Written explanation and changes (ACC59173C)

Journal:	Advances in Concrete Construction
Title of Paper:	Thermal resistance of fiber-reinforced reactive powder concrete with marble powder waste
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Ms. Ref. No.:	ACC59173C

The authors are grateful for the editor decision and reviewers' comments. These comments have been seriously considered and thoroughly addressed in this reviewers' response. Accordingly, changes have been made in the revised manuscript and written in blue colour.

Comments from the Reviewer 1:

The purpose of this study is to investigate the thermal performance of fiber-reinforced powder concrete (FRPC) with added marble powder, specifically its spalling resistance and compressive strength under high-temperature conditions. Systematic experiments were conducted to evaluate the effects of steel fibers and polypropylene(PP) fibers at temperatures of 200°C, 300°C, and 400°C. By analyzing temperature-dependent spalling behavior, strength retention, and optimal fiber content, this study provides valuable insights into the different roles of steel fibers and PP fibers in improving the thermal durability of FRPC. The findings provide meaningful experimental evidence and practical guidance for fiber selection in high-temperature environments. However, researchers should make some adjustments to improve grammatical errors and readability, considering the comments below.

Authors' reply:

The authors appreciate the possitive feedback from the reviewer. It encourages the authors to improve the article and revise the contents substantially as per reviewer's comments. The authors have tried the best to improve the grammatical errors and readability. Subsequently, all the reviewers' comments have been addressed below.

Comments from the Reviewer 1(#1):

On page#3, line#2, There is no clear explanation of the description of "SikaFume.".

Authors' reply:

The authors thank the reviewer for this comment. The description has been revised to clearly indicate that SikaFume refers to the commercial name of the silica fume used in this study. The revised sentence also specifies the applicable ASTM standard and supplier information.

Change made:

The sentence in Section 2.1 related to the description of SikaFume has been revised accordingly.

Comments from the Reviewer 1(#2):

On page#3, line#17, The verb "views" should be changed to "shows" for grammatical correctness.

Authors' reply:

Thanks for pointing out this error. The authors have revised the word accordingly.

Comments from the Reviewer 1(#3):

On page#5, The caption of Fig. 3, "temperature s" should be corrected to "temperatures".

Authors' reply:

Thanks for pointing out this error. The authors have revised the word accordingly.

Comments from the Reviewer 1 (#4):

On page#6, line#1, There are no full spellings of 'SD'. The author should provide the full spelling of the abbreviations when they appear first in the manuscript.

Authors' reply:

The authors thank the reviewer for this comment. We would like to respectfully clarify that the abbreviation "SD" is already defined as "spalling degree (SD)" at its first occurrence in Section 2.3 of the manuscript.

Comments from the Reviewer 1(#5):

On page#8, The images of Figure.6, clarification is required regarding the definition of spalling degree and the occurrence of negative values.

Authors' reply:

The authors thank the reviewer for this comment. The definition of spalling degree (SD) is provided in Section 2.3 and calculated according to Eq. (1). We have further clarified the occurrence of the small negative SD values shown in the figures. According to Eq. (1), a negative SD value occurs when the measured unit weight after thermal exposure (UW_t) is slightly higher than the initial unit weight at 25 °C (UW_{25}). Such small negative values may arise from experimental variation in the unit-weight measurements and are therefore interpreted as indicating negligible spalling.

Although the reviewer refers to Figure 6, negative SD values are first presented in Figure 4. Therefore, the clarification has been added to the discussion of Figure 4 so that the occurrence and interpretation of negative SD values are explained at their first appearance in the manuscript.

Change made:

A clarification on the occurrence and interpretation of negative SD values has been added to the discussion of Figure 4 in Section 3.1.1, where negative SD values first appear.

Comments from the Reviewer 1(#7):

On page#9, line#30, a reference should be provided to support this statement. (By 400 °C, the bond strength~).

Authors' reply:

The authors thank the reviewer for this comment. An appropriate reference has been added to support the statement regarding the deterioration of the bond strength between steel fibers and the cementitious matrix at elevated temperature.

Change made:

A supporting reference has been added to the relevant statement in Section 3.2.

Comments from the Reviewer 1(#8):

On page#11, in Table 4, the terms should be modified as 'Spalling' to 'Spalling resistance' and 'Reserving' to 'Retaining'.

Authors' reply:

The authors thank the reviewer for pointing out these errors and the two words have been revised accordingly as per reviewer's suggestions.

Comments from the Reviewer 2:

This study investigates the thermal resistance of fiber-reinforced reactive powder concrete (RPC) according to fiber type. While the results are potentially useful for fire-safety design standards, the following revisions are required to improve the clarity and academic quality of the manuscript.

