**Adelaide Street North Underpass**

**Comprehensive Quality Report**

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Project Risk and Quality

MGMT-6062-(01)-24W

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# Adelaide Street North Underpass Comprehensive Quality Report

## Introduction

The Adelaide Street North – CP Grade Separation project, known as the "Adelaide Underpass," represents a significant undertaking by the City of London to enhance transportation infrastructure and safety within the community. This project aims to reconstruct Adelaide Street North from Elias Street to 80 meters north of McMahen Street, as well as Central Avenue from William Street to Elizabeth Street. The central feature of the project is the construction of an underpass beneath the CP Rail tracks, eliminating the existing at-grade crossing. In addition to the underpass, the project encompasses intersection improvements and the establishment of active transportation connections, including wide multi-use paths along Adelaide Street North. Aligned with the principles of Complete Streets, these enhancements are designed to improve amenities for pedestrians, cyclists, and transit users, fostering a more accessible and inclusive urban environment.

In the Excel document, we have outlined a comprehensive plan for the Adelaide Underpass project. The document includes four worksheets: Customers List, Customer Priority, Requirements Priority, and Requirements Specifications.

### 1.1 Customers List Worksheet

The Customers List worksheet identifies key stakeholders involved in the project, categorized into external, internal, and hidden customers.

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### 1.2 Customer Priority Worksheet

The Customer Priority worksheet prioritizes these stakeholders based on their importance to the project, considering factors such as impact, influence, and dependency.

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### 1.3 Requirements Priority Worksheet

The Requirements Priority worksheet lists 16 customer requirements, paired with the top five prioritized customers. These requirements are measurable and essential for the success of the project.

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### 1.4 Specifications Worksheet

Finally, the Specifications worksheet provides detailed specifications for the top 8 requirements identified in the Requirements Priority worksheet. These specifications outline the specific features and standards that will be incorporated into the Adelaide Underpass project to meet the identified requirements effectively.

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## Material Requirements

Three important selected materials and supplies used in the Adelaide Underpass Project are concrete, steel, and LED lighting fixtures. Here's why these choices are important:

**Concrete:** Concrete is a fundamental material in infrastructure projects like underpasses due to its durability, strength, and versatility. In the case of the Adelaide Underpass, concrete is essential for constructing the underpass structure, including the walls, columns, and foundation. Its ability to withstand heavy loads, harsh weather conditions, and long-term exposure to moisture makes it an ideal choice for providing stability and structural integrity to the underpass, ensuring the safety and longevity of the infrastructure.

**Steel:** Steel is another crucial material used in underpass construction, particularly for reinforcement purposes. Steel rebar is commonly embedded within concrete structures to enhance their tensile strength and prevent cracking. In the Adelaide Underpass project, steel will be used extensively for reinforcing concrete elements such as beams, slabs, and columns, providing additional support and resistance against bending forces. Additionally, steel may also be utilized for constructing railings, barriers, and other safety features within the underpass, contributing to the overall safety and functionality of the infrastructure.

**LED Lighting Fixtures:** LED lighting fixtures are an important component of the underpass design, contributing to both functionality and aesthetics. LED technology offers numerous advantages over traditional lighting sources, including energy efficiency, long lifespan, and superior illumination quality. In the Adelaide Underpass project, LED lighting fixtures will be strategically installed to ensure adequate visibility and safety for pedestrians, cyclists, and motorists traversing the underpass. Furthermore, LED fixtures can be tailored to provide uniform lighting, minimize glare, and enhance the overall ambiance of the space, improving the user experience and promoting a sense of security within the underpass environment. Additionally, the energy efficiency of LED lighting aligns with sustainability goals, reducing operational costs and environmental impact over the lifespan of the infrastructure.

### Detailed Description

### 2.1 Concrete

Concrete used in the underpass project will typically consist of cement, aggregates (such as sand and gravel), water, and admixtures. The concrete mix design will be tailored to meet specific performance requirements, considering factors such as compressive strength, durability, and workability. Reinforcement detailing will be carefully planned to ensure proper placement of rebar within the concrete elements, following engineering specifications and design drawings.



