

The Museum of Contemporary Art Cleveland v The Diego Portales University.

COMPARING AND CONTRASTING THE FRAMING MATERIALS USED TO CONSTRUCT THE MOCA CLEVELAND AND THE DIEGO PORTALES UNIVERSITY CAMPUS.

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DATE: 02.03.2021

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1. Introduction

Concrete and steel are both commonly used materials throughout the construction industry due to their renowned workability and strength. The purpose of comparing and contrasting The Museum of Contemporary Art Cleveland, known as moCa, and The Diego Portales University campus is to establish how each building represents concrete and steel frameworks impact on the construction industry, during the building's life cycle, socially and environmentally.

2. The Museum of Contemporary Art Cleveland

The 34,000 sq. ft structure completed in 2012 is a four storey, six-sided structure is covered with 1,354 stainless steel panels and stands at 65' tall at the top of its exterior walls (Zahner, 2012). Farshid Moussavi, the appointed architect, was in charge of ensuring the replacement building would maximise the use of space as well as reflect on the town's interests. The design is completely unique with an internal structure of a 92' x 92' cube of steel. Moussavi created a bold design inspired by the placement of the structure on a corner plot of the Uptown area. By using triangle and trapezoids it allows the geometry of the structure to mirror its surroundings (Cilento, 2010).

2.1 Original Design

The design process took place during a heavy recession which ultimately added pressure and influenced various changes to the design. With limitations on the budget, it was imperative that Moussavi and her team made the design feasible within these restrictions. This led to interior changes to the design such as the staircase that runs through the entire building. Moussavi realised early on that stacking the fire staircase on top of the public stairwell would allow more gallery space and still work well within the structure. Due to the financial issues surrounding the country at the time, it was decided that creating a space for the air-conditioning and heating equipment within the second floor instead of creating a new basement would allow money to be used elsewhere in the project (Litt, 2012).

2.2 Construction Method

The framework is a steel cube, with steel beams that shape the exterior design. Steel was used as the main framework as well as the exterior aesthetic. Due to the design and geometric façade, designers and engineers had concerns over the construction method and in 2011 built a mock-up of the structure to be used as a reference point (Zahner, 2012). Large steel components were also used for the staircase and it is reported that they were craned into place through the roof due to the size and stature (Litt, 2012). Cleveland is known as a 'Rust Belt' city, and the use of steel was not only fitting for the design concept, but also pays homage the cities industrial past (Ryan, 2012).



Figure 1: Mock-up of the moCa in 2011 observed by design team (Zahner, 2021).

2.3 Social and Environmental Impact

As a non-collecting museum, it was crucial that the building would accommodate public programmes and events. Moussavi envisioned a living space and working space, from the galleries to 'back of house' and her aim was to build an interspersed area (Frearson, 2012). As stated by (moCa Cleveland, 2021), the building

was “devised for both environmental and fiscal sustainability”. The panelled exterior allows for the buildings appearance to mirror the external environment. It also cools and heats the adjacent plaza’s geothermal wells (CWRU, 2021). The building serves as an extension of the community by providing a space for contemporary art, education and history. In 2015, the building was awarded a Silver rating by the U.S Green Building Council’s LEED for its environmental design (Litt, 2019).

3. The Diego Portales University

The first two campuses at Diego Portales university outline the architect’s goal of creating a space that not only provides a high level of comfort but also coincides with its landscape, technical facilities and geography (Frearson, 2014). Architects Rafael Hevia, Rodrigo Duque Motta and Gabriela Manzi designed the Diego Portales campuses with aims to achieve a beautiful structure that offered sustainability and somewhere that connected everyday life with its environment (Hudson, 2014).

