Initial PFP Evaluation Report for Euston Tower:

Commentary on the Investigation of an Existing Spray Fire Resistive Material Applied to Concrete Structural Elements

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EXECUTIVE SUMMARY

PFP Specialists Ltd. were instructed by British Land to carry out an investigation of the Sprayed Fire Resistive Material (SFRM) at Euston Tower with specific focus given to an assessment of it condition as applied to the underside of the concrete ribbed floor slab and floor beams on Floors 3 to 13.

A first-stage report with reference PFPS-TR-2037 has previously been issued to British Land which documented findings by visual inspection only. The first stage report included: -

a) Comments on the scope of the SFRM application in Euston Tower
b) An opinion that the same material has been used for the full scope
c) Collection of samples for first-stage laboratory analysis testing
d) Conducting a survey of the extent of the material application on each level with the view to lead into a future condition report and associated advice on the capability of the installed material to protect the substrate to which is attached.
e) Recommendations to further develop the initial work conducted and provide more definitive data relating to the installed product throughout the building.

This second-stage report builds on the findings of the first-stage report to provide British Land with a conclusive identification of the SFRM material type and manufacturer and verify its fire resistance capability and functionality.

A four-stage investigation process has been adopted as follows: -

1. Visual and tactile observations of the material on each level
2. A bulk density and material binder broad synopsis to shortlist possible proprietary products for consideration.
3. A FT-IR spectroscopy analysis of a specimen of material and a benchmark product sample
4. A Condition Survey to assess that the SFRM is functional and remains robust

This report has identified the material as Cafco MANDOLITE® CP2 which is manufactured by Promat.

The minimum coating thickness recorded in the inspection, when cross-checked against the Cafco MANDOLITE®-CP2 literature, shows that it would be sufficient to upgrade the insulation requirement of concrete soffits and compensate for lack of concrete cover to reinforcement for 120 minutes fire resistance.

CONTENTS

1 TERMS AND ABBREVIATIONS

CS **Condition Survey**

Inspection of in service SFRM is better described as “Condition Survey” as it involves making judgement when assessing the severity of anomalies.

CVI / **Close Visual Inspection**

Major CS A close examination by visual and/or tactile means of an SFRM to detect anomalies (damage, failure, or irregularity).

This level of inspection may require the use of specific inspection equipment, magnifying lenses, or other aids to provide a means to accomplish a focused inspection.

GVI / **General Visual Inspection**

Interim CS A general examination by visual means of the SFRM to identify type and detect obvious anomalies (damage, failure, or irregularity).

This level of inspection is made from within touching distance unless otherwise specified. While maintaining this level of inspection, use of a specific inspection equipment or other aids may be necessary to allow visual access to exposed surfaces in the inspection area.

PFP **Passive Fire Protection**

A barrier, coating or other safeguard which provides protection against the heat from a fire without additional intervention.

PFPS **PFP Specialists Ltd**

Providing a service for passive fire protection, including design, fire engineering, product selection and installation.

SDI **Special Detailed Inspection**

An intensive examination of an SFRM to detect anomalies (damage, failure, or irregularity) that is not evident through visual and/or tactile means.

This level of inspection requires the use of specialized techniques and/or equipment (thickness measurement methodology and equipment)

SFRM **Spayed Fire Resistive Material**

Sprayed Fire-Resistive Material (SFRM), more commonly referred to as spray-applied fireproofing, is a passive fire protection material intended for direct application to structural building members. The intent of this material is to increase the fire resistance characteristics of those members, primarily through insulation.

SFRM materials come predominantly in cementitious, gypsum mineral-fibre or intumescent paint-based forms

VGP **Vermiculite Plaster**

Vermiculite plasters can be made with either gypsum or Portland cements and comprise a relatively simple mixture. Usually factory made they can also be batched on site and spray applied.

