Report

Project: Non-combustibility of concrete

To: Cement Concrete and Aggregates Australia (CCAA)

March 2020

School of Engineering

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Major findings of the project

1. Type GP mortar is not deemed to be combustible according to AS 1530.1:1994 (R2016).
2. Type GP concrete is not deemed to be combustible according to AS 1530.1:1994 (R2016).
3. The oxygen calorific value of Type GP mortar is 0 kJ/kg according to ISO 1716:2018.
4. The oxygen calorific value of Type GP concrete is 0 kJ/kg according to ISO 1716:2018.
5. Point 1 – 4 shows that in a fire, Type GP concrete does not burn or contributes any additional heat to the fire. This means if a building or a construction element is made of Type GP concrete, no additional fuel load is expected in the design for fire safety of that building/element.
6. Type GP concrete and Radiata Pine (RP) timber of similar compressive strength at room temperature (i.e. normal working temperature) were selected to undergo the same heat exposure and mechanical loading according to AS 3837:1998 (R2016) and AS 10129:2014. At room temperature, the compressive strength of Type GP concrete (28 days) and RP timber was 25.6 MPa and 28.6 MPa respectively.
7. At normal working temperature, the failure mode of Type GP concrete is radiant (from surface inwards) while RP timber was deconstructed with an inclined horizontal plane across its cross-section.
8. When placed under the same heating condition of 50 kW/m2, the maximum temperature inside RP timber can be over 4000C higher than the temperature inside Type GP concrete. This can be partially explained by point 5 above that Type GP does not contribute additional heat to a fire. At the exposed surface, the temperature difference between RP timber and Type GP concrete can be as high as 5000C.
9. After 120-minute exposure, the temperature at the back surface of Type GP concrete was 1220C while the temperature at the back surface of RP timber exceeded 5000C only after 112 minutes owing to the fact the combustion heat by the RP timber was sufficient to ignite the sides and unexposed surface of RP timber.
10. After 112-minute exposure, RP timber lost 82% of its original weight while Type GP concrete maintain 92% of its original weight after 120-minute exposure.

11. Undergoing the same testing condition in accordance with AS 3837:1998 (R2016) and AS 10129:2014, Type GP concrete maintains 75% its compressive strength while RP timber shows inconsistent performance with only 27 – 54% of its original compressive strength.
12. When exposed to the heating condition specified in Procedure 3 of Report IFFE200312, RP timber obtained a different failure mode of vertical damage while Type GP concrete still reserves the same radiant failure mode.
13. The project report is produced in accordance with five individual reports namely
    a. Modified Cone exposure tests of Type GP concrete and RP timber (Report no.: IFFE200312)
    b. Determination of heat of combustion for building materials (Report no.: IFFE200304)
    c. Determination of heat of combustion for building materials (Report no.: IFFE200305)
    d. Reaction to fire test report (Report no.: RTF190386)
    e. Reaction to fire test report (Report no.: RTF190387)

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Reaction-to-fire test report

A reaction-to-fire test in accordance with AS 1530.1:1994 (R2016)

Test sponsor: RMIT University - School of Engineering

Product: Type GP concrete

Job number: RTF190386

Test date: 11 February 2020 Revision: R1.0

Amendment schedule

Version	Date	Information about the report			
R1.0	17 February 2020	Description	Initial issue.		
			Prepared by	Reviewed by	Authorised by
		Name	Atousa Aris	Muntaqim Pereira	Anthony Rosamilia
		Signature			

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Contents

1. Introduction

This report documents the findings of the fire hazard properties test of Type GP concrete undertaken on 11 February 2020 in accordance with AS 1530.1:1994 (R2016) using the supplementary standard of ISO 1182:2010.

Warringtonfire Australia did the test at the request of RMIT University - School of Engineering.

Table 1 Test sponsor details

Test sponsor	Address
RMIT University - School of Engineering	Building 10 (Level 12) Room 17, 376-392 Swanston Street Melbourne VIC 3001 Australia

2. Product description

Table 2 describes the sampled product.

Table 2 Product description

Product name	Description
Type GP concrete	The sponsor described the material as concrete. As nominated by the test sponsor the composition of the material was 50 - 70 wt% 7 mm aggregates, 30 - 50 wt% natural sand and 5 - 10 wt% water. The material is to be used as a general construction material. The material was grey in colour with a rough surface finish. The material had a measured density of 2030 kg/m^3 after conditioning. The samples as nominated by the test sponsor were cured for 28 days. Warringtonfire personnel were not involved with the selection of the material, however, they were commissioned to modify the specimens to make them meet requirements of AS 1530.1. Before conducting these tests, the test specimens were conditioned in a ventilated oven maintained at a temperature of 60 ± 5 °C for 24 hours. Prior to conducting these tests, the samples were cooled to room temperature in a desiccator.

