AURAVANA PROJECT

PROJECT FOR A COMMUNITY-TYPE SOCIETY

The Habitat System

SSS-MS-HS-002 | May 2024

SOCIETAL SPECIFICATION STANDARD

aurvana.org

THE AURAVANA PROJECT

SOCIETAL SPECIFICATION STANDARD
THE HABITAT SYSTEM

Document Reference Identifier: SSS-MS-HS-002

Date of Document Distribution: May 2024

aurava.org

To cite this publication:
- *The Habitat System.* (2024). Auravana Project, Societal Specification Standard, SSS-MS-HS-002. [auravana.org]

To cite an article in this publication *(authors and article title will change)***:**
- Grant, T.A. (2024). *The Habitat System Overview*. The Habitat System. Auravana Project, Societal Specification Standard, SSS-MS-HS-002. [auravana.org]

ISBN:

auravana.org

GREETINGS

In an effort to provide the greatest possible clarity and value the Auravana Project has formatted the system for the proposed society (of the type, 'community') **into a series of standard publications. Each standard is both a component of the total, unified system, as well as intended to be a basis for deep reflective consideration of one's own community, or lack thereof. These formal standards are "living" in that they are continually edited and updated as new information becomes available; the society is not ever established, its design and situational operation exists in an emergent state, for it evolves, as we evolve, necessarily for our survival and flourishing.**

Together, the standards represent a replicable, scalable, and comprehensively "useful" model for the design of a society where all individual human requirements are mutually and optimally fulfilled.

The information contained within these standards represent a potential solution to the issues universally plaguing humankind, and could possibly bring about one of the greatest revolutions in living and learning in our modern time. Change on the scale that is needed can only be realized when people see and experience a better way. The purpose of the Auravana Project is to design, to create, and to sustain a more fulfilling life experience for everyone, by facilitating the realization of a better way of living.

Cooperation and learning are an integral part of what it means to be a conscious individual human. A community-type societal environment has been designed to nurture and support the understanding and experience of this valuable orientation.

The design for a community-type society provides an entirely different way of looking at the nature of life, learning, work, and human interaction. These societal standards seek to maintain an essential alignment with humankind's evolving understandings of itself, combining the world of which humans are a regenerative part, with, the optimal that can be realized for all of humanity, given what is known.

The general vision for this form of society is an urgent one considering the myriad of perceptible global societal crises. Together, we can create the next generation of regenerative and fulfilling living environments. Together, we can create a global societal-level community.

THE UNIFIED SOCIETAL SYSTEM: MATERIAL SPECIFICATION STANDARD

This publication is one of six representing the proposed standard operation of a type of society given the category name, 'community' (a community-type society). This document is a specification standard for a material system.

Every society is composed of a set of core systems. Different types of societies have different internal compositions of these systems. The composition of these systems determines the type of society. The type of society described by the Auravana Project societal standard is a, community-type society. The standard is a composition of sub-system standards. The Auravana societal standard may be used to construct and duplicate community at the global level.

For any given society, there are four primary societal sub-systems. Each of these sub-systems can be specified and standardized (described and explained); each sub-system is a standard within a whole societal specification standard. The first four primary standards of the six total standards are: a Social System; a Decision System; a Material System; and a Lifestyle System. Each standard is given the name of its information system. The fifth publication is a Project Plan, and the sixth is an Overview of the whole societal system. Together, these standards are used to classify information about society, identify current and potential configurations, and operate an actual configuration. Because of the size of some of these standards, they may be split into two or more publications.

Essential figures and tables related to this standard exist beyond what is shown in this document.

Figures and tables on the website are named according to their placement in the standard.

- Those figures that could not be accommodated here are readily accessible in their full size, and if applicable, in color, on the Auravana Project's website [auravana.org/standards/figures].
- Those tables that are too large to include in this document are referenced with each standard on the Auravana Project's website [auravana.org/standards].

Articles

Article Section Headings

Contents

List of figures

This is the list of figures within this document.
There are more figures associated with this standard than are identified in this document; those figures that could not fit are freely available through auravana.org, in full size, and if applicable, color.

List of tables

This is the list of tables within this document.
There are more tables associated with this standard than are identified in this document; those tables that could not fit are freely available via the project's website.

Document Revision History

A.k.a., Version history, change log.

This document is updated as new information becomes available.
The following information is used to control and track modifications (transformations, changes) to this document.
Only the current version, and one prior, are detailed below:

VERSION	REVISION DATE	SUMMARY (DESCRIPTION)
002	May 2024	Significant changes to every article have been made throughout this document. This document, now, only contains the list of habitat service sub-systems. A food service system has been added. Citations have been improved throughout and are now at APA 7th generation.

GENERATION ON	NAME	CONTACT DETAIL
May 2024	Travis A. Grant	trvsgrant@gmail.com

Life Support: Architecture Service System

Travis A. Grant,

Affiliation contacts: *trvsgrant@gmail.com*

Version Accepted: 1 April 2024

Acceptance Event: *Project coordinator acceptance*

Last Working Integration Point: *Project coordinator integration*

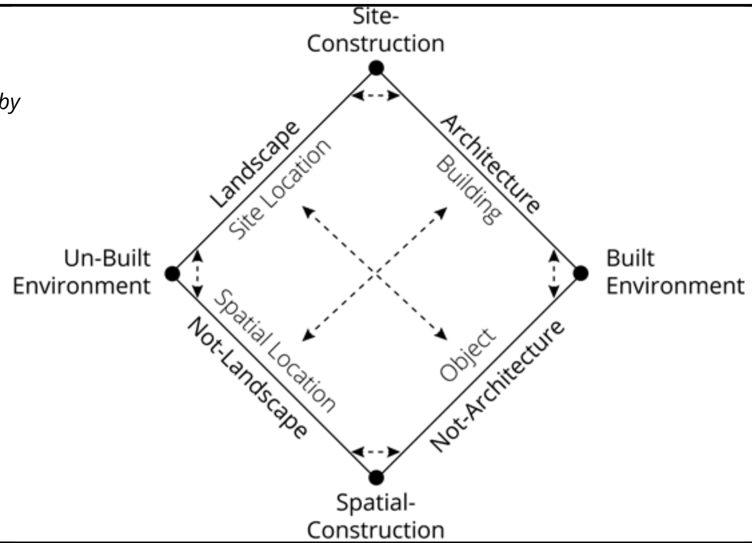
Keywords: architecture, structure, suprastructure, buildings, built environment, architectural engineering and construction (AEC)

Abstract

There are several different common names for that which has been engineered to separate humans and their objects from external environmental influences. The name given to the results of this process is varied, and often, discipline dependent. Most simply, the name given to any such deliverable could be "structure" - something created on land or some other platform used to contain ("house") humans and selected objects, to shelter humans and their work. The fundamental purpose of any structure is to control the separation of two objects. Other names for a structure include, infrastructure, architecture, buildings, and clothing *(these are all structures)*. Structures can be on a physical individual's person, such as clothing. Structures can be positioned on and in land, on and in water, on and in the Earth's atmosphere, and in space. Most structures are buildings and clothing. Inside building structures are a sub-structures called a room. Buildings (structures) can consist of one or more rooms. Some structures are not buildings, for instance, clothing. Some structures are not clothing or buildings, per say, but are containers of objects with useful function (for example, a light post or radar array). Technically these structures are still buildings; they are just buildings designed to "house" technology and not humans. Similarly, there are structures used (interacted with) directly by humans, such as merry-go-rounds and boats. There is also the possibility of structures with purely aesthetic (Read: look and/ or feel) function and no ability to contain other objects.

Graphical Abstract

Figure 1. *The architectural representation of a structure on a landscape or other platform for use by humans or having some other function.*



1 Architectural service overview

A.k.a., Architectural engineering, architectural-engineering, architectural engineering and construction (AEC), enclosure service.

NOTE: *Architecture is the most interconnected habitat service system because architectural constructions include and contain many, if not all, of the other habitat service systems; because, all architecture is enclosure, and most other habitat services need the service of enclosure.*

Architecture is the designing, building, and operating of human and/or machine utilized, generally static, structures on land (a.k.a., shelter construction and operation); however, there are related architectural constructions (shelters) that are not land based. Architecture is any built structure that occupies space on land, water, or in space, including occupying the volume of organisms (Read: clothing). Shelter includes buildings and clothing, including shoes and hats, which are also a form of sheltering. More simplistically, architecture is both the process and the product of planning, designing, and constructing buildings and other physical structures, and clothing, into the physical environment. It refers to the materially built environment and necessarily involves mathematics and engineering. Another possible definition is based on enclosure -- architecture is a sturdy enclosure. If a person or object can go inside of a structure, then it is considered architecture. In this sense, architecture is the reordering (reorganization) of the material environment to produce and operate enclosures for biological life and machines. It is relevant to note here that the most generalized use of the term 'architecture' is used to refer to the design of a structure. A ‘design’ is a set of relationships that form a constructable and functional object or service, which necessarily has a structure. In other words, a ‘design’ is a description of a construction, which may or may not have been constructed. When expressed materially, architecture becomes the spatial structures we use to contain objects and pass time within. Architecture is the physical structures, both permanent and impermanent, which are created into the habitat's landscape (or oceanscape/spacescape) for any period of time. Therein, an architectural space is the void between physical boundaries of the enclosures where its existence is independent of the user’s presence. In a design sense, architecture is a communicable representation of that which has been constructed or could be constructed into the "built" environment, and is not, a device. In its physical application, architecture becomes the integration of structures, materials, and construction technology. Architecture (or, architectural structures) are human-made constructions simultaneously driven by functional, engineering, and often, aesthetic considerations (Read: feeling and beauty). Most architecture is an expression of function and aesthetics -- an architectural space exists is to meet both (often) physical and psychological needs.

The design of structures (i.e., when doing “architecture”) involves working with elements that are put together to accomplish a life-orienting function - the use of structure to control for environmental variables in a given space. Architectural structures must satisfy the needs and aesthetics of their users. They must also be safe, since they will ultimately be used by people and/or machines.

CLARIFICATION: *There is a significant requirement here to clarify some common architectural terminology. The term, 'structure', has many contextual applications. In general, a structure is an arrangement and organization of interrelated elements in a material object or system. Material structures include man-made objects such as buildings and machines, as well as natural objects such as biological organisms, minerals and chemicals. Abstract structures include data structures in computer science and musical form. Conceptual structures include information structures in the form of information models.*

Architecture, as part of the habitat, is a life-support functional service, which has historically been given the survival-oriented term “shelter”. A shelter is designed to protect its occupants from weather fluctuations and functions to cancel out a large portion of the ‘variety’ of the surrounding environmental climate. Clothes, shoes, and buildings are all part of this “primitive skills” category known as “shelter”. In community, that which has historically been known as “shelter” is now called “architecture” (which, is inclusive of platforms, technologies, and decor).

Architecture has to do with planning, designing and constructing form, space and ambience to reflect functional, technical, social, environmental and aesthetic considerations. Its realization involves the reconfiguration and coordination of materials and technology. Just like social organization can produce a social “navigational” model, decision organization can produce a decision resolution space, the product of architectural work is typically drawings, plans and technical specifications, defining the structure and/or behavior of an architectural system that is to be, or has been, constructed. **A**rchitecture concerns the behavior of humans in how they use an environmental space, as well as how the structure of the space relates to its own surrounding.

An architectural space is not an independent entity from its environment; separations and integrations between the space and its environment shape experiences. An architectural space is defined by its geometry and materiality. Geometrical characteristics define its form, proportions and dimensions, while materials express its appearance. Generally speaking, there are several high-level categories of architecture: A complete architectural design ought to include all aspects of perception, including human and machine (where applicable) perception. Space perception is a concept that includes the use of all human senses, and also machine sensors. Sight and hearing are the two most important ones. The other minor senses of smell, touch and taste are involved in a secondary way when experiencing a space. (Rodríguez-Manzo, p.1, 2010)

Note that many types of society are capable of being identified by their architectural constructions. However, such a label would be an imprecise representation of the totality of a given society because it doesn't account for the societal living system as a whole, which necessarily includes a social organization, a decisioning organization, and an expressed lifestyle.

The primary functions of shelter as a need for service are:

1. To enable the user to maintain a homeodynamic body temperature and comfort.
2. To provide an environmentally controllable space.

Humans can adapt/regulate their climactic/atmospheric exposure with a physical environment with one self-regulator, and two forms of architecture ("skins"):

1. The skin of the body is a self-regulator, it can control temperature changes by altering blood vessel diameter.
2. The second level is the clothes (wearing-proximity shelter) someone can add or remove some clothes to lessen or increase temperature (i.e., heat and cold).
3. The third level is the enclosure of a building (room shelter).

At a very high level, architecture fits within a human-built environment consisting of [at least] the following parameters:

1. **Architecture** - for example, buildings (shelter), walls (shelter), structure (shelter), windows (shelter), balconies (shelter), signage (communication), lighting (power), decoration (aesthetics), canopies (shelter), landmarks (communication), monuments, banners (communication), etc.
2. **Infrastructure (sub-architecture)** - for example, paths and roads (transportation), transportation buildings (architecture), path signs (communication), path lighting (power), public toilets (sanitation), waste and recycling bins (architecture), CCTV and cameras (transparency), gutters/drainage (sanitation), electrical lines (power), data lines (power), water pipes (water), etc.
3. **Landscape** - for example, path plants (cultivation), garden plants (cultivation), pasture (cultivation), water bodies and channels (cultivation), play areas (recreational), etc.
4. **Path** - topographic transportation layout between all architecture and infrastructure over a landscape.
5. **Clothing** - for example, shoes, pants, hats, etc.
6. **Uses (zoning, sectors, services)** - functions for life, technology, and exploratory service support.
7. **Wild environment** - local wild topology, biome and [micro-]climate.

> **NOTE:** *In the broadest sense, every material construction is the result of 'architecture'. Physical architecture is not limited to buildings. If something involves a relationship with material form, then it involves the generalized concept of architecture. However, not all processes are architectural processes.*

Architecture exists for every user in two ways:

1. As the physical forms that are built (as enclosures) and people see (e.g., that building).
2. As volumes ("spaces") that people use and move through (e.g., that room).

Architecture provides enclosure control using the following possible "fixable" conditions:

1. Clothes (self-wearing architecture).
2. Fixed buildings (with fixed foundations).
3. Unfixed buildings with fixed foundations.
4. Unfixed buildings with unfixed foundations.
5. Fixed non-building architecture with fixed foundations.
6. Non-fixed, non-building architecture with fixed foundations
7. Non-fixed, non-building architecture with unfixed foundations.
8. Fixed infrastructure.
9. Unfixed infrastructure.
10. Fixed internal volume (fixed room partitioning).
11. Flexible internal volume (flexible room partitioning).

> **NOTE:** *The definition of architecture as a permanent structure, or even, a land-based structure, is imprecise. In concern to permanence, what is temporary? One hour, one day, one year?*

Some architecture is spatially mapped to a specific geographic coordinate (e.g., buildings). Other types of architecture move position regularly (e.g., boats, vehicles, and clothing) move, and so their geographic coordinates change, sometimes rapidly, with time. From a high-level view, architecture may be depicted as objects on a geo-spatial map that represent relationship boundary elements and circulation spaces.

1. Building architecture (a.k.a., building structures, buildings) - a building or shelter.
2. Non-building architecture (a.k.a., non-building

structures) - something other than a shelter.
   A. Bridges.
   B. Tunnels.
   C. Pools.
   D. Canals.
   E. Furniture.
   F. Coastal defenses.
   G. Etc.
3. Landscape architecture (a.k.a., cultivation architecture).
   A. Planters.
   B. Ponds.
   C. Etc.
4. Transportation architecture.
   A. Road (including specialized roads like runways).
   B. Railways.
   C. Paths.
   D. Pipelines (pipeline architecture, pipeline engineering).
   E. Vehicles (vehicular architecture, vehicular engineering).
   F. Boats (naval architecture, maritime engineering).
   G. Spacecraft (space architecture, spacecraft engineering).
   H. Etc.
5. Power architecture.
   A. Dams.
   B. Etc.
6. Clothing architecture.
7. Monuments (a.k.a., monumental architecture; generally classified as a form of art and not traditional architecture).
8. Hardware architecture (a.k.a., devices, tools, and equipment; note this type of architecture is classified separately from traditional; software architecture is similarly classified separately).

NOTE: *Among community there is always a purpose to [architectural] presence, where architecture becomes an emergent completion of nature for climactic survival and flourishing.*

1.1 Architecture as a [scientific] service

Within a habitat service system, architecture is the service that develops, constructs, disassembles, and sometimes, operates, architectural systems. Architecture is a life support service function within the habitat service system. Some architectural systems are used and operated by the architecture service system, whereas other are used and operated by other service systems, although they still include architectural service InterSystem team functions.

As a life support service, architecture provides:

1. Buildings (shelter, enclosure).
   A. Dwelling buildings - home shelter.
      1. Rooms for personal [access] use only.
   B. [Habitat] Information working group buildings - office space, information working shelters.
      1. Rooms for InterSystem Team use only.
      2. Rooms for common [access] use only.
      3. Rooms for mixed [access] use.
   C. [Habitat] Production team buildings - habitat production support-service shelters (e.g., power generation building, hydroelectric dam, medical building, technology production building, cultivation support building, sports arena, restaurant/cafeteria, etc.).
      1. Rooms for InterSystem Team use only.
   D. [Habitat] Common service buildings.
      1. Rooms for common [access] use only.
2. Non-building structural architecture, such as:
   A. Bridges.
   B. Tunnels.
   C. Pools.
   D. Ponds.
   E. Furniture.
   F. Statues (monuments, art objects).
   G. Etc.
3. Clothing (note: clothing is a form of architecture, is a form of shelter). In this way, there are really two architectural service systems: the architecture-engineering and construction (AEC) system and the architectural clothing system.
4. Architectural objects and systems for other habitat service systems, including but not necessarily limited to:
   A. The cultivation service system, such as: planters, ponds, etc.
   B. The transportation service system, such as: roads (including, bridges and tunnels), paths, vehicles, boats, spacecraft, etc.
   C. The art and music service system, such as monuments.

TERMINOLOGICAL CLARIFICATION:
Throughout this article, the word 'building' may sometimes, depending on context, be used to mean any architectural system, such as a tunnel, pool, or even clothing.

1.1.1 Architectural standards

A.k.a., Building design, built design, structural design, enclosure design.

Architecture, like all habitat service systems, must be master planned (i.e., designed) to effectively account for the evolving demands of it users and context, thus maximizing user value (i.e., architectural function) through life. In common parlance, building design (though more generally, architectural design) is separated at a high-level into the following categories (or disciplines):

1. Architecture.
2. Structural engineering.
3. Civil engineering.
4. Construction engineering.
5. AEC engineering (architectural, electrical, and construction).
6. MEP engineering (mechanical, electrical, and plumbing).
7. ME engineering (mechanical and electrical).
8. Other engineering (e.g., fire suppression, rainwater flow, etc.).

These disciplines all involve:

1. Connecting design to function[al] operation.
2. Connecting design to fabrication/construction and eventual disassembly/destruction.
3. Connecting design to site.
4. Incorporating architectural system data or building data (i.e., data about the current and/or future operation of the architecture and the architectural-engineering services within it; for example, about a building and the services within it).

1.1.2 Architectural design

Different architectural types have different goals for the type of space and usage they want to create. The design of any given architectural construction confers the following four characterizations (i.e., the design of an architectural system can be categorized by the following high-level design elements):

1. **Architecture type:**
    A. What is the primary function(s) of the architecture?
    B. If a building, what is the occupancy size of the building (for persons and/or equipment)?
    C. If a non-building system, what is the size requirement?
    D. What materials compose the construction of the system?
2. **Activity type** *(function transfers from architecture type)***:**
    A. What activities will occur within and around the architecture?
    B. What equipment do those activities require?
3. **Space type** *(equipment transfers from activity type)***:**
    A. What are the interior dimensions of areas in the architecture?
    B. What are the surfaces of the spaces composed of?
    C. What objects will be used in those space?
4. **Affect type** *(felt sensation transfers from space type)***:**
    A. How will the user/occupant be affected by the building, what will the user(s) sense (as being present) in and around the system?
    B. What feelings will the system drive/promote in users?

It is possible for local habitat systems (local residents) to customize the architecture of their habitat in a cyclically master-planned way given the following architecturally associated variables:

1. Enclosure: Architecture has the function to meet the human need for enclosures for the population.
2. Aesthetic: Architecture has the capacity to meet the aesthetic object (shape and texture) preferences ("style") of the "unique" and individual region/culture.
3. Vegetation: Architecture has the capacity to meet the greenspace preferences ("vegetation quantity and style") of the "unique" and individual region/culture.
4. Illumination: Architecture has the capacity to meet the illuminance preferences ("light quantity and style") of the "unique" and individual region/culture.

1.1.3 Architectural positioning

Architecture can be positioned on the landscape, as a service, in the following scaled way (with distinct levels of integration into the land-built environment):

1. Between habitats (i.e., between city perimeters).
    A. Architecture as a path for transport.
2. Between habitat sectors (i.e., between sectors in the perimeter of a local habitat).
    A. Architectural functional clusters (or, functional clusters of architecture).
3. Between architectural objects proximal one another.
    A. Proximal personal dwellings (in the case of the dwelling sectors) with personal/shared area in-between.
    B. Proximal common/team access architecture with common/team area in-between.
4. Architectural enclosure itself: structure/exterior.
5. Architectural interior itself: room /interior.

A building may be viewed as several layers of "usage of built components" in temporal and physical relation. The physical and temporal layers/categories of buildings are:

1. **Shell (a.k.a., enclosure)** - the permanent structure and enclosure of the building.

2. **Service (a.k.a., infrastructure, utilities)** - heating, cooling, ventilation, hydraulics, electricity that pass through and/or are attached (fixed to or into) to the building shell.
   A. **Sub-services** - the interior components that are tailored to accommodate the specific function within the solid shell.
3. **Setting (a.k.a., set)** - the current/temporary reorganization and adjustment of furniture and belongings to suit daily activities.
4. **Look (a.k.a., vision)** - the exterior and interior enclosure shape and style that people have to see as they move through the local environment.

1.2 Building architecture

In the context of a building, architecture is the conceptual design and fundamental operation of a building-type structure. Building architecture is the sculpting (i.e., re-configuration) of the physical environment to meet a set of user requirements/demands for shelter. Historically, it was the craft of building a shelter. Architecture is the design and process of constructing (and operating) buildings. A building may be regarded as simply an envelope which encloses and subdivides space in order to create a protected environment, one that may serve additional functions. Here, architecture is the designing and building and operating of human and/or machine occupied, generally static, structures positioned on, in, and/or above Earth's surfaces. Herein, an architectural structure is a human-made, free-standing, relatively immobile outdoor (or, underground) construction. Note here that architectural forms are always functional and aesthetic, always three-dimensional, and always user driven. Similarly, architecture is the science and practice of designing and organizing buildings for human and machine occupation.

Buildings (architecture in general) change over time to be adapted to the new requirements of human knowledge, need and preference. Homes adapt to new lifestyles, new sizes of family, new resource situations, new technology situations, and so on. Adaptive architecture is concerned with enclosures that are adapted to their environments, their users and their technologies. Here, there is the ability of a building unit to be a dynamic system that carries the capacity to accommodate a set of evolving demands regarding space, function, and technical componentry. The concept of extendability is sometimes used here to mean the ability of the building and its installation to adapt in a simple way to additional/new user demands.

> **CLARIFICATION:** *The language here can sometimes be confusing, for example, it is often said that, "building architecture is the design and construction of a building, while structure is a building or other object built." Of course, architecture includes more than just buildings, and all of materiality has structure. Additionally, building architecture, which generally refers to the overall process of designing, engineering, and constructing a building, also may describe the design/style of a building. Finally, note that the terms building, architecture, and construction can all be used as an object or verb. Structure can only refer an object, whereas structuring can refer to the process of designing, developing, and creating a structure.*

1.2.1 Buildings

> **INSIGHT:** *The function of architecture is to design spaces that generate wellbeing.*

Human physiology and machines are capable of tolerating only a narrow range of environmental conditions. Beyond this range, health and wellbeing are compromised, and machines fail. Buildings protect their occupants from climactic environmental elements (Read: provide shelter) and protect other habitat system services (Read: provide a built structure within which other services are provided). Through the materialisation of specific types of masses (volumes), architecture is able to create enclosed spaces in the form of structures. A building is a systems; it is an integrated assembly of interacting architecturally related elements, designed to carry out cooperatively predetermined shelter-type functions. A building consists of a collection of spaces bounded by separators of the interior environment, and separators of the exterior environment (the enclosure). The word 'building' is commonly considered to refer to an enclosed structure within which people and/or machines can perform activities (Designing Buildings, 2021). Buildings offer unique possibilities for human flourishing. In general, the term, building, refers any permanent or temporary building but not any other kind of structure or erection, and a reference to a building includes a reference to part of a building.

There are many ways of classifying types of building, including but not limited to:

1. Number of floors (and positioning of ground).
2. Number of openings in-to and out-of enclosure volume(s).
3. Partitionality of internal volume of the enclosure:
   A. Fixed internal volume: In this case, the internal layout and room partitioning within a space are immovable and cannot be altered. The room configurations and divisions are predetermined and cannot be (easily) changed to create different arrangements. Here, there is no possibility for internal volume re-arrangements without load-bearing changes. In some cases, furniture and various technologies are integrated into the fixed structure of an enclosure.
   B. Flexible internal volume: This refers to a space

where the internal layout and room partitioning are adaptable and can be reconfigured as needed. The design allows for flexibility in creating various room arrangements and adapting the internal volume to different purposes or preferences.
4. Material composition type (e.g., organic, mineral).
5. Construction/fabrication type (i.e., construction technique).
6. Use class (i.e., function or activity type, nature of occupancy).
7. Historic period (e.g., heritage, museum).
8. Design (e.g., size, style, shape).
9. Performance (for example, energy consumption, accessibility, wind, earthquake, etc).
10. Jurisdictional-legal definition.

A building is a complex assemblage of physical elements, components, and systems, wherein:

1. **Building assembly (building complex)** - a combination of components.
2. **Building enclosure (building envelope)** - the name given to any part of a building that physically separates the external from the interior environment. Sometimes 'enclosure' is defined as a mass/volume that creates a feeling of contained space.
3. **Building component** - a constituent part of a building (or other built asset) that is manufactured as an independent unit, subsystem or sub-assembly, that can be joined or blended with other elements to form a more complex item. Generally, components are 'self-contained' and sourced from a single supplier, typically the complete unit provided by that supplier rather than its constituent parts.
4. **Building elements** - the main components of a structure like a bridge (foundations, piers, deck) or a building (floors, walls and roofs).

Enclosures are either monolithic or composite assemblies. Monolithic enclosures involve a single material acting as the structure, the cladding, and the interior finish. In composite assemblies, separate materials or combinations are assigned critical control functions, such as control of heat transfer or air leakage.

The physical components of a building enclosure include:

1. The roof system.
2. The above-grade (above ground) wall system (including windows and doors).
3. The below-grade (below ground) wall system.
4. The base floor system.

The principles of a building enclosure include:

1. Strength and rigidity.
2. Control of heat flow.
3. Control of air flow.
4. Control of water vapour flow.
5. Control of liquid water movement.
6. Stability and durability of materials.
7. Control of fire.
8. Control of climactic elements.
9. Aesthetic considerations.
10. Cost (market only).

In general terms, enclosure types include can be categorised as the following:

1. Compact or distributed.
2. High rise or low rise (relative).
3. Massive or lightweight.
4. Passive or active.
5. Permeable or impermeable.
6. Single or multiple units.
7. Temporary or permanent.
8. Transparent or opaque.
9. Hybrids: Combinations of the above.