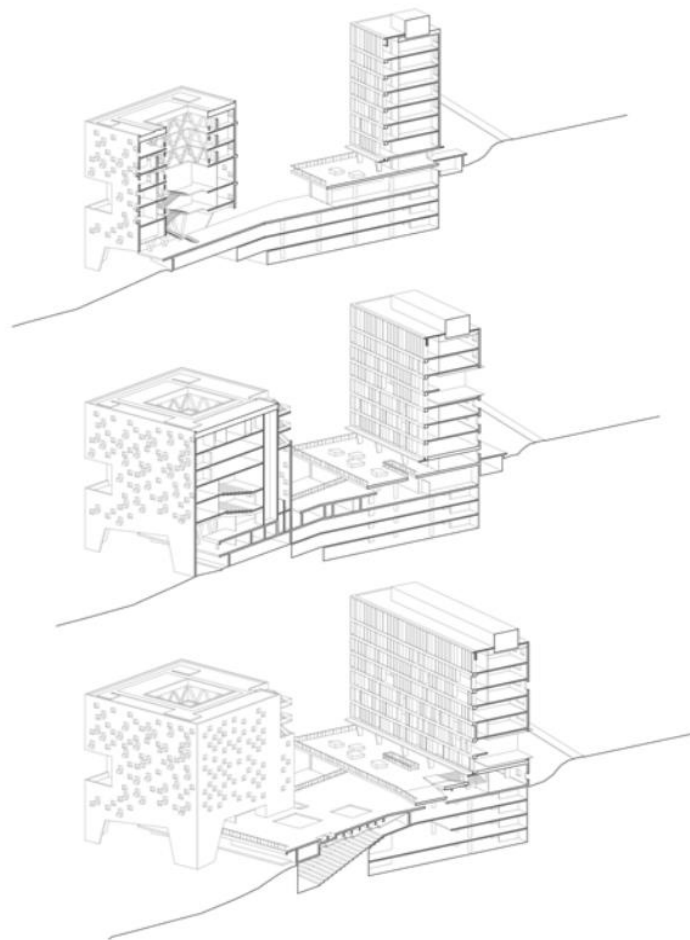


Figure 2: Drawings of original design (Dezeen, 2014).

3.1 Original Design

The architects hope is to continue the project and create a total of four elements on site, all interlinked with the underground squares below the courtyards. The site consists of 2 large concrete structures connected by courtyards which provide views over the Huechuraba landscapes. Below the courtyards are three access squares that connect the buildings and additional access points for the future phases. Situated amongst a river of glass box structures, the building contrasts with its architectural surrounding. The scheduled masterplan was designed to fully utilise the landscape and is embedded into the slope of the Cerro San Cristóbal foothills (Icon, 2014).

3.2 Construction Method

Precast concrete allowed the architects innovative design to come to life with the Diego Portales campuses. The decision to use precast concrete for the main infrastructure as well as the external design was based on the architect's ideology of matching to completed building to its surrounding aesthetic. Concrete would allow for the strength and stability required for the design as well as act as a suitable material for the sustainability of the project. This was also an opportunity for the architects to showcase their goals in creating an everlasting structure. The connecting underground theatres are constructed with precast concrete which follows the building up over the 8 storeys. Concrete lattice work is also used to the east of the building with a concrete wall decorated with reflective glass to the west (Frearson, 2014).

3.3 Social and Environmental Impact

From the earliest stages it was clear that the universities commitment to building a sustainable and impactful campus was important. This was also visible through the architects designs and chosen methods. Examples of this can be found with the implementation of planters throughout the buildings for deciduous vines to provide shade and humidity during the warmest months. The architect's aspiration was to not stray away from the landscape and its facilities but to incorporate it into the structure. The framework and design allow for the surrounding elements such as the

breeze to create a cross ventilation into classrooms and up through the central void of the taller building. Overall, the intention was to create a sustainable building that would fit the town and universities needs which would lead to an improved social environment for all (ArchDaily, 2014).

4. Comparing Framing Material

Table 1: Advantages and disadvantages of using concrete or steel as a framework material.