Figure 1 Photo of product

3. Test results

Table 3 shows the summary of observations and calculations of the material samples.

Table 3 Test calculations

Parameter	Symbol or expression	Unit	Results					Arithmetic mean = ∑results/5
			1	2	3	4	5	
Initial specimen mass	m_{si}	g	166.7	166.5	164.7	160.3	171.6	
Final specimen mass	m_{sf}	g	163.5	163.8	162.4	157.5	168.9	
Mass loss	$\delta m = (m_{si} - m_{sf})/m_{si}$	%	1.9	1.6	1.4	1.7	1.6	1.7
Total duration of sustained flaming	Cumulative total of duration of flaming (>5s)	s	0	0	0	0	0	0
Initial furnace thermocouple temperature	T_{fi}	°C	751.5	750.1	752.9	748.2	750.8	
Maximum furnace thermocouple temperature	T_{fm}	°C	768.6	767.9	771.7	762.8	768.7	
Final furnace thermocouple temperature	T_{ff}	°C	767.6	766.8	771.2	761.6	768.3	
Furnace thermocouple temperature rise	$\delta T_f = T_{fm} - T_{ff}$	°C	1.0	1.1	0.5	1.2	0.4	0.9
Maximum specimen centre thermocouple temperature	T_{cm}	°C	726.6	708.2	728.2	699.2	705.5	
Final specimen centre thermocouple temperature	T_{cf}	°C	726.4	707.8	728.1	699.2	705.4	
Specimen centre thermocouple temperature	$\delta T_c = T_{cm} - T_{cf}$	°C	0.2	0.4	0.1	0.0	0.1	0.2
Maximum specimen surface thermocouple temperature	T_{sm}	°C	738.5	741.5	749.3	746.5	739.7	
Final specimen thermocouple temperature	T_{sf}	°C	736.7	740.4	748.2	745.1	737.4	
Specimen surface thermocouple temperature rise	$\delta T_s = T_{sm} - T_{sf}$	°C	1.8	1.1	1.1	1.4	2.3	1.5
Test duration		s	3600	3600	3600	3600	3600	3600

Table 4 Summary of results

Characteristic	Result
Mean furnace temperature rise:	0.9 °C
Mean specimen centre thermocouple temperature rise:	0.2 °C
Mean specimen surface thermocouple temperature rise:	1.5 °C
Mean duration of sustained flaming:	0 seconds
Mean mass loss:	1.7 %

4. Criteria of combustibility

Clause 3.4 of AS 1530.1:1994 (R2016) states that a material be deemed combustible under any of the following circumstances:

- The duration of sustained flaming – as determined by summing the individual durations of flaming of 5 seconds or longer for all the samples and dividing by five, is greater than zero, or
- The arithmetic mean of the temperature rise of the furnace thermocouple exceeds 50 °C or
- The arithmetic mean of the specimen surface thermocouple temperature rise exceeds 50 °C.

Decision rule

Any measurement resulting in a temperature rise of 50 °C or more is taken to meet the temperature rise criteria for combustibility.

5. Observations

- There were sounds of cracking from the samples during the test.
- The samples cracked and expanded during the test.

6. Combustibility

The material is NOT DEEMED COMBUSTIBLE according to the test criteria for combustibility specified in Clause 3.4 of AS 1530.1:1994 (R2016).

7. Comments

A suitable alternative insulating material was used to fill the annular space between the furnace tubes, as specified in Clause 4.2 of ISO 1182:2010.

During all the tests, the thermocouples did not reach equilibrium. The tests were ended after 3600 seconds as described in Section 7.4.7 in ISO 1182:2010.

8. Application of test results

This test report does not provide an endorsement by Warringtonfire Australia Pty Ltd of the performance of the actual products supplied.

These test results only relate to the behaviour of the tested specimens under the particular conditions of the test and they are not intended to be the sole criterion for the assessing the potential fire hazard of the material in use.

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Reaction-to-fire test report

A reaction-to-fire test in accordance with AS 1530.1:1994 (R2016)

Test sponsor: RMIT University - School of Engineering

Product: Type GP mortar

Job number: RTF190387

Test date: 13 February 2020 Revision: R1.0

Amendment schedule

Version	Date	Information about the report			
R1.0	11 March 2020	Description	Initial issue.		
			Prepared by	Reviewed by	Authorised by
		Name	Atousa Aris	Muntaqim Pereira	Anthony Rosamilia
		Signature			

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1. Introduction

This report documents the findings of the fire hazard properties test of Type GP mortar undertaken on 13 February 2020 in accordance with AS 1530.1:1994 (R2016) using the supplementary standard of ISO 1182:2010.

Warringtonfire Australia did the test at the request of RMIT University - School of Engineering.

