ISSN 2522-3488 Vol. 7, Issue 6: 60-65, DOI: 10.25236/IJNDES.2023.070610

An Investigation of the Application of New Concrete Materials in the Field of Civil Engineering

Zhao Yue[1,2], Aiman Al-odaini[1,*]

[1]*Faculty of Engineering, Lincoln University College, Petaling Jaya, Selangor Darul Ehsan, Malaysia*
[2]*China Steel Tendering Co., Ltd, 8 Haidian Street, Haidian District, Beijing, 100080, China*
** Corresponding author*

Abstract: *A variety of new types of construction technology, construction materials, and construction equipment continue to emerge, with concrete serving as the primary structure of the main body of the civil engineering project. As a result of the new situation of economic development in the new era, the number of civil engineering-related projects is increasing, on the one hand to meet the needs of people's lives, on the other hand, it also led to the development of the construction industry. Its quality is closely related to the building's overall quality. New concrete differs from traditional concrete in a number of ways, including strength, durability, and other factors. Because new concrete materials outperform traditional concrete materials on all counts, its physical characteristics, uses, and service life have all demonstrated significant benefits. This led this article to concentrate on investigating the utilization of novel concrete materials in the field of civil engineering.*

Keywords: *new concrete materials; civil engineering field; application investigation*

1. Introduction

With the advancement of technology and the ongoing urbanization process, the construction industry has experienced unprecedented growth opportunities. Concrete structures, which are the primary structural form of civil engineering, offer benefits like low construction costs, durability, and speedy construction, among others. With the rapid development of the industry, a variety of new concrete materials continue to emerge, and the scope of its application has become more and more extensive, providing the construction side of the Convenience. New concrete materials play an important role in promoting the stable development of the construction industry.

2. Overview of concrete materials

Concrete is a material mixed with cement, fine-grained aggregate, coarse-grained aggregate and an appropriate amount of water. It is widely used in modern construction and infrastructure. In concrete, cement acts as a binder. Cement reacts with water to form hydration products that make concrete strong and durable. There are various types of cement such as silicate cement, sulfur-aluminate cement and blast furnace slag cement. Fine-grained aggregate is the granular material in concrete and sand is usually used as fine-grained aggregate. Sand has a strong particle structure and proper particle size to provide strength and stability to concrete. Concrete has many advantages, such as high strength, durability, fire resistance, and thermal insulation, so it is widely used in building structures, roads, bridges, and water conservancy projects. In addition, concrete can be changed by additives, such as adding plasticizers to improve the plasticity of concrete, adding water reducers to reduce the amount of cement and improve the strength of concrete, and adding pigments to change the color of concrete[1].

New concrete refers to the concrete improved with new materials, new techniques or new technologies. It has advantages that traditional concrete does not have and can meet special technical requirements and engineering needs. Compared with traditional concrete, new concrete has stronger performance. New concrete has higher strength and better durability, and can withstand greater loads and harsher environmental conditions. This is achieved by optimizing the material ratios, additives, and improving the construction process. New types of concrete such as self-compacting concrete have automatic flow properties and fill the formwork without additional vibration and compaction. This greatly improves construction efficiency and quality and reduces the need for labor and equipment. Some new types of concrete, such as fiber concrete, where the addition of fiber materials to the concrete can

ISSN 2522-3488 Vol. 7, Issue 6: 60-65, DOI: 10.25236/IJNDES.2023.070610

significantly improve the crack resistance and toughness of the concrete and reduce the generation and extension of cracks[2].

3. The value of new concrete application in civil engineering

3.1 Improvement of structural performance

New concrete has higher strength and durability and can withstand greater loads and harsher environmental conditions. This enables the design of thinner and finer structures in buildings, bridges, tunnels and other projects, reducing the amount of material and lightening the structural load.

3.2 Improvement of construction efficiency

The new concrete can have automatic fluidity and self-compacting properties, and can be fully filled in the formwork, reducing the need for vibration and compaction processes. This greatly improves construction efficiency and quality, shortens the construction period and reduces the need for manpower and equipment[3].

3.3 Reduction in durability and maintenance costs

The new concrete has better durability and is able to resist external erosion and damage, extending the service life of the structure. This reduces the need for maintenance and repair, lowering maintenance costs and environmental impact.