Characteristics of Framing Materials		
Concrete	Advantages	Disadvantages
	> Strength > Durability and workability > Fire resistant > Noise reduction > Low expansion rate in high temperatures	> Heavy to handle > Weak in tension > Difficult to control quality > Non-renewable resource > Negative effects from production process
Steel	Advantages	Disadvantages
	> 100% Recyclable > Non-deteriorating with protection > Good span > Prefabricated shapes > Strength	> Can corrode when exposed > Heavy to handle > Possible to bend/buckle under high pressure > High expansion rate in high temperatures

As indicated in Table 1, there are various different advantages and disadvantages of using concrete or steel as a framework material. Both consist of traits that prove valuable such as strength, as well as offer contrasting properties that might prove beneficial in dissimilar conditions. Components such as concrete's resistance to fire will have played a part in the decision to use this material in conditions where the surrounding environment might increase the risk of a high temperature atmosphere or fires, for instance Santiago, Chile. On the other hand, steel would have been a more appropriate fit for a structure that requires good flexibility and offers great spans, such as the moCa. The above factors would have participated in the architect's considerations on climatic resistance, production processes and the ease of assembly and adaptability of their chosen material.

4.1 Durability and Climatic Resistance

The moCa, set in Cleveland and the Diego Portales campus, set in Chile, will both undergo different climatic experiences. On average, Cleveland will encounter warm summer weather, reaching between 20°C and 27°C from June to September. And during their winter months the weather can drop as low as -5°C, more often than not resulting in medium to heavy snowfall (Weather Spark, 2021). Using a Steel frame in this environment is extremely beneficial. In areas where the temperatures create a suitable climate for snow during winter followed by a warmer climate a few weeks or possibly days later can result in serious damage to a structure's framework. Steel has a great snow load capacity, not only can it securely hold the weight and load of potentially heavy snow but it also copes well with the melting snow. Steel is non-porous meaning water is prevented from penetrating the materials and potentially degrading its internal structural properties. (Fedsteel, 2019). On the other side of the spectrum, we have a concrete framework in a much more humid climate.

Set in Santiago, Chile the Diego Portales buildings would not have to withstand such cold temperatures. With the highest temperatures reaching up to 30°C and a lowest of 3°C during the winter, the architects faced a very different climate (Weather Spark, 2021). To use Steel in a warmer climate means the building would need additional protection such a vapour barrier and additional insulation (CDMG , 2019). The risk of metal sweating in a humid climate is high therefore additional precautions must be installed which can lead to longer construction time and potentially a much higher cost. This also means sourcing of material is much more difficult and costly as steel is not usually produced in warmer countries. Sourcing the material from a different country also reduces the buildings environmental factor as it is now causing further emission to be used for transportation (Steel Technology, 2021). Not only is concrete best produced in a warmer climate but its thermal mass acts as its own ventilation system. Concrete absorbs heat throughout the daytime keeping interior spaces cool and in the night the material will naturally ventilate resulting in the concrete cooling but internal spaces remaining warm (UKQAA, 2005). This has been largely considered with the design of the Diego Portales campus by the continuous use of open spaces throughout both buildings. The taller building ventilates throughout its centre and the wider building has air corridors allowing the natural breeze through to ventilate the entire structure. Given the environmental conditions both buildings are

exposed to during their life cycle, the chosen framework material for each provide suitable characteristics for their durability.



Figure 3: Diego Portales Campus (Guerra, 2014)

4.2 Production Process

The production process for concrete can be complex and is reliant on factors such as composition, additives and temperature. Cracking in concrete is a common occurrence during the curing process under colder conditions. If concrete is cast in cold temperatures it is more liable to cracking, due to setting too quickly, leading to a weaker material (Cemex, 2021). If concrete had been used for the moCa framework this could have led to possible delays due to out-sourcing precast concrete, adding to cost and time, or only curing concrete during the warmer months. This also would have led to a longer construction time.