In the design of buildings, there are also considerations relating to the natural phenomena occurring in the external world, and the functions required to sustain structures within that environment. Some of the environmental phenomena, or 'loadings', that can impact on enclosure include:

1. Gravity (i.e. structural loads).
2. Climate and weather.
3. Seismic forces.
4. Noise and vibration.
5. Soil type.
6. Topography.
7. Organic agents (i.e. aerobic life forms such as insects and mould).
8. Inorganic agents (i.e. natural and artificial substances such as radon and methane).

The general functions of the building enclosure may be divided into four areas:

1. **Support** - to resist and transfer all structural forms of loading imposed by the interior and exterior environments.
2. **Control** - of water, air transfer, heat, sound, access and security, electricity, objects and flows, privacy, the provision of views and daylight, and so on.
3. **Finish** - the enclosure surfaces in terms of visual, aesthetic, durability, and so on.
4. **Distribute** - services or utilities such as electricity, communications, water, and so on.

1.2.2 Building [infrastructural] sub-systems

NOTE: *The term building herein refers to the built structure, not the process of constructing the built structure.*

Building systems refers to all of the sub-systems within a building, including coordination and control systems. These systems include, but are not limited to:

1. Building information management systems, intelligent building management systems.
2. Infrastructural systems and controls.
3. Floor systems and controls.
4. Walling systems and controls.
5. Roof systems and other enclosure perimeter surface systems and controls.
6. Energy management systems.
7. Fire detection and alarm systems.
8. Electrical systems and controls.
9. Heating and cooling systems and controls.
10. Atmospheric systems and controls.
11. Building automation and control systems.
12. Lighting and shading (curtain) systems (illumination control systems).
13. Data networking systems and controls.
14. Sanitary and septic systems.
15. Security and defense systems.
16. Solar utilization systems.
17. Structural support systems.
18. Thermal insulation systems.
19. Water systems (plumbing systems).

1.2.3 Building spaces

In buildings, spaces are provided for various activities to take place. In some cases a space is only suitable for one activity, for example a kitchen, but an "activity hall/room" may, for example, be used for assemblies, sports, concerts and dramas. Also classed as spaces are transport corridors that run between two locations. There are hundreds of different types of spaces, each related to the category of activity or general types of activities that can take place in those space. There are also open spaces. Note here that large areas upon a landscape, which may or may not have buildings placed on them, are also called 'spaces', but more commonly known as 'zones'.

Note here that building complexes (buildings with many spaces) can also be broken down into individual activities, such as exercise space, sleeping space, eating space, working, etc.

1.2.3.1 Interior design

Interior design is the science of understanding behaviors and preferences to design functional and aesthetic rooms within a building. Interior design includes both technical and aesthetic solutions.

1.2.4 Building density and floor efficiency

Understanding building density is crucial in urban planning and architectural design as it directly influences the utilization of space, population density, and overall cityscape. Building density encompasses multiple dimensions, including the space between buildings, occupancy density, floor efficiency, and the relationship between building height and area coverage. This comprehensive concept also extends to city-level planning, considering inter-building density and integration of habitat services within defined perimeters. Determining building density significantly shapes the structure of urban spaces and holds the potential to establish a harmonious balance between spatial efficiency, accommodating population needs, and having sustainable urban developments.

1. **Perimeter** - refers to a fixed/set shape/layout on the landscape, and within it, a habitat service integration. The perimeter set shape/layout defines the boundaries within which habitat services are fully integrated. It involves planning how habitat services (and infrastructures) are built into the urban environment.
2. **Building density as space between buildings on a landscape (a.k.a., landscape built density)** - refers to the amount of built-up area in relation to available land or open space. Building density by area considers the ratio of built-up area to the total land area. It relates to how much of the landscape is covered by buildings. A larger surface area occupied by buildings results in higher density. Higher building density generally means more buildings and less open space. Closer building proximity leads to higher density, while more space between buildings reduces density.
    A. **Inter-build density and master planning** - concerns the collective density and layout of buildings within a city or master-planned area. City planning influences how buildings are situated and their density relative to each other, impacting overall urban density.
3. **Occupancy density:** refers to the number of people (or, other objects) occupying (or, capable of occupying) a building or a given area. It's a measure of how densely populated a space is.
    A. Building height and occupancy density: Taller buildings with more floors generally contribute to higher building density. A skyscraper with more floors within a limited footprint area increases vertical density, accommodating more people or usable space.
        1. Taller buildings involve more complex engineering and calculations. Errors in design or construction become more likely with taller

structures.
2. Space efficiency, because of structural load optimization, is one of the most important design considerations in any tall building.

4. **Floor efficiency** - refers to the efficient use of floor space to meet occupancy and structural requirements. Flor efficiency in a building represents the usable space, unoccupied by infrastructure, on each floor, in relation to the total floor area. Floor efficiency by area considers the ratio of infrastructure-occupied area, to the total area.

1.3 Architectural processes: architecture, engineering, construction, and demolition

There are several processes and accompanying roles (a.k.a., architectural disciplines) involved in bringing an architectural structure (object, building, etc.) into existence, and possibly, removing it from existence:

1. **Architecting (role: architect) is:**
   A. The process of coming up with some kind of solution for some kind of architectural problem with an associated set of architectural requirements.
   B. The process of creating and building an architectural object/structure.
   C. The process of conceiving, defining, expressing, documenting, communicating, certifying proper implementation of, maintaining, and improving architecture throughout an architectural system's life cycle.
2. **Engineering (role: engineer) is:**
   A. The process of calculating the structure (notably, load bearing structural elements) of an architectural system.
   B. The process of designing and calculating the utility infrastructure for an environment.
3. **Architectural-engineering (role: building engineer) is:**
   A. Understand and design the architecture.
   B. Understand and design the engineered sub-systems of the architecture (e.g., structural, electrical, HVAC, etc.)
   C. Integrate engineeried systems in the building envelop.
4. **Constructing or fabrication (role: construction manager, fabrication coordinator, constructor, builder, contractor) is:**
   A. The process of constructing (fabricating and assembling) an architectural system.
5. **Demolition or recycling (role: demolisher, and also, constructor, builder, contractor) is:**
   A. The process of disassembling and possibly recycling an architectural system.

The **role of the architect** (or, architectural processes) generally involves:

1. **Concept design** - produces concept design documents.
2. **Total object development planning and monitoring** - produces object development documents.
3. **Construction planning and monitoring** - produces construction documents.

The **role of the architectural-engineer** (or, architectural engineering processes or building engineering processes) generally involves:

1. **Calculating what is physically possible and optimal for architectural related subsystems** - produces engineering documents with complete descriptions, formula, calculations, results, and alternatives for both the structure and utilities infrastructure.
2. **Architectural-engineers design, assess, and inspect** - infrastructural systems to ensure that they are efficient and stable.

The **role of the structural engineer** (or, engineering processes) generally involves:

1. **Calculating what is physically possible and optimal for structural related subsystems** - produces engineering documents with complete descriptions, formula, calculations, results, and alternatives for both the structure and related elements of the infrastructure.
2. **Structural engineers design, assess, and inspect** - structures to ensure that they are efficient and stable.

The **role of the civil engineer** (or, engineering processes) generally involves:

1. **Calculating what is physically possible and optimal for civil related subsystems** - produces engineering documents with complete descriptions, formula, calculations, results, and alternatives for both the structure and utilities infrastructure.
2. **Oversee** - a variety of workers, including construction managers, architects, and mechanical engineers.
3. **Civil engineers design, construct, maintain and improve** - the non-building systems (e.g., bridges, tunnels, roads, etc.).

The **role of the constructor** (or, constructing process) generally involves:

1. **On-site construction coordination** - uses construction documents. This phase produces the final object(s).

The **role of the demolisher** (or, demolition process) generally involves:

1. **Pre-demolition design** - to ensure the building can be demolished safely by means of a analysis and plan.
2. **On-site disassembly and demolition coordination** - uses construction and demolition documents. This phase removes the final object(s) from existence.

1.4 Architectural-engineering

A.k.a., Architectural engineering, building engineering, structural engineering, infrastructural engineering.

All architecture is [also] engineered; it is often more correct to use the term architectural-engineering as opposed to the term architecture alone. Architectural-engineering is always dependent on the allocation of resources, physics, and human effort. Architectural-engineering combines all aspects of building design and construction, including mechanical, electrical, structural, infrastructural, calculations, and other mathematical precision notions.

CLARIFICATION: *In academia and the building industry, architects are guided more by aesthetic, functional, and spatial design [of buildings], whereas architectural-engineers are guided more by an integration of functional design, aesthetic design, and engineering principles [in the construction, planning, and design of buildings]. It is often observed in the early 21st century that architectural-engineers use more technology and integrated design methods than architects whose creations are deeply rooted in subjective artistic expression. In this sense, it is possible to think of architectural-engineering as an extension of architecture. The architecture uses spatial planning to produce drawings (floor plans, sections, and elevations) evaluated by engineers for physical constructability. Note that in the architectural industry in the 21st century, some architecture firms are also architectural engineering firms, which means that they don't have to outsource their projects and can maintain full control of a project from start to finish.*

1.4.1 Engineering

CLARIFICATION: *In general, engineering is the process of designing, inventing, building and maintaining machines, structures, tools and other things that are a part of daily technical life fulfillment.*

Architecture is an operational service process accounted for by habitat design and development. Engineering is a knowledge application process for designing and developing systems and services, including architectural services. Engineering is the application of mathematics, empirical evidence, as well as scientific and practical knowledge in order to invent, design, build, maintain, research, and improve structures, machines, tools, systems, components, materials, and processes. All architecture is engineered. Engineering involves the application of scientific principles to a design to ensure it functions as intended. Engineering necessarily involves mathematical calculations.

When it comes to architecture there are rules. There are rules because no one needs a roof caving in on them, or clothing failing when at risk to exposure. Hence, there are standards that ensure the safe standard socio-technical decisioning and operation [of a community-type] society. Architectural-engineering is part of the "solution inquiry" process of the Community's common decision space. One could state that "architectural engineering" is the application of engineering principles and technology to architectural design and construction.

To understand the interrelationship between architecture and engineering in community design it is important not to have your thinking limited by the language of a paradigm where all economic work is segregated into labor disciplines like "mechanical engineering", "architecture", and "industrial engineering". Instead, it is important to think in terms of systems and the ecologies of systems. All architectural design requires engineering, and we engineer everything that comes into material service as part of the habitat service system, which exists in an ecological dynamic with a larger environment.

NOTE: *In engineering, adventurousness is akin to incompetence.*

1.4.1.1 Architects and civil engineers

In the market-State there are differences between the architectural and civil engineering professions (note, however, that these differences are not universal and may not always carry over to a community-type society):

1. Civil engineers manage a broader range of projects encompassing transportation infrastructure and water systems, while architects focus on buildings.
2. Architects are more deeply involved in the pre-construction phases, while civil engineers directly oversee all phases of construction work. However, in the case of residential project, it is often the construction manager, or sometimes the architect, that oversees all phases of construction.
3. Civil engineers oversee a variety of workers,

including construction managers, architects, and mechanical engineers.
4. Architects spend a majority of their time in offices, while civil engineers divide their time between desk work and direct site supervision.
5. Both roles require a bachelor's degree and state licensure, but civil engineers often earn advanced degrees to secure a senior position.

1.4.1.2 Architects and structural engineers

In the market-State there are differences between the architectural and structural engineering professions (note, however, that these differences are not universal and may not always carry over to a community-type society):

1. Architects manage the whole architectural project.
2. Structural engineers run do analysis and run calculations on the structural efficacy and viability of the architectural structure.

1.4.2 Building science

A.k.a., Building physics, building engineering physics, architectural science, etc.

In general, building science (a.k.a., building physics) refer to the knowledge of the physical behaviour of buildings and other built systems (a.k.a., architectural system) and their impact on energy efficiency, comfort, health, safety, durability, etc. This is the application of the principles of physics to the built environment. An understanding of building science is vital if the design of buildings is to be optimised and the performance of buildings maximised. The term, 'building engineering physics', usually relates more specifically to the energy performance of buildings and the impact of a building on the indoor and outdoor environments. By properly understanding the physics of the built environment it is possible to develop high performance buildings that are comfortable and functional, and to minimise the negative environmental impacts of their construction and operation. Building science applies empirical techniques to architectural design problems, and explains why buildings work and why they fail.

Aspects of building design that might be considered 'building science' could include, but are not limited to:

1. Physical sciences:
   A. Human sciences (a.k.a., human-socio sciences).
   B. Materials science.
   C. Structural science.
   D. Acoustics science.
   E. Atmospherics science
   F. Power science.
   G. Signals science.
   H. Climate and weather science.
2. Techniques within the life-cycle of a building:
   A. Building design.
   B. Building construction.
   C. Building operation.
   D. Building demolition/disassembly.

QUESTIONS: *How do we scientifically respond to architectural needs, and how we might best design our architectural environments to fulfill our requirements?0.*

1.5 Architecture and consciousness

APHORISM: *We shape our buildings and later our buildings shape us. We build the roads, and then, the roads build us. We make the house, and then, the house makes us. We build architecture, and then, the architecture builds our lifestyles and shapes our lives.*

Architecture reflects consciousness and directs its experience. Architecture can facilitate or get in the way, of us experiencing the fullest from our environment. We don't want to put up façades that block our direct experience. Our creations can just as easily trap things in, as keep things out.

NOTE: *Space has socio-technical power relative to its configuration. Architecture can reconfigure "power" relationships in society. Who is excluded and included from the space is essentially the difference between utopia and dystopia. Architecture that uplifts everyone.*

Architecture is, in a way, a reflection of those people who have manifested it and maintain its construction. Materializations (e.g., buildings, landscapes, and technologies) are, in a way, like reflections of the people who manifest them. Their design and appearance give an indication of the occupiers' characteristics and understandings. They are a reflection of their integration and realisation as well as their individuality. The materializations of a population are a chosen representation of its character.

INSIGHT: *Momentum represents forward movement. Monuments represent movement in the past. A current theory is like a monument made to an old fact. Most of early 21st century society has lost all momentum and has become a monument to old thoughts.*

Architecture can shape us (our thinking and behaviors) in ways that we don't realize, and yet, are highly predictable.

INSIGHT: *All architecture with a habitat service system exists within a social context.*

1.6 Atmospheric sightlines

A.k.a., Sight line, visual axis.

Ground foundationed (a.k.a., above ground) buildings take up space on the land. A sightline is an unobstructed line of sight through the atmosphere between an intended observer (spectator) and a subject of interest, such as a building, area, etc.

> **INSIGH***t: In community, buildings turn into "sculptures" when seen from a distance.*

1.6.1 Architectural aesthetic pollution

Early 21st century sightlines are highly polluted with human [mental and commercial] "defecant". The question must be asked, Why are people "defecating" in their visual environment? For their very well-being, people do not defecate in the same water they drink from. Why then are they expelling into their visual environment, whatever is in their mind, without consideration given to the larger environment and its many users?

1.7 Starchitects

Modern cities are monuments to "great names" and amusing attractions, most of which are not representative of humankind's true potential for fulfillment. Many architects in the architectural industry, and even among the resource-based economy (RBE) movement, are more akin to "starchitects". The prefix "star-" is intended to mean that an architect has become a celebrity, a "star". Starchitects often copy protect their works. Most starchitects designs buildings as sculptures distinctive to their own subjective whims or the whims of a collective. Here, the term 'starchitect' is a pejorative. Besides copy protecting their work, starchitects create environments where people have to live in and among their artistic and subjective mental creations.

In modern commercialized society the architect designs the look, and the engineer determines how (if the design is novel) to make the look feasible. In community, the results of architecture are a whole integration into a materialized service system, wherein everything encoded into the system has been systematically engineered to do so. The distinction here is between starchitects in the market-State who (1) protect their efforts (thus, limiting cooperation and unification) and (2) do not account for others fulfillment in their work, and material design in a community-type society, where there is (1) no copy protection and (2) recognition of a social population with the potential for greater and lesser states of fulfillment, (and this, the effort to produce integrated and functional systems for that fulfillment).

> **INSIGHT:** *In early 21st century society, architecture works on the principle of money: no money, no building; no money, no access to the architectural drawings.*

Here are some characteristics of the labor-market appearance of a starchitect:

1. Refusal to share their designs openly.
2. Disregard the effort and energy required to construct, maintain, disassemble, and clean the structure.
3. Disregard integration with the surrounding environment.
4. Disregard the integration of service functions, both within the structure itself and with concern to infrastructure.
5. Disregard nature-patterned aesthetics.
6. Disregard the nightmare/headache that an abstract piece of architecture will give to a structural engineer who has to design around the modernist structure.

The labor role of an architect involves the building of structures for others. In community, we build structures for ourselves. Instead of a contextual world of harmonious geometric relationships and connectedness, architects tend to see a world of objects set apart from their contexts, with distinctive, attention-getting qualities. There are many such confirming studies. For example, Gifford (et al., 2002) surveyed other research and noted that "architects did not merely disagree with laypersons about the aesthetic qualities of buildings, they were unable to predict how laypersons would assess buildings, even when they were explicitly asked to do so." The researchers traced this disagreement to well-known cognitive differences in the two populations: "Evidence that certain cognitive properties are related to building preference [was] found."

The division of construction by labor role has important consequences for the kinds of constructions that are produced into an environment. The same could be said for the field of engineering. Consider the engineering of living environments around the form of transportation we know as a "car", and the consequences that has had on our movement throughout life space engineered around vehicles. The architectural label, the architectural labor role, and socio-economic compartmentalization can prevent someone from seeing how certain designs disconnect and isolate people, and create hostile environments that cannot be shared well by people physically. Reward in service of effort is unhelpful; it decouples the designer from the context of human fulfillment.

An article by Mehaffy and Salingaros (2011) describes why, in the last half-century, the clear result of architectural construction is buildings whose makers have been so concerned with the drama of their appearance that they fail on the most fundamental human criteria. The following are some adapted quotes from the article.

> *Instead of a contextual world of harmonious geometric relationships and connectedness, architects (people providing the profession of architecture) tend to see a world of objects set apart from their contexts, with distinctive,*

attention-getting qualities. Their buildings celebrate the individuated form, as objects standing dramatically apart from context. Why do architects see the world in this unique way? Historically, and in part, this behavior is due to the conditioning present in architectural schooling (Gifford et al., 2002). Architectural students are typically asked to produce drawings that are pinned up next to one another, and then evaluated in a "crit" (or critique). In such an abstract setting, it is difficult for anyone to evaluate how well a project integrates with its context, if at all. Moreover, projects that are especially distinctive — object designs that stand out visually in an imaginative way by presenting an unusual structure — tend to get more attention from the faculty, and often, better grades. Those architects get rewarded, and selected out to be the later stars of the profession. Hence, architecture in the market-State has turned into something of a "novelty spectacle". However surprising and novel the forms of today's new architecture might appear, they remain tightly bound within this almost century-old model. The novelty spectacle approach has become the model not just for buildings, but also for whole cities.

This focus on object-design has a deeper history in architecture. Up to about 1900, architects were understood to be practicing an adaptive craft, in which a building was an inseparable part of a dynamic living environment. "Blending in" respects the extant complex connective geometry, where components contribute to overall coherence. A building was assumed to meet the physiological and social needs of the people of that neighborhood first and foremost, and only then it would express its aesthetic qualities.

Yes, our architect friends share much of the blame for the state of architecture, but let us remember that city officials, corporate executives, urban developers, mortgage bankers, and many others were part of this process of "architectural commodification", creating attention-getting product design rather than good sustainable environmental design. Clients, following what they took to be general consensus on what is great architecture, commissioned architects to build inhuman structures.

All of these things are not, of course, trivial. They are the essence of a functional whole community, in which people are able to walk, navigate, feel well, and even feel any desire to live there in the first place. In short, the desires and gut reactions of the individual are the very essence of a great, living city, as opposed to a banal and dysfunctional one. The dysfunction of such image-based urban places — sadly all too common in the post-war era — is what has sent many people fleeing for the suburbs, with their simplistic ideas of retreat into a private garden. This too has turned into a dysfunctional failure of traffic congestion, blighted strip development, and isolated, car-dependent homes.

In the early 21st century, many leading architects feel compelled to change the world drastically to make it conform to their preferred industrial paradigm. Unless non-architects (i.e., the rest of the population) stand up to this pressure, we risk the slow loss from attrition of all of humankind's most emotionally-nourishing creations. For example, architects see a well-functioning and beloved urban space but perceive it as ugly and offensive, desperately in need of immediate "re-qualification" to turn it into a contemporary hard industrial object. Politicians are happy to go along so as to please construction companies who profit from the unnecessary tearing down and rebuilding. The result is a sterile open space, unused, dysfunctional, and dead — but in the eyes of the architects, the operation has been a success!

Architects spend more time talking to their users, sharing their perception and understanding their needs: not just the architect's selfish need for artistic self-expression, or worse, his/her need to impress other architects and elite connoisseur-critics.

We are now dealing with an environment in which such image-based sculptural buildings are imposed upon people, whether they choose them or not. If such buildings "fall down on the job" of meeting human needs — if they are unduly stressful, or damaging to the quality of life — then that is a kind of architectural malpractice, and nothing less.

And thus we conclude that "architectural myopia" is a symptom of adopting a contradictory and opposite way of viewing the world. It also explains architects' insistence — continuous, strident, and bordering on the obsessive — of the need to "educate" the public. For every time public debate focuses upon the basic dichotomy in perceiving architectural form between architects and non-architects, the standard response by the former is to beg for more "education" of ordinary citizens, and to dismiss natural human responses to their work as being "unsophisticated" and "philistine". Architects really wish that normal people would undergo the same reversal, and then everyone might agree on the same non-contextual, non-adaptive building aesthetics.

Since the non-indoctrinated continue to see complexity and coherence in the living environment and refuse to accept "architectural myopia", the architect's strategy is simply to replace the built environment so that it no longer contains those essential elements of living structure.

For example, architects see a well-functioning and beloved urban space but perceive it as ugly and offensive, desperately in need of immediate "re-qualification" to turn it into a contemporary hard industrial object. Politicians are happy to go along so as to please construction companies who profit from the unnecessary tearing down and rebuilding. The result is a sterile open space, unused, dysfunctional, and dead — but in the eyes of the architects, the operation has been a success!

A culture based upon an abstract, disconnected conception of space is re-shaping our world right now for the worse. The parallel reality is replacing the living one. Enthusiastically supported by politicians and the building industry, architects have been commissioned to destroy historic buildings and urban spaces worldwide. Because "architectural myopia" is justified as perfectly normal in the press, such interventions are praised by their promoters but turn out disastrous for the urban fabric, and are hated by potential users. Those projects all tend to look and feel the same. This is not surprising, since the designs are generated by the same abstract modernist images in the minds of architects oblivious of the connective geometry that would catalyze the eventual life in such a space.

We desperately need a new kind of architect: one more focused on process than on systems and context, rather than just objects. We need an architecture that actually optimizes the user (human) experience of the built environment.

Firstly, it is important to re-integrate the needs of human beings, including their sensory experience of the world, and their participation into the process of designing buildings and cities. Preparing our new type of architect for practice, we should re-examine the ways that architects are rewarded today: the corrupt and incestuous system of financial incentives, corporate branding, and image-making that rewards the extravagant "starchitect" over the contextual practitioner. Once we have created a consensus for radical change, it will be straightforward to find new ways of compensating good work, through more incentives such as awards, commissions, scientific research that identifies both successes and failures, and other, stronger feedback.

2 Architectural planning

A.k.a., Building planning, built environmental planning.

The Life-Support Service Sub-System of Architectural (-Engineering) can be planned, and its plan can be integrated into a unified plan for the Life-Support Service System, and therein, the Habitat Service System as a whole.

2.1 Architectural-engineering design timeline

Architectural-engineering design involves at least the following deliverables:

1. **Services (utility services, architectural services) deliverables.**
    A. **Analysis** of identifiable need(s) and selection of specific [architectural] service functions. [Documentation of decision analysis]
    B. **List** of specific architectural service functions. [Documentation of list].
2. **Architectural engineering design deliverables.**
    A. **Design development documentation** (a.k.a. design associated development documentation; project planning the architectural sub-systems; including, planning and documentation).
        1. Architectural design plan.
        2. Structural design plan.
        3. Mechanical design plan.
        4. Electrical design plan.
        5. Civil design (Municipal hookup design) plan.
        6. Landscape design plan.
        7. Interior design plan.
            i. Fittings, fixtures, and equipment design plan.
            ii. Illumination design plan.
            iii. Acoustic design plan.
        8. Materials plan.
        9. Construction (fabrication) plan.
        10. Software plan.
    B. **Schematic designs** (A.k.a., producing specification designs; including, visualization and text) .
        1. Architectural design drawings.
        2. Structural design drawings.
        3. Mechanical design drawings.
        4. Electrical design drawings.
        5. Civil design (Municipal hookup design) drawings.
        6. Landscape design drawings.
        7. Interior design drawings.
            i. Fittings, fixtures, and equipment design

drawings.
    ii. Illumination design drawings.
    iii. Acoustic design drawings.
8. Materials specifications.
9. Construction (fabrication) drawings.
10. Software specifications.

2.2 Architectural-engineering development

Architectural-engineering development involves a timeline of tasks, deliverables, and events that include:

1. **Pre-design (Phase 1)**
    A. Project coordination (project administration; project management).
        1. Coordination with team (internal coordination).
        2. Coordination with market.
        3. Coordination with State (government).
            i. Who are the authorities that have jurisdictional requirements?
                1. What are the taxation requirements?
                2. What are the duty and customs (etc.) requirements?
            ii. What are the regulatory issues:
                1. Zoning requirements?
                2. Building code requirements?
    B. Programming (a.k.a., functional program, design brief, facilities program, architectural program, user's/owner's statement of requirements, space needs analysis, program) - refers to adding function to form. A functional program describes the requirements which a building must satisfy in order to support and enhance human activities. Generally, functional programs are prepared as part of a design report. The programming process seeks to answer [at least] the following questions:
        1. What is the nature and scope of the problem?
        2. What information is required to develop a proper architectural solution to the problem? What are the site requirements (e.g., parking, circulation, orientation, vegetation, soil type, etc.)?
        3. How much and what type of space is required? What activities will take place in each space or sub-space? What is the functional relationship of the spaces? Visualize spatial relationships in a spatial relationship diagram and/or flow diagrams.
        4. What space will be needed in the next five to ten years to continue to operate efficiently? What is the size of each space? Are there special technical requirements of each of the spaces and systems?
    C. Space diagrams.
    D. Survey of existing facilities.
    E. Studies.
        1. Market studies.
        2. Economic studies.
        3. Location/situational studies.
            i. What are the community goals and concerns?
            ii. What are environmental and ecological concerns?
        4. Jurisdictional studies.
        5. Geopolitical studies.
        6. Site studies.
    F. Project financing - What are the financial requirements for the project?
        1. Permanent financing.
        2. Interim financing.
    G. Project budgeting - What is the preliminary and post-preliminary budget for the project?
        1. At the pre-design phase or beginning of a project, determine the likely budget and what it includes. Verify that this project is financially viable to the greatest extent possible.
            i. Object design cost (OD).
            ii. Object construction cost (OC).
            iii. Fixed equipment cost (FC).
            iv. Site development cost (SC).
            v. Total construction (demolition) cost (TCC) = OD + OC + FC + SC.
            vi. Site acquisition cost (AC).
            vii. Transportation cost (TC; movable equipment cost).
            viii. Risk cost (RC).
            ix. Project coordination cost (administration cost) (PC).
            x. Total budget required = TCC + AC + TC + RC + PC.
2. **Site Analysis (Phase 2)**
    1. Project coordination (project administration; project management).
        i. Coordination with team (internal coordination).
        ii. Coordination with market .
        iii. Coordination with State (government).
    2. Surveys.
        i. Needs analysis (program of needs).
            1. Questionnaire / survey.
            2. Identification of needs.
            3. Identification of functions and services to meet needs.
            4. Analysis of needs; assess capabilities.
                a. Identification of space needed to

support functions.
- ii. Identify stakeholders.
  1. List stakeholders - stakeholders which affect and are affected by.
  2. Mapping stakeholders - viewpoints and positions (relationships) to each other.
  3. Ranking stakeholders - influence and power within the stakeholders.
  4. Categorizing stakeholders - set up of groups with identification of their influence to the process.
     - a. Collaborators.
     - b. Affected by.
     - c. Could affect.
3. Site analysis and site selection.
4. Site development planning.
5. Site utilization studies.
6. Utility studies.
7. Environmental studies.
8. Zoning.
9. Project scheduling - What is the time frame for the project?
10. Project budgeting.