MBTL Manchester Building and Testing Laboratories Limited

NDE Non-Destructive Examination*, e.g., GVI, and CVI*

No. Number

SGS SGS INTRON Laboratory

RAMS Risk Assessment Method Statement

2 REFERENCES

[1] Manchester Building and Testing Laboratories Limited (MBTL) Report
Consultant Analytical Investigation Laboratories Materials Testing Service
Report, 18 February 2021
(*Appendix A*)

[2] SGS INTRON Laboratory Report
Consultant Analytical Investigation Laboratories Materials Testing Service
Results laboratory testing sprayed fire-resistive material (MATERIAL) Report 09 March 2021
(*Appendix B*)

[3] Promat Cafco MANDOLITE® CP2 technical Data Sheet TDS136
Cafco MANDOLITE® CP2 to upgrade the fire resistance of Concrete and Composite Soffits
(*Appendix C*)

[4] PFPS-TR-2037 Issue 01. Initial PFP Evaluation Report for Euston Tower: General Visual Inspection of Existing Sprayed Fire Resistive Material. PFP Specialists. 24th November 2020.

[5] Fire protection for structural steel in buildings (Yellow Book). 2nd Edition. Association of Specialists Fire Protection (ASFP). Circa 1980s. Note that 5th Edition (2018) is current.

3 INTRODUCTION

PFP Specialists Ltd. (PFPS) were instructed by British Land to carry out an assessment of the spray fire resistive material (SFRM) at Euston Tower.

The investigation concerned a sprayed material applied to the underside of the concrete ribbed floor slab and floor beams supporting floors 3 to 13. Access to the material is from the level below.

The details of the material, including product, manufacturer, and application date, were unknown to British Land.

The SFRM could have been applied at the time of the construction of the building (completion 1970) or during a reported refurbishment in 1993/4.

It is understood ARUP suggested the material may likely to have been installed as a retrofit acoustic treatment.

This investigation by PFP Specialists was commissioned by British Land Company PLC, to provide condition reports, give an estimate of the level of fire protection provided and if it is insufficient, to make recommendations for upgrading.

The investigation consists of four stages:

1. An Interim Condition Survey. General visual inspection (GVI) on October 22, 2020 which ascertained the scope and collected specimens of the material for analysis.
2. Desk based/secondary research
3. Consultant analytical materials testing and benchmarking of specimens from Euston Tower
4. Major Condition Survey consisting of a General Visual Inspection (GVI) and Close Visual Inspection (GVI) of the material on March 11, 2021.

Figure 1 and Figure 2 are extracted from the ARUP Invasive Survey report to aid understanding.

Figure 1: Soffit of Level 5 slab showing sprayed material on ribbed slab applied around ceiling and services supports (image courtesy of 190925 ARUP Invasive Survey Report)

Figure 2: Soffit of Level 17 slab as-struck concrete ribs with some cast-in channels and some surface-fixed services (image courtesy of 190925 ARUP Invasive Survey Report)

4 INFORMATIVE CLIENT REFERENCES

The client documents referenced in Table 1 were provided by British Land and have been used in the scope of work for this production of this report.

Table 1: Documentation provided by British Land

Author	Filename
IDF	2020.10.14 Euston Tower - Feasibility study (003)
SANDBERG	66429s Spray Material (002)
SANDBERG	66429s1 Euston Tower Sandberg Report Summary
SANDBERG	67629S-K Report
ARUP	190925 ARUP Invasive Survey Report
ARUP	Arup Commentary on Structural Investigations
McGEE	Euston Tower site investigation 003
NDY - Google	NDY - Google Structural Fire Resistance Consultant Advice
SANDBERG	P5851s-rl-Euston Tower Add Cores

5 INTERIM CONDITION SURVEY

Stage 1 of the investigation consisted of an Interim Condition Survey. A general visual inspection (GVI) of the material on October 22, 2020. The key aspects of this study included: -

- **Scope**
  The SFRM material was observed on the underside of the concrete floor slabs at Level 13 viewed from the plant room area and all levels down to and including Level 3.

- **Material type**
  The visual and tactile observations of the material on each level are similar indicating the same product was used throughout at floor levels within the scope.

