SUB-COMMITTEE ON SHIP DESIGN AND CONSTRUCTION
11th session
Agenda item 11

SDC 11/11/1
8 November 2024
Original: ENGLISH
Pre-session public release: ☒

GUIDELINES FOR USE OF FIBRE-REINFORCED PLASTICS (FRP) WITHIN SHIP STRUCTURES

Comments on the fire integrity test method of FRP elements in the report of the Correspondence Group (SDC 11/11)

Submitted by China

SUMMARY

Executive summary:	This document comments on the report of the Correspondence Group on the Revision of the Interim guidelines for use of Fibre-Reinforced Plastic (FRP) (MSC.1/Circ.1574) and proposes recommendations for improvement in temperature measurement methods during the test based on China's fire resistance test data of FRP composite, and influencing factors and characteristics of failure of FRP core fire resistance divisions under thermal action.
Strategic direction, if applicable:	2
Output:	2.6
Action to be taken:	Paragraph 13
Related documents:	MSC.1/Circ.1574; SDC 9/15/2, SDC 9/16; SDC 10/12, SDC 10/12/2 and SDC 10/17

Background

1 This document is submitted in accordance with the provisions of paragraph 6.12.5 of the *Organization and method of work of the Maritime Safety Committee and the Marine Environment Protection Committee and their subsidiary bodies* (MSC-MEPC.1/Circ.5/Rev.5), and provides comments on document SDC 11/11 (Sweden) with respect to the fire integrity test method of FRP elements.

Introduction

2 MSC 107 agreed to include the post-biennial output on the revision of the "Guidelines for use of fibre-reinforced plastics (FRP) within ship structures" into the provisional agenda of SDC 10.

3 SDC 10 established the Correspondence Group (CG) on the Revision of the Interim guidelines for use of Fibre-Reinforced Plastic (FRP) (FRP Interim Guidelines) (MSC.1/Circ.1574) and instructed the CG to revise the FRP Interim Guidelines and submit a written report to this session.

4 The CG received a proposal related to fire safety (DRAFT PROPOSAL), included as an external link in the CG report (SDC 11/11). However, owing to lack of time, the CG could not finalize the revision of the FRP Interim Guidelines and agreed to invite the Sub-Committee to establish the Working Group on the Revision of the Interim Guidelines for use of Fibre-Reinforced Plastic (FRP) (MSC.1/Circ.1574), with a view to finalizing the revision, taking into account the DRAFT PROPOSAL, as well as other documents to be submitted.

5 It was determined by the CG that, during the testing of fire-resisting divisions of FRP core, considerations should be given to the positions for measuring core temperature. The DRAFT PROPOSAL suggests placing thermocouples on the fire exposed side underneath the insulation of the FRP division and the FRP skin to monitor the temperature rise of the FRP skin (APPENDIX D/D.7/Paragraph 6.2.1 of DRAFT PROPOSAL).

Discussion

6 China agrees that the temperature rise of the FRP skin directly underneath the insulation layer(s) of the fire exposed side should be monitored. However, it is noted that for the FRP composite sandwich construction, overall structural failure of the panel often occurs when the bond of the laminate skin to the core reaches a critical temperature or the pyrolysis temperature (APPENDIX A/B/Paragraph 3.2 of DRAFT PROPOSAL).

7 Some typical critical temperatures for an FRP composite sandwich panel including the polymer TG temperature, delamination temperature, core material pyrolysis temperature, and laminate polymer pyrolysis temperature are summarized in figure 1. It is observed from the figure that the delamination temperature and core material pyrolysis temperature are far lower than the laminate polymer pyrolysis temperature. Therefore, it is possible that FRP composite may experience the overall structural failure due to the pyrolysis of core material or delamination when the laminate skin is detached from the core well before the failure of the laminate skin.

