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Analysis of the Compatibility Between Traditional and Modern Materials in Concrete Structures

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Abstract

A documentary review was carried out on the production and publication of research papers related to the study of the variables of Traditional Materials, Modern Materials, and Concrete Structures. The purpose of the bibliometric analysis proposed in this paper was to know the main characteristics of the volume of publications registered in the Scopus database during the period 2017-2022 achieving the identification of 83 publications. The information provided by the said platform was organized using tables and figures categorizing the information by Year of Publication, Country of Origin, Area of Knowledge, and Type of Publication. Once these characteristics had been described, a qualitative analysis was used to refer to the position of different authors on the proposed topic. Among the main findings of this research, it is found that Russia, with 14 publications, was the country with the highest scientific production registered in the name of authors affiliated with institutions of that country. The Area of Knowledge that made the greatest contribution to the construction of bibliographic material referring to the study of Traditional Materials, Modern Materials, and Concrete Structures was Engineering with 45 published documents, and the most used type of publication during the above-mentioned period was Journal Articles with 46% of the total scientific production.

Keywords: *Traditional Materials, Modern Materials, Concrete Structures, Concrete Structures.*

1. Introduction

The concrete structure, which has been a fundamental piece in modern construction processes, has changed over time, the elaboration of this concrete structure has changed in a rudimentary way from traditional materials and has gone through improvement

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processes under the composition of high engineering, which has served as a cornerstone in contemporary construction. The search for durable, sustainable, and high-performance concrete structures has led to a dynamic interaction between traditional and modern materials. These cooperations represent a new construction approach that seeks to connect traditional empirical knowledge and the cutting-edge high technology brought about by the present revolutionary era of globalization.

Historically, traditional materials such as lime, clay, and pozzolanic admixtures formed the basis of early concrete formulations. The Pantheon in Rome, a marvel of ancient engineering, is a testament to the enduring strength and durability of these early concretes. However, as the demands of construction became more complex and varied, the need for materials with improved properties became apparent. This prompted the advent of modern materials such as Portland cement, chemical admixtures, and supplementary cementitious materials.

Based on several investigations, the compatibility of traditional and modern materials in concrete structures is a topic of interest in the development of contemporary architecture. Based on various research, the compatibility of traditional and modern materials in concrete structures is a topic of interest for the development of contemporary architecture.

An important aspect of this compatibility lies in the potential to leverage the strengths of traditional materials to mitigate the environmental impact of concrete structures. Traditional pozzolanic materials are a clear example of this is evident when looking at how complementary binders interact, reducing reliance on Portland cement, which is a major contributor to carbon emissions in the construction industry. This intersection of ancient wisdom and contemporary environmental awareness underscores the importance of integrating traditional and modern materials to achieve concrete sustainable solutions.

Furthermore, the compatibility between these materials extends beyond the environmental realm to encompass structural performance. The incorporation of fibrous materials, such as natural fibers and steel reinforcement, into concrete mixes is a good example. Traditional reinforcement methods, such as the use of bamboo in certain cultures, offer insights into alternative approaches that can be harmoniously integrated with modern steel reinforcement to improve the structural integrity of concrete elements. For this reason, this article seeks to describe the main characteristics of the compendium of publications indexed in the Scopus database related to the variables Traditional Materials, Modern Materials, and Concrete Structures, as follows. As the description of the position of certain authors affiliated with institutions, during the period between the years 2017 and 2022.

2. General Objective

To analyze from a bibliometric and bibliographic perspective, the elaboration and publication of research papers in high-impact journals indexed in the Scopus database on the variables Traditional Materials, Modern Materials, and Concrete Structures, during the period 2017-2022.

3. Method

This article is based on a mixed research approach combining quantitative and qualitative methods.

On the one hand, a quantitative analysis of the information selected in Scopus is carried out under a bibliometric approach to the scientific production corresponding to the study of Traditional Materials, Modern Materials, and Concrete Structures.

On the other hand, examples of some research papers published in the area of study mentioned above are analyzed from a qualitative perspective, based on a bibliographic approach that allows describing the position of different authors on the proposed topic. It is important to point out that the entire search was carried out through Scopus, establishing the parameters referenced in Figure 1.