3.4 Realization of special functions

New concrete can be added with specific additives and controlled material ratios according to engineering needs to realize concrete with special functions. For example, anti-cracking fibre concrete, self-healing concrete, alkali resistant aggregate concrete, etc. can meet special engineering needs and technical requirements.

3.5 Environment-friendly and sustainable development

Some new types of concrete can utilise industrial by-products or waste, reducing the use of natural resources and environmental pollution. At the same time, the durability of new concrete and the reduction of maintenance costs also help to reduce resource waste and energy consumption[4].

4. Analysis of the practical application of new concrete in civil engineering

4.1 High-Performance Concrete

High-Performance Concrete (HPC) has a wide range of applications in civil engineering, some of the main applications are as follows:

High-rise buildings: in high-rise buildings, HPC can be used to support the high strength and thinner members required for most structures. This increases the space utilisation of the building and reduces the structural weight. In addition, HPC can improve the seismic performance of floor slabs and beams, making the building safer[5].

Bridges: bridges are one of the civil engineering projects that require high strength and durability of concrete. The use of HPC can provide higher seismic performance and durability, enabling bridges to withstand greater loads and harsher environmental conditions.

Tunnels and Underground Structures: In underground structures and tunnels, HPC provides better resistance to infiltration and chemical attack, reducing groundwater infiltration and chemical attack. This helps to extend the service life of the structure and ensure its safety[6].

Motorways and airports: In transport facilities such as roads and aprons of motorways and airports, HPC provides better impact and abrasion resistance, ensuring smoothness and durability of the pavement. The use of HPC also reduces the maintenance and rehabilitation of pavements and lowers the cost of use.

4.2 Self-Compacting Concrete

Self-Compacting Concrete (SCC) is a kind of concrete with auto-flowability and self-filling properties, which has a wide range of applications in civil engineering, including the following aspects:

Building structures: SCC is widely used in building structures, especially for those parts with complex geometries, dense reinforcement and narrow apertures, such as concrete walls, columns, beams[7],SCC can automatically fill the formwork to maintain consistency, and it can smoothly encase and fill the reinforcement to improve the overall quality and strength of the structure.

Tunnelling: In tunnelling, SCC is able to completely fill and wrap the filling body and pre-built equipment to ensure that the interior of the tunnel is dense and free of voids. This helps to improve the overall strength, durability and waterproofing of the tunnel. In addition, SCC reduces the need for vibration and manpower during the construction process and improves construction efficiency.

Bridge Construction: The application of SCC in bridge construction includes pier, girder section and bridge deck. As SCC has automatic mobility, it can automatically fill all parts of the formwork, completely wrap and fill the steel reinforcement, and improve the seismic performance and durability of the structure. In addition, SCC can be applied to grouting reinforcement in anchor anchorage areas to improve anchorage effect and structural stability.

4.3 Fibre Reinforced Concrete

Fiber Reinforced Concrete (FRC) is a kind of concrete material, by adding fibre materials (e.g. steel fibres, glass fibres, polypropylene fibres, etc.) to the concrete to increase its toughness and crack resistance. In civil engineering, fibre concrete has a wide range of applications, including the following:

Underground structures and foundation reinforcement: fibre concrete can provide better crack resistance and durability properties in underground structures (e.g. underground car parks, underground pipelines, underground facilities). The addition of fibres reduces shrinkage and cracking in concrete, as well as improving the bond between concrete and soil, increasing the stability and load-bearing capacity of foundations.

Bridges and tunnels: In bridge and tunnel construction, fibre concrete provides high seismic and impact resistance. The addition of fibres gives the concrete better flexural resistance and toughness to better withstand deformation and impact loads under external loading such as earthquakes.

Ground and pavement works: Fibre concrete provides better durability and abrasion resistance in ground and pavement works (e.g. airport runways, roads, car parks). The addition of fibres increases the impact resistance of the concrete, reduces cracking and improves the smoothness and durability of the pavement.

4.4 Alkali Resistant Aggregate Concrete

Alkali Resistant Concrete (ARC) is a type of concrete that resists alkaline attack and is mainly used in those civil engineering works that are subjected to high alkaline environments[8]. Alkali Resistant Aggregate Concrete has several major applications in civil engineering:

Tanks and Pipelines: in vessel structures such as tanks and pipelines, alkali resistant aggregate concrete prevents penetration and corrosion by alkaline liquids or gases. This helps to protect the integrity of the tanks and pipelines and avoids safety hazards such as oil spills or leaks.