### 2.2 Steel

The steel reinforcement used in the underpass will be high-quality, deformed steel bars designed to resist tensile stresses and bond effectively with concrete. Rebar sizes, spacing, and placement will be determined based on structural calculations and design requirements to ensure adequate reinforcement throughout the underpass structure. Corrosion protection measures, such as epoxy coating or galvanization, may be employed to enhance the longevity of the steel reinforcement in corrosive environments.

A construction site with a crane and a bridge

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### 2.3 LED Lighting Fixtures

LED lighting fixtures offer numerous advantages for the underpass project, including energy efficiency, longevity, durability, reliability, and enhanced lighting performance. Their careful selection and installation will contribute to creating a safe, well-lit, and sustainable transportation infrastructure for the benefit of the community.

* Fixture Design: LED fixtures will be chosen with a design suitable for outdoor applications and optimized for uniform light distribution. The fixtures may feature a rugged housing made of materials like aluminum or polycarbonate, providing durability and protection against corrosion, vandalism, and environmental elements.
* Light Output: The LED fixtures will deliver sufficient light output to illuminate the underpass area adequately, ensuring visibility for both pedestrians and vehicles. The fixtures will be strategically positioned and spaced to minimize glare, shadows, and dark spots while maximizing safety and comfort for users.
* Color Temperature and Color Rendering: The LED fixtures will offer a desirable color temperature and color rendering index (CRI) to provide natural-looking illumination and enhance visibility, contrast, and object recognition. Warm white or neutral white LEDs with high CRI values will be preferred to create a welcoming and visually appealing environment within the underpass.
* Energy Efficiency and Controls: LED fixtures will incorporate energy-saving features such as dimming capabilities, motion sensors, and daylight harvesting to optimize energy usage based on ambient conditions and user traffic. Smart lighting controls may be integrated to adjust light levels dynamically, reduce energy consumption during off-peak hours, and enhance operational efficiency.
* Maintenance and Serviceability: LED fixtures will be selected for ease of maintenance and serviceability, with accessible components and tool-free access for lamp replacement or repair. Modular fixture designs may be employed to facilitate quick and cost-effective maintenance without disrupting normal underpass operations.



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## Standards Applied.

The standards ensure the integrity and quality of the finished product by specifying requirements and best practices for material selection, fabrication, installation, and performance. Compliance with these standards helps to ensure the safety, reliability, and longevity of the infrastructure components.

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| --- | --- |
| **Concrete** | * **Standard Applied:** Canadian Highway Bridge Design Code (CAN/CSA-S6-06) * **Regulatory Requirement:** The Canadian Highway Bridge Design Code is a regulatory standard designated by the Ontario Regulation 104/97 under the Public Transportation and Highway Improvement Act. Compliance with this code is mandatory for the design, construction, evaluation, and rehabilitation of bridges in Ontario. |
| **Steel** | * **Standard Applied:** CSA Standard W59 - Welded Steel Construction (Metal Arc Welding) * **Regulatory Requirement:** CSA Standard W59 is a regulatory requirement in Canada for the welding of steel structures, including bridges. It outlines the requirements for the qualification of welding procedures and welders, as well as the fabrication and inspection of welded steel components. |
| **LED Lighting Fixtures** | * **Standard Applied:** IEEE Std 1789-2015 - Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers. * **Industry Practice:** IEEE Std 1789-2015 is not a regulatory requirement but rather a recommended industry practice. It provides guidelines for modulating current in high-brightness LEDs to reduce the risk of potential health issues such as flicker and visual discomfort for viewers. |

## Specifications

### 4.1 Steel Bridge

Specifications ensure that the steel bridge beams meet the required standards for material quality, fabrication, coating, installation, and documentation, thereby ensuring the structural integrity, durability, and safety of the bridge components.