3.1. Methodological design

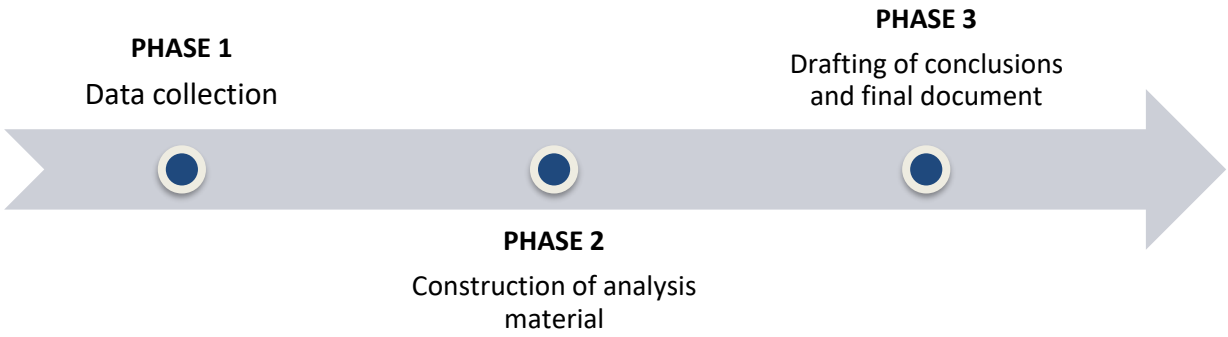

Figure 1. Methodological design

Source: Own elaboration

3.1.1 Phase 1: Data collection

The data collection was carried out using the Scopus web page search tool, where 83 publications were obtained by choosing the following filters:

TITLE-ABS-KEY (traditional AND materials, AND modern AND materials, AND concrete AND structures) AND PUBYEAR > 2016 AND PUBYEAR < 2023

- Published papers whose study variables are related to the study of Traditional Materials, Modern Materials, and Concrete Structures.
- Limited to the years 2017-2022.
- Without distinction of country of origin.
- Without distinction of the area of knowledge.
- No distinction of type of publication.

3.1.2 Phase 2: Construction of analysis material

The information collected in Scopus during the previous phase is organized and subsequently classified using graphs, figures, and tables as follows:

- Cooccurrence of words.
- Year of publication.
- Country of origin of publication.
- Area of knowledge.
- Type of publication.

3.1.3 Phase 3: Drafting of conclusions and final document.

This phase is followed by the analysis of the results previously obtained, resulting in the drawing of conclusions and, consequently, the final document.

4. Results

4.1 Co-occurrence of words

Figure 2 shows the Co-occurrence of keywords found in the publications identified in the Scopus database.