Resistant to oil-contaminated areas: In some oil-contaminated areas, ARC is able to resist the erosion of concrete by alkaline oil-contaminated substances. This has led to the widespread use of alkali resistant aggregate concrete in projects related to oil processing plants, oil fields and petroleum storage tanks.

4.5 Self-Healing Concrete

Self-Healing Concrete (SHC) is a concrete material that can repair cracks and damages on its own and has the following applications in civil engineering:

Construction and infrastructure: Self-Healing Concrete can be widely used in buildings, bridges, tunnels, underground structures and other infrastructure. It can automatically repair cracks, reduce maintenance and repair costs, and improve the durability and service life of structures.

ISSN 2522-3488 Vol. 7, Issue 6: 60-65, DOI: 10.25236/IJNDES.2023.070610

Hydraulic engineering: In hydraulic engineering, self-healing concrete can be applied to berms, dams, canals, reservoirs and so on. It can self-heal damaged areas, reduce seepage and leakage, and improve the safety and stability of the project.

Roads and airports: in pavement works for roads and airports, self-healing concrete can be used to reduce crack development and water infiltration, improve pavement smoothness and durability, and reduce maintenance and rehabilitation work[9].

4.6 Glass Concrete

Glass Fiber Reinforced Concrete (GFRC) is a composite material with glass fibres added to concrete. It has the characteristics of light weight, high strength, crack resistance, impact resistance and durability, and has a wide range of applications in civil engineering, including the following aspects:

Architectural decoration: GFRC can be used for various architectural decorations and facades, such as columns, cornices, sculptures and curtain walls. It has a very high degree of modelling freedom and can produce a variety of complex shapes and textures, which can meet the creative needs of architects and designers.

Building facades: GFRC can be used for the decoration and protection of building facades. Due to the addition of glass fibre, GFRC has high crack resistance and weather resistance, which can effectively prevent cracking and cracking of concrete, prolong the service life of the facade and improve the overall aesthetics of the building.

Roads and bridges: GFRC can be applied to guardrails, street light poles and other parts of roads and bridges. It has good impact resistance and durability, can withstand the challenges of road traffic and environment, and reduce the cost of maintenance and replacement.

4.7 Low Strength Concrete

Low Strength Concrete (LSC) is concrete with a relatively low compressive strength, usually between 10 and 20 megapascals (MPa). Despite its low compressive strength, low strength concrete has a number of applications in civil engineering:

Filling and insulation: low strength concrete is often used as a filling material, e.g. as insulation in walls or to fill voids. Due to its relatively low strength, it is easy to construct and work with and can provide some thermal insulation[10].

Non-structural components: low-strength concrete can be used as an economical and durable material for non-structural components that are not subjected to large loads, such as parapets, landscape beds, and wall panels. In these applications, the strength requirements are relatively low, but the use of low strength concrete can still meet the needs.

Ground and road works: In some ground and road works where low traffic loads are required and strength requirements are not high, low strength concrete can be used as a material for pavements or site foundations. For example, as a foundation layer for road facilities such as footpaths, cycle paths and car parks.

4.8 Roller Concrete

Roller-Compacted Concrete (RCC) is a material in which the raw concrete material is moulded and hardened on site by roller pressing. It has the following applications in civil engineering:

Dams and embankments: Due to its high densification and impermeability properties, Roller-Compacted Concrete is widely used in the construction of dams, embankments and flood control levees. Crushed concrete provides a high-strength structural body, reduces the risk of seepage and enhances the safety and stability of dams[11].

Non-motorised paths and car parks: crushed concrete is suitable for non-motorised paths, car parks and goods yards and other areas that are subject to heavy loads. It has a smooth and even surface that can withstand the operation of motorised and heavy vehicles and has good abrasion resistance and durability.

Industrial sites and storage areas: Crushed concrete can be used for hardened pavements, loading and unloading areas and storage platforms in industrial sites and storage areas. It can withstand the transport and stacking of heavy equipment and materials, reduce potholes and wear on the road surface, and improve the service life and smoothness of the site.

Highways and roads: Crushed concrete can be used as an alternative material for road surfacing with high durability and load-bearing capacity.

Temporary roads and waterways: Crushed concrete is suitable for the construction of temporary roads and waterways and can be quickly constructed and removed.