Concrete consists of cement, aggregates, water and chemical admixtures. These ingredients can influence the many types of concrete and allow the mixture to be modified for different results. A larger design such as the Diego Portales campus

would require a well graded aggregate to create the characteristics required for a good mix for its workability, durability and resistance to stresses. This can be measured using concrete grading which is calculated using its compressive strength after 28 days (Base Concrete, 2021). As important as getting the appropriate mixture is, it is crucial to consider how this production process impacts the environment and its carbon footprint. Concrete's production process accumulates 4 – 5% of the worldwide total CO₂ emissions which is produced at two individual points. CO₂ emissions are subsequently released during both the burning of fossil fuels to generate the heat required for cement and during the thermal decomposition of calcium carbonate to create the cement clinkers. It is reported that the production of one tonne of cement leads to 780kg of CO₂ (GreenSpec, 2021). Due to its known impact on the environment as well as its large demand within the construction industry, cement is currently being modified to improve its environmental impact. This can be seen in Australia where the company Wagner has successfully created an 'earth friendly concrete' known as EFC. Wagner uses industrial waste from steel production as well as waste from coal power generation to replace Portland cement in the mixture. By replacing the Portland cement entirely with slag, it is suggested that this EFC concrete reduces carbon emissions up to 90% (Kane, 2016).

The steel production process is also known as a heavy contributor to emitting serious amounts of CO₂, CO and N₂O. These greenhouse gasses are being produced at large due to the mining of iron ore which is required to produce steel and it is proposed that the current production process is the most damaging for the environment in the construction industry (The World Counts, 2021). The biproducts of the steel production process has irreversible effects but with its high demand from the industry it is vital that this process changes to create a sustainable method. The construction industry relies on steel massively with enough being produced globally to build the Eiffel Tower every 3 minutes (The World Counts, 2021). Although steel is 100% recyclable it is important to understand in order to recycle the material it must endure the same production process with the recyclable material added in. To do this, are we considering that although it can be used again and again and its life cycle might be endless that we are still emitting the detrimental biproducts when we reuse the material in its current production process (World Steel Association, 2012).



Figure 4: The life cycle of steel (World Steel Association, 2021)

Much like concrete, the construction industry does aim to improve the steel production process. A Korean based steel manufacturer, POSCO, has been working on a more sustainable steel production process since 1992. Following their advances, they successfully created FINEX technology which combines the processes of sintering, coke making and the blast furnace into one. This enables the use of a lower-grade ore and ultimately reducing the release of the air pollutants such as CO₂ and CO (POSCO, 2016). More recent reports suggest that material production processes are under scrutiny from governments, the UK in particular, and that numerous new regulations are being imposed to encourage the industry to re-evaluate these procedures for more sustainable and environmentally friendly methods (Grey, 2020).

Total industry CO2 emissions

By subsectors (%)

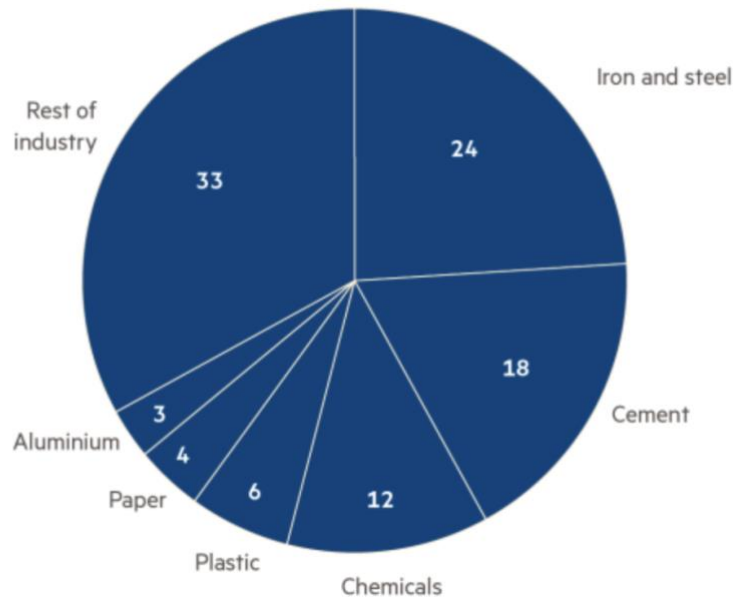


Figure 5: Total industry CO2 emissions (Pooler, 2019)