3. **Design Development (Phase 3)** and **Schematic Design (Phase 4)**
   - A. Project coordination.
     1. Coordination with team (internal coordination).
     2. Coordination with market.
     3. Coordination with State (government).
   - B. Architectural-engineering design deliverable.
     1. Architectural line and cut measurement and whole 3D object/environment visualization in line layout of whole space with all appropriate cuts, wholes, and all associated data:
        - i. Space identifiers; boundary identifiers; floor plans; terrain plans; shows locations, positions, and relevant data in a whole space.
        - ii. Sub-architectural engineering design plans (as sub-deliverables).
          1. Structural design.
          2. Mechanical design.
          3. Electrical design.
          4. Civil design.
          5. Landscape design.
          6. Interior design.
          7. Software design.
          8. Etc.
     2. Materials research and specifications.
        - i. Materials analysis.
        - ii. Materials specifications.
     3. Fabrication design and specifications.
        - i. Constructability analysis.
        - ii. Construction specification.
   - C. Project scheduling.
   - D. Cost controlling and cost estimating.
     1. Cost of land.
     2. Cost of financing.
     3. Cost of architectural/engineering (A/E).
     4. Cost of terrain modification.
     5. Cost of construction/fabrication.
     6. Cost of Furniture, Fixture, and Equipment (FF&E).
     7. City or government fees.
     8. Account for lifecycle costs.
        - i. Initiating costs.
        - ii. Development costs.
        - iii. Operations costs.
          1. Market costs (obsolescence/replacement costs).
          2. Updating, adapting, or module modifying costs.
          3. State costs (tax, fees).
        - iv. Maintenance costs (rental costs).
4. **Construction Documents (Phase 5)**
   - A. Project coordination.
     1. Coordination with team (internal coordination).
     2. Coordination with market .
     3. Coordination with State (government).
   - B. Specifications issued for construction (IFC) documents (typically, 2D):
     1. Architectural documents.
     2. Structural documents.
     3. Mechanical documents.
     4. Electrical documents.
     5. Water documents.
     6. Civil documents.
     7. Landscape documents.
     8. Interior design documents.
     9. Software documents.
     10. Etc.
   - C. Materials specifications documents (material engineering documents).
   - D. Fabrication specifications documents (construction documents).
   - E. Software specifications documents.
   - F. Project scheduling.
   - G. Cost controlling and estimating.
     1. Cost of land.
     2. Cost of financing.
     3. Cost of architectural/engineering (A/E).
     4. Cost of terrain modification (sitework).
     5. Cost of construction/fabrication (sitework).
     6. Cost of Furniture, Fixture, and Equipment (FF&E).
     7. City or government fees.

5. **Bidding and Negotiating (Phase 6)**
   A. Project coordination.
      1. Internal team coordination check.
      2. Market plan check .
      3. Government plan check.
   B. Pre-qualification of bidders.
   C. Bidding materials.
   D. Bidding / negotiations.
   E. Alternatives / substitutions.
   F. Special bidding services.
   G. Bid evaluation.
   H. Construction contract agreements.
6. **Construction and contract coordination (Phase 7)**
   A. Project coordination.
      1. Internal team coordination check.
      2. Coordination with market.
      3. Coordination with government.
   B. Final construction documentation (typically 2D, 3D, and possibly simulated, VR positioning).
   C. Field observation.
   D. Inspection coordination.
   E. Supplemental documents.
   F. Change orders.
   G. Schedule monitoring.
   H. Construction cost accounting.
   I. Project closeout.
7. **Post construction services (Phase 8)**
   A. Project coordination.
      1. Internal team coordination check.
      2. Coordination with market.
      3. Coordination with government.
   B. Maintenance and operational programming.
   C. Startup assistance.
   D. Warranty review.
   E. Post construction evaluation.
8. **Supplemental services (Phase 9)**
   1. Special studies.
   2. Renderings.
   3. Model construction.
   4. Life cycle cost analysis.
   5. Valve engineering.
   6. Quantity surveys.
   7. Detailed cost estimates.
   8. Energy studies.
   9. Environmental monitoring.
   10. Client related services.
   11. Furnishings design.
   12. Equipment.
   13. Project public relations.
   14. Materials and systems testing.
   15. Disassembly services.
   16. Relocation/transportation services.
   17. Demolition services.
   18. Special disciplines consultants.
   19. Special building type consultants.

Clarifications:

1. Costs (including, resources, financial, and labor) can be affected by weather, season, materials shortages, work practices (labor practices).
2. Construction scheduling (timing) can be affected by weather, season, materials shortages, person shortages, work practices (labor practices).

2.2.1 Simplification of an architectural project

The following is a simplified procedure with different phases that include tasks that must be completed to complete the whole architectural/building project (note: the project plan for an architectural project consists of multiple simultaneous and following phases):

1. Pre-designed, conceptual design, and research:
   A. Building type selection.
   B. Building function(s) selection.
   C. Building aesthetics selection.
   D. Site assessment.
   E. Budget analysis.
2. Schematic design (preliminary site plan):
   A. Architectural concept design (floor plans, architecture and interiors, preliminary ste plan)
   B. Architectural materials selection (structure, envelope).
   C. 3D massing.
   D. Preliminary cost estimate.
3. Detailed design (design development, technical drawings and specifications):
   A. Architectural detailed modeling, detailed drawings.
   B. 3D model of exterior and interior
   C. BIM model.
   D. Architectural materials selection (structure, envelope).
   E. Energy modeling.
   F. Structural engineering.
4. Finish, fixture, and appliance selection and integration:
   A. Detailed cost estimate.
   B. Construction documents.
   C. Architectural documentation.
   D. Structural documentation.
   E. Construction plan.
   F. Assemblage (fittings, fixtures, appliances) plan.
   G. Building permit documentation.
5. Materials, technologies, and permission procurement:
   A. Manufacture and supplier documentation:

1. Manufacturer (made by; works with supplier):
   i. Cost of system.
   ii. Availability of system.
   iii. Name.
   iv. Location.
   v. Website.
2. Supplier (distributed by; works with manufacturer):
   i. Cost of system.
   ii. Availability of system.
   iii. Name.
   iv. Location.
   v. Website.

B. QTQ and cost estimating.
C. Project scheduling.
D. Building permissioning.

6. Project execution:
   A. Site development.
   B. Work with manufacturers, suppliers, fabricators, transporters, and builders/constructors.
   C. Unit development:
      1. Geometry.
      2. Physical properties.
      3. Color.
      4. Material.
      5. Texture.
   D. Punch list.
7. Utilization:
   A. Site operation.

The following is a simplified view of the above project phases (architectural-engineering project timeline):

1. Pre-design.
   A. Needs analysis.
   B. Initial concept vision.
2. Schematic design.
   A. Architectural concept design.
   B. Architectural material selection (structure, envelope).
   C. Preliminary cost estimating.
3. Detailed design.
   A. Architecture material selection (structure, envelope).
   B. Architectural detailed model.
   C. Energy and other sub-system modeling (e.g., acoustic, etc.).
   D. Structural engineering.
   E. Interior design.
4. Construction documents.
   A. Architectural documentation.
   B. Structural documentation.
5. Procurement.
   A. QTQ and cost estimating/budgeting.
   B. Project scheduling.
   C. Material procurement.
6. Project execution.
7. Utilization.

The following is an even more simplified view of the above project phases using more general project language (architectural-engineering project timeline):

1. Architecture needs program - what is needed?
2. Feasibility study - what is feasible?
3. Preliminary study - does the concept feasibly meet the need?
4. Preliminary design - the schematic design.
5. Pre-executive project - the detailed design.
6. Executive project - all the architectural, engineering, and construction documentation.
7. Legal architecture project - all legal documentation.
8. Construction project - construct the architecture.
9. Post work project - review the construction.

2.2.2 Other views of the architectural planning process

Simplistically, a typical architectural-engineering-construction project might follow stages such as:

1. Stage 1: Societal decisioning (a.k.a., societal justification, or business justification in the market).
2. Stage 2: Feasibility studies.
3. Stage 3: Project brief.
4. Stage 4: Concept design.
5. Stage 5: Detailed design.
6. Stage 6: Production information.
7. Stage 7: Tender (market only).
8. Stage 8: Preparation (mobilisation).
9. Stage 9: Construction.
10. Stage 10: Occupation and defects evaluation period.
11. Stage 11: Post occupancy/usage evaluation.

In 2020, The Royal Institute of British Architects (RIBA) 'plan of work' stages are [architecture.com]:

1. 0 - Strategic definition.
2. 1 - Preparation and briefing.
3. 2 - Concept design.
4. 3 - Spatial coordination.
5. 4 - Technical design.
6. 5 - Manufacturing and construction.
7. 6 - Handover.
8. 7 - Use.

The BIM Task Group Digital Plan of Work and the Government Soft Landings process map is based on an alternate set of stages:

1. 0 - Strategy.

2. 1 - Brief.
3. 2 - Concept.
4. 3 - Definition.
5. 4 - Design.
6. 5 - Build and commission.
7. 6 - Handover and close-out.
8. 7 - Operation and end-of-life.

The Construction Industry Council (CIC) scope of services adopts [cicbca.org]:

1. Stage 1 - Preparation.
2. Stage 2 - Concept.
3. Stage 3 - Design Development.
4. Stage 4 - Production Information.
5. Stage 5 - Manufacture, Installation & Construction Information.
6. Stage 6 - (Post Practical Completion).

2.3 The architectural development process

A..k.a., The architectural construction process.

The standard building and construction process is:

1. Engage stakeholders to determine requirements.
2. Pre-design (which includes programming.
3. Site analysis.
4. Schematic design.
5. Design development.
6. Construction documents.
7. Contract administration during actual construction following documentation and procedures set by a larger authority (or, standards setting organization).

The abbreviations for these phases are generally:

1. Schematic design (SD).
2. Development design (DD).
3. Construction documents (CD).
4. Contract administration (CA; contract documents).

The design through to construction of an architectural structure in the market generally involves the following phases. From start to completion, the industrial-State construction process usually maintains the following phases:

> **NOTE:** *these phases may be repeated, skipped, or modified as necessary for each uniquely purchased construction project.*

1. **Pre-design** - the project is defined by the customer in terms of its function, purpose, scope, size, and economics.
2. **Schematic design (SD)** services develop study drawings, documents, or other media that illustrate the concepts of the design and include spatial relationships, scale, and form for the owner to review. Schematic design also is the research phase of the project, when zoning requirements or jurisdictional restrictions are discovered and addressed. This phase produces a final schematic design, to which the owner agrees. The architect provides a preliminary evaluation of the program, schedule and construction budget developed in the pre-design phase and prepares a number of Schematic Design drawings illustrating the project to review with the owner. The designs lay out the program on the site and address schedule and construction budget requirements. The architect submits a preliminary estimate of construction cost to the owner.
   A. Meet with client to determine design objectives, site conditions
   B. Form design concepts and compare pros/cons of each
   C. Designs incorporate preliminary code and materials research
   D. Internal review
   E. While client is reviewing design options, consultants such as interior designer, landscape architect, builder, manufacturers, engineers also review for added insight
3. **Design development (DD)** services use the initial design documents from the schematic phase and take them one step further. This phase lays out mechanical, electrical, plumbing, structural, and architectural details. Typically referred to as DD, this phase results in drawings that often specify design elements such as material types and location of windows and doors. The level of detail provided in the DD phase is determined by the owner's request and the project requirements. The DD phase often ends with a formal presentation to, and approval by, the owner. Based upon the approved Schematic Design plans and required adjustments to program, budget and schedule, the architect prepares more detailed Design Development drawings describing the architectural, structural, mechanical and electrical systems, and makes adjustments to the preliminary estimate of construction cost.
   A. Refine client-selected schematic design
   B. Materials selection
   C. Determine alternates for design influenced by phasing or budget
   D. In-depth code research
   E. Incorporate consultant comments
   F. Develop construction details
   G. Internal review
   H. While client is reviewing final design, consultants

review again

I. Drawing may be sent for preliminary review by municipality or other appropriate authorities

4. **Construction documents (CDs; contractors documents)** - Once the owner and architect are satisfied with the documents produced during DD, the architect moves forward and produces drawings with greater detail. A set of construction documents is a set of drawings and specifications that an architect (or, architectural processes) produce during the design/development phase of a construction project. These documents serve as a project [construction] manual during the construction phase, and they assist the public, private, and governmental organizations in having an open source and clear view of the project. These drawings typically include specifications for construction details and materials. Once CDs are satisfactorily produced, the architect sends them to contractors for pricing or bidding, if part of the contract. The level of detail in CDs may vary depending on the owner's preference. If the CD set is not 100% complete, this is noted on the CD set when it is sent out for bid. This phase results in the contractors' final estimate of project costs. The construction document phase produces a set of drawings that include all pertinent information required for the contractor to price and build the project. Based upon the Design Development documents, the architect prepares bidding information, conditions of the contract, and an Architecture Institute of America (AIA) agreement between owner and contractor. The architect advises the owner of adjustments to preliminary construction cost estimates and assists in filing documents for approval of governmental authorities.
   A. Construction details are refined and specifications are finalized.
   B. Alternates are explicitly defined.
   C. Code analysis is generated, if applicable.
   D. Consultant drawings and documents are incorporated as appropriate.
   E. Internal review.
   F. While client is reviewing, consultants prepare final drawing tweaks for inclusion in construction set.
   G. Incorporate final client and consultant comments.
   H. Final internal review.
5. **Contract administration (CA)** services are rendered at the owner's discretion and are outlined in the owner-architect construction agreement. Different owner-architect contractor agreements require different levels of services on the architect's part. CA services begin with the initial contract for construction and terminate when the final certificate of payment is issued. The architect's core responsibility during this phase is to help the contractor to build the project as specified in the CDs as approved by the owner. Representing the owner, the architect observes the construction and administers the agreement between the owner and the contractor, determines that work is done in accordance with the contract documents, and certifies the contractor's pay applications. The architect reviews shop drawings, prepares change order documents, determines a date of substantial completion, and issues a final certificate for payment.
6. **Bidding & negotiation** *(market only)* - The owner approves the Construction. Documents and the estimate of construction cost. The architect assists the owner in obtaining bids from General Contractors, negotiating proposals, and preparing and awarding contracts for construction.
7. **Construction phase** - Construction of the system.
8. **Post-construction phase** - Occupation and evaluation of the system.

Note: *Architectural industry institutes notably state that pre-design and CA are not "basic services", but should be considered additional services.*

In the construction industry there are a whole host of labor positions including architects, engineers, consultants, contractors, sub-contractors, and government agencies. The relationships therein can make a construction process a very tedious and challenging task to coordinate.

2.4 The architectural plan

An architectural plan is a design and planning framework for a building, and can contain:

1. Architectural drawings.
2. Specifications of the design.
3. Calculations.
4. Materials list (including, interior fixed and fitting equipment).
5. Quantities list.
6. Time planning of the building process.
7. Tools, techniques and building technologies & equipment.
8. Other documentation.

3 Architectural documentation and coding

A.k.a., Construction documentation and coding, fabrication documentation and coding, architectural documentation and coding, architectural sheets.

There are two categories of documents included in architectural construction documentation:

Clarification: In some cases, drawings and specifications are synonyms that mean visualizations, and in other cases, drawings mean visualizations and specifications are all addition non-visual information.

1. **Drawings** - visualizations, graphical representations. Note that written information about materials and workmanship should not appear on drawings or in bills of quantities as this can result in contradictory specifications and can cause considerable confusion, instead they should refer to the appropriate clauses in the specification.
   A. Drawings typically include, but are not limited to:
      1. Visualizations (a.k.a., drawings, graphical representations).
         i. Visualizations include: Floor plans, structural plans, elevations, sections, details, mechanical, electrical, and plumbing.
      2. Legends.
      3. Areas lists (a.k.a., area table, table of areas, general frame table).
      4. Architectural/construction schedule (a.k.a., materials list and quantities).
      5. Etc.
2. **Specifications** - all other information about the architecture and construction, including instructions and other written technical requirements. Note that in some cases, the term drawing and specification will mean the same thing. When the term specification is used to mean all other information besides the drawing.
   A. Specification information typically includes, but is not limited to:
      1. Written descriptions (a.k.a., written instructions) - written in a standardized format and provide a clear and detailed description of the materials and work required for each aspect of the construction project.
      2. Materials and products - the specifications outline the specific types and qualities of materials and products to be used in the project.
      3. Construction methods - detail the methods and procedures to be followed during construction. May include instructions.
      4. Quality standards - defines the level of quality expected for different aspects of the construction, ensuring that the final product meets the desired standards.
      5. Architectural/construction schedule (a.k.a., materials list and quantities).
      6. Costs list (sometimes included; market only).
      7. Contractual documents.
      8. Etc.

When drawings and/or specifications are combined together into a single document, each page of the document that contains a drawing and/or specification content is referred to as a "sheet":

1. **Sheets (a.k.a., architectural sheets, engineering sheets, construction sheets)** - typically refers to a drawing and specification that conveys specific information related to a construction (architectural-engineering) project and is presented on a single page (or, "sheet"). These sheets are used to communicate drawings, design details, specifications, and instructions to individuals involved in the architectural engineering and construction process. In a single document, sheets are usually organized according to specific disciplines and represent various aspects of the project. Drawing sheets will include floor plans, elevations, sections, details, electrical layouts, mechanical systems, plumbing systems, etc. Specifications sheets include primarily written content. Each sheet is dedicated to a particular aspect of the project, and when combined together in a single document (with many sheets), they form a comprehensive set of information for completion of the construction project. These sheets are compiled into a coherent and organized package, allowing the construction team to easily access the information they need during the construction process. Each sheet is a project deliverable.
   A. **Drawing set (a.k.a., specification set, construction set, etc.)** - when the individual drawing sheets in are combined into a single document. Typically the drawing set is organized into individual sheets, each representing a specific aspect of the construction project. The drawing set typically includes all the different types of sheets mentioned earlier. This comprehensive set of drawings contains all the necessary information and instructions required to construct a structure according to the design

developed by the architectural-engineering team. Note that this document primarily consists of graphical representations (drawings), but typically includes some specifications also. The drawing set is a project deliverable.

B. **Specification set (a.k.a., construction specification set, construction specifications)** - when the individual specification sheets in are combined into a single document. Whereas the drawing set primarily consists of visualizations (graphics) , the specification set provides detailed written instructions and technical requirements for the [construction] project.

Together these two sets of sheets form a comprehensive package that provides complete guidance to architectural-engineers about the project, and to the construction team in particular. Note that sometimes the drawing set and specification set are combined into a single integrated document. Typically the drawing set also includes specification content.

Each affiliated building practice (discipline) has associated standards and construction document, including but possibly not limited to:

1. Architecture.
2. Structural.
3. Mechanical atmospheric.
4. Electrical.
5. Illumination.
6. Mechanical transportation (e.g., elevators, etc.).
7. Plumbing (a.k.a., hydro system, water network).
8. Interior.
9. Landscape.
10. Civil (a.k.a., infrastructure).
11. Software.

Both the drawings and specifications follow standards, respectively. There are different standards present on the planet. The MasterFormat, for example, is a specification standard from the Construction Specifications Institute. The MasterFormat is a common method of specification in construction documents. Similarly, construction drawings follow a standard coding in order to organize the documentation. Different standards use different coding for the identification of construction drawings.

3.1 Drawings

A.k.a., Drawing sheets.

The following types of drawings are generally included in a complete architectural drawing set/plan:

1. **Architectural drawing board** - includes all drawing related information on one paper (e.g., drawings, legends, area lists, etc.).
2. **General drawings** - plans (views from above) and elevations (side or front views) drawn on a relatively small scale. Both types of drawings use a standard set of architectural symbols. The most common construction plans are site plans, plot plans, foundation plans, floor plans, and framing plans:
   A. **Site plan** - A site plan is a large scale drawing that shows the full extent of the site for an existing or proposed development. Site plans, along with location plans, may be necessary for planning applications. It shows the contours, boundaries, roads, utilities, trees, structures, and any other significant physical features on or near the construction site. It shows the locations of proposed structures in outline. This plan also shows corner locations relative to reference lines, shown on the plot, which can be located at the site. By showing both existing and finished contours, the site plan furnishes essential data for the graders and excavators.
   B. **Plot plan** - shows the survey marks, including the bench mark (BM), with the elevations and the grading requirements. Surveyors use the plot plan to set up the corners and perimeter of the building using batter boards and line stakes. The plot plan furnishes the essential data for laying out the building.
   C. **Structural plans** - shows the structural characteristics of the building at the level of the plane of projection. Includes plans (views from above) and elevations (side or front views).
      1. **Foundation plan** - is a plane view of a structure. That is, it looks as if it were projected onto a horizontal plane and passed through the structure.
      2. **Framing plan** - a plan view of the layout of girders, beams, and joists. Types of framing plans include, but are not limited to: floor framing plans and roof framing plans.
   D. **Floor plans (and ceiling plans)** - views of a building as though cutting planes were made through the building horizontally. The cutting plane is generally taken 5 feet 0 inches above the floor being shown.
   E. **Infrastructural (utility) plans** - shows the utilities in the building.
      1. **Plumbing plans** - shows the plumbing system. Includes plans (views from above) and elevations (side or front views).
      2. **HVAC plans** - shows the HVAC system. Includes plans (views from above) and elevations (side or front views).

3. **Electrical plans** - shows the electrical system. Includes plans (views from above) and elevations (side or front views).
4. **Illumination plans** - shows the illumination system. Note that the electrical and illumination plans are linked. Includes plans (views from above) and elevations (side or front views).
5. **Gas plans** - shows the gas system. Includes plans (views from above) and elevations (side or front views).
6. Etc.

3. **Elevation views (elevations)** - shows different side views of the building (e.g., north, east, west, south). Elevations show the front, rear, and sides of a structure, as they would appear projected on vertical planes. Studying the elevation drawing gives a working idea of the appearance and layout of the structure. Elevation views are vertical projections.
4. **Section views (sections; a type of detail drawing)** - a vertical cut view of the building selected by the designer. Includes plans (views from above) and elevations (side or front views). Section views provide important information about the height, materials, fastening and support systems, and concealed features of a structure. The cutting plane is not necessarily continuous, but, as with the horizontal cutting plane in building plans, may be staggered to include as much construction information as possible. Like elevations, sectional views are vertical projections. They are also detail drawings drawn to large scale. This aids in reading, and provides information that cannot be given on elevation or plan views. Sections are classified as typical and specific. Selected sections should represent the average condition throughout a structure and are used when construction features are repeated many times. They give a great deal of information necessary for those constructing the building.
5. **Detail views** - large-scale drawings of construction assemblies and installations that cannot be clearly shown in the sections. These enlarged drawings show the various parts in more detail and how they will be connected and placed. The scale depends on how large the drawing needs to be magnified to explain the required information clearly. Details are usually drawn at a larger scale than the sections.
6. **3D whole view** - a three-dimensional perspective view of the whole building.
7. **3D cut view** - a three-dimensional cut-view from a certain perspective.

NOTE: *Architectural symbols provide reference locations for all architectural sub-elements, including fixtures and fittings.*

3.1.1 Construction plan documents

A.k.a., Construction plans, construction sheets.

The process of building something is called construction. In order to construct something effectively, efficiently, and safely, the constructor requires access to all possible visual documents and relevant lists. The construction documents (construction plans) below are standard documents:

1. **A0 sheets:** These project information documents serve as cover sheets for a permit set or construction set. They lay out the general scope of work, including a site plan with the general condition of the work site, and plans that show fire protection and accessibility.
2. **A1 sheets (demolition):** Demolition plans show the current state of the structure and indicate what must be demolished as part of the construction project.
3. **A2 sheets (floor plans, blueprints):** Working drawings that show an aerial view of each level of the building. They include building dimensions, interior walls, exterior walls, and relevant fixtures.
4. **A3 sheets (elevations):** Elevation drawings are architectural drawings that show cross-sections of a building. Also called section drawings, they show ceiling heights, wall construction, foundation plans, and framing plans.
5. **A4 sheets (finish plans):** An architect or design team provides these plans to show what materials will be laid atop the core structure. A4 sheets include a reflected ceiling plan, which shows the ceiling as viewed from the floor, including any lighting fixtures. These sheets also show the location of power outlets, and they make reference to what's known as a finish schedule (found later in the plans).
6. **A5 sheets (interior elevations):** A more detailed variation on the A3 sheets, these elevations might show furniture, light switches, and wall finish types.
7. **A6 sheets (schedules):** In the construction industry, the word "schedule" refers to lists or spreadsheets of certain materials. Construction sets and permit sets feature door schedules (showing all the doors that appear on other sheets) and window schedules (showing all the windows that appear on other sheets).
8. **S sheets (structural drawings):** These building design drawings are the work of a structural engineer, who has a different role than an

architect. The structural engineer's S sheets show the structural schematics of a building, including concrete footings, wall-to-roof connections, joist layout, and any specially engineered pieces in the building's framing. Complex projects may require greater levels of detail in these engineering drawings.

9. **M sheets (mechanical drawings):** These types of drawings show mechanical systems in a building, most notably an HVAC system (which controls heating and air conditioning and is required in most new homes and office buildings).
10. **P Sheets (plumbing drawings):** These show the location of pipes, water tanks, and plumbing fixtures. These drawings show deailed information about a buildings plumbing plan.
11. **E Sheets (electrical drawings):** These drawings show detailed information about a building's electrical plan.

Note that the following elements not necessary for construction directly, and are generally not included in a building permit set or construction set [of documents]:

1. Bidding documents.
2. Contract documents.
3. Project management agreements.
4. Legal conditions of the contract.
5. Cost estimates, interior design proposals.
6. Informal shop drawings.
7. Contract modifications.
8. Supplementary conditions.
9. Other contract addenda.

3.1.2 Materials list and quantities

A.k.a., Bill of materials and quantities.

In order to complete the construction a materials list and associated quantities are required. This information is often included within the drawings, but may be separately associated with (i.e., included within) the specifications.

1. **Architectural schedule (a.k.a., construction schedule)** - a schedule as applied to architectural construction drawings is an organized method of presenting lists of materials, building components (doors, windows, etc.), equipment, and so forth in a drawing in tabulated form.
2. **Architectural bill of quantities (a.k.a., construction bill of quantities; BOQs, BoQ or BQ)** - a document prepared by a quantity survey (or, the cost consultant) that provides project specific measured quantities of the items of work identified by the drawings and specifications.

3.1.3 Construction drawings standards

There are a variety of construction drawing standards, and usage depends of region/jurisdiction.

3.1.3.1 United States National CAD Standard

The United States National CAD Standard [nationalcadstandard.org] places a code in the lower right hand corner of each drawing sheet contains a series of letters and numbers (the sheet number). The sheet number lets the reader know where they are in the drawing set, and allows the reader to know where to look in the drawing set for specific information.