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| Material | **Grade:** ASTM A709 Grade 50W  **Composition:** High-strength, low-alloy steel with enhanced atmospheric corrosion resistance  **Certification:** Material certificates confirming compliance with ASTM A709 Grade 50W requirements. |
| Dimensions | **Length:** As per design requirements, typically ranging from 10 meters to 40 meters  **Width:** Standard width as per bridge design specifications  **Depth:** Determined by structural engineering calculations based on load requirements. |
| Fabrication | **Welding Procedure:** Compliant with CSA Standard W59  **Welding Method:** Metal arc welding (SMAW or FCAW)  **Weld Quality:** Welds to be visually inspected and ultrasonically tested to ensure integrity. |
| Surface Preparation and Coating | **Surface Preparation:** Sandblasting to achieve SSPC-SP10/NACE No. 2 Near-White Metal Blast Cleaning.  **Coating:** Application of two coats of high-performance epoxy primer and one coat of polyurethane topcoat, meeting AASHTO M270/ASTM A709 requirements. |
| Quality Control | **Inspection and Testing:** Third-party inspection of materials and fabrication processes.  **Non-Destructive Testing:** Ultrasonic testing of welds, magnetic particle testing, and dye penetrant testing as per CSA Standard W59. |
| Installation | **Alignment and Leveling:** Bridge beams to be installed according to design specifications, ensuring proper alignment and levelness.  **Connection:** Bolting or welding of bridge beams to supporting structures as per design drawings and engineering calculations. |
| Documentation | **Material Certificates:** Documentation confirming compliance with ASTM A709 Grade 50W specifications.  **Inspection Reports:** Detailed reports of material inspections, weld inspections, and coating inspections.  **As-Built Drawings:** Updated drawings reflecting the actual dimensions and configurations of installed bridge beams. |
| Compliance | **Standards:** Compliance with CSA Standard W59 for welding procedures and welding quality.  **Regulations:** Adherence to regulatory requirements outlined in Ontario Regulation 104/97 for bridge construction and safety. |

### 4.2 LED Lighting Fixtures

**Types of LED Lighting Fixtures**

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| Straits-Square-LED-Canopy-Light | 30W-standard-LED wall pack 500x500 | LED-Flood-Light |

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| Product Type | **Type:** LED (Light Emitting Diode) lighting fixtures  **Application:** Illumination for the Adelaide underpass to ensure safety, visibility, and aesthetic appeal. |
| Material | **Housing Material:** High-grade, corrosion-resistant aluminum alloy for durability in outdoor environments  **Lens Material:** Impact-resistant polycarbonate with UV protection for long-lasting clarity and protection against vandalism.  **Certification:** Product certifications confirming compliance with relevant safety standards. |
| Lighting Performance | **Luminous Flux:** Output ranging from 3000 to 6000 lumens per fixture, depending on the size and configuration of the underpass.  **Color Temperature:** Warm white (3000K) to provide a welcoming and visually comfortable atmosphere for pedestrians.  **Color Rendering Index (CRI):** High CRI (>80) for accurate color representation, enhancing visibility and security.  **Beam Angle:** Wide beam angle (120°) to ensure uniform illumination across the underpass area. |
| Energy Efficiency | **Power Consumption:** Low power consumption, typically ranging from 30 to 50 watts per fixture, to minimize energy costs and environmental impact.  **Efficiency:** High efficacy, achieving energy savings of up to 60-70% compared to traditional lighting sources  **Dimming Capability:** Dimmable fixtures compatible with standard dimming protocols (e.g., 0-10V) for adjustable lighting levels and additional energy savings during off-peak hours. |
| Durability and Reliability | **IP Rating:** IP65 or higher for dust and water resistance, ensuring reliable performance in outdoor environments and protection against weather elements.  **IK Rating:** IK08 or higher for impact resistance, safeguarding against vandalism and accidental damage.  **Operating Temperature:** Wide operating temperature range (-20°C to 40°C) for consistent performance in varying weather conditions  **Lifetime:** Long lifespan exceeding 50,000 hours, reducing maintenance frequency and associated costs. |
| Control and Integration | **Control Options:** Compatible with centralized lighting control systems for automated scheduling, remote monitoring, and energy management.  **Integration:** Seamless integration with smart city infrastructure for real-time monitoring, predictive maintenance, and data-driven insights  **Compatibility:** Interoperability with standard communication protocols (e.g., DALI, Zigbee) for seamless integration with existing lighting networks. |
| Quality Assurance | **Testing Standards:** Compliance with relevant industry standards such as IESNA LM-79 and LM-80 for photometric and lifetime testing  **Quality Control:** Stringent quality control measures ensuring consistent performance and reliability across all fixtures.  **Warranty:** Manufacturer's warranty covering defects in materials and workmanship, typically ranging from 5 to 10 years to guarantee long-term reliability. |

## Grades of Materials (suitable and not suitable)

When selecting grades of materials, it's crucial to consider factors such as structural requirements, environmental conditions, and regulatory standards. This section discusses the suitability of grades for three common construction materials: concrete, steel, and plywood.