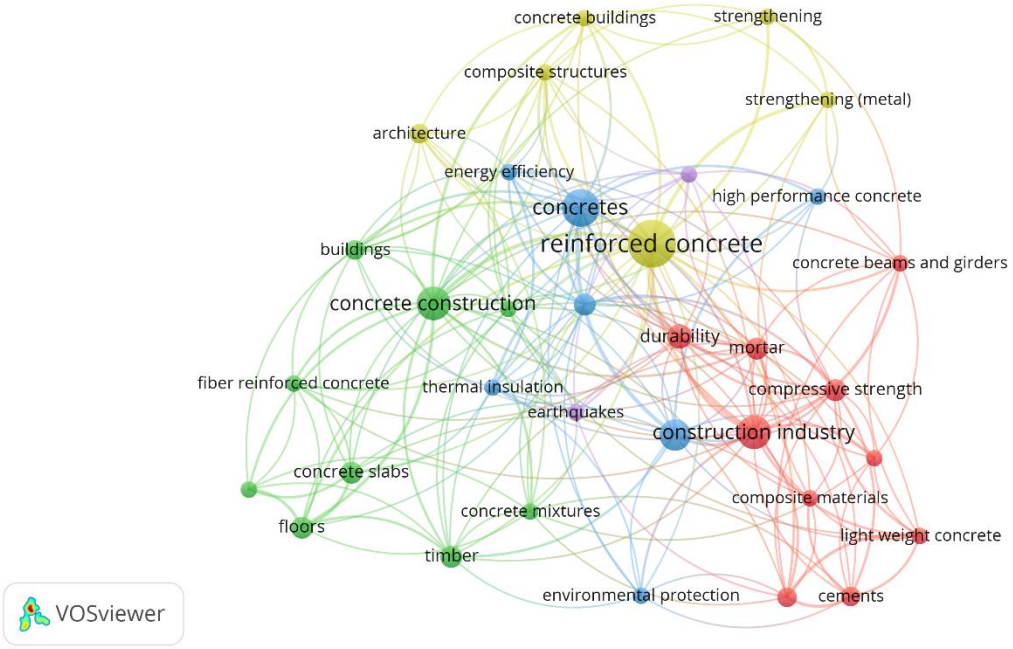

Figure 2. Co-occurrence of words

Source: Own elaboration (2023); based on data exported from Scopus.

Reinforced concrete was the most frequently used keyword in the studies identified through the execution of Phase 1 of the Methodological Design proposed for the development of this article. The construction Industry is among the most frequently used variables, associated with variables such as Concrete, Material Composition, Cement, Durability, Structural Composition, and Architecture. This exploration of the interaction of traditional and modern materials in concrete structures is not simply a theoretical pursuit; it has practical implications for the construction industry. Striking the right balance between tradition and innovation can lead to the development of concrete formulations that not only meet the demands of contemporary construction but also adhere to the principles of sustainability, resilience, and cultural sensitivity. In this comprehensive journey through the compatibility of traditional and modern materials in concrete structures, we will delve into specific case studies, technological advances, and sustainable practices that show the potential for a harmonious coexistence of old and new. From ancient architectural marvels to the latest innovations in concrete science, this exploration aims to unravel the intricate tapestry that unites tradition and modernity in the field of concrete construction.

4.2 Distribution of scientific production by year of publication

Figure 3 shows the distribution of scientific production by year of publication.

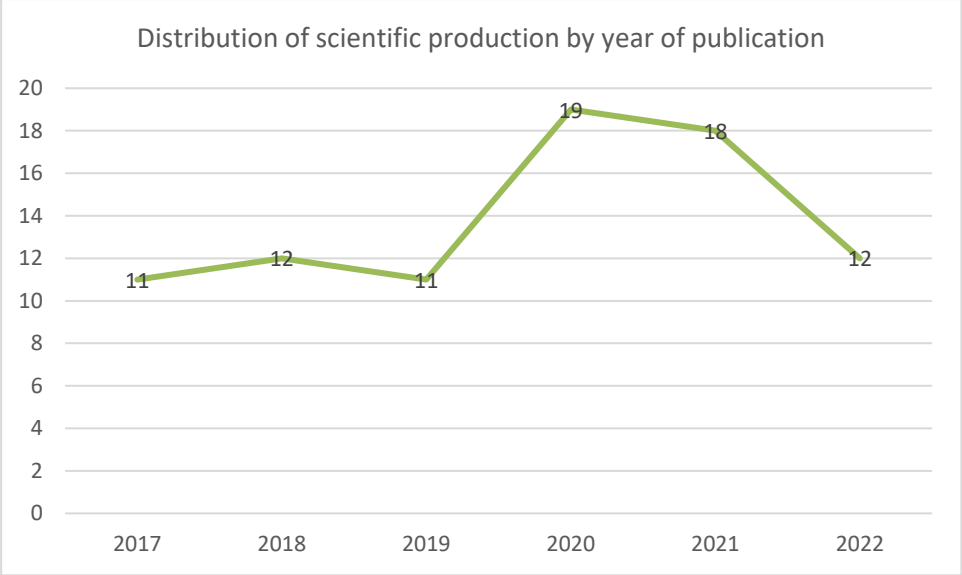

Figure 3. Distribution of scientific production by year of publication.

Source: Own elaboration (2023); based on data exported from Scopus,

Among the main characteristics evidenced by the distribution of scientific production by year of publication, the number of publications registered in Scopus was in 2020, reaching a total of 19 papers published in journals indexed in this platform. The above can be explained by articles such as the one entitled "Observations of the March 2021 Thessaly Earthquakes: an earthquake engineering perspective for masonry structures" (Sarhosis V, 2022). This article focuses on the earthquake swarm itself, as well as on the damage observed in residential buildings, schools, and churches in the region affected by the earthquake. The earthquakes affected mainly low-rise domestic masonry buildings, while more modern reinforced concrete structures built following recent seismic regulations were almost unaffected. The typology of buildings in the region is presented here, together with photographs showing the extent of damage. Despite the fairly satisfactory performance of modern buildings during the recent earthquakes in Greece, preliminary investigations of the Thessaly earthquakes showed that there is still a significant level of vulnerability in existing masonry buildings constructed with traditional methods and materials. This problem could resurface in future earthquakes affecting other rural areas of Greece, something that will need to be systematically addressed in the future.