1. Discipline [L] //letter, one letter
2. Drawing type [#] //number, one number
3. Sequence [##] //numbers, two or more numbers
4. For example, F-6-49

The first part of the construction drawing sheet number is a letter which lets us know the discipline for the drawing. These disciplines are arranged in the same order (United States National CAD Standard), for consistency in construction documents.

The common disciplines (Read: specialized construction plan sheet names) are:

- G - General: Sheet list, symbols, summary, life safety and code analysis.
- C - Civil
- L - Landscape
- S - Structural
- A - Architectural
- F - Fire Protection
- P - Plumbing
- M - Mechanical
- E - Electrical
- T - Telecommunications

There are other disciplines which can be included, such as

- H - Hazardous materials
- B - Geotechnical
- I - Interiors
- W - Distributed energy
- O - Operations
- Z - Contractor/shop drawings

The second component of the sheet number is a number referencing a type of drawing. This organizes the discipline's drawings into a consistent, standard sequence of drawing types:

- 0 - General (legends, symbols, general notes)
- 1 - Plans
- 2 - Elevations

- 3 - Sections
- 4 - Large Scale Drawings: plans, elevations, sections
- 5 - Details
- 6 - Schedules and Diagrams
- 9 - 3D Drawings (isometric, perspective, renderings)

Note: 7 and 8 are reserved for user defined drawing types.

3.2 Specifications

A.k.a., Architectural specification, construction specification.

ASSOCIATION: *This section is linked to a related section of The Material System: Habitat System > Technology Support: Materialization Service System > Materialization Specification standards.*

Specifications are precisely written documents that go with the construction documents and describe intent, decisioning, materials as well as installation methods. Specifications describe the all, or some combination of, the following (Construction Specification, 2021):

1. Reasoning (decisioning).
2. Description of the final result (description of design).
3. Quality standards and indicators.
4. Procedures for determining final quality.
5. Products.
6. Materials.
7. Quantities.
8. Costs.
9. Work and/or installation.

They detail the project to be constructed, supplementing drawings, and describe qualities of materials, their methods of manufacture and their installation, and workmanship and mode of construction. Specifications may, or may not, include: materials, quantities, costs, or drawn information. Specifications are written, whereas drawings (and plans) are visualizations (and lists/tables). Specifications may also include supplemental drawings as well as lists/tables. Specifications should complement principal drawings, not overlap or duplicate them. All aspects of the works are generally specified with different sub-specifications.

Specification writing has two principal objectives: to define the scope of work and to act as a set of instructions.

3.2.1 Construction specification standards

Efficient information retrieval is only possible when a standard filing system is used by everyone. There are a variety of standards that provide such a standard filing and retrieval scheme. The Construction Specifications Institute (CSI) MasterFormat is the most widely used standard for organizing specifications for building projects in the United States and Canada.

Architectural construction specifications standards are generally divided into "divisions" with [at least] the following elements:

1. Entire Project Team:
   A. Division 00 - Procurement and Contracting Requirements
   B. Division 01 - General Requirements
2. Structural (and Architectural):
   A. Division 02 - Existing Conditions
   B. Division 03 - Concrete
   C. Division 04 - Masonry
   D. Division 05 - Metals
   E. Division 06 - Wood, Plastics, Composites
3. Architectural (and Interiors):
   A. Division 07 - Thermal and Moisture Protection
   B. Division 08 - Openings
   C. Division 09 - Finishes
   D. Division 10 - Specialties
   E. Division 11 - Equipment
   F. Division 12 - Furnishings
   G. Division 13 - Special Construction
   H. Division 14 - Conveying Equipment
4. MEP (Mechanical, Electrical, Plumbing):
   A. Division 21 - Fire Suppression
   B. Division 22 - Plumbing
   C. Division 23 - Heating, Ventilating, and Air Conditioning (HVAC)
   D. Division 25 - Integrated Automation
   E. Division 26 - Electrical
   F. Division 27 - Communications
   G. Division 28 - Electronic Safety and Security
5. Landscape and civil:
   A. Division 31 - Earthwork
   B. Division 32 - Exterior Improvements
   C. Division 33 - Utilities

Note that green building specifications can be easily incorporated into construction specification standards in three general ways:

1. Environmental protection procedures.
2. Green building materials.
3. Practical application of environmental specifications.

3.3 Architectural-engineering-construction sheet sets

A.k.a., AEC sheet set, architectural drawings list, architectural drawings set, set of drawings, set of architectural drawings, engineering drawing set, engineering drawing list, construction drawing *list, construction drawing set, drawing sheet series.*

The architectural-engineering construction drawing series/set is a combined document that presents all required sheets to understand and construct an architectural[ly engineered] system. The sheets are sub-divided into "series", which each series representing a different view or element of the construction of the architectural system.

Table 1. *Table shows a list of all sheets required in a complete architectural drawing set. Sometimes the sequence/arrangement can differ and some series can be skipped (depending on the specifics of the architectural system).*

Sheet Series	Description
A000	Cover sheet, Drawing list, Legends (Symbols and abbreviations), Assembly types, Schedule & Building Code Review
A100	Site plans and details, Landscape plans and Details
A200	Floor plans, Roof Plans & Reflected Ceiling Plans (RCPs)
A300	Exterior Elevations
A400	Building & Wall Sections
A500	Enlarged Plans
A600	Plans & Section Details
A700	Finish, Furniture & Fixture Plans
A800	Interior Elevations
A900	Millwork Plans, Elevations and Details

The following is a list of typically required sheets:

Note: Different standards use different numbering associated with different conceptual elements. Always check local standards/code for correct numbering.

1. **A000 - Cover sheet, legend, assembly types, schedule and review.**
   A. **A001 - Cover sheet:** This is the first page of the set of drawings. This sheet usually includes:
      1. The title of the project (and project number).
      2. The names of everyone involved.
      3. The date of the completion of the drawing set.
      4. A rendered image of the project.
      5. Copyright information.
      6. The scale of the drawings in the document.

   B. **A001 - Legend, symbols and abbreviations:** This is typically the second page of the drawing set. This page includes a list and explanation of abbreviations and symbols used in the project so that anybody reading the drawings can understand the technical jargon in them.

   C. **A002 - Assemblies types:** Assembly types describe the various types of walls, floors and roofs used within the project. An assembly in an architectural drawing is the collection of components that make up a wall, floor, or roof. A given project can have multiple wall, floor, and roof types. The various assembly types are listed, tagged and described on the assembly sheets.

   D. **A003 – Schedule:** A schedule sheet contains a list of all the fixed components used within the project. Each item in the schedule is usually listed with specific details, such as its name, description, location in the building, quantity required, specifications, and any other relevant information. The fixed components include, but are not limited to: windows and doors; finishes; built-in cabinetry and millwork; staircases and railings; fixtures and fittings; structural elements; specialty features. These components are tagged, dimensioned and described on the schedule sheets. Note that an architectural schedule sheet is sometimes confused with an architectural schedule, which is a separate document (or, set of documents) that outline the timeline and sequence of various architectural activities and milestones throughout a project.

   E. **A004 – Code analysis, review & compliance:** The use of this sheet varies, and there may be more than one of these sheets in the documentation set. In countries where building codes are used, a code review of the designs is always required. This sheet identifies the codes applicable to the project (first code sheet; code analysis) and explains how they were adhered to (second sheet; code compliance).

2. **A100 - Site Plan:** This sheet contains the layout of the building and its surroundings; including, the location of the building on the site and all significant surrounding features such as pathways (streets and sidewalks), landscaping, parking lots, and driveways. Typically, site plans also include information about the zoning and zoning regulations of the area, as well as any existing utility lines and other infrastructure. The A100 series of sheets may also include landscape drawings and site details.

3. **A200 - Plans.**
   A. **A201 - Floor plans:** This sheet series presents the comprehensive arrangement of a building by floor (or, level). It visually represents the interior layout, displaying the positioning of walls, doors, windows, stairs, and other elements. The A200 series of sheets may comprise multiple sheets, each illustrating different floor plans like the ground floor, first-

floor, second-floor, and so on.

B. **A211 - Roof Plans:** This sheet shows the layout and design of the building's roof. It is used to provide a visual representation of the roof's shape, slope, and direction, as well as the location of any roof penetrations such as skylights, vents, and chimneys.

C. **A221 - Reflected Ceiling Plans (RCP):** This sheet shows the layout of the ceiling of the building, including the location of lights, speakers, vents, and other ceiling-mounted fixtures and features. It is called "reflected" because it shows the ceiling elements as if they are reflected on a mirror placed on the floor below the roof.

4. **A300 - Elevations:** The elevation sheet series shows the exterior of the building from one side or view, typically the front, back and/or sides. Elevations are used to communicate the overall design and appearance of the building, including the height, shape, and materials of the walls, roof, and other features.
5. **A400 - Sections.**
   A. **A401 - Building sections:** The building section sheet shows the vertical cutaway view of the building, typically at key locations, such as the stairwell or a major room. It is used to communicate the internal layout and structure of the building, including the height and location of walls, floors, and ceilings, as well as the location of any mechanical and electrical systems.
   B. **A411 - Wall Sections:** The wall section sheet is typically derived from the building section and displays a vertical cutaway view of a particular wall or a group of walls. These sheets are used to illustrate the construction details and materials utilized in the building's walls, including the positioning and thickness of insulation, vapor barriers, and other components. The wall section sheet is usually called out from the building section. "Called out" refers to the process of creating or extracting a specific drawing, in this case, the wall section sheet, from a larger drawing or plan, such as the building section. When certain details need more emphasis or require additional elaboration, they are "called out" and presented in a separate, dedicated sheet for better clarity and focus.
   C. **A500 - Enlarged plans:** This sheet displays a blow-up (i.e., enlarged) detailed floor plan, providing a closer and more comprehensive view of a specific area within the building's layout. It is commonly utilized to showcase intricate details of particular spaces.
   This enlarged plan is often used in larger projects where the overall floor plan cannot accommodate all the necessary details. The enlarged plan is called out from the main floor plans to offer a more focused and in-depth understanding of the specified area.
6. **A600 – Details.**
   A. **A601 - Plan details:** These sheets are used to present construction details of vital elements within the project from a plan view perspective, such as the connections of doors or windows to walls. They are a valuable resource for providing information about the materials and construction methods employed in the project.
   B. **A602 - Section details:** These sheets serve the purpose of offering construction details for crucial components of the project from a section view, such as the interface between two different materials or the connection of structural elements like walls to floors. They are frequently employed to convey information about the materials and construction techniques used in the project.
7. **A700 - Finish, furniture and fixture (FFE) plans:** These sheets shows the location and technical details (i.e., specifications) of the finishes, furniture, fixtures, and may include fittings and appliances.
8. **A800 - Interior elevations:** This sheet presents a vertical view of particular interior architectural elements, including walls, partitions, millwork, cabinetry, and more. Unlike an exterior elevation, it focuses on the interior side of these elements, aiming to communicate the design of specific architectural features, such as built-in cabinetry, fireplace mantels, or other millwork details.
9. **A900 - Millwork plans, elevation & details:** This sheet is the construction detail sheet for the millwork, casework, and other fixed cabinetry.

3.4 Architectural-engineering-construction schedule

A.k.a., AEC schedule.

The schedule is an essential project coordination tool used to plan, coordinate, and monitor the progress of architectural work from the design phase to completion.

The architectural schedule typically includes the following key elements:

1. **Task breakdown:** The schedule breaks down the architectural-engineering and construction work into specific tasks and activities.

2. **Duration:** Each task is assigned a duration, representing the estimated time required to complete it. The durations will vary depending on the complexity and scope of each activity.
3. **Dependencies:** Tasks often have dependencies, meaning that certain activities must be completed before others can start. Identifying these dependencies is crucial for creating a realistic and feasible schedule.
4. **Milestones:** The schedule may include key milestones, which are significant events or accomplishments that mark important stages in the project. Milestones may include design approval, submission of construction documents, and completion of specific design phases.
5. **Resource allocation:** The schedule may consider the allocation of resources, such as personnel and equipment, to ensure that the required resources are available when needed.
6. **Constraints:** Scheduling constraints, such as budget limitations or external factors that may impact the project timeline, are also taken into account.
7. **Critical path:** The critical path represents the sequence of tasks that determine the minimum time required to complete the project. Any delay in tasks on the critical path will result in a delay in the overall project timeline.
8. **Updates and monitoring:** The architectural schedule is a dynamic document that requires regular updates as the project progresses. Project coordinators and stakeholders monitor the progress to ensure the project stays on track and take corrective actions if necessary.

3.5 Additional architectural-engineering-construction documents

A.k.a., Additional AEC documents.

In architectural-engineering-construction (AEC) projects, besides the drawing sheet set, specification sheet set, and construction schedule, various additional documentation sets play a vital role. These documentation sets are integral to fostering seamless communication, efficient coordination, and successful implementation throughout the design and construction process. It is essential to note that the specific documents required may vary depending on the nature and complexity of the AEC project, and not all projects will necessitate all of these documents.

The key additional documents include:

1. **Bill of quantities (BoQ):** The BoQ is a comprehensive document that lists all the materials, quantities, and labor required to complete the construction project. It serves as a basis for cost estimation, tendering, and budgeting.
2. **Contract documents:** The contract documents outline the legal agreements and responsibilities between the project owner, contractors, and other parties involved in the construction. These documents may include the contract agreement, general conditions, special conditions, and any other relevant contractual information.
3. **Shop drawings:** Shop drawings are detailed drawings illustrating how specific building components will be fabricated and installed. They provide more detailed information than the general construction drawings and are essential for ensuring correct installation.
4. **As-built drawings:** As-built drawings are updated drawings that reflect the actual construction and any changes made during the building process. They provide an accurate record of how the project was built, capturing any deviations from the original design.
5. **Request for information (RFI) and change orders:** RFIs are formal requests for clarification or additional information regarding the design or specifications. Change orders document any approved modifications or alterations to the original construction plans.
6. **Project manual:** The project manual includes all the written documents and instructions related to the construction project. It often includes project specifications, general conditions, bidding requirements, and other project-specific information.
7. **Quality control/quality assurance (QA/QC) documentation:** This documentation includes procedures, checklists, and inspection reports related to quality control and quality assurance during construction to ensure compliance with standards and specifications.
8. **Submittals:** Submittals are documents submitted by engineers, constructors, and suppliers to demonstrate that the proposed materials and products meet the project requirements and specifications.
9. **Punch list (a.k.a. snag list, deficiency list, outstanding work list, rectification list, finish work list, final inspection list, completion list, final walkthrough list, etc.):** The punch list is a final checklist of outstanding work, deficiencies, or minor items that need to be addressed before the project is considered complete. In other words, this is a list of remaining tasks or issues

that need attention and resolution to achieve the final completion of the construction project. This list emphasizes any remaining deficiencies or discrepancies in the construction that require rectification. The punch list often includes items related to finish work, such as touch-ups, adjustments, or final details to complete the project. The punch list can be viewed as a final inspection checklist, detailing the remaining items that must be checked and resolved before project acceptance.

10. **Closeout documentation:** Closeout documentation includes all the final documents and records required at the completion of the project.

4 Architectural standards

A.k.a., Architectural specification standards, architectural regulations, building standards, building regulations, construction standards, construction regulations, building standards, building engineering standards, building codes, construction codes, architecture codes, BIM codes, etc.

A technical standard is a datum document established through a systems science process that provides for common and repeated need of technology for, use, protocols, guidelines, or characteristics of activities or their results. A standard in this technical form is usually a formal document that establishes uniform engineering or technical criteria, methods, processes and practices. Clarification: The term standards can also refer to the interoperability of connecting objects/systems. In this case, higher standardization (as a technical objective) will allow for interchangeability of parts, system interoperability, and possibly ensure higher quality, reliability and safety.

A code is the market-State term for a set of [legal, State enforced] rules and specifications for the correct methods and materials used in a certain product, building or process, which exists because of State legislation. Codes can be approved by local, state or federal governments and can carry the force of law. In the market-State, the main purpose of codes is to protect the public by setting up to some minimum acceptable level of safety for buildings, products and processes. In community, the term code is replaced by protocol. This protocol has been decided in the decision system by contributors to the InterSystem team who form the protocol(s) from systems science into safe and appropriate engineering rules.

NOTE: *It is possible for code to limit progress toward community due to restrictions on building locations and techniques in a specific jurisdiction.*

Every architectural service in an building, from its structure to the installation of plumbing and electricity has an associated standard, somewhere in the world. Building standards are often just called building codes, building regulations, etc. Different criteria may be selected for optimization in different jurisdictions using different standards (codes, laws, etc.). Standards explain how do to something, they may also explain why, and provide for community requirements. In the market-State, because optimality is often not possible, there is "cost cutting", which must be handled by the State using building regulations and building codes. Different jurisdictions have different rule making processes as well as different objectives, which results in different codes/standards. In concern to codes, "code" is a number of digits and/or characters associated with a phase and or object type (e.g., slab, furniture, etc.).

It the market-State it is understandable why some standards intentionally introduce lower quality designs and materials, because they are cheaper. Designs and materials can be allowed for economic reasons and not for health or optimization reasons. In the market-State, businesses use the regulatory power of the government to enhance and/or improve the sale of their products by having the government create standards that unnecessarily mandate their usage (e.g., using flame retardant chemicals in mattresses was lobbied by the chemical industry and incorporated into legislation in some jurisdictions). Fundamentally, in the market-State, some standards are composed of stupid rules, and some are composed of sensible rules. In political contexts, standards can serve as a vehicle by which some corporate and/or State members use leadership positions within the standards setting organization to promote their own interests and harm competitors.

Changes to a building code occur to:

1. Corrects errors and omissions.
2. Integrate new understandings and knowledge.
3. Address a critical life/safety need.
4. Clarify the intent or application of the code.
5. Address a specific state policy or statute (market-State only).
6. Address consistency with state or federal regulations (market-State only).

The following are the most common building-related standards (note: some are more related to categorization and others to safety and optimization engineering):

1. Master specifications (Masterspec®, SPECSystem™, MasterFormat™, SpecText®, BSD Speclink®, ezSPECS On-Line™, 20-20 CAP Studio, and many others).
2. Local and national codes and ordinances.
3. Federal specifications (Specs-In-Tact, G.S.A., N.A.F.V.A.C., N.A.S.A.).
4. National standards organizations, such as:
   A. U.S. American National Standards Institute.
   B. U.S. National Institute of Building Sciences.
   C. U.S. National Fire Protection Association [nfpa.org]
   D. U.S. National Institute of Standards and Technology.
   E. U.S. Association for Contract Textiles
5. Manufacturers' industry associations (Fire Equipment Manufacturers' Association, American Plywood Association, The Brick Industry Association, etc.).
6. Testing societies (American Society for Testing and Materials, American Society for Nondestructive Testing, Underwriters Laboratories).
7. Manufacturers' catalogs (Sweet's Catalog File, Man-U-Spec, Spec-data).
8. Industry-related magazines and publications (Construction Specifier, Architecture, Green Magazine On-line, Interior Design, Architectural Lighting, Architectural Record).

4.1 Architectural categorization by means of titling and numbering

A.k.a., Construction titling and numbering, material specification titling and numbering, architectural categorization.

All the architectural elements of a building of a building (including, fixtures, fittings, and utilities) fit in a set of titling and numbering categories for organizational and integration purposes. In the market-State, different organizations (e.g., international organizations, national organizations, and businesses) often follow different titling and numbering standards. All architectural elements are associated with construction classifying titles and numbers.

In the market-State, there exist a variety of materialization and other construction specification standards, including but not limited to:

- **American Institute of Architects (AIA)**, [aia.org] - publishes the AIA MasterSpec, which is produced for AIA by Deltek [deltek.com]. MasterSpec is a library of master specifications. MasterSpec is organized by MasterFormat number, but it fills in the actual specification content that MasterFormat isn't intended to provide.
  - *Student Access to MasterSpec*. (2018). Deltek. [avitru.com]
- **ASTM**, [astm.org] - ASTM International, formerly known as American Society for Testing and Materials, is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services. ASTM specifications and codes address material and testing procedures. The specifications issued by ASTM are organized on the basis of the type of material, and the letters prefixed to the specification number are indicative of the material type. For example, letter A is for all ferrous materials; B is for all nonferrous materials, etc.
  - *Construction standards*. ASTM. Accessed: January 7, 2020. [astm.org]
  - *Additive Manufacturing Standards Activities*. ASTM. Accessed: January 7, 2020. [amcoe.org]
- **British Standards Institution (BSI)**, [bsigroup.com]
  - *Standards and schemes for certification*. BSI.

Accessed: January 7, 2020. [bsigroup.com]

- **Building and Construction Authority of Singapore**, [bca.gov.sg]
  - *Publications*. Building and Construction Authority. Accessed: January 7, 2020. [bca.gov.sg]
  - *Guide on Construction of Industrial Developments in Singapore*. (2010). Building and Construction Authority. [bca.gov.sg]
- **Building Information Standards**
- **Construction Specification Institute (CSI)**, [csiresources.org] - publishes the CSI MasterFormat. MasterFormat is the intellectual property of the Construction Specifications Institute. MasterFormat is a numbering system for specifications. Construction specifications used in the United States typically conform to the guidelines of the Construction Specifications Institute's "MasterFormat". The MasterFormat index groups specification sections into identifiable disciplines using a six-digit system with digits in groups of two, such as: 01 24 30. Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC). MasterFormat is the protected intellectual property of the Construction Specifications Institute (CSI) so there is no publicly provided full list of numbers and titles. Unfortunately, CSI no longer makes the list available for free. MasterFormat is used throughout the construction industry to format specifications for construction contract documents. MasterFormat is a coding system for organizing construction documents, contracts, design specifications, and operational manuals. MasterFormat is also a publication created and maintained by the Construction Specification Institute (CSI) and Construction Specifications Canada (CSC). CSI MasterFormat is the standard used to provide synchronicity between manufacturers and builders. The MasterFormat is used by manufacturers to ensure that their products meet requirements such as size, weight, or material types.
  - *MasterFormat: Numbers and Titles*. (2016). Edmonton Construction Association. [edmca.com]
  - *MasterFormat Specification Divisions (CURRENT). (2018).* ArchiMat. [archtoolbox.com]
  - *CSI 3-Part Formatted Specifications*. ARCAT. Accessed: January 7, 2020. [arcat.com]
  - *CSI MasterFormat™ Division List.* Builders Exchange of St. Paul. Accessed: Januayr 7, 2020. [plainsbuilders.com]
  - *Master Construction Specifications (PG-18-1).* (2019). US Department of Vetrans Affair, Office of construction and facilities management. [cfm.va.gov]
- **European Committee for Standardization (CEN)**, [cen.eu]
  - Search Standards. CEN. Accessed: January 7, 2020. [standards.cen.eu]
- **International Code Council (ICC)**, [iccsafe.org]
  - *Standard Development & Consensus Committees*. International Code Council. Accessed: January 7, 2020. [iccsafe.org]
- **International Construction Information Society (ICIS)**, [icis.org]
  - *ArchiveSpecifications*. ICIS. Accessed: January 7, 2020. [icis.org]
- **International Standards organization (ISO)**, [iso.org]
  - *ISO and Construction*. (2017). ISO. [iso.org]
- **U.S. Occupational Safety and Health Administration (OSHA)**, [osha.gov]
  - *Law and Regulations*. OSHA. Accessed: January 7, 2020. [osha.gov]
- **The Associação Brasileira de Normas Técnicas** (ABNT), Brazilian Technical Norm (Norma Tecnica Brasieira, NBR) [abnt.org.br; braziliannr.com]
  - ABNT NBR ISO 9001:2015
- **Panamerican Standards Commission; Comisión Panamericana de Normas Técnicas (COPANT)** [copant.org]
- **Asociación Mercosur de Normalización (AMN)** [amn.org.br] - Asociación Mercosur de Normalización is a civil, non-profit, non-governmental association, recognized by the Common Market Group (GMC). It is the only body responsible for the management of voluntary standardization within the scope of Mercosur.

NOTE: *There are a variety of terms that relate to construction costing standards. For example, construction measurement standards refer to the way construction costs are calculated, classified, analysed and presented.*

4.2 State building codes

A.k.a., Building regulations, building law, construction code, construction law, building legislation, construction legislation.

Building codes (regulations, laws restricting building) state building requirements, given by a jurisdiction, for any number of purposes. Ideally, a building code, or building control standard, is a set of rules that specify the minimum standards for constructed objects such as buildings and non-building structures. The main purpose of building codes are to protect human health and safety while supporting human fulfillment and ecological restoration. A building code becomes law of a particular jurisdiction when formally enacted by the appropriate governmental or private authority. Enacted building legislation exists to regulate individuals and business.

What makes a good shelter? For thousands of years we've been attempting to regulate the idea. Even the bible had building codes. The book of Deuteronomy mandates railings on roofs to prevent falls. After the great London fire of 1666, cities began creating stricter regulations for how we build. Over the centuries the codebooks have only grown thicker. It's undeniable that building codes have saved lives, but something has changed over the past couple decades. Now thanks to the Internet the average homeowner has unlimited access to building techniques (both traditional and experimental) so we're experimenting more than ever, often without regard for the rulebooks.

Like most things in early 21st century society, codes have turned into big business. They are a key source of revenue for governments. They're also leveraged by many industries and organizations to push their political and economic agendas. These groups all benefit from code complexity.

These codes/standards become the backbone of justification for the very existence of hundreds of government [building] departments. With these departments come [building] codes, plan reviews (for permission), zoning, permits (plan and operating permission), and inspection (and safety review), and [code/law] enforcement. This hierarchy, along with associated fees and expenses is, by design, supposed to protect human beings from serious harm under market conditions, and to keep them safe from scientifically unproven, dangerous building/materialization practices and or materials. Rules, regulations, certifications, licensing requirements, bonding, and insurance requirements are all claimed to work toward the common goal of "protecting and keeping safe under market conditions".

In general, the [building/materialization] codes are based on the minimum requirement at every level. Additionally, many States/governments use different standards. In practice, from zoning to permissioning, to code requirements, most States in the 21st century follow a market-type form of oversight, planning and inspecting. Habitat (city/rural) zones are split into: residential, commercial, industrial, etc. Planning creation (and permissioning) is not at the habitat level. Codes are often written to a standards minimum requirements.

In the market, without control, building can become a "free for all" where those who assume the labor role of "constructor" frequently display behavior indicating a lack of consideration for anyone but themselves and construct constructions that are dangerous or damage other constructions when doing their own. Or, create an unaesthetic environment brought forth from their own ego. Others who have assumed the labor role of "constructor" may have the best intentions, but either forget something, or just don't know how to build something safely, and their construction fails and hurts something or someone.

State building codes reduce problems [in the market] through coercion and force. In community, we design and test so that our active designs don't hurt us. Community is a place where everyone desires and decides to build safely. In community, we masterplan for our global fulfillment. In community, we integrate our builds into a habitat service system designed to regeneratively fulfill our lives. In the market, buildings are integrated into the market; and, they are be bought, sold and taxed (by the State to provide some semblance of safety under market conditions).

Coding [law] refers to the code requirements of a jurisdiction in order to construct something, including identifying and conforming to them (in community, coding is part of the decision system). Different jurisdictions may have different codes, but a safely designed building should meet and often exceed building code, unless the code is purposefully restrictive due to cultural norms.

The International Building Code (IBC) is often used to architect buildings that meet safety code requirements. Some common steps in the IBC include:

1. Establish occupant load.
2. Determine occupancy classification.
3. Determine allowable area.
4. Determine allowable height.
5. Determine construction type.
6. Determine hourly ratings of construction components for construction type.
7. Determine required occupancy separations.
8. Determine sprinkler requirements.
9. Determine if area separation walls are needed.
10. Determine if exterior walls and windows have adequate fire protection.
11. Check exiting and entering.