### 5.1 Concrete

Concrete indeed holds a crucial role in large-scale construction projects like Adelaide Underpass Project, particularly in bridge construction. Its versatility, flexibility, and ability to evenly distribute weight make it an excellent choice for such structures. Over time, advancements in technology have led to the development of various types of concrete, each tailored to meet the specific requirements of different projects. These innovations allow engineers to select the most suitable type of concrete based on factors such as load-bearing capacity, durability, and environmental conditions, ensuring optimal performance and longevity.

**Types of Concrete used for Constructing Bridge**

* **Reinforced Concrete** - Reinforced concrete is a durable material that enhances ductility, enabling it to withstand heavy loads without bending or breaking. It resists expansion and contraction due to climatic changes, reducing internal stresses. Additionally, it absorbs structural stress well and distributes weight evenly throughout the structure.
* **Prestressed Concrete** - Prestressed concrete, on the other hand, is lighter than reinforced concrete and is ideal for structures requiring shock absorption. It's also preferred for heavily loaded structures due to its lighter weight.
* **Precast Concrete** - Precast concrete involves fabricating components off-site and assembling them using post-tension cables, often employing Ultra High-Performance Concrete (UHPC). This method allows for quick readiness for traffic after assembly.

### 5.2 Steel

**Suitable Grades:** In the case of steel bridge beams, ASTM A709 Grade 50W is commonly used. This grade offers high strength and enhanced atmospheric corrosion resistance, making it suitable for outdoor applications like bridges. The specific grade is necessary to meet the ASTM standard, ensuring the structural integrity and durability of the bridge components under varying environmental conditions.

**Unsuitable Grades:** Lower-grade steels with insufficient strength or corrosion resistance would be unsuitable for bridge construction, as they may compromise the safety and longevity of the structure. For example, using a mild steel grade instead of ASTM A709 Grade 50W could lead to premature deterioration and structural failure, particularly in corrosive environments.

**Toughness at Low Temperature**

Toughness at low temperatures is crucial for materials like steel, as low temperatures can reduce their ability to absorb energy when subjected to shock. This reduction in toughness increases the risk of brittle fractures. To address this, standards such as CAN/CSA G40.21 and ASTM A709 impose minimum toughness requirements, often measured through Charpy tests.

In CAN/CSA G40.21, Charpy tests are categorized into five levels based on test temperatures, ranging from Category 1 at 0°C to Category 4 at -45°C. Category 5 allows for specified testing temperatures based on special requirements. Steel meeting toughness requirements at low temperatures is designated with a "T" suffix, indicating its notch toughness category.

In the US, ASTM A709 uses different classification zones instead of categories. Steel with required toughness at low temperatures is denoted with "F" for Fracture-Critical or "T" for Non-Fracture-Critical, with similar testing temperatures but higher minimum energy requirements for Fracture-Critical steel.

### 5.3 Plywood

**Suitable Grades:** For structural applications requiring plywood, grades such as Canadian Plywood Standard (CPS) plywood rated for construction or structural purposes (e.g., C-D Exposure 1) are suitable. These grades are necessary to meet the standards set by organizations like the Canadian Wood Council (CWC) for structural performance and durability. For example, plywood panels graded for sheathing (e.g., APA Rated Sheathing) meet specific standards for strength and stiffness required in wall and roof sheathing applications.

There are a few plywood types and grades available, each offering different qualities suitable for various tasks.