4.3 Distribution of scientific production by country of origin

Figure 4 shows the distribution of scientific production according to the nationality of the authors.

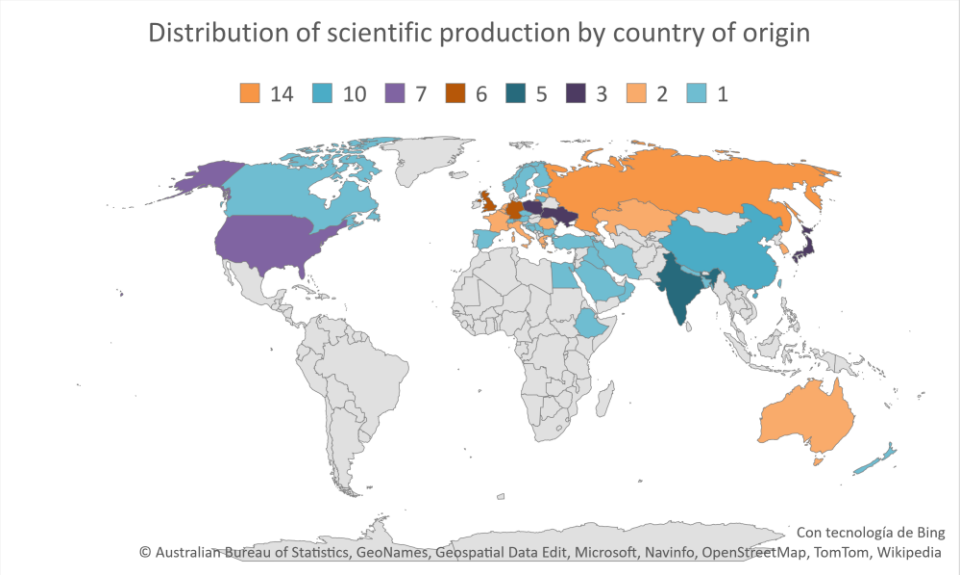

Figure 4. Distribution of scientific production by country of origin.

Source: Own elaboration (2023); based on data provided by Scopus.

Within the distribution of scientific production by country of origin, the records coming from institutions were taken into account, establishing Russia, as the country of that community, with the highest number of publications indexed in Scopus during the period 2017- 2022, with a total of 14 publications. In second place is China with 10 scientific papers, and the United States ranked third presenting to the scientific community, with a total of 7 papers among which is the article entitled "Modern trends in the architecture of railway stations and transportation hubs" (T.R, 2022). The article analyzes current trends in the construction of railroad stations and transportation hubs. The problems of large-scale public buildings, as well as railroad stations, were studied and their shortcomings in terms of technical equipment, architectural solutions, and passenger comfort were studied. In the course of the research, several methods were used to study and analyze the problems of interest: fixation of photographs and videos, thorough analysis of project materials and publications in professional literature and project practice, discussion of problems at professional conferences and round tables together with representatives of Russian Railways. It is determined that there is a need to replace traditional railway stations and complexes with transport interchange centers (TIH). Modern TIHs will make it possible to organize convenient distribution of traffic flow and at the same time meet the needs of passengers to use different modes of transport. This is determined by the increased mobility of the population, on the one hand, and the requirements of movement conditions on the other hand. It has been established that thanks to new design solutions, elements, and materials, the costs of structures can be reduced and large unsupported spaces can be provided within the building, which will allow the software to adapt freely to any premises and implement various planning solutions

4.4 Distribution of Scientific Production by Area of Knowledge

Figure 5 shows the distribution of scientific publications according to the area of knowledge through which the different research methodologies are implemented.