Building regulations generally include, but may not be limited to, the following categories:

1. Structure.
2. Fire safety.
3. Site preparation and resistance to contaminants and moisture.
4. Toxic substances.
5. Resistance to the passage of sound.
6. Ventilation.
7. Sanitation, hot water safety and water efficiency.
8. Drainage and waste disposal.
9. Heat producing appliances.
10. Fuel storage systems.
11. Protection from falling, collision and impact.
12. Conservation of fuel and power.
13. Access to and use of buildings.
14. Glazing - Safety in relation to impact, opening and cleaning.

15. Electrical safety.
16. Security - Dwellings.
17. Physical infrastructure for high-speed electronic communication networks.
18. Materials and workmanship.
19. Illumination.
20. Data and communications.

4.3 State construction permits

A.k.a., Construction permits, building permits, zoning permits, construction waiver, etc.

A "construction permit" (a.k.a., "building permit") is a permit/license required [as permission] in most jurisdictions for new construction. Building permits are to a large degree considered the profit end of building code, for they come with fees and taxes. The question is, Who can *issue (sell)* permits and who can *obtain (purchase)* permits? Note here that the word "obtain" is the word which jurisdictions often use when speaking of acquiring a permit. However, "obtain" is deceptive language -- what is really occurring is that the authority is forcing the purchase. Codes are enforced by the authority, and there is socio-economic punishment if they are not followed. The jurisdiction sells the permits, which have a financial cost associated with them. In most jurisdictions, the only person who can obtain a permit is a State licensed contractor, who pays the State for a license to do contract work in accordance with the standards (i.e., "building codes") of the State.

5 Architectural decisioning

Any architectural process will include most of the following data-oriented decisioning elements:

1. **Decision of function:**
   A. Purpose of architecture.
      1. **Functional usage mapping** of architecture to users.
      2. **Psychological (aesthetic) mapping** of architecture to users.

   B. Space requirements.
   C. Intended length of existence.
   D. All architecture, as an enclosure must have:
      1. appropriate structure [rigidity and function], and
      2. appropriate surface [contact and vision area].
2. **Decision of materials** (note: materials may be individual isolated, such as pain, or formed into mechanisms and appliances, such as motors and faucets):
   A. Material flow mapping of material decision data:
      1. Material composition.
      2. Material amount.
         i. Amount of decided material(s). Quantities of materials.
      3. Cost of material (market-only)
      4. Material origin.
      5. Material transportation
         i. Amount of energy needed for transportation of materials.
      6. Material processing.
         i. Material [pre-]processing requirements. Material processing requirements prior to allocation in construction.
         ii. Amount of energy needed for processing materials into constructions.
      7. Material positional allocation in HSS.
         i. Amount of technology and energy needed for positioning materials, as constructions, into the environment.
      8. Material post-allocation, including usage, disposal, and recycling.
         i. Amount of technology and energy needed for re-purposing or recycling materials.
3. **Decision of construction and assembly (technology):**
   A. Technology flow mapping of construction and assembly decision data:
      1. Type of technology.
      2. Technology materialization requirements.
      3. Amount of effort per technology.
      4. Amount of energy required per technology.
      5. Cost of technology (market-only).

6. Operation and maintenance requirements (and associated market costs).
7. Time to realization (construction time duration).
4. **Decision of structure** (integration of structure and infrastructure:
   A. Structural engineering the optimal structure given architectural building shape and functional requirements. This includes all performance assessments on the structure (e.g., acoustic, thermal, etc.).
   B. Viable construction processes (on site), including assembly process.
   C. Amount of human effort for construction of structure.
   D. Amount of human effort for maintenance of construction.
   E. Amount of energy for maintenance of construction.
   F. Durability of systems and materials deployed.
5. **Decision of modularity**:
   A. Viable future dismount and disassembly, or deconstruction.
   B. Modularity of the indoor use of the construction. Indoor use flexibility (internal modularity).
   C. Modularity of the structure of the construction. Structural re-use of the system (con-structural modularity).

5.1 Architectural decisioning requirements for optimality

A.k.a., Architectural performance, architectural optimization requirements.

The optimization of an architectural construction for society can be achieved by accounting for each of the following factors:

1. Local production or prefabrication cost and energy requirements (i.e., footprint).
2. Relatively fast, simple and automatable construction method.
   A. Low/reduced labor requirements for construction.
3. Water-proof (including, moisture-proof).
4. Termite-proof (Read: insect-proof).
5. Rodent-proof (Read: pest-proof).
6. Mold-proof.
7. Fireproof.
8. Earthquake resistant.
9. Sufficiently thermally (climactically) insulated.
10. Possibly applicable to all climatic conditions.
11. Highly sound insulation and appropriate acoustics.
12. Highly durable, and repairable if damaged (relatively).
13. Interior adaptations and modularity.

Simplistically speaking, selection is based on:

1. Reproducability (i.e., continued producability), regenerability, and/or sustainability.
2. Costability - Spend sufficiently and don't spend more than you have to spend.
3. Duplicability - how long into the future can the system be duplicated using available resources and finances.
4. Material resource availability.
5. Labor resource availability.
6. Beneficial health impact (physical, emotional, psychological, communal, and environmental).

5.1.1 Structural decision requirements

The structure must be sufficiently impermeable to:

1. **Impermeable to water (a.k.a., water resistant, water tightness, moisture resistant)** - under normal conditions, the building should be impermeable to water.
   A. Water should not be able penetrate the exterior surface of the building.
   B. Water within the building should be appropriately conduited and drainable (if a water-related incident occurs).
2. **Impermeable to adverse weather (a.k.a., weather tightness, weather resistant)** - under regular adverse weather conditions, the building should be impermeable to snow, hail, wind, and water (including, wind-driven spray of water).
3. **Impermeable to mold (a.k.a., mold resistant)** - under normal conditions the structure of the building should be impermeable to mold and molding.
4. **Impermeable to fire (a.k.a., fire resistant)** - the building should be less likely catch and sustain a fire.
5. **Impermeable to pests (a.k.a., pest resistant)** - the building should be impermeable to pests.

5.1.1.1 Moisture resistant

In terms of resistance to moisture, the regulations state that the building should be protected from harmful effects caused by:

1. Ground moisture.
2. Precipitation including wind-driven spray.
3. Interstitial and surface condensation.
4. Spillage of water from, or associated with, sanitary fittings or fixed appliances.

5.1.1.2 *Environmental relative mold index (ERMI) test*

The "environmental relative mold index" (ERMI) is an algorithm used to calculate a ratio of water damage-related species (that are likely to harm human health) to common indoor molds and the resulting score is called the. The ERMI test is based on an instrument that uses quantitative polymerase chain reaction (MSQPCR) testing.

5.2 *Building life-cycle performance*

There are a variety of standards and indices for building appropriate resource lifecycle coordination into buildings and other structures. Some of these standards are optional, and others are legal (market-State only) and/or community-protocol, decided. While these minimums and/or optimums may vary from jurisdiction to jurisdiction. Some of these standards and indices have been turned into certifications businesses; wherein, businesses sell the certification of a piece of architecture as representing the alignment with their criteria. There are no businesses in community, and so community uses community goals and objectives in conjunction with physics-engineering performance of systems to meet user requirements. In community, an algorithmic decision protocol is used by InterSystem teams to fulfill requirements. In the market, there are many competing businesses, which leads to secrecy, uncooperative, and cost-cutting behavior. Thus, the certification business exists to inform consumers (and States) as to what criteria are appropriate for what objectives.

For example, the LEED ("leadership in energy and environmental design") Green Building Rating Systems (Read: index) are voluntary systems that assess the environmental performance of built projects across a spectrum of key energy and environmental criteria. From water and energy use efficiency to location, the impact of materials used, etc. In 2013, members of the US Green Building Council (USGBC) voted (85 percent) to include cradle-to-cradle certification in LEED V4, which will even more stringently enforce the environmental qualities of materials used in green buildings, the opposite of what industry interests want. Now, those seeking LEED certification will get credits for Materials & Resources for disclosing and optimizing where building materials are sourced and purchased.

The following organizations and standards provide information the design and development of high-performance buildings:

- **Building performance standard (Building Performance Institute (BPI)** [bpi.org] - The Building Performance Institute works to advance building performance by developing production standards that foster quality and consistency in home performance and weatherization. Maintain the healthy home evaluator standard.
  - ANSI/BPI-1200-S-2017 Standard Practice for Basic Analysis of Buildings [bpi.org/standards/current-standards]
    - *Note: This is one of the most significant standards available in analyzing the performance of a "home"-type buildings.*
- **The International Green Construction Code (IgCC)**, [iccsafe.org] - The IgCC is a model code that provides minimum requirements to safeguard the environment, public health, safety and general welfare through the establishment of requirements that are intended to reduce the negative impacts and increase the positive impacts of the built environment.
  - IgCC: A member of the International Code Family. (2018). ASHRAE. [ashrae.org]
- **US Green Building Council (USGBC)**, [usgbc.org]
  - USGBC Publications. USGBC. Accessed: January 7, 2020. [usgbc.org]
- **World Green Building Council,** [worldgbc.org]
  - Green building rating tools. World Green Building Council. Accessed January 7, 2020. [worldgbc.org]
- **Cradle-to-Cradle (C2C),** [c2ccertified.org]
  - Cradle to Cradle Certified Version 4. (2019). Cradle-to-Cradle. [c2ccertified.org]

5.2.1 Building performance requirements

Performance requirements typically comprise a set of criteria which stipulate how things should perform or the standards that they must achieve in a specific set of circumstances.

The design of a building can be divided into precise performance requirements which might include:

1. Capacity.
2. Appearance (aesthetics).
3. Durability (reliability).
4. Strength (and rigidity).
5. Stability.
6. Acoustic performance.
7. Thermal performance.
8. Comfort.
9. Weather tightness.
10. Fire protection.
11. Pest protection.
12. Accessibility of design.
13. Automation (or manualization) of design.
14. Lighting.
15. Ventilation.
16. Security (market-State only).
17. Safety.
18. Privacy.

19. Energy efficiency.
20. Cost (market only).

5.2.1 Common building performance issues

Some examples of building performance issues include, but are not limited to:

1. **Structural stability** - The architecture should not have any progressive structural movement that could cause any part of the building to fail or collapse.
   A. Concerns include, but are not limited to:
      1. Leaning chimney stacks and pots.
      2. Sagging roofs.
      3. Bulging brickwork to the main external walls.
      4. Settlement cracks above windows and doorways.
      5. Distorted window and door openings.
      6. Sloping floors.
2. **Damp (structural integrity to water)** - The architecture should be free from rising and penetrative dampness (which could damage health).
   A. Concerns include, but are not limited to:
      1. Rising dampness to ground floor walls - this is normally indicated by a damp tide mark.
      2. Rising dampness to ground floors - old quarry tile floors and poorly constructed solid concrete floors with no damp-proof membrane are particularly susceptible.
      3. Penetrating dampness to walls and ceilings due to leaking roofs and gutters, perished external brickwork and mortar joints, leaking hot or cold water pipes.
3. **Condensation (structural integrity to water)** - The architecture should be free from condensation.
   A. Concerns include, but are not limited to:
      1. Condensation can lead to mould growth on walls and ceilings in kitchens and bathrooms.
      2. Condensation gathers on bedroom walls behind cupboards and wardrobes and beneath windows.
4. **Heating and cooling (structural integrity to thermal energy)** - The architecture should heat and cool efficiently, safely, and be energy/cost efficient to operate.
   A. Concerns:
      1. Cracking due to heating and cooling.
      2. Architecture heats and cools at different rates.
      3. Architecture heats to dangerous levels.
      4. Architecture does not, where appropriate, hold heat or cold.
5. **Insulation (structural integrity to thermal energy transfer)** - The architecture should have good/appropriate thermal insulation.
   A. Concerns:
      1. Insulate all structural surfaces, including: roofs, floors, walls.
      2. Insutate windows.
      3. Replace draughty, ill fitting windows and doors; louvre blade windows are particularly wasteful in terms of heat loss as well as being an added security risk.
      4. Draught proof external doors and windows, (but not rooms containing an open-flue gas appliance).
      5. Make sure that all water pipes likely to be exposed to frost, such as those in the roof space are properly insulated or take other suitable steps to prevent burst pipes during the winter.
      6. Make sure that the hot water tank is fitted with a good quality insulation jacket and/or insulated storage location.
6. **Lighting (structural illumination)** - The architecture must have adequate lighting for human health and functioning.
   A. Concerns:
      1. All appropriate rooms need adequate natural lighting to allow people to: 1) do functional activities; and 2) maintain naturally lighted circadian rhythms.
      2. All staircases, landings, kitchens, bathrooms and toilets should have a window wherever practical.
      3. There should be adequate, electric lighting to all accessible parts of the architecture including: light switches suitably positioned so that you can switch on quickly when entering any room, hallway or landing two way switches that switch on and off at the top and bottom of stairs.
7. **Ventilation** - The interior of the architecture should have adequate ventilation.
   A. Concerns:
      1. Lack of fresh air and fresh air exchange.
      2. All habitable rooms should be ventilated directly to the open air by opening a window. Kitchens, bathrooms and toilets should have a window which opens wherever possible. Where this is not possible, there should be adequate mechanical ventilation. In kitchens and bathrooms with windows, it is good to install an automatic humidistat extractor fan to remove moist air before it condenses on walls and ceilings.
      3. All rooms containing an open flue gas heating appliance and all kitchens, bathrooms and

toilets should be provided with enough suitable permanent ventilation by air brick or similar.

5.3 Maintenance and cleaning performance

The optimization of the maintenance and cleaning of architecture involves the following factors.

1. Services:
   A. Hygienic floor drains that are resistant to corrosion from blood and chlorine should be provided in all "wet areas" of the mortuary and should be directly connected to the sewer system. These areas include body preparation, autopsy space, etc. These areas require thorough cleaning after every procedure, using large quantities of water and decontaminating and disinfecting chemicals and soaps.
   B. Open floor channels should be avoided. Where this is not possible, these should be covered by durable, flush-fitted stainless steel grids.
2. Structural cleaning:
   A. Cleaning of the outside surface of the building requires pressure washing, which needs to be integrated. The exterior of the building, including the veranda area needs conduits and outlets for a pressurized washing system for the surface of the structure. The utility for this pressurized washing system is located in the utilities room.
3. Finishes:
   A. Wall and floor finishes should be impervious to liquids and easily cleanable; by what measure of resistance?
   B. Structure should be weather proof; by what measure of resistance?
   C. Surface of structure must be cleaned periodically; by what optimal method of timing, method, and material?
   D. Surface of structure must be re-applied periodically; by what optimal method of timing, method, and material?
4. Common cleaning and replacement issues:
   A. Water heater [flushing] - Flushing the water heater. It can extend the life of your water heater, and it needs to be done once a year. If it's not done often enough, mineral sediment can build up inside the tank, causing banging, popping or rumbling noises as water bubbles up through it. That layer of sediment will make it harder to flush your water heater. Eventually, the sediment layer will cause the bottom of the tank to rust out, and you'll need a new water heater much sooner than you otherwise might have.
   B. Dryer vent [cleaning] - Lint build-up in dryer vent ductwork is a leading cause of house fires, and that's why cleaning your dryer vent ductwork every six months. A blocked duct can extend drying times or make the house smell strange.
   C. Window cleaning [cleaning]
   D. Refrigerator [cleaning] - dust off refrigerator coils every three months.
   E. Illumination - replacement of ceiling bulbs.
5. Assembly, positioning, disassembly, and removal:
   A. Assembling and positioning the subsystem should not damage the surrounding area.
   B. Removing and disassembling a subsystem should not damage the area surrounding it.

6 Planning architectural functions

Functional material planning refers to the design, development, and construction of 3D objects and systems, particularly material architecture at the level of human and other organismal habitation size spaces. Material-space (material-object) systems and flows may be fully visualized, understood, and constructed to be correct functional operations in the real world where precision, efficiency, and safety are [decision system inquiry] values. A complete architectural systems engineering deliverable includes all possible known functions for a space/environment/system. This model allows for efficient and effective integration in production (and society as a whole) to economically calculate social object/environment constructions optimally and in a coordinated matter [toward the optimal fulfillment of each and every human individual being].

6.1 Basic architectural functions

Architecture has a set of basic functions (i.e., a building has functional demands place upon it):

1. Providing **shelter** from the elements (user demand for shelter service).
2. Provide **structural control** within the environment (e.g., bridge or tunnel), possibly of some element (e.g., pond or pool).
3. Providing a workable **sub-functional environment** (user demand for other services).
4. Emotional **stimulation** (user demand for aesthetics).

Material interfaces requirements between architectural systems include:

1. Physical interfaces (e.g., pipes/conduits and wires).
2. Electrical interfaces (e.g., voltage).
3. Pressure interfaces (e.g., water pressure, gas and atmospheric pressure).
4. Signals interfaces (e.g., communications signaling).

More completely, architectural functions include (all functions may not be included in a specific, unique architectural object):

1. **People functions (people requirements)**
   A. Follow flow of occupants from one space to another. This includes sources of vertical transportation (stairs, elevators, etc.) including pathways to service equipment.
   B. Follow flow of occupants to enter building from off site.
   C. Follow flow of occupants to exit building as required by code, and in case of an emergency code.
   D. Follow flow of accessible route as required by law (jurisdiction).
   E. Follow flow of materials to supply an architecture construction.
   F. Follow the timing of the materials in the supply to the architectural construction.
   G. Follow flow of input and output (e.g.,) to leave building (including to Off-site).
2. **Structural functions (structural requirements)**
   A. Follow flow of gravity loads from roof down columns, through floors, to foundations and soils/terrain/water.
   B. Follow flow of lateral loads:
      1. Earthquake from ground up through foundations, columns, walls, floors, and roof.
      2. Wind from side walls to roof and floors, through columns, to foundations and the earth.
      3. Follow flow of uplift loads from wind and earthquake by imagining the roof being pulled up and that there are positive connections from roof to columns and walls (through floors) down to foundations and the earth.
3. **Acoustic and seismic functions (structural mechanical waves, structural vibration; seismic; seismic requirements)**
   A. Identify potential mechanical wave sources, potential receiver locations, and the potential vibration paths between the two.
   B. Follow sound through structure from source to receiver. Mitigate by isolation of source or receiver, and/or dampen.
   C. Identify potential dampening materials and locations for positioning in the environment.
   D. Identify potential sound sources, potential receiver locations, and the potential sound paths between the two.
   E. Follow sound through air from source to receiver. Mitigate with distance or barrier or absorber.
4. **Hyrdological functions (water, moisture, and drainage requirements)**
   A. A building's floors, walls and roof should adequately protect the building and its users from harmful effects that may arise from:
      1. Ground moisture.
      2. Precipitation, including wind-driven spray.
      3. Interstitial and surface condensation.
      4. Water spillage from sanitary fittings, fixed appliances and associated fittings.
   B. Follow rainwater from highest point on roof to drain ("drain the rain"), through the piping system to outfall, including direction and conduits thereafter to where data is accessible.

C. Follow rainwater from highest points of site, around building, to outfall off site.
D. Follow rain or moisture at exterior walls and windows down building sides or "weeped" through assemblies to outfall. Remember: Moisture moves from more to less. Moisture moves from warm to cold.
E. Follow vapor from either inside or outside the building, through the "skin" (roof and walls) to outfall. Things get wet. Let them dry out.
F. Follow water supply from source to farthest point of use.
G. Follow contaminated water from farthest point of use to outfall (fathers point where data is available).
H. Follow atmospheric and water flow into materials, including conduits over years and allow for blockage, swelling, or shrinkage.

5. **Thermal functions (thermal requirements)**
   A. Follow sun paths to and into building to plan for access or blocking. Use position and orientation on some surface (compass directions and geo-positional data with associated object orientation.)
   B. Follow excessive external (or internal) heat through building skin and block, or if necessary, allow.
   C. Follow source of internal heat loads (lights, people, equipment, etc.) to their "outfall" (natural ventilation or AC, etc.).
   D. Follow heat flow into materials over a year, a day, etc. and allow for expansion and contraction.
6. **Atmospheric functions (atmospheric requirements)**
   A. Follow wind patterns through site to encourage or block natural ventilation through building, as required.
   B. Follow air patterns through building. When natural ventilation is used, follow flow from inlets to outlets. When air is still, hot air rises and cold air descends.
   C. Follow forced air ventilation patterns through building to address heat (add or dissipate) and odors. CFM out equals CFM in.
7. **Illumination functions (light requirements)**
   A. Follow paths of natural light (direct or indirect sun) to and into building. Encourage or block as needed.
   B. Follow paths of circulation and at spaces to provide artificial illumination where necessary. This includes both site and building.
8. **Power functions (power requirements)**
   A. Follow electric or gas supply from off site to transformer, to breakers or panels to each outlet or point of connection.
9. **Communications functions (communications requirements)**
   A. Follow data source/supply from off site to switches, routers, etc. to each port or point of connection.

6.2 Baseline functional standards for architecture

There is a minimum baseline "fitness" standard for all architecture. To meet the "fitness" standard, the architecture must:

1. Be structurally stable.
2. Be free from serious disrepair.
3. Be free from dampness and dangerous/toxic materials that could damage the occupant's health or performance.
4. Have adequate provision for lighting, heating and ventilation and piped water.

To meet the "fitness" standard for dwellings, architecture must also have:

1. Have satisfactory facilities in the house for the preparation and cooking of food, including a sink with hot and cold water.
2. Have a suitably located water-closet for the occupant's exclusive use.
3. Have, for the occupant's exclusive use, a suitably located fixed bath or shower and wash-hand basin each with hot and cold water.
4. Have an effective system for the draining of foul, waste and surface water.

7 Planning architectural materials

Materials include manufactured products such as components, fittings, items of equipment and systems; naturally occurring materials such as stone, timber and thatch; and backfilling for excavations in connection with building work.

There are two categories of application concerning materials generally used within the bounds of a building-type structural object:

1. **Structural materials** - materials used because of its compressive (or other force characteristic) strength.
   A. **Primary materials -** the materials that make up the majority of the structural components, foundation and envelope of construction projects.
2. **Non-structural materials**: materials used that have little to no significant compressive strength.
   A. Non-structural architectural elements (internal).
   B. Non-structural architectural elements (surface).

7.1 Materials analysis

A.k.a., Materiality analysis.

A complete materials analysis for a building includes:

1. Analysis of materials for structural elements.
2. Analysis of materials for non-structural elements.

7.1.1 Structural materials

The shapes which are adopted for structural elements are affected, to a large extent, by the nature of the materials from which they are made. The physical properties of materials determine the types of internal force which they can carry and, therefore, the types of element for which they are suitable.
(Macdonald, 2001)

Types of structural (and infrastructural) materials include, but may not be limited to, the following types of (note: some of these categories overlap):

7.1.1.1 Minerals

These systems are composed solely of minerals. Here, without organics, there is no risk of decomposition or biological degradation.

The following is a list of common mineral materials for architectural structures:

1. **Masonry (non-metal minerals)** - a composite material in which individual stones, bricks or blocks are bedded in mortar to form columns, walls, arches or vaults. Note that the range of different types of masonry is large due to the variety of types of constituent. Bricks may be include, but are not limited to, the following materials:
   A. Fired clay.
   B. Baked earth.
   C. Concrete.
2. **Earth (non-metal minerals)** - inclusive of dirt, soil, and clays.
   A. This can be achieved through the use of labor-efficient techniques like reusable molds and lego-type bricks.
   B. Earth-type material choices could be based on local availability like the earth itself for walls, lime for plastering, and wood/bamboo/hemp for other rigid structures.
3. **Concrete and cement (non-metal minerals)** - is a composite of stone fragments (aggregate) and cement binder, may be regarded as a kind of artificial masonry because it has similar properties to stone and brick (high density, moderate compressive strength, minimal tensile strength). It is made by mixing together dry cement and aggregate in suitable proportions and then adding water, which causes the cement to hydrolyse and subsequently the whole mixture to set and harden to form a substance with stone-like qualities. Concrete has one considerable advantage over stone, which is that it is available in semi-liquid form during the building process and this has three important consequences. Firstly, it means that other materials can be incorporated into it easily to augment its properties. Secondly, the availability of concrete in liquid form allows it to be cast (and pre-cast) into a wide variety of shapes. Thirdly, the casting process allows very effective connections to be provided between elements and the resulting structural continuity greatly enhances the efficiency of the structure.
   A. Concrete - Aggregates make up some 60 -80% of most concrete mixes. They provide compressive strength and bulk to concrete. Recycled concrete can be used as aggregate in new concrete, particularly the coarse portion.
   B. Cement - Chemically, cement is a mixture of calcium silicates and small amounts of calcium aluminates that react with water and cause the cement to set. Calcium derives from limestone and clay, mudstone or shale as the source of the silica and alumina. The mix is completed with the addition of 5% gypsum to help retard the setting time of the cement.
   C. Non-reinforced concrete - has similar properties to masonry and so the constraints on its use are

the same as those which apply to masonry.

D. Reinforced concrete - semi-liquid concrete is mixed with steel in the form of thin reinforcing bars which give the resulting composite material (reinforced concrete) tensile and therefore bending strength as well as compressive strength. Reinforced concrete possesses tensile as well as compressive strength and is therefore suitable for all types of structural element including those which carry bending-type loads.

E. Foamed concrete (lightweight concrete, aircrete) - made from (ingredients): Portland cement, shampoo to create a foam, and some glass fiber for extra strength. Made by mixing ingredients.
   1. Aircrete blocks often have at least one metal frame within them.

F. Shotcrete - a sprayable mix of concrete.
   1. Uses an interior foam surface, that has a metal frame placed on its surface. The shotcrete is then sprayed on top of the foam, and ends up covering the metal frame.

4. **Steel (and other metal minerals)** - a mineral material that has good structural properties. It has high strength and equal strength in tension and compression and is therefore suitable for the full range of structural elements and will resist axial tension, axial compression and bending type load with almost equal facility. Its density is high, but the ratio of strength to weight is also high so that steel components are not excessively heavy in relation to their load carrying capacity, so long as structural forms are used which ensure that the material is used efficiently.

7.1.1.2 Organics

These systems are composed solely of dead vegetation (i.e., organics). Here, without metal, there is no risk of corrosion (a.k.a., mineral degradation).

The following is a list of common organic materials for architectural structures:

1. **Timber plants (organics, cellulose)** - composed of long fibrous cells aligned parallel to the original tree trunk and therefore to the grain which results from the annual rings. The material of the cell walls gives timber its strength and the fact that its constituent elements are of low atomic weight is responsible for its low density. The lightness in weight of timber is also due to its cellular internal structure. Timber is a regenerative material because it comes from living organisms. The use of cellulose carries an increased risk of fires, mold, insect penetration, etc.
2. **Non-timber plants (organics, cellulose)** - composed of fiberous content that does not have significantly long fibrous cells aligned parallel to the original trunk.

7.1.1.3 Hybrids (mineral and organic)

These systems integrate both organic and mineral elements into their matrix.

The following is a list of common hybrid materials for architectural structures:

1. **Hempcrete (organic mineral mix)** - made by mixing the pulpy core of the plant with a lime binder to create a light concrete (bio-composit) material that can be used as infrastructural filling for insulation and support. Hempcrete retains thermal mass well and is highly insulative. Hempcrete is a type of non-structural material. Hempcrete has to be case around a timber, steal, or concrete frame. Highly resistant to mold and pests due to alkalinity of limestone. Low density material resistant to cracking under movement. Can be applied through a spray apply technique. Pre-cured hempcrete blocks can also be created.