**Types of Plywood**

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| Structural Plywood | * Designed for framing and construction purposes. * Manufactured with robust and waterproof glues. * Suitable for subfloors, internal constructions, and roof bracing. |
| Exterior Plywood | * Resistant to moisture and weather elements. * Designed for outdoor use. * Suitable for applications exposed to the elements, such as underpass structures. |
| Marine Plywood | * Resistant to delamination and fungal attacks. * Highly durable and moisture resistant. * Ideal for applications requiring longevity and resilience in challenging environments. |

**Grades of Plywood**

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| A-grade | This is the highest-quality plywood, featuring excellent veneers that result in a smooth surface. A-grade plywood is ideal for projects where appearance is crucial, as it can be easily painted and finished to a high standard. |
| B-grade | B-grade plywood offers a firm foundation and is slightly less smooth than A-grade plywood. While it may have minor defects, they can typically be repaired, making it a cost-effective option for projects that prioritize functionality over appearance. |
| C-grade | C-grade plywood may contain a few 1.5-inch-diameter knots in the sheets. It is suitable for projects where aesthetics is less critical, such as construction or utility applications. |
| D-grade | D-grade plywood is the most affordable option and may feature slightly larger defects compared to other grades. Knots in D-grade plywood can be up to 2.5 inches across, making it suitable for projects where appearance is not a primary concern, such as temporary structures or rough construction work. |

**Unsuitable Grades:** Non-structural plywood grades, such as those intended for interior use or decorative purposes (e.g., A-C Interior), would not be suitable for structural applications where strength and durability are paramount. Using these lower-grade plywood panels could compromise the structural integrity of the building and lead to safety hazards.

Selecting the appropriate grades of materials is essential to ensure compliance with standards and specifications, as well as to guarantee the structural integrity and durability of the constructed elements. Unsuitable grades may fail to meet regulatory requirements and compromise the safety and longevity of the structure. Therefore, careful consideration of material grades is necessary during the design and construction phases of any project.

## Customer Requirements

Here's an elaboration on customer requirements for the three types of materials and supplies (Concrete, Steel, and LED lighting fixtures), along with the importance of meeting standards, specifications, and grades to fulfill these requirements.

|  |  |  |
| --- | --- | --- |
| **Material** | **Customer Requirements** | **Importance of Standards, Specifications, and Grades** |
| Concrete | **Strength and Durability:** Customers often require concrete with specified compressive strength and durability characteristics to ensure that structures can withstand intended loads and environmental conditions over time.  **Workability:** Depending on the construction method and complexity of the project, customers may have requirements for concrete that is easy to place, compact, and finish to achieve desired shapes and surface textures.  **Curing Time:** Customers may require concrete that sets and gains strength within a specified timeframe to facilitate construction schedules and minimize project timelines.  **Appearance:** In architectural applications, customers may have aesthetic preferences for concrete with uniform color, texture, and surface finish to achieve desired visual effects. | **Standards:** Compliance with industry standards such as ASTM C94 for ready-mixed concrete or ASTM C150 for Portland cement ensures that the material meets minimum performance requirements for strength, durability, and workability.  **Specifications:** Following detailed specifications for concrete mix design, including proportions of cement, aggregates, water, and admixtures, is crucial to meet customer requirements for strength, durability, and workability while accommodating project-specific conditions and constraints.  **Grades:** Selecting the appropriate concrete grade, such as normal weight, lightweight, or high-strength concrete, is essential to meet customer requirements for specified compressive strength and performance characteristics based on structural design criteria and project requirements. |
| Steel | **Strength and Structural Integrity:** Customers often require steel with specified mechanical properties, such as yield strength and tensile strength, to ensure the structural integrity and safety of buildings, bridges, and other infrastructure.  **Corrosion Resistance:** In outdoor applications or harsh environments, customers may prioritize steel with corrosion-resistant coatings or alloy compositions to minimize corrosion and extend service life.  **Dimensional Accuracy:** Customers may have requirements for steel components with precise dimensions and tolerances to facilitate fabrication, assembly, and fit-up during construction.  **Compliance with Building Codes:** Customers often require steel materials that meet or exceed building code requirements and industry standards to ensure regulatory compliance and obtain necessary approvals. | **Standards:** Adherence to standards such as ASTM A36/A36M for structural steel or ASTM A123/A123M for hot-dip galvanizing ensures that the material possesses the required mechanical properties, dimensional tolerances, and coating thicknesses specified by industry standards and building codes.  **Specifications:** Following detailed specifications for steel fabrication, welding procedures, and quality control measures is essential to meet customer requirements for structural integrity, dimensional accuracy, and corrosion resistance while ensuring compliance with project specifications and design requirements.  **Grades:** Selecting the appropriate grade of steel, such as ASTM A992 for structural shapes or ASTM A572 for high-strength low-alloy (HSLA) steel, is crucial to meet customer requirements for specified mechanical properties, including yield strength, tensile strength, and ductility, based on structural design criteria and project specifications. |
| LED Lighting Fixtures | **Energy Efficiency:** Customers often prioritize LED lighting fixtures with high efficacy and low power consumption to reduce energy costs and environmental impact while meeting sustainability goals.  **Light Quality:** Customers may have requirements for LED fixtures with specific color rendering index (CRI), correlated color temperature (CCT), and light distribution characteristics to meet the functional and aesthetic lighting needs of interior and exterior spaces.  **Longevity and Reliability:** Customers typically require LED lighting fixtures with long lifespans and high reliability to minimize maintenance and replacement costs over time and ensure uninterrupted operation in commercial, industrial, and institutional applications.  **Compatibility and Controls:** Depending on project requirements, customers may specify LED fixtures that are compatible with advanced lighting controls, such as dimming systems, daylight harvesting, and occupancy sensors, to optimize energy savings and enhance lighting flexibility and convenience. | **Standards:** Choosing LED lighting fixtures that comply with industry standards such as ENERGY STAR, DLC (Design Lights Consortium), or IES (Illuminating Engineering Society) recommendations ensures that the products meet established criteria for energy efficiency, performance, and reliability, providing assurance to customers regarding product quality and performance.  **Specifications:** Following detailed specifications for LED fixtures, including wattage, lumen output, beam angle, and color characteristics, is essential to meet customer requirements for light quality, brightness, and functionality while ensuring compatibility with lighting controls and integration into lighting design schemes.  **Grades:** While LED lighting fixtures may not have traditional grades like concrete or steel, selecting products from reputable manufacturers known for producing high-quality, reliable fixtures is crucial to meet customer expectations for longevity, performance, and reliability, providing confidence in the durability and performance of the installed lighting system. |