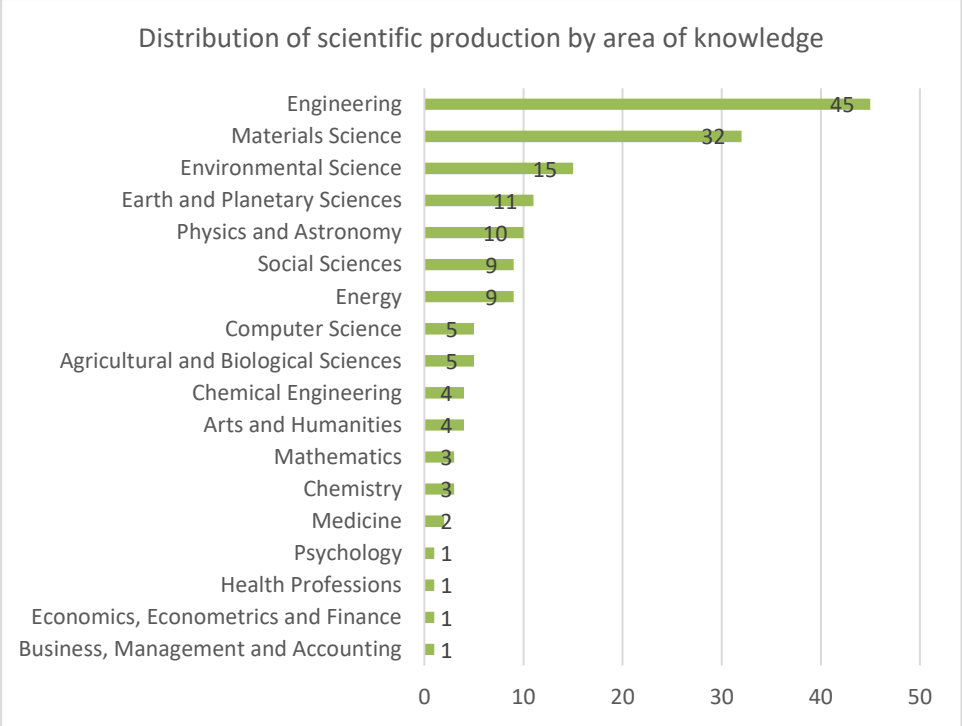

Figure 5. Distribution of scientific production by area of knowledge.

Source: Own elaboration (2023); based on data provided by Scopus.

Engineering was the area of knowledge with the highest number of publications registered in Scopus with a total of 45 documents that have based their methodologies on Traditional Materials, Modern Materials, and Concrete Structures. In second place is Material Sciences with 32 articles, and Environmental Sciences in third place with 14. The above can be explained thanks to the contribution and study of different branches, the article with the greatest impact was registered by Engineering entitled "Finite element analysis of the behavior and ultimate strength of a composite column" (Vijayan, 2022). The main objective of this study is to experimentally analyze the behavior of steel-encased concrete composite columns under axial compression and failure mode under ultimate failure and yield strength. The steel-concrete composite system combines the formability and stiffness of reinforced concrete with the ductility and strength of structural steel to meet the demand for seismic-resistant constructions. Three specimens were chosen for this study: one was a composite column, and the other two were ordinary RC columns and structural steel columns. The natural properties of the raw materials are evaluated. As a result, material tests were completed for cement, fine aggregate, and coarse aggregate, as well as a concrete mix design. A comparative analysis of the local and post-local buckling behavior of different composite sections was studied and the column sections were designed according to Eurocode 4 (ENV 1994) to determine the plastic strength of the section. These three specimens were subjected to compression tests and the results are tabulated and compared.

4.5 Type of publication

Figure 6 shows the distribution of the bibliographic findings according to the type of publication made by each of the authors found in Scopus.