Authors' reply:

The authors thank the reviewer for the constructive comments and for recognizing the potential contribution of the findings to fire-safety design. The authors have carefully considered all the reviewer's comments and revised the manuscript accordingly to improve its clarity, technical rigor, and academic quality. Detailed responses to each comment and the corresponding revisions are provided below.

Comments from the Reviewer 2(#1):

The study utilizes marble powder waste (CaCO3); however, its fundamental characteristics are not described in detail. Please explain the chemical characteristics, advantages/disadvantages compared to OPC and its environmental impact. The rationale for selecting marble powder waste should be clearly justified in the Introduction.

Authors' reply:

The authors thank the reviewer for this important comment. We agree that the fundamental characteristics of marble powder waste and the rationale for its selection should be more clearly described. In response, the Introduction has been expanded to discuss its chemical characteristics, advantages and limitations compared with ordinary Portland cement (OPC), and environmental significance.

The revised manuscript clarifies that marble powder waste is a calcium-carbonate-rich ($CaCO_3$) material and differs from OPC in its cementitious contribution. Importantly, previous studies have demonstrated that, at an appropriate replacement level, marble powder can partially replace OPC while maintaining, and in some cases improving, the performance of cement-based materials. This demonstrates its potential as a beneficial supplementary material for reducing OPC consumption while maintaining the required material performance. The manuscript also acknowledges that this beneficial

effect depends on the replacement level, as excessive substitution may adversely affect mechanical performance.

From an environmental perspective, partial replacement of OPC with marble powder can reduce OPC consumption and its associated environmental burden while simultaneously providing a beneficial reuse pathway for marble-processing waste. This is particularly relevant to RPC because of its characteristically high cement content. These material and environmental benefits therefore provide the rationale for selecting marble powder waste for incorporation into RPC in the present study.

Change made:

The Introduction has been expanded to describe the chemical characteristics of marble powder waste, its potential as a beneficial partial replacement for OPC, the importance of controlling the replacement level, its environmental benefits, and the rationale for its incorporation into RPC.

Comments from the Reviewer 2(#2):

Thermal insulation performance" and "fire resistance" appear to be used interchangeably. Given that this study focuses on high-temperature behavior, I suppose it is more appropriate to use "fire resistance" consistently throughout the manuscript.

Authors' reply:

The authors thank the reviewer for this comment. We agree that "thermal insulation performance" and "fire resistance" represent different material performance characteristics and should not be used interchangeably. We would like to clarify that the term "thermal insulation" is used in the Introduction only to provide a practical application context for thermal management and elevated-temperature considerations in the built environment; it is not used to describe the performance evaluated experimentally in the present study.

For the investigated material performance, the term "thermal resistance" is used consistently, in line with the title of the manuscript. We consider this terminology more appropriate because the present study evaluates the response of RPC to controlled elevated-temperature exposure through spalling resistance and residual compressive strength, rather than conducting a standardized fire-resistance test. The findings nevertheless remain relevant to understanding the behavior of FRPC under fire-related elevated-temperature conditions.

Change made:

The terminology in the manuscript has been carefully reviewed to clearly distinguish the general discussion of thermal insulation in the Introduction from the thermal resistance investigated experimentally. "Thermal resistance" has been consistently adopted when referring to the performance evaluated in the present study.

Comments from the Reviewer 2(#3):

The experiments were conducted using small-scale specimens under constant temperature conditions. Since specimen size and thermal history significantly influence thermal response, please discuss how these factors might affect the results and how they relate to real-scale scenarios.

Authors' reply:

The authors thank the reviewer for this important comment. We agree that specimen size and thermal history can significantly influence the thermal response of cementitious materials and should be considered when relating laboratory-scale observations to real-scale applications. The present study employed 50 × 50 × 50 mm specimens under controlled constant-temperature exposure to provide a consistent basis for comparing the thermal response of the investigated RPC, SFRPC, and PFRPC mixtures.

In response to the reviewer's comment, Section 3.3 has been expanded to discuss the implications of specimen size and thermal history. The revised discussion explains that larger structural elements may develop greater temperature gradients between the exposed surface and interior, which can affect thermal stresses, moisture migration, vapour-pressure development, cracking, and spalling. It also clarifies that actual fire exposure generally involves transient heating and cooling, and that variations in heating rate, exposure duration, peak temperature, and cooling conditions may alter the progression and severity of thermal damage. In real structural applications, these effects may be further influenced by structural dimensions, loading conditions, and restraint.