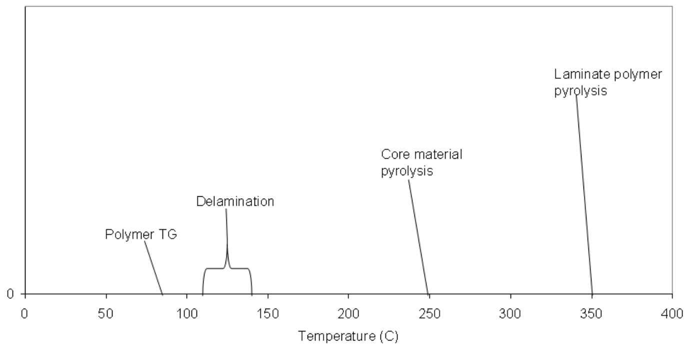

Figure 1: Typical critical temperatures for an FRP composite sandwich (PVC core, polyester FRP)

8 Figure 2 summarizes China's test results of fire unexposed side temperature of FRP, temperature between thermal insulation layer and FRP skin, and amount and rate of deformation during the testing of fire-resisting divisions of FRP sandwich construction. It is observed from the figure that when the temperature between thermal insulation layer and FRP skin exceeds the typical laminate polymer pyrolysis temperature, namely 350℃, there is no obvious change with the amount and rate of deformation of FRP fire-resistant structure, far below the ultimate load-bearing capacity of the core.

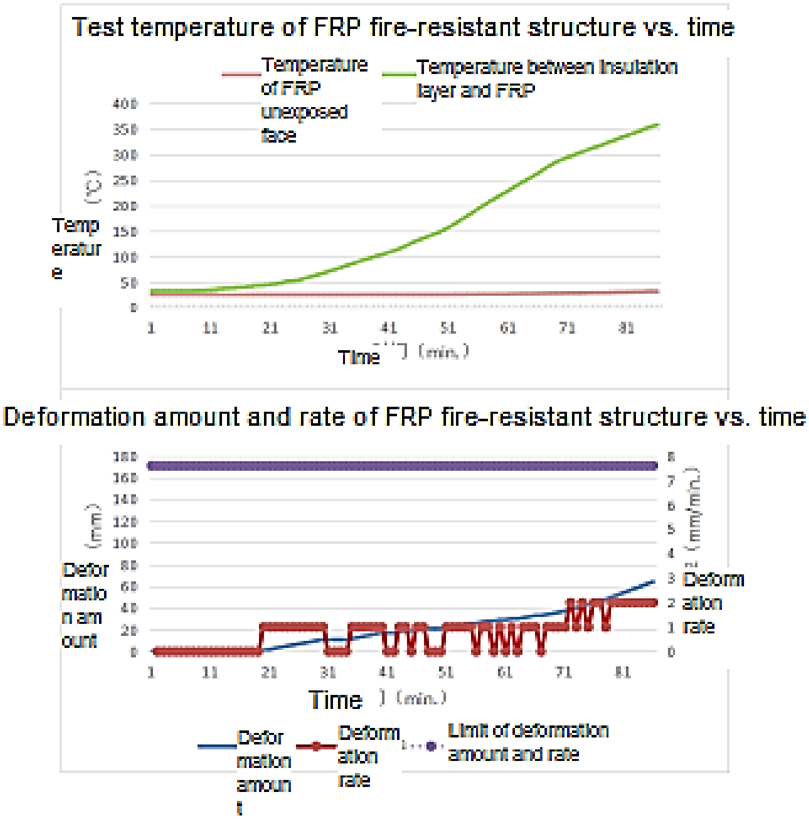

Figure 2: The test temperature vs. the amount and rate of deformation during the fire resistance test of FRP sandwich construction

9 According to the above test results, when the laminate skin on the fire exposed side reaches the pyrolysis temperature, there may be no failure in the pyrolysis of the laminate skin due to its relatively low heat conductivity coefficient. The load-bearing capacity and fire-resistant integrity of the entire FRP construction may still be in a relatively safe condition.