In concern to architecture, there are advantages and disadvantages to each type of material (organic and mineral) used in construction:

1. The negatives of organic materials construction include, but may not be limited to:
   A. Organic construction can be costly in resources and labor.
   B. Organic material is not significantly fire-proof. Timber can be a safety hazard in an uncertain social environment, and could facilitate sabotaging (a possibility that should not to be discarded).
   C. Organic material molds easily.
   D. Organic material is a source of food for some insects. Bamboo and most wood (untreated) will get eaten to dust by insects. It is possible to improve the pest resistant characteristics of bamboo with additives:
      1. Silica soak.
      2. Boric acid soak (borax soak).
      3. Metal soak (e.g., copper soak).
   E. It is possible to strengthen organic material using a:
      1. Strengthener material as frame.
      2. Strengthener material impregnating the organic material.
      3. Strengthener bamboo origami (e.g., weaving).
      4. Mineral surface coating.
   F. Organic material suffers from a phenomenon

known as ‘moisture movement’. The precise dimensions of any piece of timber are dependent on its moisture content. The moisture content of timer is affected by the relative humidity of the environment and as the latter is subject to continuous change, the moisture content and therefore the dimensions of timber also fluctuate continuously. Timber shrinks following a reduction in moisture content due to decreasing relative humidity and swells if the moisture content increases.

   1. One of the most serious consequences of this is that joints made with mechanical fasteners tend to work loose.

2. The positives of mineral materials construction include, but may not be limited to:
   A. Organic resources are regenerative locally.
   B. Organic resources require less electromagnetic energy to produce.
3. The negatives of mineral materials construction include, but may not be limited to:
   A. Mineral resources are finite and precious resources.
   B. Mineral resources require more energy (electromagnetic power) to produce.
4. The positives of mineral materials construction include, but may not be limited to:
   A. Mineral resources have a more rigid boundary and wider array of functional material properties than organic materials.
   B. Mineral resources are not food for insects.

7.2 Material stresses

Types of stresses on materials:

1. Mechanical stresses.
   A. From equipment.
   B. From the earth.
2. Chemical stresses (chemicals and biologicals consuming or decomposing "eating away" material and making it weak, brittle, etc).
3. Animal stress.
   A. Insects.
   B. Mammals.
4. Electromagnetic stresses.
   A. Sunlight.
5. Thermal stresses.
   A. Sunlight.
   B. Equipment producing heat.
   C. Temperature changes from climate and equipment.

7.3 Surface system specification

Surfacing (e.g., Weather proofing) specification involves:

1. Surface additions diagram.
2. Surface modification diagram.
3. Surface functional diagram.

7.4 Materials sourcing and transportation

Market related materials application elements include:

1. All materials are sourced.
   A. Local wild ecological environment.
   B. Habitat Service System Materialization Sub-System.
   C. Material supply businesses.
2. All materials are transported.
   A. From local wild ecological environment.
   B. From local habitat service system.
   C. From habitat service system network.
   D. From local market-State region.
   E. From non-local market-State locales.

7.5 Material selection consideration

Materials are considered in relation to their:

1. Life-cycle analysis on material.
2. Material characteristics.
3. Material handling requirements.
4. Reliability analysis.
5. Maintenance.
6. Weather proofing (finish type).
7. Fire proofing.
8. Durability.
9. Regenerability/sustainability.
10. Ease of upgrade.
11. Financial cost.

8 Planning architectural services

A.k.a., Building services, architecturally connected sub-systems, utilities and fixtures and fittings mapping, fixtures and fittings and equipment (FF & E), infrastructural connections, infrastructural services, public/utility services.

Most building and non-building architecture houses utilities, fixtures, and fittings. Fittings, fittings, and utilities represented an association of hierarchies of material connections to the architecture. Utilities are integrated into the architecture in some manner, either through conduits or into the architecture itself. Utilities allow for user usage of the architecture. Utilities (Read: services) are generally considered to include: electricity, gas, water and sewage, and communications/networking services. Fixtures are physically and permanently (within reason) attached to the architecture. Fittings are not permanently or physically attached to the architecture. Effective service systems need planning and demand surveying/forecasting to ensure that supply meets demand. In general, architectural service systems are also known as infrastructural systems. These systems interconnect the within and between architectural objects in the habitat. These service systems include but are not limited to: transport, power, water, atmosphere, etc.

8.1 *Architectural service sub-system classification*

The following hierarchy of categories will define an architectural service sub-system:

1. Standards.
   A. Documentation.
   B. Requirements.
   C. Hazards.
2. Sub-systems definition.
3. Sub-system objects (a.k.a., fittings, fittings, and appliances).
4. Sub-system installation of objects (construction and maintenance).
5. Sub-system operation of objects (production and usage; supply and demand).
6. Sub-system load identification (identify all loads).
7. Sub-system engineering calculations.

In order to sustain full understanding, the definition of the system and the definition of object must be given. The system must be conceived (planned) and the objects positioned. Herein, fixtures and fittings are the fundamental objects and technologies that are part of the operation of a specific sub-system.

8.1.1 Building services

A.k.a., Architectural services.

Building services are the systems installed in buildings to make them comfortable, functional, efficient and safe. Building services design must be integrated into the overall building design from a very early stage. The detection of clashes between building services and other building components is a significant cause of delays and variations on site, not just in terms of the physical services themselves, but also access to allow the builders work in connection with those services. The final result of building services arrangement can simplify building maintenance and operations or complexify it beyond reproach. Note here that the use of 3D computer aided design (CAD), computer-aided engineering, building information modelling (BIM), and programming/ computation software reduces the occurrence of clashing and similar issues.

Primary building services include, but are not limited to:

1. Structural
2. Electricity.
3. Water
4. Gas and fuel.
5. Atmospheric (HVAC).
6. Electrical.
7. Illumination.
8. Surfaces.

Secondary building services include, but are not limited to primary optimization functions:

1. Thermal.
2. Insulation.
3. Accessway.
4. Automation.
5. Accessibility.
6. Safe access.
7. Acoustics.
8. Fire and contaminant protection.
9. Pest control.
10. Modularity.

Secondary building services include, but are not limited to secondary optimization functions:

1. Building control systems.
2. Thermal energy transfer systems.
3. Transportation systems.
   A. Escalators.
   B. Moving walkways.
   C. Elevators.
4. Fire safety, detection and protection systems.
5. Security and alarm systems.

Note that specialist building services might also include, but are not limited to:

1. Pathogen and bacteria control.
2. Humidity control.
3. Specialist lighting.
4. Specialist security.
5. Emergency power.
6. Specialist gas distribution.
7. Fume cupboards.
8. Operating theatres.
9. Etc.

8.2 Architectural service connection system

A.k.a., Engineering utilities.

The primary architectural sub-elements of material-architecture include:

1. **Utilities** - primary functional services.
2. **Fixtures** - fixed equipment (i.e., equipment fixed to the architecture).
3. **Fittings** - appliances, movable equipment, easily unfixed equipment, etc.

8.2.1 Architectural connection network

Architectural utilities, fixtures and fittings are connected throughout an architectural structure by means of conduits that run through conduits from a source point to an outlet (endpoint).

8.2.1.1 Architectural conduits

An architectural conduit specification includes:

1. Conduit analysis
   A. Atmospheric (ducting).
   B. Gas (piping).
   C. Water (piping).
   D. Electrical power (wiring).
   E. Data and network communications (wiring).

8.2.1.2 Architectural service outlets

A.k.a., Endpoints.

Outlets (a.k.a., endpoints) are the end distribution points (a.k.a., outlets) of utilities and other flows within architecture. An endpoint analysis includes, but may not be limited to:

1. Utility analysis - what utilities are present.
2. Technology analysis - what technologies provide the utility services.
3. Atmospheric outlets (vents).
4. Gas outlets.
5. Water outlets.
6. Electrical outlets:
   A. Power outlets.
   B. Illumination outlets.
7. Data outlets.

8.2.1.3 Architectural service controls

There are both spatial mechanisms and modes for control of service systems.

Spatial service mechanisms of control include, but may not be limited to:

1. Physical controls:
   A. Barrier lock control.
   B. Open/close control.
   C. Liquid and atmosphere control.
2. Electromagnetic controls:
   A. Light control.
   B. Climate control.
   C. Electrical power control.
3. Mechanism control:
   A. Pump control.
   B. Fan control.
   C. Electrical pump control.
4. Programmatic control:
   A. Alarm control.
   B. Motion and/or [spectral] color change control.
   C. Schedule control.
5. User control:
   A. Identity control.

Modes of controlling [environmental] variables in a service space include, but may not be limited to:

1. **Manual** control (switch).
2. **Sensor** control:
   A. Motion/presence sensor
   B. Electromagnetic sensor (light and/or climate).
   C. Thermal sensor (climate and/or temperature).
3. **Schedule** control (pre-defined timing).
4. **Analytical** control (pre-defined decisioning - quantitative output of an information process passes a threshold).

8.2.2 Utilities

A.k.a., Utility service, service utility, architectural service, etc.

The characteristics of a utility include:

1. Service: Is this a service that is provided by an external source, or by a point source within the building?
2. Connection: Does the service use conduits (or other transportation mediums such as raceways and

open web floor trusses) that are within the wall, ceiling, or flooring (or atmosphere in the case of wireless communications)?

3. Adaptability (modification): Is the service difficult to modify?
   A. Providing designated, decoupled, and accessible space for utilities can reduce cost and time during construction. It can also allow utility systems to be modified or repaired over time without performing major demolition and reconstruction. Some products exist today that can help alleviate entanglement (disentanglement; for example, raceways and open web floor trusses). Decoupling utilities from the structure can occur with appropriate technologies.

Utilities common to most architecture include, but are not limited to:

1. Electricity.
2. Gas.
3. Water.
4. Sewage.
5. Communications services.

8.2.3 Fixtures

The characteristics of a fixture include:

1. Method of attachment: Is the item permanently affixed to the wall, ceiling, or flooring by the use of a connecting component (e.g., nails, glue, cement, pipes, or screws)? The method used to attach it might make it a fixture, even if it can be removed it relatively easily. Ceiling lights (i.e., light fixtures) can be removed although they're attached by wires, and they're a house fixture.
2. Adaptability: The item becomes an integral part of the architecture when it can't be removed. A floating laminate floor is a fixture, even though it's snapped together. A built-in sub-zero refrigerator is considered a fixture because it fits inside a specified space even though it can be unplugged.
3. Intention: The item is a fixture if the intent was to make the item a permanent attachment when the installation took place.
4. Removal: Not usually removed when the architecture is re-occupied for a similar purpose (i.e., a home is occupied by another family).

Fixtures common to most architecture include, but are not limited to:

1. Air conditioners.
2. Bathtubs.
3. Built-in mirror.
4. Built-in shelving.
5. Built-in furniture.
6. Built-in electronics.
7. Cabinets.
8. Carpeting.
9. Ceiling fans.
10. Chandeliers.
11. Conduits.
12. Doors.
13. Door bells.
14. Drapery rods.
15. Fences.
16. Fireplaces.
17. Garage door opener.
18. Handrails.
19. Heating systems.
20. Home automation system.
21. Hot water heater.
22. Light fixtures.
23. Security systems.
24. Shutters.
25. Sinks.
26. Smoke detectors (and other detectors).
27. Wall sconces.
28. Windows.
29. Window shades.
30. Etc.

8.2.4 Fittings

The characteristics of a fitting include:

1. Method of attachment: Is the item free standing and not permanently attached to the architecture?
   A. Adaptability: The item does not become an integral part of the architecture.
   B. Removal: May be changed or removed when the architecture is re-occupied for a similar purpose (i.e., a home is occupied by another family).

Fittings common to most architecture include, but are not limited to:

1. Cabinet/cupboard fittings.
2. Door handles.
3. Door knockers.
4. Hangers and hooks.
5. Locks.
6. Window fittings.
7. Signs.
8. Switches and sockets.
9. Faucets.
10. Appliances (e.g., kettle, coffee maker, washing and drying machine, etc.).
11. Etc.

8.3 Utility localization and transportation

A.k.a., Utility sources and utility resource flows.

All architecture, given utility requirements and distribution requirements can compute the optimal design for utility localization and utility transportation within the architecture. The localization and transportation of utility services requires architectural space. That space can be pre-defined with conduits, or not:

1. Entangled utilities (no conduit) - utilities without predefined accessible pathways, without conduits. Embedding pipes, ducts, and wires in walls, floors, and ceilings haphazardly without planning or dedicated spaces can lower efficiency and increase negative variables, including cost and team time. is built, entangled utilities are difficult to modify, Because utilities are embedded in the structure and hidden behind surfaces. Unfortunately, access to utilities almost always becomes necessary at some point due to adaptation or other changes. For example, replacing wiring or repairing household plumbing. Entangled utilities can:
    A. Lead to inefficiency in initial construction.
    B. Compromise structural integrity.
    C. Negatively affect utility function.
    D. Negatively impact sound, electromagnetic, and heat insulation function.
    E. Obstruct rework, renovation, and repair.
2. Disentangled utilities (conduit) - utilities with predefined accessible pathways, with conduits. designated, decoupled, and accessible space for utilities can reduce cost and time during initial construction. It can also allow utility systems to be modified or repaired over time without performing major demolition and reconstruction. While not technically disentangling, flexible utilities with faster connections can ease installation and subsequent alteration and are included as related topics. Disentangled utilities are essential for modular floor plans.

Utility localization and transportation planning includes:

1. **Using software and digital libraries** of building components to allow efficient and accurate planning to predefine utility pathways before construction begins.
2. **Separating building layers** by lifespan, decoupling utilities from structure with open web floor trusses and raceways, and providing for access. The most important system in the home, and the most critical one in examining entanglement, is the structure itself.
3. **Creating an integrated utility gateway** that brings all of the services into the home in a single location.
4. **Creating integrated utility modules**, for example a fully plumbed bathroom wall, which can be manufactured as one piece in a factory in a disentangled manner.
5. **Increasing the use of quick connect** electrical and plumbing components to allow even greater gains in efficiency and ease of renovation from disentangling.
6. **Anticipating potential future utility systems** before they are widely implemented and making allowances for their eventual installation.
7. **Working with the technical utility sub-systems** to create a distributed modular system that limits distribution requirements and reduces entanglement.
8. **Creating a single shared low-bandwidth data network** to replace proprietary lighting control, HVAC control, security, and sensor networks.

Common types of conduits in architecture that are useful for disentangling utilities include, one or more of the following:

1. Structural pre-cast conduits:
    A. Pre-case structural materials, such as conduit paths pre-case with concrete or bioceramic.
2. Architectural conduits:
    A. Architectural raceways (raceway conduits).
    B. Architectural floor trusses (trussed conduits).
    C. Architectural panels and panelling (e.g., false ceilings, drop ceilings, false/drop floors, removable ceiling and floor).
3. Interior conduits (e.g., piping, enclosures, etc.):
    A. Conduit types (names) include:
        1. Pipes.
        2. Tubing.
        3. Ductwork.
    B. Conduit materials include, but may not be limited to:
        1. Rigid metal conduit (RMC).
        2. Electrical metallic tubing (EMT).
        3. Intermediate metal conduit (IMC).
        4. Flexible metal conduit (FMC).
        5. Concrete or bioceramic.
        6. Bamboo.
        7. Plastic piping.
            i. PVC.
            ii. Cross-linked polyethylene (PEX) tubing (a plastic material used for water supply piping systems).

The positioning of conduits within other conduits often involves:

1. Stands.
2. Hangers.
3. Spacers.

Some utilities may have their own architecturally separate conduits, or they mare share conduits. Often conduits that could cause serious injury are separated in some manner so that mixing is unlikely, if not impossible (e.g., gas and electrical, or gas and atmosphere).

8.3.1 Structural utility distribution

A.k.a., Structural utility transportation.

The structure is used for containing function (the utility source point localizations) and for transport-distribution of those utilities throughout the architecture for end-point distribution. The common utility distribution systems in architecture include:

1. Electricity distribution.
   A. Electrical power cabling is run from a central breaker box to separate circuits to provide power to distribution endpoints.
   B. Hard-wired switches that physically break the circuit to prevent power from continuing to a particular endpoint (or set of endpoints).
   C. Requirement: The wiring should be easy to disconnect and remove, and connect and replace.
2. Data distribution.
   A. Data cabling is installed in a similar (or, the same) manner to electrical cabling. Data is usually run to fewer endpoints than power.
   B. Wireless data spreads through atmosphere and structure to space/area endpoints.
3. Atmospheric distribution.
4. Gas distribution.
5. Water distribution.

8.3.2 Localization of internal utility sources (and distribution nodes)

Utility source points can be stored in [appropriately] enclosed spaces with accessible and non-interferable panels. Utilities may be centrally distributed from an exterior source, such as for electricity or clean water, or package transportation between buildings and habitats. A building could filter its own water for drinking, as well as its own air, or a centralized space external to any particular building, but feeding multiple buildings could exist. Package utility transportation refers to the transportation of packages (anything, food, tools, prints, etc.) around the habitat and necessarily involves a networked transportation system external to any given building.

8.4 Structural integration design of utilities (architectural functions)

A.k.a., Planned utility mapping.

Designing the structural mapping of [functional] utilities involves:

1. **Delivery method** - how utilities are brought to the user.
2. **Construction method** – how the architectural object is built and how utilities are installed.
3. **User interaction** – how people interface with utility systems.

Herein, the functional mapping of utilities involves the following data elements:

1. In the market-State, all utilities are metered for a fee.
2. Some utilities may come from the market-State.
3. All utilities have centralized unit operations.
4. All utilities have distribution endpoints.
5. Some utilities have returns and/or exits.

8.5 Visualization of utility-service flow

The complete flow of utility-services can be visually mapped as a flow diagram of the utility service system within an architectural system. This flow diagram (flow visualization) shows how these utilities are converted, transformed, or redistributed into services, and finally, endpoint usages.

8.6 Architectural equipment

Architectural equipment related factors include:

1. All equipment is sourced.
   A. Tools (movable equipment).
   B. Fixtures and fittings (fixed equipment).
   C. Appliances and other equipment (flexible equipment).
2. All equipment is transported.
3. Equipment may require servicing and repair.

Sources and characteristics of equipment include:

1. Source.
2. Relative sizes.
3. Weights.
4. Location.
5. Capacities.
6. Materials and tools of construction.
7. Resources, tools, and personnel of operation.
8. Insulation and painting (aesthetic) requirements.
9. Equipment related access.

10. Vendor, model, and serial number.
11. Equipment delivery time.
12. Equipment financial costs.

9 Planning architectural construction

A.k.a., Architectural fabrication, construction work, construction engineering, architectural construction techniques, architectural construction methods.

Construction is the process of moving and assembling materials and equipment into completed forms for use. Construction is the process of building something. Architectural construction is the process through which architecture is sufficiently defined to be materialized, and then, materialized. In other words, architectural construction is the process by which material and non-material elements and overall spatial setting are made fixed in the form of a building or non-building structure. Herein, building construction is the process of preparing for and forming buildings and building systems; it is the process of adding structures to land-, sea-, and space-scapes. Different types of architecture may be constructed in different ways. This section primarily relates to the construction of building and non-building architecture, and not necessarily cultivation, transportation, or clothing architecture (although, there may be similarities to the methods by which such type of objects are created).

Note that construction may also be considered to include:

1. Fabrication and assembly.
2. Demolition and disassembly.
3. Rebuilding.
4. Alterations of or additions to architecture (remodeling).
5. Etc.

Construction work refers to the carrying out of any work related the actual construction (materialization or re-materialization) of an architectural structure. More completely, construction work may be characterized by (Construction Design and Management, 2015):

1. The construction, alteration, conversion, fitting out, commissioning, renovation, repair, upkeep, redecoration or other maintenance (including cleaning which involves the use of water or an abrasive at high pressure, or the use of corrosive or toxic substances), de-commissioning, demolition or dismantling of a structure.
2. The preparation for an intended structure, including site clearance, exploration, investigation (but not site survey) and excavation (but not pre-construction archaeological investigations), and the clearance or preparation of the site or structure for use or occupation at its conclusion.

3. The assembly on site of prefabricated elements to form a structure or the disassembly on site of the prefabricated elements which, immediately before such disassembly, formed a structure.
4. The removal of a structure, or of any product or waste resulting from demolition or dismantling of a structure, or from disassembly of prefabricated elements which immediately before such disassembly formed such a structure.
5. The installation, commissioning, maintenance, repair or removal of mechanical, electrical, gas, compressed air, hydraulic, telecommunications, computer or similar services which are normally fixed within or to a structure.
6. But, does not include: the exploration for, or extraction of, mineral resources, or preparatory activities carried out at a place where such exploration or extraction is carried out.

Similarly, it could be said that construction work includes all activities associated with a construction:

1. Construction (fabrication).
2. Reconstruction.
3. Demolition.
4. Repair or renovation.
5. Associated activities such as:
   A. Site preparation.
   B. Excavation.
   C. Erection.
   D. Building.
   E. Assembly and disassembly.
   F. Installation of equipment or materials (site installation).
   G. Decoration and finishing.
6. As well as services incidental to construction such as:
   A. Drilling.
   B. Mapping.
   C. Satellite photography.
   D. Seismic investigations.
   E. Similar services.

Because there are several types (categories) or architecture, there are simultaneously several types of construction and construction work.

For example, building work means:

1. The erection or extension of a building.
2. The provision or extension of a controlled service or fitting in or in connection with a building.
3. The material alteration of a building, or a controlled service or fitting.
4. Work required by regulation 6 (requirements relating to material change of use).
5. The insertion of insulating material into the cavity wall of a building.
6. Work involving the underpinning of a building.
7. Work required by regulation 22 (requirements relating to a change of energy status).
8. Work required by regulation 23 (requirements relating to thermal elements).
9. Work required by regulation 28 (consequential improvements to energy performance).

For clarification, sometimes the term, 'building operations', is applied to building work, in the case of:

1. Demolition of buildings.
2. Rebuilding.
3. Structural alterations of or additions to buildings.
4. Other operations normally undertaken by a builder.

> **CLARIFICATION:** *The operations and maintenance (O&M) of architectural structures is no considered construction.*

9.1 The construction process

A.k.a., Construction phases.

Construction work involves at least the following phases:

1. **Design specification access.**
2. **Tools, skills and knowledge access.**
3. **Site access** - access to the site.
4. **Site evaluation (a.k.a., site investigation, site assessment, site survey)** - evaluation of the site for construction purposes.
5. **Construction documents (including, a site plan)** - produced by architectural-engineering processes.
6. **Site layout plan and site safety plan** - a plan for the phased layout of the site prior to work commencement, including a plan for the safety of work. As sites will change in nature during the course of the works, there may be a number of different site layout plans for different phases, and there may be more detailed plans showing particularly complex areas or sequences or describing specific functions.
7. **Site preparation** - preparation of the site for construction.
8. **Site construction** - the actual construction process.
9. **Architectural evaluation** - the evaluation of the construction.

9.1.1 Sustainability in the construction process

Sustainability is achieved by using sustainable materials and construction techniques. Sustainability in construction refers to the practice of designing, constructing, operating, and maintaining buildings and infrastructure in a way that meets the needs of the present without compromising the ability of future generations to meet their own needs. It involves using environmentally friendly materials, minimizing resource consumption, reducing waste, and creating structures that are energy-efficient and environmentally responsible.

9.1.2 Site investigation

A.k.a., Site evaluation.

Sites must be thoroughly investigated prior and during construction. Site investigations should consist of four well-defined stages:

1. **Planning stage:** Setting clear objectives for the site investigation, including scope and requirements, which enable it to be planned and carried out efficiently and provide the required information.
2. **Desk study (remote study):** Reviewing historical, geological and environmental information about the site.
3. **Site reconnaissance (a walkover survey):** Identifying actual and potential hazards and the design of the main investigation.
4. **Main investigation and reporting:** Including intrusive and non-intrusive sampling and testing to provide soil parameters for design and construction.

Site investigations should include:

1. Susceptibility to groundwater levels and flow.
2. Underlying geology, and ground and hydro-geological properties.
3. Identification of physical hazards.
4. Identification of methane and other gases.
5. Determining an appropriate architectural and structural design.
6. Determining an appropriate location and orientation of buildings and other systems.
7. Providing soil parameters for design and construction.

9.1.3 Site layout plan

Site layout planning involves four basic processes:

1. Identifying the site facilities that will be required.
2. Determining the sizes, and other constraints of those facilities.
3. Establishing the inter-relationships between the facilities.
4. Optimising the layout of the facilities on the site.

Site layout plans might include locations for and sizes of:

1. Zones for particular activities.
2. Cranes (including radii and capacities).
3. Site offices.
4. Welfare facilities.
5. Off-loading, temporary storage and storage areas (laydown area)
6. Sub-contractor facilities.
7. Car parking.
8. Emergency routes and muster points.
9. Access, entrances, security and access controls, temporary roads and separate pedestrian routes.
10. Vehicle wheel washing facilities.
11. Waste management and recycling areas.
12. Site hoardings and existing boundaries.
13. Protection for trees, existing buildings, neighbouring buildings, and so on.
14. Signage.
15. Temporary services (including electrical power, lighting, water distribution, drainage, information and communications technology, site security systems, and so on)
16. Temporary works (such as propping solutions to retained structures, sheet piling details, and so on).
17. Areas for the construction of mock-ups for testing.
18. Fabrication facilities.

Problems caused by poor site layout planning can include:

1. Inappropriate storage which can result in damage to products and materials.
2. Poor siting of plant.
3. Poor siting of welfare facilities.
4. Inadequate space provision.
5. Unsatisfactory access.
6. Security and safety issues.
7. Poor wayfinding (due to complex layouts or inadequate signage).
8. Demoralised workers, delays and increased costs.

9.1.3.1 Construction safety

A.k.a., Site safety, safety management.

Safety practices and a safe culture are part of every construction operation. Some of the practices that can be employed on projects to facilitate safety include:

1. Involving workers in the safety process, through toolbox talks, safety briefings, site inductions, etc.
2. Analysis of potential site safety hazards during the pre-construction phase.
3. Adopting the principles of prevention:
   A. Avoid risks where possible
   B. Evaluate those risks that cannot be avoided
   C. Put in place measures that control them at

source.

4. Encouraging an "open-door" policy (protocol) for workers to report accidents, injuries, hazards and near misses.
5. Conducting thorough near miss and incident investigations to ensure effective action is taken.
6. Utilize specific personnel assigned to coordinate safety.
7. Designating health and safety duties to on-site staff, such as a first aider.
8. Conducting regular project safety audits.
9. Developing a site-specific health and safety plan.
10. Site specific training programmes for workers and subcontractors.
11. Proper use of personal protective equipment (PPE).

9.1.3.2 Construction risks

The physical process of constructing something always entails some form of potential risk, because of the operation of equipment and usage of potentially hazardous materials.

Key health risks (a.k.a., occupational risks) in construction include:

1. Exposure:
   A. To climactic elements (e.g., sunlight, cold, etc.)
   B. To chemicals (e.g., asbestos, dusts including silica, concrete, lead, and exhaust emissions).
2. Frequent loud noise.
3. Frequent or excessive use of vibrating tools.
4. Frequent or excessive manual handling of loads.
5. Stress and fatigue.

A risk coordination/management cycle to identify and prevent risk includes:

1. Identification of hazards.
2. Assessment of risks.
3. Selection of controls.
4. Implementation and recording of findings.
5. Monitoring and review.

Construction sites can be dangerous places, and only authorised personnel should be allowed access. Dangers to non-authorised personnel include:

1. Falling materials or tools.
2. Falling into trenches.
3. Falling from height.
4. Being struck by moving plant and vehicles.
5. Standing on sharp objects.
6. Coming into contact with electricity or hazardous materials.
7. Dust, noise and vibration.