Accordingly, the manuscript now clarifies that the present results should primarily be interpreted as comparative material-level evidence for the relative performance and selection of steel and PP fibres, rather than as direct validation of full-scale structural fire performance. Further investigations using larger structural elements and representative fire-exposure histories are recommended to extend and validate these findings for real-scale applications.

Change made:

Section 3.3 has been expanded to discuss the influence of specimen size and thermal history on the experimental results and to clarify the applicability and limitations of extrapolating the findings to real-scale structural conditions.

Comments from the Reviewer 2(#4):

Extending Comment No. 3, Can the results obtained from this experiment at 300-400°C represent actual fire exposure conditions for RPC with marble powder? Please include a discussion on the practical application aspects of these findings.

Authors' reply:

The authors thank the reviewer for this important comment. We agree that the constant-temperature exposures of 300–400 °C in the present study should not be considered direct representations of actual fire exposure conditions. Actual fires involve transient temperature histories and may reach substantially higher temperatures, whereas the present experimental conditions were selected to provide controlled elevated-temperature exposure for comparative evaluation of the investigated RPC, SFRPC, and PFRPC mixtures.

Nevertheless, the investigated range provides useful material-level information on the temperature-dependent behaviour of the fibre systems. The results show a clear transition in relative performance: steel fibres provided greater benefits at 300 °C, whereas at 400 °C the RPC and SFRPC specimens underwent severe deterioration while PFRPC retained better specimen integrity. These results therefore provide comparative guidance on the different roles of steel and PP fibres under the investigated elevated-temperature conditions, rather than establishing fire-resistance ratings or temperature limits for real structural applications.

In response to the reviewer's comment, Sections 2.3 and 3.3 and Table 4 have been revised to clarify this distinction and the practical applicability of the findings. The manuscript now explicitly states that the investigated temperatures represent controlled elevated-temperature conditions rather than direct simulations of actual fire exposure, and that further investigation using representative fire-exposure histories, higher temperatures, and larger structural elements is required for validation under real-scale fire conditions.

Change made:

Sections 2.3 and 3.3 and Table 4 have been revised to clarify the relationship between the investigated 300–400 °C exposure conditions and actual fire scenarios, and to define the practical applicability and limitations of the findings.

Comments from the Reviewer 2(#5):

In Table 3, please specify the number of specimens tested for each experimental series to ensure statistical reliability.

Authors' reply:

The authors thank the reviewer for this comment. We confirm that the experiments were conducted in triplicate. For each mix and elevated-temperature exposure condition, three specimens were tested, and the reported results represent the average of the three specimens. Since the same number of specimens was used consistently for all experimental series listed in Table 3, this information has been clarified in the accompanying text in Section 2.2 rather than repeated for each mix in Table 3.

Change made:

Section 2.2 has been revised to specify that three specimens were tested for each mix and elevated-temperature exposure condition and that the reported results represent the average of three specimens.

Comments from the Reviewer 2(#6):

Please clarify the formula for SD. Is it calculated by (UW25-UWt)/UWt or (UW25-UWt)/UW25? In the case of SD=100% (complete disintegration), what is the value for UWt?

Authors' reply:

The authors thank the reviewer for identifying this point. We clarify that the spalling degree (SD) is calculated relative to the initial unit weight of the specimen at 25 °C. Therefore, the correct equation is (UW 25−UWt)/UW25×100%. The denominator in Eq. (1) has been corrected from UWt to UW25, and the percentage symbol (%) has also been added for clarity.

Regarding SD = 100%, this value was assigned to specimens that underwent complete disintegration. It does not imply that UWt=0. Following complete disintegration, the specimen no longer retained its original geometry and volume; consequently, UWt, which is defined based on the mass-to-volume ratio of the specimen, could not be meaningfully determined. SD = 100% was therefore used to represent complete disintegration of the specimen.

Change made:

Eq. (1) in Section 2.3 has been corrected by changing the denominator from UWt to UW25, and the percentage symbol (%) has been added to explicitly indicate that SD is expressed as a percentage.

Comments from the Reviewer 2(#7):

Can optimal fiber content be determined by introducing a new parameter that simultaneously considers both the increase in compressive strength and the spalling degree?

Authors' reply:

The authors thank the reviewer for this valuable suggestion. We agree that simultaneously considering compressive strength and spalling degree could provide a more comprehensive basis for determining fibre content than evaluating either parameter independently. The present results support this approach, as the fibre content providing the best spalling resistance was not necessarily the same as that providing the highest residual compressive strength. Furthermore, the experimental findings demonstrate that the thermal performance of FRPC is influenced collectively by exposure temperature, fibre type, fibre content, spalling resistance, and residual compressive strength.