Table 1 Test sponsor details

Test sponsor	Address
RMIT University - School of Engineering	Building 10 (Level 12) Room 17, 376-392 Swanston Street Melbourne VIC 3001 Australia

2. Product description

Table 2 describes the sampled product.

Table 2 Product description

Product name	Description
Type GP mortar	The test sponsor described the material as mortar. The material is to be used as a general construction material. As nominated by the test sponsor the composition of the material was 60 - 80 wt% natural sand, 20 – 30 wt% general purpose cement and 5 - 10 wt% water. The material was grey in colour with a rough surface finish. The material had a measured density of 1919 kg/m^3 after conditioning. The samples, as nominated by the test sponsor, were cured for 28 days. Warringtonfire personnel were not involved with the selection of the material, however, they were commissioned to modify the specimens to make them meet requirements of AS 1530.1. Before conducting these tests, the test specimens were conditioned in a ventilated oven maintained at a temperature of 60 ± 5 °C for 24 hours. Prior to conducting these tests, the samples were cooled to room temperature in a desiccator.

Figure 1 Photo of product

3. Test results

Table 3 shows the summary of observations and calculations of the material samples.

Table 3 Test calculations

Parameter	Symbol or expression	Unit	Results					Arithmetic mean = ∑results/5
			1	2	3	4	5	
Initial specimen mass	m_{si}	g	155.5	154.2	156.2	156.3	155.8	
Final specimen mass	m_{sf}	g	153.9	151.1	152.7	153.0	152.1	
Mass loss	$\delta m = (m_{si} - m_{sf})/m_{si}$	%	1.0	2.0	2.2	2.1	2.4	2.0
Total duration of sustained flaming	Cumulative total of duration of flaming (>5s)	s	0	0	0	0	0	0
Initial furnace thermocouple temperature	T_{fi}	°C	751.4	747.9	747.6	748.7	749.5	
Maximum furnace thermocouple temperature	T_{fm}	°C	769.3	765.0	767.3	763.5	757.9	
Final furnace thermocouple temperature	T_{ff}	°C	768.0	764.4	766.4	762.9	756.0	
Furnace thermocouple temperature rise	$\delta T_f = T_{fm} - T_{ff}$	°C	1.3	0.6	0.9	0.6	1.9	1.0
Maximum specimen centre thermocouple temperature	T_{cm}	°C	715.2	709.3	702.1	703.0	735.9	
Final specimen centre thermocouple temperature	T_{cf}	°C	715.1	709.2	701.8	702.8	735.7	
Specimen centre thermocouple temperature	$\delta T_c = T_{cm} - T_{cf}$	°C	0.1	0.1	0.3	0.2	0.2	0.2
Maximum specimen surface thermocouple temperature	T_{sm}	°C	782.5	775.0	774.6	772.4	771.5	
Final specimen thermocouple temperature	T_{sf}	°C	781.4	774.7	774.3	772.1	770.8	
Specimen surface thermocouple temperature rise	$\delta T_s = T_{sm} - T_{sf}$	°C	1.1	0.3	0.3	0.3	0.7	0.5
Test duration		s	3600	3600	3600	3600	3600	3600

Table 4 Summary of results

Characteristic	Result
Mean furnace temperature rise:	1.0 °C
Mean specimen centre thermocouple temperature rise:	0.2 °C
Mean specimen surface thermocouple temperature rise:	0.5 °C
Mean duration of sustained flaming:	0 seconds
Mean mass loss:	2.0 %

4. Criteria of combustibility

Clause 3.4 of AS 1530.1:1994 (R2016) states that a material be deemed combustible under any of the following circumstances:

- The duration of sustained flaming – as determined by summing the individual durations of flaming of 5 seconds or longer for all the samples and dividing by five, is greater than zero.
- The arithmetic mean of the temperature rise of the furnace thermocouple exceeds 50 °C.
- The arithmetic mean of the specimen surface thermocouple temperature rise exceeds 50 °C.

Decision rule

Any measurement resulting in a temperature rise of 50 °C or more is taken to meet the temperature rise criteria for combustibility.

5. Observations

- There were sounds of cracking from the samples during the test.
- The samples cracked and expanded during the test.

6. Combustibility

The material is NOT DEEMED COMBUSTIBLE according to the test criteria for combustibility specified in Clause 3.4 of AS 1530.1:1994 (R2016).

7. Comments

A suitable alternative insulating material was used to fill the annular space between the furnace tubes, as specified in Clause 4.2 of ISO 1182:2010.

During all the tests, the thermocouples did not reach equilibrium. The tests were ended after 3600 seconds as described in Section 7.4.7 in ISO 1182:2010.

8. Application of test results

This test report does not provide an endorsement by Warringtonfire Australia Pty Ltd of the performance of the actual products supplied.

These test results only relate to the behaviour of the tested specimens under the particular conditions of the test and they are not intended to be the sole criterion for the assessing the potential fire hazard of the material in use.