In addition, construction sites can be vulnerable to vandalism, theft, arson, protests, suicides and so on. Construction sites will generally adopt perimeter security measures to control access, both for safety purposes, and to prevent damage, theft or vandalism. Hence, construction sites present a challenge in terms of securing access as:

1. Their nature and layout is subject to frequent change.
2. Access is required by a large number of contractors, suppliers, consultants and so on.
3. They are often in highly-populated areas.
4. It may be necessary to maintain user access to neighbouring sites, or parts of the site itself.
5. There can be time pressures to complete the works quickly.

Methods of controlling access to construction sites include, but may not be limited to:

1. Security fencing (a.k.a., perimeter hoarding) creates a primary boundary for controlling access. Hoarding is a temporary construction, of at least 2.4m that is more difficult to climb than fencing and prevents viewing of the site interior. However, can also prevent people from seeing unauthorised personnel if they manage to gain access to the site.
2. Turnstiles, security gates and guards can then be used to ensure that only authorised personnel can enter. Other types of barriers and bollards may be used.
3. Electronic access control systems (ACS) and locks.
4. Signage.
5. sign-in and reception areas.
6. Storing materials and machines away from the perimeter.
7. Lighting.
8. CCTV.
9. Motion detectors.
10. Removal of ladders.
11. Protection of scaffolding, public address systems.
12. Keeping the site clean and tidy.
13. Secure storage.

Special measures may be necessary for works in the vicinity of vulnerable groups such as the elderly, children and people with disabilities. Children in particular may be drawn to construction sites, seeing them as places to play.

9.1.4 Site preparation

Before construction (building) work can start on a site, certain activities must be taken to ensure that construction is feasible, that maximum health and safety is achieved, and that construction operations will not be hindered; these include, but are not limited to:

1. The ground to be covered by the building shall be reasonably free form any material that could damage the construction process or affect the final construction's stability. This requires the clearing of vegetation, topsoil and any pre-existing foundations. This can include turf and roots, especially if they are close to the proposed construction.
2. Precautions should be taken to avoid danger to health and safety from contaminants in the ground and any other land associated with the building.
3. Installation of adequate sub-soil drainage, if required.

9.1.4.1 Site contaminants

> **NOTE:** *Where a site may be affected by contaminants, a combined geotechnical and geo-environmental investigation should be considered and remediation maybe necessary.*

Sites must either safely account for or be free from contaminants. A 'contaminant' as any substance that is or may become harmful to persons or buildings, including substances which are corrosive, explosive, flammable, radioactive or toxic.

Site contaminants include, but are not limited to:

1. Animal and animal products of processing works.
2. Asbestos works.
3. Ceramics and asphalt manufacturing works.
4. Chemical works.
5. Dockyards and dockland.
6. Gas works.
7. Landfill and other waste disposal sites.
8. Oil storage and distribution sites.
9. Power stations.
10. Scrap yards.
11. Sewage works.
12. Texile and dye works.
13. Molds.

Site contaminants are handled in [at least] the following ways:

1. Clearance or treatment of unsuitable material – includes guidance on various site investigation measures and types of unsuitable material.
2. Resistance to contaminants – includes risk assessment and remedial guidance on solid and liquid contaminants, methane and other gases from the ground, and radon.
3. Subsoil drainage.
4. Floors – includes guidance and technical solutions for ground supported floors, suspended timber ground floors, suspended concrete ground floors, floors exposed from below, and resistance to surface condensation and mould growth.
5. Walls – includes guidance and technical solutions for internal and external walls (moisture from the ground), external walls (moisture from outside), solid external walls, cavity external walls, cavity insulation, framed external walls, cracking of external walls, impervious cladding systems, joints between doors and windows, door thresholds, and resistance of external walls to damage from interstitial condensation, surface condensation and mould growth.
6. Roofs – includes guidance and technical solutions for roof resistance to damage from moisture from outside, interstitial condensation, surface condensation and mould growth.

Note, when contaminants are found on a site, it may be necessary to notify findings to regulatory authorities, for example:

1. Where contaminants are found that had not been previously known about.
2. In planning applications.
3. In relation to waste management and the protection of water quality and resources.

Some contaminants such as radon, landfill gases and those from organic solvents and fuel can penetrate the building by a variety of means. In most cases the rate of penetration can be reduced by sumps and sub-floor ventilation, as well as other ventilation strategies.

9.2 Architectural construction techniques

> *A.k.a., Architectural construction methods, methods of building, architectural building methods and techniques, building construction methods and techniques, building technologies, site technologies.*

It is important to clarify here that the terms "building technology", "construction technology", and "construction techniques" refer to the technical processes and methods used in the constructing of architecture, particularly, buildings.

Construction technology factors includes, but are not limited to the following factors:

1. Materials and their applications.
2. Physical properties.
3. Capacities and vulnerabilities.
4. The functioning of components and systems.
5. The engineering principles.
6. Procedures and details of building assembly.

7. Procedures and details of building startup and operation.

Construction information factors include, but may not be limited to:

1. Technical drawings for the building and its construction.
2. Technical specifications for the building and its construction.
3. Site investigations and surveying.
4. Construction materials, components, systems and techniques.
5. Building services.
6. Operation and maintenance.
7. Energy supply and efficiency.
8. Structural systems.
9. Communications.
10. Smart technology.
11. Sustainability.
12. Waste water and water management.
13. Building engineering physics.
14. Building science.
15. Prefabrication and offsite manufacturing.
16. Modelling and assessment.
17. Collaborative practices.
18. Research, development and innovation.
19. Construction plant.
20. Craning technology (note that crane technologies are most commonly used to position large architectural objects on-site).

Like anything in the real-world, architecture must be produced (constructed). There are a number of ways to construct architecture, the possible architectural construction techniques include, but may not be limited to:

1. **Pressing** - includes the ramming of one surface into anther (e.g., rammed earth).
   A. Pressing earth, or minerals in general.
      1. **Rammed earth construction (ak.a., bricking and brick laying)** - compacting a mixture of soil, gravel, sand, and sometimes stabilizers like cement or lime into solid floors and walls.
   B. Pressing fibers, or cellulose in general (e.g., cellulose adhesive fiber-board).
2. **Organic beams and panels** - the forming, attaching, and interlocking of shaped organic materials, mostly from wood/timber and bamboo.
   A. **Organic barrels** - clumping straw (e.g., wheat, rice, or barley straw) as insulation within timber or post-and-beam structures.
3. **Cob construction** (mixed organic-earth solution) - clumping clay, sand, and straw, mixed with water to create a thick, sculptable material. The material is rammed into position. It is used to build walls by hand-forming lumps of the mixture into place.
4. **Cutting and joining** - includes the cutting of materials (on- or off-site) and then assembling them (on- or off-site), and then moving them into their final position on-site. Joining can be done by interlocking based on:
   A. **Weaving (ak.a., secured multi-object interlacing bond)** - the intricate interlacing or intertwining of separate strands or components to form a unified and strong bond.
   B. **Object interlocking (a.k.a., secured object bond)** - relies on objects (e.g., nails), grooves, or mechanisms designed for components to connect/fit-together securely, creating a strong and stable bond without the need for additional fasteners or adhesives.
      1. Nailed (or, screwed):
         i. Wood, metal, or plastic nails/screws.
      2. Adhesive (Read: glued, cemented, etc.).
      3. Perfect joint interlocking (a.k.a., sashimono, Japanese woodworking) uses only wood, and no nails, screws or glue. It relies entirely on perfectly aligned joints, designed out of one material; but, are two objects that fit together precisely and perfectly. This technique has several advantages over nails. No minerals (only made out of one material, typically wood). Because the joints are made out of one material, the joined system tends to contract and expand together, versus when there are different materials combined that expand and contract at different rates, causing damage overs time.
   C. **Electromagnetics and chemicals (a.k.a., paint bonding and magnetic boding)** - are adhesives. Here, there is joining through Joining through electromagnetics and/or chemicals involved in creating a bond between materials using electromagnetic forces and chemical reactions.
5. **Mineral-brick and mineral-mortar** (small or large, interlocking or not) - the forming, attaching and interlocking of shaped mineral materials.
6. **Concrete-metal construction (a.k.a., mineral-metal frames within and around mineral-concrete blocks, ferrocement construction, reinforced concrete construction, steel-reinforced concrete construction, steel-concrete composite construction, conventional steel and concrete)** - the forming of a combined metal- and non-metal mineral shell (enclosure). This technique uses concrete strengthened with steel reinforcement bars (rebar, mesh bars, metal beams and columns) to enhance its (compressive and tensile) strength.

This creates a composite system (mineral composit system). It utilizes the strengths of both materials, with steel providing tensile strength and concrete providing compressive strength.

A. These composites can be fabricated:
   1. In-place, on-site:
      i. Forming the physical foundation [piles] of the enclosure (a.k.a., the feet and platform).
      ii. Forming the framed structure of the enclosure.
      iii. Forming the whole structure of the enclosure (i.e., it wraps around the inside volume, forming a continuous enclosure).
   2. Off-place, on-site (e.g., hollow core panels made of ferrocement).
   3. Off-site, pre-fabricated (e.g., structural insulated panels made of ferrocement).

B. **Hollow core panels (a.k.a., hollow-core panels, hollow-core concrete rebar panels, prefabricated alveolar concrete panels, lightweight concrete panels, reinforced autoclaved aerated concrete AAC panels)** - are prestressed concrete slabs and walls with voids in them. These are mostly made using an extrusion process that extrudes cementing material into panels with core holes inside of them, which reduces material usage, and opens designable conduits within the panels. These panels are typically prestressed concrete with continuous cores, or voids, running through them (the void space may be intentionally designed as an specified conduit network extending throughout the enclosure). The void space considerably reduces weight (up to 50% compared with a poured-in-place flat slab) and cost. These panels can be used for walls, floors, and roofs.

7. **Structural insulated panels (SIP panels, construction insulation sandwich panels)** - are a construction material used in building structures. SIP panels are pre-fabricated. SIP panels consist of two enclosing layers of structural material (typically oriented strand board, OSB) that enclose a core of insulating and conduit allowing material. The insulating material can by anything, but is usually, expanded polystyrene (EPS), polyurethane foam, or polyisocyanurate foam. The boards and insulation are laminated together to form a single structural unit. SIP panels are pre-fabricated and come in various sizes and thicknesses, customized to fit specific building designs. They are used as walls, floors, and roofs in residential, commercial, and industrial construction. Where there is a metal frame, it can be inside of the concrete volume, or exterior to it. In the case of it being exterior, a final surface finish will have to be applied, unless the metal frame exterior to the concrete volume is intended as the final surface. SIP panels, if appropriately designed, can be used for all structural surfaces (walls, floors, and roofs).
   A. Types of SIP panels include:
      1. Clay and earthen straw SIP panels.
      2. Particle board SIP panels containing an exterior and interior sheathing, often made of particle board, and a foam central core.
      3. Polystyrene SIP panels have an exterior and interior made from expanded polystyrene, with poured and aired concrete as the core. Metal ties run through the core, connecting the two polystyrene exterior objects.
      4. Geopolymer concrete SIP panels (a.k.a., lightweight geopolymer composite panels LGC). (Li, et al., 2023) (Refaie, F., et al., 2020)
   B. The benefits of SIP panels include:
      1. Excellent insulation properties, providing higher thermal resistance compared to traditional construction methods.
      2. Reduced air leakage and energy consumption in buildings.
      3. Faster construction time due to their prefabricated nature.
      4. Structural strength and durability, offering good resistance to bending and shear forces.
   C. Potential fabrication locations of SIP panels includes:
      1. **In-place and on-site fabrication** - fixed foundation construction (type of site-fabrication). The panels are constructed on-site and at/in their final resting place.
         i. Cast in-place (CIP) structural insulated panels (a.k.a., CIP-SIP system).
      2. **Off-place and on-site fabrication** - mobile fabrication (type of site-fabrication). The panels are fabricated on-site, but not in-place. Once fabricated they are moved (on-site) into their final resting place.
      3. **Off-site fabrication** - in-factory fabrication (off-site fabrication). The panels are pre-fabricated in a factor and transported to site.

8. **3D print layering (a.k.a., addition extrusion)** - involves the layering of a material and then the incorporation of other services, such as utilities, fixtures and fittings.
   A. **Extrusion by 3D layering** - a manufacturing process that creates three-dimensional objects layer by layer based on a digital model. It encompasses various methods, including Fused

Deposition Modeling (FDM), Stereolithography (SLA), Selective Laser Sintering (SLS), and others. Each method involves different mechanisms for material deposition, solidification, or binding to create the final object.

1. **A machine that extrudes or affixes media-substrate material angularly (a.k.a., 3D printing, additive manufacturing)** - a 3D printing machine that extrudes mineral materials (and may include metal frames) into the shape of the enclosure, over time, layer-by-layer, building the structural surface.

9. **Extrusion by force (a.k.a., subtraction, cutting and deforming/melting)** - pushing, forcing, or shaping a material through a shaped die or nozzle to create a continuous profile, typically in a long, constant shape or form. The extrusion of a solid element, usually in a factory, which is then transported to the construction site. The utilities, fixtures and fittings may be incorporated in the factory, or on-site. Via this method, it is possible to extrude a whole enclosure; pushing a material through an extruder that cuts away a useful shape/object.
   A. **A machine that extrudes horizontally (a.k.a., CNC machine, milling machine, subtractive manufacturing, cutting manufacturing)** - a machine that removes material layer-by-layer as it moves through the machine.
10. **Intricate dexterous ("hand") work and surface finishing techniques (i.e., separate layer surface addition)** - the manual and dexterous movements necessary to apply an additional finishing surface material:
   A. Objects: Laying of tiles (in cement). For example, a tiled roof, floor, or bathroom wall.
   B. Liquids: Painting of walls.
11. **Integral surface finishing techniques (i.e., integrated surfacing, intrinsic surface treatment)** - the finishing material or texture is an inherent part of the structure itself, integrated into the enclosure during construction rather than being applied as a separate layer. Effectively, the surface treatment technique leaves the surface with the inherent finished characteristic of the enclosure (perhaps due to the material used, or a specific construction technique that creates the final surface as an integral part of the structure).

9.2.1 Fabrication location

Fabrication of architectural elements used in construction can either be on-site or prefabricated off-site (as in, the degree of pre-fabrication, modularity and flexibility of fabrication):

1. **Pre-fabricated (factory built)** - The architecture is constructed in a factory; it is pre-fabricated in a factory.
   A. Prefabrication works most efficiently where there is repetition. In the market-State, there is little repetition (because of businesses and their "intellectual" properties).
   B. Prefabricated modules, limited by the size constraints of highway transportation, are shipped to the final site on truck beds and then joined in the field.
2. **Site fabricated (site built, site construction)** - The architecture is constructed on-site, which allows for larger constructions and possible usage of local materials.

In concern to the transportation of fabricated elements:

1. All fabrication efforts are sourced.
2. Some fabrication elements may require transport.
3. Some fabricated elements may require servicing and repair during construction.

9.2.2 3D printing systems

To print a 3D architectural structure requires:

1. The digital object (a basic template or CAD drawings).
2. A printer.
3. Materials.
4. Time, skills, and power.

The primary types of 3D printing and extrusion techniques used in this industry:

1. **Fused deposition modeling (FDM; a.k.a., used filament fabrication, FFF)** - one of the most common 3D printing methods used in construction. It involves the deposition of layers of heated thermo-material (e.g., thermoplastic, cement, plastic filament, typically plastic or composite materials), through a nozzle, building the structure layer-by-layer. The material is extruded layer-by-layer according to the design to create the desired structure.
   A. **Concrete extrusion (a.k.a., cement extrusion, contour crafting):** is a 3d printing technique specifically designed for constructing buildings. It involves the precise layering and extrusion of a concrete mixture through a nozzle or robot-controlled arm to build structural components or entire buildings layer by layer. Concrete extrusion is used for constructing walls, floors, and entire building structures in a layer-by-layer fashion. It offers speed, cost-efficiency, and

the potential for intricate design capabilities in large-scale construction projects. The contour crafting can be automated to include block/brick placement, as well as infrastructural placements within the surface of the enclosure (e.g., windows, cables, etc.).

2. **Selective laser sintering (SLS; a.k.a., powder bed fusion):** the powder bed fusion methods involve the use of a laser or other heat source to selectively fuse powdered material, such as polymer, metal, or ceramic powders, layer-by-layer based on a digital model. This system is not used in building construction, however, powder bed fusion methods are sometimes used in creating detailed architectural decorative elements, intricate structural components, or specialized building parts with complex geometries.
3. Binder jetting - involves depositing a binding agent onto a powdered material layer by layer. The binding agent solidifies the material, forming the desired structure. This method is not used in construction and is used to a limited extent in creating architectural models, molds, or small-scale physical building components with various materials like sand or polymers.

A good architectural [3D printing] system print surfaces, particularly walls, that will not cracks, and have strong water proofing, better air permeability, better heat preservation and low carbon pollution.

Problems with 3D printing include, but are not limited to:

1. 3D printing takes time
2. Printed parts are mechanically weak
3. Material choices are limited

There are two main types of structure for 3D printers for the construction of buildings:

1. Gantry-based systems.
2. Robotic arm-based system.
3. Comparison [cobod.com]
   A. It is possible to mix robotic and gantry technologies using cooperative robotics. This allows for 3d print around other objects, such as around steel reinforcement with concrete objects.

The following are the possible material types for the 3D printing of architectural objects (Read: buildings):

1. **Concrete mixtures** - mixtures of concrete (and cement).
   A. Characteristics of concrete mixtures:
      1. Can be printed on-site, or printed in a factory, transported to the site, and assembled on-site.
      2. Does not cure instantly. Curing time can be lowered by replacing water with alcohol in the mixture (because alcohol evaporates more rapidly).
      3. Can be mixed with ethanol, which evaporates more rapidly than water and will harden and complete faster.
   B. Technology / development companies:
      1. **Winsun 3D Builders**, China [winsun3dbuilders.com]
      2. **COBOD**, Denmark [cobod.com]
         i. Purchasable gantry system consisting of
         ii. Advantages include:
            1. The materials are open source and the company advise customers to source materials locally.
            2. Inclined or overhangs (non vertical walls) can be accomplished with the BOD2. The degree that is possible to print is depending on material properties and geometry.
      3. **Constructions-3D**, France [en.constructions-3d.com]
         i. Purchasable robotic-arm system consists of: a mixing and pumping station, control system, and robotic 3D printer (comes in standard 20 foot container).
      4. **Lightweight concrete**, United States [website]
         i. https://www.bradenton.com/news/business/article247233154.html
      5. **Icon**, United States [icon.com]
         i. Purchasable gantry system consisting of: a robotic system, a software system, and materials. A fully automated system, including the mixing and pumping.
         ii. Disadvantages include:
            1. Uses a proprietary formula.
2. **Synthetic stone (a.k.a., light stone material, LSM)** - UV curable material combined with mineral filler (a.k.a., synthetic stone).
   A. Technology / development companies:
      1. **Mighty Buildings**, United States [mightybuildings.com] [youtube.com, *LIVE Factory Walkthrough: Webinar + Q&A*]
         i. Built in a factory and shipped to final destination (pre-fabricated).
         ii. Machine produces panels and building components, or an entire building.
         iii. Disadvantages include:
            1. In a promotional video an employee said the printer could not be purchased.

2. Patents on materials.
iv. Advantages include:
1. Factory building means less setup and tear-down time to build multiple buildings.
2. Cures almost instantly.
3. Large gantry system.
4. Zero-waste production process (eliminates 3-5kgs that normally go to landfill).
5. Fiber reinforcement possible with strength similar to steal.
6. Reduced time duration of project.

3. **Clay mixtures** - mixtures of clays and/or ceramics.
   A. Objects can be printed by extruding layers of a ceramic / clay paste from a nozzle or by glue-bonding powder particles layer-by-layer.

NOTE: *These are additive processes (as opposed to subtractive where material is cut away from a block).*

10 Architectural modeling

Architectural modeling is the process of creating a model of a building, or other architectural structure. In this way, architectural modeling is the design of real (not virtual) 3D representations of architectural systems. An architectural model is an information model (artifact) that comprises all the possibilities in terms of construction. Architectural model capture all (or, some) of the design decisions that comprises a system's architecture. Architectural modeling is the reification and documentation of architectural design decisions.

All architectural models are made on a scale; for example, 1: 100, which means they are 100 times smaller than the original, although they could be 1: 1, which is normal or even larger, or for example 8: 1, where the model would be eight times the size of the original. In the early 21st century, architectural modeling is a computer-aided process of creating 2D and 3D representations of architectural designs. However, 3D models create a more complete picture of the project than 2D models, and should be used over 2D models wherever possible. There are many different benefits of using a 3D building model. Not only does it help visualize the completed project, but it also reduces conflicts in design of architectural sub-systems.

10.1 Modeling accuracy

Models shall be checked for:

1. Scale.
2. Geometric accuracy of modeled components.
3. Locational accuracy in the horizontal and vertical dimensions.
4. Conformance with the BIM Standards identified in these standards.

10.2 Level of development and level of detail (BIM LOD)

Level of development (LOD) is a set of specifications that gives developers the ability (through categorization) to document, articulate and specify the content of BIM effectively and clearly. LOD is an "industry" standard that defines the development stages of different systems in BIM. LOD is a measure of the information represented by a BIM element, developed by a standard that refers to the level of certainty about an object. By using LOD categorization, developers can clearly communicate with each other without confusion for faster execution. The specification defines six (previously five) different levels of development to define the detailing levels in a BIM model.

Level of development (LOD) is the degree to which the components' specification, geometry, and attached information have been thought through – the degree to which project team members may depend on the information when using the model. The LOD specification allows developers to state how an element's geometry and associated information has evolved throughout the entire process. It signifies the degree to which different members of the team can rely on information associated with an element. It also allows for developers to define the inherent characteristics of the elements in a model at different stages of development.

The LOD levels are:

1. **100 (Conceptual)** - The Model Element may be graphically represented in the Model with a symbol or other generic representation. Information related to the Model Element can be derived from other Model Elements. Any information derived from LOD 100 elements must be considered approximate.
2. **200 (Approximate geometry)** - The Model Element is graphically represented within the Model as a generic system, object, or assembly with approximate quantities, size, shape, location, and orientation. Any information derived from LOD 200 elements must be considered approximate.
3. **300 (Precise geometry)** - The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of quantity, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element. The project origin is defined and the element is located accurately with respect to the project origin.
4. **350 (Precise geometry with connections)** - The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, location, orientation, and interfaces with other building systems. Non-graphic information may also be attached to the Model Element.
5. **400 (Fabrication-ready geometry)** - The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of size, shape, location, quantity, and orientation with detailing, fabrication, assembly, and installation information. Non-graphic information may also be attached to the Model Element.
6. **500 (Operations/As-built models)** - The Model Element is a field verified representation in terms of size, shape, location, quantity, and orientation. Non-graphic information may also be attached to the Model Elements.

For example, the following are three labels of precision and accuracy:

1. LOD 300 Generic BIM model.
2. LOD 350 custom model.
3. Manufactures 2D model.

Level of detail (LOD) refers to the proportion of detail enclosed within the model element. The Level of Detail can be thought of as input to the element, while the Level of Development is a reliable output.

10.3 Building information modeling (BIM)

A.k.a., Engineering model, object materialization model and data, BIM data, BIM metadata.

Building information modeling (BIM) is a rules-based design process that allows for configurable architectural products. Rules-based design enables the viewing of 3D product models that users or habitat teams can configure as needed, on demand, that account for allowable specifications and fabrication constraints. A decisioning system (i.e., decision engine) can be added to the collaborative engineering-production system to control for decision objectives, constraints, and requirements. Here, a database and configurator allows for the selection of custom products using rules-based design to control the allowable customization options without complex programming.

The application of BIM allows for:

1. Metadata integration (i.e., allows for association of parameters, values, with model elements).
   A. BIM is a process where all data about an object is grouped into one [interoperable] system.
2. Model simplification and comprehensive calculation.
   A. When all data about a model is available, calculations can be performed to optimize the model.

The workflow for a BIM configurator usually runs as follows:

1. Start with the fully detailed, configurable engineering model (engineering rule-base).
2. Create the architectural master model.
3. Create the MEP connections model.
4. Complete all object (e.g., BIM) metadata.
5. Upload for access to population user base.
6. Users chooses options, and see dynamic, high-detail 3D rendering/simulation.
7. The materialization system builds the product.

10.3.1 BIM model types

An engineered architectural system shall be created [in a software project] as either:

1. **Complete building** - A[n aggregated] building

object.
   A. A combination of other architectural objects that form a complete building.
2. **Architectural-engineering elements** - The first aggregate of elements that form a building. These elements generally include walls, floors (slabs), and support structures. A generic or manufactured architectural-engineering element/object.
   A. A generic architectural-engineering object - intended for use in the initial stages of design, until a specific manufacturer's object is select (see B, directly below).
   B. A manufacturers architectural object - intended to represent an obtainable product provided by a manufacturer or supplier. The term 'manufacturer object' is also synonymous with proprietary object or product object.
3. **Fixtures and assemblage objects** - A component or layered object. Component objects include structurally assemblage objects such as doors, windows, sanitary ware, furniture, etc. These objects can be held outside the model and be imported into it. Component and layered objects can be aggregated together to form an assembly (e.g. a room).
   A. Component objects can be further defined as:
      1. Static objects - available in one size.
      2. Parametric object - available in a range of predetermined sizes (or else the size can be determined by the designer).
   B. Layered objects: Comprise walls, floors, ceilings, roofs, etc. These objects are typically constructed from a number of layers and do not have a fixed geometry; this is defined by the designer (e.g. a concrete floor layer thickness may be determined by the designer's structural calculations). The thickness of the object layers may also be determined by manufacturers (e.g. an insulation board may be available in a set number of thickness). Layered objects may comprise single or multiple products, for example: A single product layered object could be a composite insulation board with facings and core or a concrete slab. Alternatively, a multiple product layered object could be a warm roof, consisting of waterproof covering, underlay, insulation, vapour control layer and concrete slab.

Assembly objects refer to separate objects which have been combined and managed as a group in the model or object library. The assembled group of objects may contain metadata solely for the group; may have additional metadata relating to the group; or just contain the metadata of the constituent objects. As an example, an accessible toilet is an assembled group containing a toilet, handrails, cubical walls, and a door. Each of these objects will have their own metadata, but the assembly itself could also have metadata giving the overall size or the standard it complies with. In some instances, when aggregated together to form an assembly, some component information may become irrelevant. For example, a door handle that comes as part of an overall door assembly. Care must be taken when an assembly is made up of multiple objects where each material has performance criteria that may be unrelated to the assembly as a whole.

An object may be gathered into an assembly to aid understanding of the context in which a product can be used. For example, a manufacturer's wall insulation BIM object may be shown within a generic wall build-up, even if the insulation manufacturer does not supply any other objects within the wall. The accompanying objects forming the wall assembly should have a minimum graphical detail equivalent to a generic object.

Note that BIM objects are provided as either layered objects or component objects; both types can be found in generic, manufacturer and project object form. Additionally, the BIM object may, where relevant, be part of a larger collection of objects that forms an assembly, including an assembly that represents the context in which an object is used.

10.4 BIM object development

In a general sense, every BIM object includes all of the following data categories:

1. **Naming** convention for files.
2. **Objects** (architectural systems).
3. **Locations** (localization).
4. **Views** (visual representations).
5. **Materials** (surface / internal composition).
6. **Parameters** (properties).
   A. Software-related parameters.
   B. Object-related parameters.
7. **Values** (descriptions).