However, introducing a new unified parameter requires appropriate normalization and scientifically justified weighting of these different factors. Since such weighting criteria were not established within the scope of the present study, defining a new parameter at this stage could introduce an arbitrary optimization criterion. Instead, the manuscript has been revised to emphasize that these factors should be considered collectively in a comprehensive evaluation of FRPC performance. The development and validation of a unified performance parameter incorporating these factors is recommended for future investigation.

Change made:

The concluding discussion in Section 3.1 has been expanded to emphasize that exposure temperature, fibre type, fibre content, spalling resistance, and residual compressive strength should be integrated into a comprehensive evaluation of FRPC performance, and the development of a unified performance parameter has been identified as a direction for future research.

Comments from the Reviewer 2(#8):

The reason why steel fibers do not contribute to spalling resistance requires further clarification. Do steel fibers fail to induce sufficient microcracking for pressure relief/proventing larger crack propagation? Please elaborate on this mechanism.

Authors' reply:

The authors thank the reviewer for this important comment. We would like to clarify that steel fibres did contribute to spalling resistance under the investigated conditions, particularly at 300 °C; however, their effectiveness decreased substantially at 400 °C. The discussion in Section 3.2 has therefore been expanded to clarify the mechanisms responsible for this temperature-dependent behaviour.

Steel fibres primarily contribute through crack bridging and restriction of crack propagation, thereby improving the mechanical integrity of the RPC matrix. However, this mechanism differs fundamentally from that of PP fibres. Although thermal mismatch between steel fibres and the cementitious matrix may promote local microcracking, these cracks may not provide sufficiently interconnected pathways for effective release of accumulated water vapour. As temperature increases, thermal expansion mismatch, deterioration of the cementitious matrix, and progressive degradation of the fibre–matrix interface further reduce the ability of steel fibres to restrain crack propagation. Consequently, the reinforcing effect of steel fibres becomes insufficient to counteract the combined effects of vapour-pressure build-up and thermally induced damage, which is consistent with the severe deterioration of SFRPC observed at 400 °C.

In contrast, PP fibres soften and melt at elevated temperatures, leaving additional voids and interconnected pathways within the matrix. These pathways increase permeability and facilitate moisture and vapour release, thereby reducing internal vapour-pressure accumulation and the associated risk of severe spalling. The experimental difference between SFRPC and PFRPC at 400 °C therefore reflects the distinct mechanisms of the two fibre types: steel fibres primarily provide mechanical crack control, whereas PP fibres additionally facilitate pressure relief through the pathways generated following fibre melting.

Change made:

Section 3.2 has been expanded to clarify the different mechanisms by which steel and PP fibres influence spalling. In particular, the revised discussion explains why microcracking associated with steel fibres may be insufficient to provide effective vapour-pressure relief and why deterioration of the steel fibre–matrix interaction reduces their spalling-control effectiveness at higher temperatures.

Comments from the Reviewer 3:

In this study, the influence of steel and PP fibers on the spalling resistance and compressive strength of FRPC incorporating marble powder after exposure to high temperatures was investigated. The experimental program was well established, in-depth discussions are provided, which contributes to understanding the spalling and mechanical resistance under evaluated temperature. The paper is also well-structured. The following revisions are suggested before its publication.

Authors' reply:

The authors appreciate the possitive comments from the reviewer regarding the works presented in the article. In addition, the authors would like to thank for the reviewer's comments such that the article can be improved for proper publication.

Comments from the Reviewer 3(#1):

Some references are highlighted in the submitted manuscript. Please check and remove the highlight.

Authors' reply:

The authors thank the reviewer for this comment. We have carefully checked the highlighted references in the submitted manuscript and confirmed that the cited references remain relevant and necessary to support the corresponding statements. Therefore, the citations have been retained, while the highlighting has been removed as requested.

Change made:

All highlighted references have been reviewed, and the highlighting has been removed throughout the manuscript. The relevant citations have been retained.

Comments from the Reviewer 3(#3):

The title of Fig. 8 should be revised for conciseness and clarity, ensuring it is easier for readers to interpret the content of the figure.

Authors' reply:

The authors thank the reviewer for this comment. The figure caption has been revised to provide a more concise and clear description of the main content while retaining the information necessary to

interpret the graphical elements. We would also like to clarify that the figures have been rearranged in the revised manuscript; consequently, the original Figure 8 referred to by the reviewer is now presented as Figure 7.

Change made:

The caption of Figure 7 (formerly Figure 8) has been revised for improved conciseness and clarity.