4.9 Coloured concrete

Coloured concrete is a concrete with a specific colour achieved by adding pigments to the concrete or by surface treatment. It has the following applications in civil engineering:

Pavements and landscaping: coloured concrete is commonly used in pavements, walkways and landscaping, where a rich variety of colours and textural effects can be created by concrete pigments. This adds a unique artistic and aesthetic touch to the urban landscape.

Road marking: Coloured concrete can be used for traffic marking facilities such as road marking lines and carriageway dividers. By adding pigments to the concrete or using colour delineation techniques, it is possible to provide clearly visible road markings that enhance traffic safety.

Car parks and garages: coloured concrete can be used for marking and signage in car parks and garages. By using different coloured concrete, different parking areas, lanes or arrows can be delineated to provide easy navigation and parking guidance.

Building facades: Coloured concrete can be used to decorate and personalise building facades. By using dyes or stains on the concrete surface, various colours and texture effects can be achieved, highlighting the uniqueness and taste of the building.

4.10 Lightweight Concrete

Lightweight Concrete (LCC) is a relatively low density concrete, usually achieved by adding lightweight aggregates or foaming agents to the concrete. It has the following applications in civil engineering:

Building insulation: The low thermal conductivity of Lightweight Concrete makes it an excellent insulating material, particularly suitable for the construction of thermal insulation and insulated walls. It reduces energy transfer, lowers the energy consumption of buildings and provides a more comfortable indoor environment[12].

Structural weight reduction: due to the low density of lightweight concrete, it reduces the deadweight burden of the structure and reduces the loads on the building. This is particularly useful for projects that require consideration of foundation capacity, seismic performance, and construction efficiency.

Ground Fill and Road Base: Lightweight concrete can be used to fill voids, fill low ground surfaces or as a road base material. It has a low density and good compressive strength, providing stable support and drainage.

Acoustic engineering: Lightweight concrete has good acoustic properties and can be used as sound insulation and sound absorption materials for walls, partitions and suspended ceilings in buildings to provide a comfortable indoor environment for professionals.

5. Conclusion

In summary, the current civil engineering construction scale is expanding, the number is increasing, the demand for construction materials is larger, and concrete is the most commonly used material in engineering construction. The quality of the project body composed of concrete has a direct relationship with the quality of concrete materials, from which the importance of concrete materials can also be seen. With the development of the construction industry and modern technology, there are constantly new types of concrete appearing in the construction field, which not only improves the overall quality of the building, but also reduces the construction cost to a certain extent and promotes the development of the construction industry.

ISSN 2522-3488 Vol. 7, Issue 6: 60-65, DOI: 10.25236/IJNDES.2023.070610

References

[1] Han Xiaofan(2022). Application and practice of new concrete materials in the field of civil engineering[J]. Paper Equipment and Materials,51(09):pp.67-69.
[2] Zhao Cunlian(2022). Exploration of the use of new concrete materials in civil engineering[J]. Science and technology innovation and application,12(13):pp.91-94.
[3] Gao Yali(2022). The application of new concrete materials in the field of civil engineering[J]. Construction and Budget,(01):pp.7-9.
[4] Li Sha, Li Yang(2021). Application of new concrete materials in civil engineering[J]. Construction Technology Development,48(17):pp.97-98.
[5] Liang Chaodeng(2021). Research on the application of new concrete materials in civil engineering[J]. Paper Equipment and Materials,50(08):pp.153-154.
[6] Sun Peihua,Yang Liping(2020). An analysis of the use of new concrete materials in civil engineering[J]. Residence,(24):pp.23-24+37.
[7] Zhang Yaoyao(2020). Application of new concrete materials in civil engineering[J]. Henan building materials, (05):pp.101-102.
[8] Wang Xiwei,Zhang Zhiwei,Liu Hong(2020). Analysis of common problems of concrete technology in civil engineering[J]. Journal of Harbin Institute of Vocational Technology,(02):pp.128-130.
[9] Ye Xiao,Gao Fei(2020). Application of new concrete materials in civil engineering[J]. Henan building materials,(02):pp.95.
[10] Guo Huan(2020). Application of new concrete materials in the field of civil engineering[J]. Sichuan cement,(01):p.38.
[11] Li Yong(2019). Application of new concrete materials in the field of civil engineering[J]. Low carbon world,9(06):pp.160-161.
[12] Xu Chunya(2019). Research on new civil engineering materials[J]. Low carbon world, 9(01):pp.183-184.