4.3 Ease of Assembly and Adaption

By using precast concrete, the assembly process on site can be much quicker resulting in a shorter overall construction time for the project. Installation of the precast elements do however require large machinery, frequent working from height and skilled contractors. In a location such as the moCa building, this construction method would not have been suitable due to its narrow and busy positioning. Precautions such as health and safety measures as well as site accessibility need to be considered when using precast concrete frameworks (Designing Building Wiki, 2020). Over the decade, the approach to end-of-life concrete buildings has developed. With several projects having taken place where reuse of concrete panels and even derelict buildings have been used on new projects. During 2008-2010 a rehabilitation project in Finland saw a small housing estate reuse concrete panels and walls which saw a 36% saving in cost to the overall project (Salama, 2017). As we find it possible to use elements of end-of-life concrete buildings it does emphasise on the matter that concrete itself is not fully adaptable once in situ. Therefore, not a material you would

choose to create a project that might require a different shape or alternative use during its life cycle.

Similarly, steel fabrication and assembly can be done off site and delivered. Steel is known in the construction industry for its potential to adapt. It is a flexible material, under the right pressure, thus very good at resisting dynamic forces on a construction site (Understand Building Construction, 2021). For the design of the moCa, steel is supreme due to its ability to take any shape and the wide range of assembly options such as bolting and welding. Although steel provides the correct qualities for the moCa framework, it is prone to corrosion in humid locations and would have had to have undergone several protective elements to use as a framework for the Diego Portales campus (Whirlwind Team, 2015). In comparison to concrete, steel structures are adaptable and can be changed, modified or refitted during its life cycle. Steel frames are more manageable when it comes to change of use or shape and succeeding steel structures to out-live concrete structures (DPL Steel Buildings , 2021).

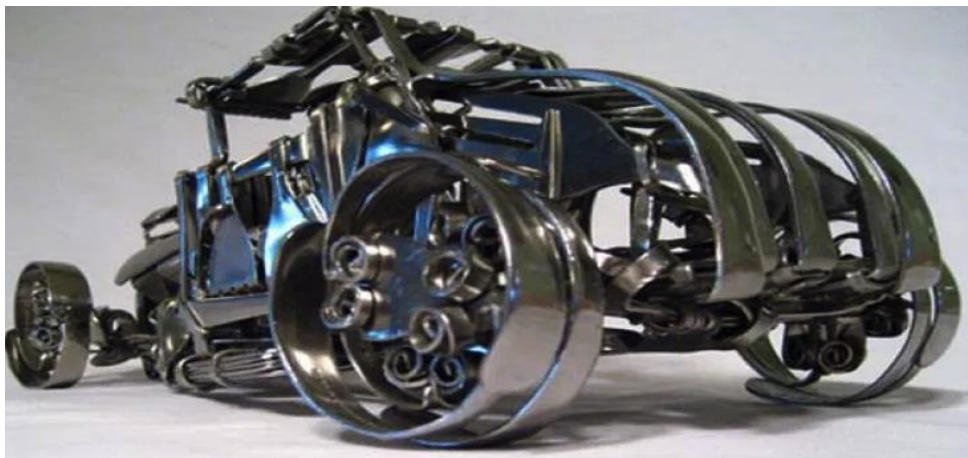


Figure 6: Recycled metal fork vehicle (Community Writer, 2021)

5. Summary

In conclusion, no two construction materials are alike. When choosing a framing material for a habitable building there are numerous factors to consider in terms of its durability, climatic resistance, environmental impact and adaptability during its life cycle. Materials such as concrete and steel are extremely beneficial in contrasting circumstances, where one might succeed in colder climates and exceed expectations on strength and adaptability. The other might offer better resistance in humid conditions and have a lower impact on the environment during its production. It appears concrete does not surpass the advantages steel brings to the construction industry with a recorded 50% of all produced steel contributing to the industry (OECD, 2010). (RG Group, 2020) state "In any discussion about climate change, the construction industry has an important role to play." This supports the evidence that the production process for steel and concrete currently have an everlasting negative effect on the planet and must play a part in the framework consideration as we reach a critical point in global warming.

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