In other words, the organizational structure for architectural-engineering [software] includes the following top-level categories (Yori, 2020):

1. Locations (coordinates and extents).
2. Objects.
   A. BIM systems (architectural components).
   B. BIM components (infrastructural components).
3. Properties (BIM parameters and classes).
4. Representations (views).
5. Coordination (BIM project phasing).
6. Modeling (creating masses/objects).

The four elements of a model in an architectural-engineering program are:

1. **Model parameters**
   A. Design-time parameters for the all data related to the model.
      1. There are multiple parameter types, including but not limited to: dimension, visibility, materials, assembly, etc.
2. **Model geometry**
   A. Masses.
      1. Voids.
3. **Model data (model data views)**
   A. Orthographic views.
   B. 3D views.
   C. Sheet views (i.e., geometric views, orthographic views).
4. **Model materials lists and quantities**
   A. Material sheets (a.k.a., schedules, quantities).

NOTE: *A mass (a.k.a., model, object) is simply a form with geometric substance (solids and voids) that is not related to any specific building element category. It is intended to allow designers to create a lightweight component that can represent either an entire architectural system/building or a architectural/building system. Alternatively, it can serve as a guide for a single component, such as a complex wall or roof form. When a mass is created in the context of a whole building, it is possible to quantify the surface area, assign functional elements (e.g., floors) to the mass, and perform energy analysis—all without creating a single wall, floor, window, or roof. Massing is a term in architecture which refers to the perception of the general shape and form as well as size of a building.*

10.4.1 BIM file naming convention

NOTE: *The "BIM" object file name shall also include the default file extension for its respective "BIM" object creation and visualization platform or file format.*

The "BIM" object shall use naming by means of the approach taken by the parent resource. Naming conventions should be intuitive to aid information retrieval. They shall be composed of alphanumeric characters without text formatting (e.g. a - z, A - Z, 0 - 9) and single spaces. Names shall be limited to a maximum of 50 characters. Fields shall be separated by the underscore character (_) or a hyphen (-). Note that the European BIP 2207 Guide to BS 1192 states that the use of hyphen (-) delimiters between the fields in a file identifier enable the use of varying length codes.

BIM software allows naming to be visible within both the object and the project model, offering the ability to provide search functionality and interactions with other databases.

The BIM object shall include properties and values that are consistently named. The BIM object and file name should be unique to avoid duplication of information and to aid export of information and interpretation.

The file and BIM object name shall be composed of:

1. <Role>_<Source>_<Type>_<Subtype/ product code>_<Differentiator>
   A. **Role** - Used to convey the library object author by a 3 – 6 digit code.
   B. **Source** - Used to identify the object manufacturer. The manufacturer name shall not be abbreviated. For a generic object this field may be omitted.
   C. **Type** - Used to identify the object type.
   D. Subtype - Used to convey additional information to further define the construction product such as the product range. The manufacturer product range shall not be abbreviated. This field can also be used to identify the predefined (Sub)type.
   E. **Differentiator** - Used to convey additional specialist information not captured in property data.
2. <HSS>_<Type>-<Subtype/product code>-<Differentiator>
   A. **HSS** - Used to identify the functional application of the object into the operation of the habitat service system.
   B. **Type** - Used to identify the object type.
   C. **Subtype** - Used to convey additional information to further define the construction product such as the product range. The manufacturer product range shall not be abbreviated. This field can also be used to identify the predefined (Sub)type.
   D. **Differentiator** - Used to convey additional specialist information not captured in property data.

10.4.2 BIM object categorization (architectural systems)

Types of systems within an architectural object include, but are not limited to:

1. Architecture: common (non-structural architecture).
2. Architecture: structural.
3. Infrastructure: Mechanical, electrical, plumbing (MEP).
   A. Heating, ventilation, and air conditioning (HVAC; mechanical, M).
   B. Electrical (E).
   C. Plumbing (piping; P).
4. Infrastructure: other.
   A. Fire protection.

B. Telecommunications.
C. Etc.
5. Landscape.
6. Energy [assessment].
7. Acoustics [assessment].

The totality of architectural object classifications include:

1. Complexes (Co).
2. Entities (En).
3. Activities (Ac).
4. Spaces / locations / areas (SL).
5. Elements / functions (EF).
6. Systems (Ss).
7. Products (Pr).
8. Tools and equipment (TE).
9. Project management (PM).
10. Form of information (Fi).
11. Roles (Ro) .
12. CAD (Zz).

10.4.2.1 BIM infrastructural components

Architectural-engineering software uses families [of CAD/BIM blocks] to represent infrastructural components:

1. **BIM families (e.g., Revit families)** - fully parametric models or drawings that can be used in a greater variety of ways. It is possible to embed families within families, allowing you to create a hierarchy of parametrically controlled models.
   A. **System families** - (also called host families) are content that is part of the project environment and are more akin to rule sets rather than physically constructed components. These elements are not created and stored in external files; instead, they are found only in the project file. If another type of a system family is required, then it will be duplicated from an existing type from within the project. System families can be 3D elements such as walls, curtains, floors, roofs, ceilings, stairs, and railings, or 2D elements such as text, dimensions, and revision clouds.
      1. 2D examples:
         i. Text.
         ii. Dimensions.
         iii. Details.
         iv. Lines (drafting).
         v. Filled regions.
         vi. Revision bubble.
         vii. Match line.
      2. 3D examples:
         i. Wall.
         ii. Curtains.
         iii. Floor.
         iv. Roof.
         v. Ceiling.
         vi. Stair.
         vii. Railing.
         viii. Ramp.
         ix. Model lines.
   B. **Component families** - are created in the a family editor and are either 2D or 3D content. This means someone (or some algorithm) will have to create and load these kinds of families outside the project environment. When a component family is initially created the designer (or algorithm) will need to select an appropriate family template. By selecting the correct family template, the designer (or algorithm) will be certain that the component being created is going to behave, view, schedule, and (if necessary) export properly.
      1. 2D examples.
         i. Annotations.
         ii. Detail components.
         iii. Profiles.
         iv. Sheets.
      2. 3D examples.
         i. Doors.
         ii. Windows.
         iii. Furniture.
         iv. Equipment.
      3. Spaces.
         i. Rooms.
         ii. Areas.
         iii. Volumes.
2. **Blocks (e.g., AutoCAD Blocks)** - blocks are the collection of geometries that act as a single object and they can be used in a drawing repetitively.
   A. Static blocks (static geometry).
   B. Dynamic blocks (dynamic geometry).

One of the primary reasons for using a block is its ability to modify all its references by modifying a single block. For example, if creating a block for windows in a floor plan, and then after adding the windows, it is decide to modify the type of window. In this case, the designer can simply modify the window block and all its references used in the drawing will change automatically.

> **NOTE:** *Blocks also help you in keeping the file size under control. A drawing made with blocks for repetitive objects will be far smaller than the drawing which uses copied instances of repetitive objects.*

10.4.3 BIM coordinates and extents (locations and positions)

Location data consist of references, grids, and levels. Location datum objects establish geometric behaviors by controlling the location and extents of objects (i.e., model content).

The four types of software specific location data are:

1. **References** - datum objects that are allow a user to work with any working point, line, or plane.
   A. Points.
   B. Lines.
   C. Planes.
2. **Levels** - datum objects that are parallel to the ground plane.
   A. View.
   B. Reference.
3. **Grids** - datum objects used to locate structural elements in a project.
4. **Coordinates** - data about object position in the world space.
   A. **Project base point** - This point is used almost exclusively for internal purpose. It is used to place dimensions relatively to the building. It can also be used to set the angle difference between the True North and the Project North.
   B. **Survey point** - This is used to create a "shared coordinates" system among multiple linked files. That means it's location is most useful when exporting and importing files. It is usually placed relatively to the Site.
   C. **Internal origin** - This point is invisible and cannot be moved (but, it can be made visible). In most software, by default, importing or exporting a file will be made relatively to this point (and when invisible, it confuses people).

NOTE: *References, levels, and grids can be used as extents in some architectural software.*

10.4.4 BIM representations (views)

Object engineering software uses views to display infrastructural components. Views are the visualizations a user interacts with.

1. 2D examples:
   A. Planes.
   B. Sections.
   C. Elevations.
   D. Callouts.
   E. Drafting.
   F. Legends.
2. 3D examples:
   A. Orthographic.
   B. Perspective.
3. Tabular examples:
   A. Schedule.
   B. Material takeoffs.
4. Simulation (animation) examples (motion of objects with magnitude; in time):
   A. Animation (films).
   B. Virtual environments (virtual reality simulations).

10.4.5 BIM parameters (properties)

A.k.a., Model parameters, object parameters.

Parameters store and communicate information about all elements in a model. Parameters create a rule or relationship that has user-editable properties. All content (i.e., objects) in an architectural-engineering project have associated parameters, which are simply the information or data about some thing. Here, parameters can affect many different aspects of an object, such as visibility, behavior, size, shape, materiality, assembly code standard, etc. Parameters are used to show and control an element's information and properties. Parameters are used to define and modify elements, as well as to communicate model information in tags and schedules.

Essentially, parameters are placeholders for data and should have descriptive names, for example:

1. Asset tag.
2. Building code.
3. Serial number.
4. Length.
5. Material surface.
6. Etc.

In BIM software, there are two top-level categories for parameters:

1. **Software-related parameter categories** - relate to how the parameters are stored, accessed, and usable by the software.
   A. System.
   B. Shared.
   C. Project.
   D. Global.
   E. Family.
2. **Object-related parameter categories** - relate specific objects (object properties).
   A. Assembly.
   B. Non-assembly.
   C. Habitat service.

10.4.5.1 BIM software-related parameter categories

Software-related parameter types and their usages include:

NOTE: *Different software products will have different categories of parameters. The following parameter categories are specific to REVIT.*

1. **System parameters** - are built-in (default) to the

software and cannot be changed or deleted, and they are always available.
   A. In REVIT software:
      1. Value available for schedule/sheet: Yes
      2. Value available for tag: Yes
2. **Shared parameters** (*most commonly ued*) - Shared parameters are parameter definitions that can be used in multiple families or projects. In REVIT, the definition of a shared parameter is stored in a separate file (not in the project or family), it is protected from change. For this reason, shared parameters can be tagged and scheduled. In REVIT, if a parameter in a family or project needs to be scheduled or tagged, that parameter must be shared and loaded in both the project (or element family) and the tag family.
   A. In REVIT software:
      1. Value available for schedule/sheet: Yes
      2. Value available for tag: Yes
3. **Project parameters** - specific to a single project file. A project parameter can be used to categorize views within a project. Note that in REVIT, information stored in project parameters cannot be shared with other projects. Project parameters are used for scheduling, sorting, and filtering in a project.
   A. In REVIT software:
      1. Value available for schedule/sheet: Yes
      2. Value available for tag: No
4. **Global parameters** - Global parameters are specific to a single project file, but are not assigned to categories. In REVIT, a global parameter can assign the same value to multiple dimensions.
   A. In REVIT software:
      1. Value available for schedule/sheet: No
      2. Value available for tag: No
5. **Family parameters** - Family parameters control variable values of the family, such as dimensions or materials. They are specific to the family. In REVIT, a family parameter can also be used to control a parameter in a nested family by associating the parameter in the host family to the parameter in the nested family.
   A. In REVIT software:
      1. Value available for schedule/sheet: No
      2. Value available for tag: No

There are two general kinds of project parameters:

1. **Type parameters** - control information about every element of the same type. For example, if the material of a piece of furniture is designated as a type parameter and it can be changed, the material for all the furniture of that type will change.
2. **Instance parameters** - control only the instances that a user have selected. So if the material of the piece of furniture that has been selected is an instance parameter, the user will be editing only the selected elements. Instance parameters should be constantly exposed in a properties panel. In REVIT, selecting something initially displays the instance parameters.

10.4.5.2 BIM object-related parameter categories

A.k.a., BIM parameter organization.

At the highest level, all parameters are sub-divided into groups, which are then sub-divided into parameter types, which are then sub-divided into parameter classes:

1. Architectural parameter group (property group).
   A. Architectural parameter type (parameters).
      1. Architectural parameter classes (classes).

In general, there are three types of groups for a BIM model:

1. The assembly code group.
2. The non-assembly code group.
3. The habitat service group.

An example of the **assembly code group** is as follows:

1. Parameter group: Assembly code standard.
   A. Parameter type: OmniClass Code.
      1. OmniClass code class: 23-31 25 25 11.
   B. Parameter type: OmniClass Title.
      1. OmniClass code class: Electric Heated Towel Bars.

An example of a **non-assembly code group** is as follows:

1. Parameter group: Material.
   A. Parameter type: Material.
      1. Material class: Metal.

An example of the **Habitat Service group** is as follows:

1. Parameter group: Habitat service
   A. Parameter type: Habitat Service Sub-System.
      1. HSS class: Life Support.
   B. Parameter type: Habitat Service Sub-System.
      1. HSS-S class: Water.
   C. Parameter type: Object Function.
      1. HSS-S class: Bathroom sink.

10.4.5.3 Assembly classification data (assembly code group)

A.k.a., Assembly classifications, construction classifications, building classifications, building and construction codes, BIM data exchange classification, etc.

All assembled objects have codes associated with them within a branching (tree-like classification) structure. Every BIM asset (entity, element, etc.) is classifiable within a standardized (and codified) classification tree. Most assets are physical, but some standards also allow for conceptual entities (e.g., tasks). Some coding standards are more detailed and others are less detailed. These codes represent identity data about the object(s), and allow for the comprehensive classification of BIM assets. Functional elements, also referred to as systems or assemblies, are common major components in buildings that perform a known function regardless of the design specification, construction method, or materials used.

Herein, building life cycle refers to the observation and examination of a building over the course of its entire life. The life cycle of a building considers everything about the building from design, commissioning, operation, and decommissioning.

> **NOTE:** *The classification of products/system is essential for economic calculation and planning within the habitat.*

A classification system for an assemblies includes:

1. **Codes** - coded identifier of [functionally unique] assembly.
2. **Titles** - label of [functionally unique] assembly.
3. **Descriptions** - description of [functionally unique] assembly.
4. **Tree levels** - location of [functionally unique] assembly within a classification tree.

> **NOTE:** *Assembly code files are tab delimited (to create a tree-like structure).*

10.4.5.1 Assembly classification standards (assembly code group)

> *A.k.a., BIM assembly code classification group types, assembly code format standards, assembly code parameter types, BIM assembly code formats, BIM data exchange standards.*

These standardized parameters (i.e., parameter types) may be associated with any physical object, and some may be associated with concepts.

> **NOTE:** *Some BIM standards are more focused on construction and not so much focused on operation and coordination (lifecycle management).*

The following are the master list of producers of standards that include titles and numbers (codes) used to organize specifications and other project information for most building design and construction (BIM) projects:

1. International standards include, but may not be limited to:

A. **Industry foundation classes (IFC)** [buildingsmart.org] - developed by buildingSMART International. Open standard for BIM data exchange. Semantic schema which defines the way the building related data is described and inherited. The classes can described anything, from a physical object (e.g., wall) to an concept (e.g., task).

B. **United Nations Standard Products and Services Code (UNSPSC)** [unspsc.org] - an open, global, multi-sector standard taxonomy for accurately classifying goods and services.

C. **NBS** [thenbs.com] - the National Building Specification (NBS) is a UK-based system of construction specifications used by architects, engineers and other building professionals to describe the materials, standards and workmanship of a construction project.

D. **Uniclass 2015 (2020 update)** [thenbs.com/our-tools/uniclass-2015] - non-proprietary classification system. For all aspects of the design and construction process. In particular, for organizing library materials and structuring product literature and project information. Uniclass originated in the United Kingdom and is produced by the Construction Industry Project Information Committee (CPIC) and the National Building Specification (NBS).

E. **MasterFormat (CSI)** [csiresources.org] - proprietary classification system. A master list for organizing construction work results, requirements, products, and activities. Mostly used in bidding and specifications, MasterFormat originated in North America and is produced by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC).

F. **UniFormat (CSI)** [csiresources.org] - classifying building specifications, cost estimating, and cost analysis in the U.S. and Canada (primarily). | For arranging construction information, organized around the physical parts of a facility known as functional elements, and mainly used for cost estimates. UniFormat originated in North America and is produced by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC).

G. **OmniClass** [higherlogicdownload.s3.amazonaws.com] - OmniClass Construction Classification System, also known as OmniClass (OCCS) is a proprietary classification system. For organization, sorting, and retrieval of product information for all objects in the built environment in the project lifecycle. OmniClass originated in North America and is produced by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC).

H. **Construction Operation Building information exchange (COBie)** [nbis.org] - a non-proprietary data format for the publication of a subset of building information that primarily includes equipment and spaces.

2. National standards include, but are not limited to:
   A. **BRAZIL - Associação Brasileira de Normas Técnicas (ABNT)** [abnt.org.br]

NOTE: *Because different industrial organizations have created different assembly codes for the same item, a mapping table may be required to map codes from one industrial standard to another (generally, a competitor). A mapping table for multiple classification systems may be necessary in BIM. Governments may force the use of a specific assembly format.*

Table 2. *Table shows BIM classification standard and associated example values.*

BIM Category	Example Value/Identification
BIMobject Category	HVAC - Heaters
IFC Classification	Furnishing Element
UNSPSC Name	Heating equipment and parts and accessories
UNSPSC Code	401018
Uniclass 1.4 Code	L75626
Uniclass 1.4 Description	Heated towel rails
Uniclass 2.0 Code	PR-47-36
Uniclass 2.0 Description	Heat Emitters
Uniclass 2015 Code	Ac_60
Uniclass 2015 Description	Heating, cooling and refrigeration activities
NBS Reference Code	47-36
NBS Reference Description	Heat Emitters
CSI MasterFormat 2014 Code	23 82 29
CSI MasterFormat 2014 Title	Radiators
CSI MasterFormat 2016 Code	
CSI MasterFormat 2016 Title	
CSI MasterFormat 2020 Code	
CSI MasterFormat 2020 Title	
OmniClass Number	23-31 25 25 11
OmniClass Title	Electric Heated Towel Bars
CSI UniFormat II Code	D3020
CSI UniFormat II Title	Heat Generating Systems
ABNT NBR Code	
ABNT NBR Title	

10.4.5.2 Assembly classification categories (assembly code group)

A.k.a., BIM object categories.

Architectural classes for architectural objects include, but may not be limited to:

1. Annotation symbols.
2. Cable trays.
3. Ceilings.
4. Columns.
5. Constructions.
6. Curtain panels.
7. Curtain wall mullions.
8. Detail items.
9. Division profiles.
10. Doors.
11. Electrical equipment.
12. Electrical fixtures.
13. Floors.
14. Furniture.
15. Furniture systems.
16. Generic models.
17. Mechanical equipment.
18. Parking.
19. Planting.
20. Plumbing fixtures.
21. Profiles.
22. Railings.
23. Roofs.
24. Site.
25. Speciality equipment (appliances).
26. Stairs.
27. Structural columns.
28. Structural foundations.
29. Structural framing.
30. Walls.
31. Windows.

10.4.5.3 Non-assembly parameter group types (non-assembly code group)

Non-assembly code parameters types include, but may not be limited to:

1. Length.
2. Text.
3. Integer.
4. Number.
5. Area.
6. Volume.
7. Angle.
8. Slope.
9. Currency.
10. Mass (as amount of matter and as density).
11. URL.
12. Material.
13. Image.
14. Yes/No (boolean).
15. Multiline text.

16. Family type

The most common non-assembly code parameter types are:

1. Length - width, depth, height.
2. Material - surface/finishes.
3. Text - coding.
4. Yes/no - movement (e.g., table folding ability).

10.4.5.4 Habitat service type parameter group

These Habitat Service System parameters (i.e., parameter types) associate physical objects with the [service system] functioning of the habitat in three ways:

1. Habitat service system.
2. Habitat service sub-system.
3. Object function.

Table 3. *Table shows classification for the Habitat Service Type parameter group.*

Parameter Group Name	Example Value/Identification
Habitat Service System	Life Support
Habitat Service Sub-System	Water
Object Function	Bathroom sink

10.4.6 BIM Material classes (non-assembly code parameters group)

A.k.a., Object surface composition parameter classes.

Material classes for architectural objects include, but may not be limited to:

1. Ceramic.
2. Concrete.
3. Earth.
4. Enamelled, cast iron.
5. Gas.
6. Generic.
7. Glass.
8. Glassy.
9. Liquid.
10. Masonry.
11. Metal .
12. Miscellaneous.
13. Non-assigned.
14. Paint, coating.
15. Plastic.
16. System.
17. Stone.
18. System.
19. Textile.
20. Unassigned .
21. Wood.

11 Architectural software

A.k.a., Architectural-engineering software, architectural-engineering-construction-operation software, building software, building construction and operations software, building information software, architectural-engineering collaborative design and visualization software.

Architectural-engineering uses databases that store architectural-engineering related data (possibly including construction and operations data also), and software to compute and visualize data. Data (plural) are sometimes referred to in object/building engineering software as datum objects. A community-based architectural-engineering software system facilitates a common data environment where all the stakeholders can work from the design phase all the way through to operations.

IMPORTANT: *The optimal architecture software for Decision System solution resolution is precise 3D, BIM (OIM), title documentation layout, clash-detection software.*

The purpose of the software can be summarized in the following elements:

1. **Collaborate** – Multiple project contributors can access centrally shared models. This results in better coordination, which helps reduce clashes and rework. The software must enable coordination of projects.
2. **Design** – Model building and environmental components, analyze and simulate systems and structures, and iterate designs. Generate documentation from object models. The software must enable the development and calculable design of systems.
3. **Visualize** – Communicate design more effectively to project stakeholders and team members by using models and model animation (simulation) to create high-impact 3D visuals and visual timelines. The software must enable visualization of systems.
4. **Document** - The software must enable documentation (and recording) during the entire life cycle of the project (plan, design, build, operation, maintenance).
5. **Operate** - The software must enable coordinated operation of the building.

In general, architectural-engineering software uses the following design restrictions (i.e., categories of restriction) to develop architectural elements:

1. Locations (position, orientation, coordinates).
2. Phasing (i.e., phase of execution).
3. Design options.
4. Design templates.

5. Worksets:
   A. System managed.
   B. User managed.
6. Line styles.
7. Object styles.

The six universal tasks of 3D software for architectural development are:

1. Creation (object creation).
2. Navigation (scene navigation).
3. Manipulation (object manipulation).
4. Selection (object selection).
5. System control (object and scene parameters).
6. Text input.

11.1 Parametric architectural design

A.k.a., Associative design, algorithmic design, computational design, scripting design.

Parametric city/architecture design is known by many names and essentially uses associations between architectural elements (parameters) in conjunction with rules to design optimal built environments. Parametric design software involves the development and application of algorithms using computational tools and software to determine optimized forms and structures of the built environment. With the assistance of a programmed algorithm, the parameters and rules determine the relationship between the “design intent” and the “design response”. Parametric design can help cities and architecture to be high-performance, aesthetic, functional, sustainable, and adaptive. A healthy algorithm ought to include a set of design rules derived from the lives of the city's inhabitants, and their interactions, rather than abstract geometric forms.

Parametric means to express a set of quantities as explicit functions of a number of independent variables, known as 'parameters'.

11.2 Architectural software

The following types of software (collaborative software design and decisioning) are required:

1. **Architectural-engineering software (collaborative architectural-engineering design software) -** Uses building information modelling software for architects, landscape architects, structural engineers, mechanical, electrical, and plumbing (MEP) engineers, designers and constructors. BIM (Building Information Modeling) is the process of creating a model of a building (or environment) and embedding into it all of the data regarding that building (or environment). A building is an object, and in a unified information system, this category of software is more optimally known as OIM (Object Information Modeling; or, Physical Information Modeling, PIM). This software provides an intelligent model-based process to plan, design, visualize, construct and manage buildings and infrastructure (and all objects in general). Software for the BIM/OIM process must facilitate the representation of the physical and informational properties of a building/object as an object-oriented model tied to a database. This software enables the users to create a dynamic database model which is tied to geometry, with constraints on connected features that adjust parametrically. As the model is developed and edited, all other linked drawings within the project are updated. Summarily, this software encompasses the design, infrastructure, and construction of all objects in an integrated manner.
   A. **Coordinated building software** - There are three categories of software required for the coordinated development and construction of a building project:
      1. **Project coordination software (building information modeling, BIM software)** - the project coordination software for a building project. The whole software package connects design and construction processes, and project teams, in one service system (to inform decisioning, as well as provide effective and efficient project execution). This is sometimes known as project coordination and integration software, project management software, and workflow management/coordination software.
      2. **Design building software (design software)** - The creation of an intelligent 3d model. Intelligent in that the software understands surface differences. The BIM process starts with the creation of an intelligent 3D model. AuraCurve uses building design and building information modeling (BIM) software by means of computer-aided design (CAD) services to architect buildings.
      3. **Engineering calculation software** - AuraCurve uses structural analysis software to design and operate a BIM environment. There are several sub-categories of systems herein:
         i. Structural
         ii. Electrical
         iii. Hydrologic and hydrologic
         iv. Atmospheric
         v. Construction
2. **Visual rendering software -** Uses a a rendering engine to enable visualization of model components. The user can view and interact with

the model in three-dimensional (3D) views as well as orthographic two-dimensional plans, sections and elevation views of the model, and in time (i.e., simulation, animation). The user can also view the 3D environment in virtual reality.

3. **Construction operations software (a.k.a., construction management)** - facilitates oversight of all construction operations.
4. **Building operations software (a.k.a., facilities management software)** - enables the coordinated operation of the constructed building. This is facilities management software for building operations.

Specific software products for these services currently include, but are not limited to:

1. **Building modeling software:**
   A. Autodesk REVIT (3D architectural design and development) [autodesk.com]
   B. Autodesk AutoCAD [autodesk.com]
   C. Autodesk Navisworks (3D model review software for architecture, engineering, and construction) [autodesk.com]
   D. Archicad [graphisoft.com]
2. **Infrstructure modeling software:**
   A. Autodesk REVIT [autodesk.com]
   B. Autodesk Civil 3D (civil infrastructure design and development) [autodesk.com]
3. **Building information modeling coordination software** (with issue tracker):
   A. AutoDesk BIM 360 [autodesk.com]
   B. SmartSheet [smartsheet.com]
   C. Projet Manager [projectmanager.com]
   D. GitHub [github.com]
   E. Etc.
4. **Engineering calculation software:**
   A. Autodesk Architecture, Engineering & Construction (AEC) Collection [autodesk.com]
      - Autodesk Robot Structural Analysis Professional - structural load analysis software that verifies code compliance and uses BIM-integrated workflows to exchange data with Revit. Available only as part of the Architecture, Engineering & Construction Collection.
   B. SAAP 2000 [csiamerica.com]
   C. Bently STAAD Pro [bently.com]
   D. RISA [risa.com]
   E. Clearcalcs [clearcalcs.com]
   F. **Concrete specific software:**
      1. Multiplus Cypercad [multiplus.com]
   G. **Metallic specific software:**
      1. Multiplus Metalicas 3D [multiplus.com]
5. **Landscape modeling software:**
   A. Autodesk REVIT [autodesk.com]
   B. Viz Terra (3D landscape design) [structurestudios.com]
6. **Visual rendering software:**
   A. AutoDesk REVIT
   B. Epic Unreal engine
   C. Epic Twinmotion
   D. Lumion
   E. Cryengine
   F. Unity engine
   G. Etc.
7. **Construction operations software (a.k.a., construction management software)**:
   A. AutoDesk Construction Cloud [construction.autodesk.com]
   B. BuilderTREND [buildertrend.com]
8. **Building operations software (a.k.a., facilities management software)**:
   A. AutoDesk BIM 360 Ops [autodesk.com]