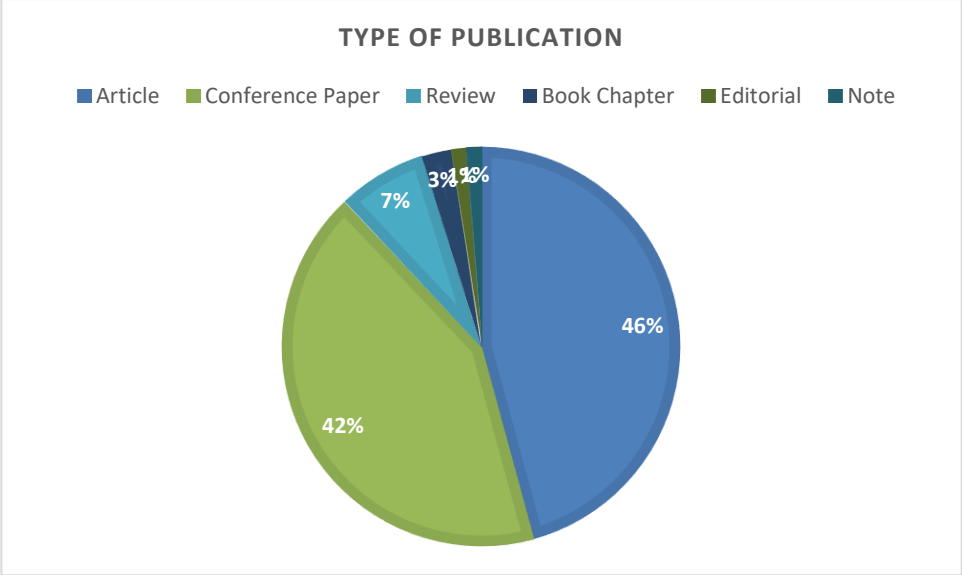

Figure 6. Type of publication.

Source: Own elaboration (2023); based on data provided by Scopus.

The type of publication most frequently used by the researchers referenced in the body of this document was the one entitled Journal Articles with 46% of the total production identified for analysis, followed by Session Papers with 42%. Journals are part of this classification, representing 7% of the research papers published during the period 2017-2022, in journals indexed in Scopus. In the latter category, the one entitled "Experimental study on the axial compression performance of a short concrete column made of high strength aluminum alloy circular tube 7A04" (Zhang, 2022) stands out. In this paper, the influence of tube thickness and concrete strength grade on the compressive strength, ductility, transverse deformation coefficient, and strength enhancement coefficient of strong concrete of a composite column is considered. The results show that the failure mode of composite short columns is by central uplift or shear failure. The thickness of the high-strength aluminum tube has a great influence on the strength of the specimens, and the ductility of the composite columns decreases with the decrease of the collar coefficient. The finite element model can reflect the development trend of the load-deformation curve, and the composite column load capacity formula proposed by the regression analysis can predict the strength of the 7A04 aluminum alloy tubular concrete short column. The research results have a certain reference significance for the structural design of high-strength aluminum concrete-filled columns.

5. Conclusions

Through the bibliometric analysis carried out in this research work, it was possible to establish that Russia was the country with the highest number of published records regarding the variables Traditional Materials, Modern Materials, and Concrete Structures, with a total of 14 publications in the Scopus database. Likewise, it was established that with the application of theories framed in the Engineering area, the compatibility between traditional and modern materials in concrete structures represents a harmonious combination that takes advantage of the strengths of both worlds. The incorporation of modern materials, such as supplementary cementitious materials like fly ash or slag, and advanced reinforcements like fiber-reinforced polymers, introduce innovative solutions to improve performance and address environmental concerns. The cooperation found between traditional and new modern materials in concrete structures is particularly found in the ability to improve the sustainability of this fundamental material in construction. By reducing reliance on resource-intensive Portland cement and incorporating recycled

materials, concrete becomes more environmentally friendly. The incorporation of these new modern materials is also expected to have a positive impact on the structure of concrete, improving its strength, durability, and resistance to various environmental factors. Compatibility also extends to the economic aspect, since the integration of modern materials can contribute to long-term profitability. For example, the use of SCM can mitigate the demand for primary raw materials while offering comparable or even superior performance. In addition, advances in reinforcement technologies, such as corrosion-resistant FRP, can extend the service life of concrete structures, reducing maintenance costs over time.

In the quest for successful compatibility between these two materials, both traditional and modern materials depend on unprecedented research, much more optimal design, and comprehensive compression for material improvement. Engineering practices must evolve to incorporate these advances, ensuring that the benefits of both traditional and modern materials are fully realized. Essentially, the compatibility between traditional and modern materials in concrete structures is not simply a juxtaposition of old and new, but rather a strategic integration that drives the construction industry toward a more sustainable, resilient, and economically viable future.

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