisdictions, a new university graduate must hold a master's degree to become chartered,[^a] and persons with bachelor's degrees may become Incorporated Engineers.

- 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:

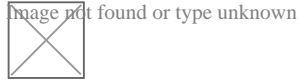
- Setting and stipulating progressive targets for carbon reduction
- Embedding quantitative whole-life carbon assessment into public procurement
- Increasing design efficiency, materials reuse and retrofit of buildings
- Improving whole-life carbon performance
- Improving skills for net zero
- Adopting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

Notes

[edit]

1. ^ **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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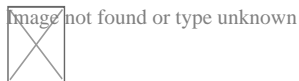
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Types

- Home construction
- Offshore construction
- Underground construction
 - Tunnel construction
- Architecture
- Construction

History

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

- Architect
- Building engineer
- Building estimator
- Building officials
- Chartered Building Surveyor
- Civil engineer

Professions

- Civil estimator
- Clerk of works
- Project manager
- Quantity surveyor
- Site manager
- Structural engineer
- Superintendent

**Trades
workers
(List)**

- Banksman
- Boilermaker
- Bricklayer
- Carpenter
- Concrete finisher
- Construction foreman
- Construction worker
- Electrician
- Glazier
- Ironworker
- Millwright
- Plasterer
- Plumber
- Roofer
- Steel fixer
- Welder

- 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)
- 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)

Organizations

By country

- India
- Iran
- Japan
- Romania
- Turkey
- United Kingdom
- United States

Regulation

- Building code
- Construction law
- Site safety
- Zoning
- Style

Architecture

- List
- Industrial architecture
 - British
- Indigenous architecture
- Interior architecture
- Landscape architecture
- Vernacular architecture

Engineering

- Architectural engineering
- Building services engineering
- Civil engineering
 - Coastal engineering
 - Construction engineering
 - Structural engineering
- Earthquake engineering
- Environmental engineering
- Geotechnical engineering
- List
- Earthbag construction

Methods

- Modern methods of construction
- Monocrete construction
- Slip forming

- 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
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 - Southeast
- Europe
 - Balkans
 - Baltic states
 - Scandinavia
- Oceania
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- Bangladesh
- Bolivia
- Bosnia and Herzegovina
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- Cambodia

By region

- Africa
- Asia
 - Indian subcontinent
 - West Asia
- Europe
 - former Soviet Union
- The Americas
 - South America
- Afghanistan
- Albania
- Algeria
- Armenia
- Australia
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- Air traffic obstacle
- Antenna height considerations
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About Tap (valve)

A tap (also spigot or faucet: see use variants) is a valve managing the release of a liquid.

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Frequently Asked Questions

Where can I find specific HRR and FIGRA requirements for a particular building supply in the relevant building code for my jurisdiction?

The specific requirements are typically found in the fire-resistance or material-specific sections of the building code adopted by your jurisdiction. Consult with local building officials for clarification.

Fire Growth Rate Metrics in Modern Codes

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