## Conclusion

In conclusion, the report has highlighted the importance of meeting customer requirements through adherence to standards, specifications, and grades for selected materials and supplies in Adelaide Underpass Project. Specifically, the significance of concrete, steel, and LED lighting fixtures has been discussed, along with their respective customer requirements and the extent to which meeting standards, specifications, and grades is essential.

Concrete plays a vital role in providing strength, durability, and workability to structures, with customer requirements focusing on these aspects along with appearance. Steel is critical for structural integrity and corrosion resistance, with dimensional accuracy and compliance with building codes being key customer requirements. LED lighting fixtures are valued for their energy efficiency, light quality, longevity, and compatibility with advanced controls, meeting customer needs for efficient and reliable lighting solutions.

Future research should focus on exploring advancements in materials technology, construction methods, and sustainable practices to address evolving customer demands and regulatory requirements. This research can be conducted by interdisciplinary teams comprising engineers, architects, materials scientists, and sustainability experts. Adequate resources, including funding for research projects, access to testing facilities, and collaboration opportunities with industry partners, will be necessary to undertake comprehensive studies and develop innovative solutions.

**Agenda for Future Research:**

1. Investigation of alternative materials and construction techniques to enhance sustainability and resilience in building design and construction.
2. Development of performance-based standards and specifications for emerging materials and technologies to ensure safe and efficient implementation in construction projects.
3. Exploration of digitalization and Building Information Modeling (BIM) technologies to streamline the design, procurement, and construction processes while improving project outcomes and reducing environmental impacts.
4. Assessment of life cycle analysis (LCA) methodologies to evaluate the environmental footprint of construction materials and identify opportunities for optimization and eco-friendly alternatives.
5. Collaboration with industry stakeholders, regulatory bodies, and academia to establish industry best practices, foster knowledge exchange, and drive innovation in the construction sector.

Overall, continued research and innovation efforts are essential to address evolving challenges and opportunities in the construction industry, enabling the development of sustainable, resilient, and high-performance built environments that meet the needs of present and future generations.

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