10 Figure 3 summarizes China's test results of fire unexposed side temperature of FRP, temperature of FRP core, and amount and rate of deformation during the testing of fire-resisting divisions of FRP sandwich construction. It is observed from the figure that when the FRP core temperature reaches the typical delamination temperature, namely 120℃, the deformation of core exceeds the standard limit of the structure and the rate of deformation rises sharply, exceeding the ultimate load-bearing capacity of the core. Therefore, it is feasible and meaningful to monitor the fire resistance performance of FRP divisions by monitoring the temperature between the core material and FRP laminate skin.

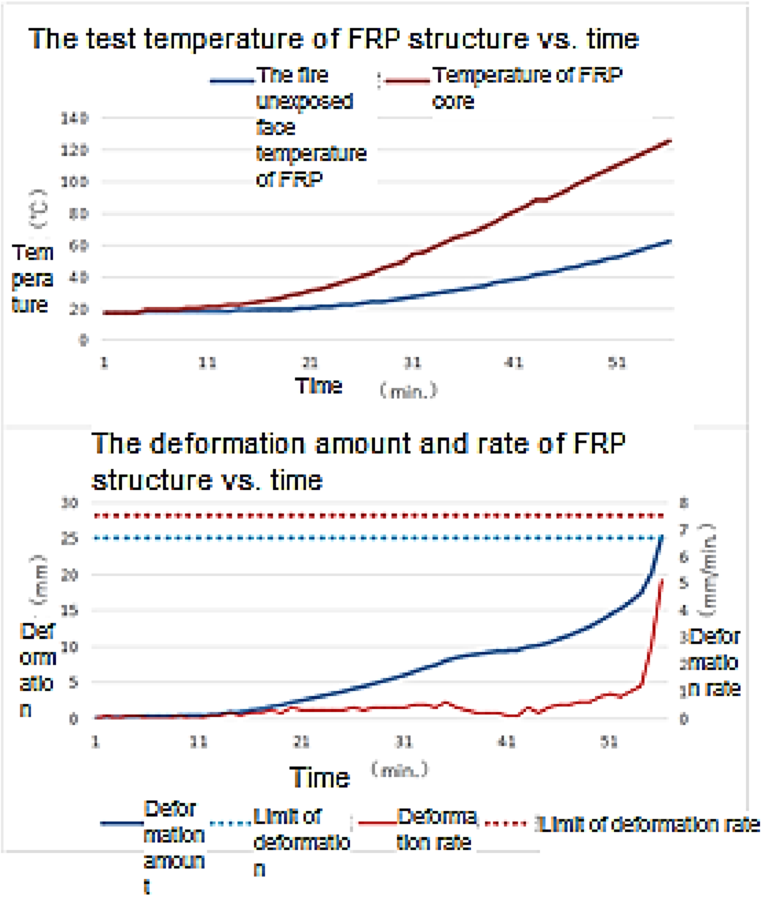

Figure 3: The test temperature vs. the amount and rate of deformation during the fire resistance test of FRP sandwich construction

11 Therefore, it is necessary, but insufficient, to determine the fire resistance performance of composite structures by monitoring the temperature between the thermal insulation layer and FRP skin. It is, in addition, necessary to monitor the temperature rise underneath the FRP laminate skin based on the features of composite structures, so as to determine the fire resistance performance of FRP structure through the comprehensive consideration of the overall temperature rise of the FRP laminate skin.

Proposal

12 Based on the above discussions, APPENDIX D/D.7/Paragraph 6.2.1 of the DRAFT PROPOSAL is recommended to be revised as follows (modifications in grey):

".1 insulation: Thermocouples should be placed on the fire exposed side underneath the insulation of the FRP division to measure the temperature of the FRP skin directly underneath the insulation layer(s). and thermocouples should also be placed on the fire exposed side underneath the FRP skin to measure the temperature of the core directly underneath the FRP skin. Thermocouple positions should be similar to those given in part 3 of the annex except that they are on the fire exposed side (i.e. to be placed under the insulation and under insulation joints). Any single temperature rise recorded by any of the individual unexposed side thermocouple shall not be more than the heat distortion temperature (HDT) of the polymer resin used in the FRP Composite."

Action requested of the Sub-Committee

13 The Sub-Committee is invited to consider the proposal contained in paragraph 12 and to take action, as appropriate.