- **Sample removal**
  Material samples were removed on Level 4 for the purposes of analytical testing. The removal of these samples is not expected to have a detrimental impact of the performance of the remaining SFRM material. These samples were subsequently sent to Manchester Building and Testing Laboratories Ltd. (MBTL) on Tuesday 27 October 2020 and SGS INTRON on 3 February 2021.

6 DESK BASED/SECONDARY RESEARCH

A review of available product literature from circa. 1992 [5] is presented in Table 2 together with the product's associated density value or range. 1992 has been taken as representative date to align with the refurbishment of Euston Tower, during which the application of SFRM was likely.

The purpose of this table is to provide a basis by which laboratory testing

Table 2: Common SFRM material product names and their respective densities. These are understood to have been commercially available circa. 1992

SFRM Products available circa. 1992	Density (kg/m³)
AUDEXG	516
CBLAZE	180-300
C280	-
C800	800
C4FP	205-300
DARFIBRE	220-360
DSPRAY HD	700
DSPRAY LD	380-450
HS3	750
CP2	390
MKV	325
MKBI	266
CV25	775
CV27	450
P720	690
RCEM	-
SDON FG	200
SLMW	-
SLVE	715-720
SLVI	350-400
VULTEX	715
Z105	350

7 CONSULTANT ANALYTICAL MATERIAL INVESTIGATION

7.1 Assessment of bulk-density and binder type

Manchester Building and Testing Laboratories Ltd. (MBTL) were requested to undertake testing to ascertain the bulk density of the samples and their associated binder type. This information would then be used to cross-check against the products in desk-based research presented in Section 6.

The results of the testing are summarized in Table 3 and provided in full in Appendix A.

Table 3: Summary of density and binder agent testing

Sample	Mass (g)	Density (kg/m³)	Binder agent
A	87.1	385	Ordinary Portland cement
B	61.8	400	Ordinary Portland cement
C	58.6	370	Ordinary Portland cement

The testing concluded that the indicative average density is 386 kg/m³ and the major binding agent is ordinary Portland cement.

Of the products in Table 2, it is possibly to identify potential products based on their density profile. These are given as: -

- Darspray LD
- MANDOLITE CP2 (CP2)
- Sprayed Limpet Vermiculite Internal (SLVI)

All three of these products use ordinary Portland cement as their binding agent.

7.2 Assessment of FT-IR spectroscopy

In order to further conclusively identify the product, FT-IR spectroscopy was undertaken as SGS INSTON laboratories. Theis assessment allows for the direct comparison of two samples to provide an opinion on their similarity.

A sample from Euston Tower was tested together with a benchmark MANDOLITE CP2 sample. The CP2 sample was proposed for testing based on assumption of this being the actual material as presented and discussed in PFPS-TR-2037 Issue 01 [4].

The Euston Tower specimen was taken from the underside of the Level 5 floor in the East spur.

The MANDOLITE CP2 sample was provided to PFP Specialists by the distributer Reppel.

The findings of the FT-IR spectroscopy are summarised below, but can be found in full in Appendix B.

- Both samples consist of a Portland cement-based material.
- In both samples, fire retardant minerals like Hydrophlogopite, Phlogopite and Vermiculite are present.
- The two samples are identical

The testing concludes that the two samples are identical which infers that the product in Euston Tower is MANDOLITE CP2.

It is of note that MANDOLITE P20 and MANDOLITE CP2 were developed by Mandoval Coatings Ltd. in the 1970s and 1990s, respectively. MANDOLITE CP2 superseded MANDOLITE P20.

The products are virtually identical in physical and mechanical properties; additives differ which affect the rheological properties.

The SFRM product name in Euston Tower, will likely depend on the date at which it was installed: -

- Material applied during construction is likely MANDOLITE P20
- Material applied during refurbishment in 1994/5 is likely MANDOLITE CP2

In essence, both products are the same and they both provide fire resistance, thermal and acoustic insulation functionality.

Promat acquired the intellectual property in 2007 and currently manufacture MANDOLTE CP2.

8 MAJOR CONDITION SURVEY

The purpose of the survey is to establish as far as practical, the condition of the SFRM and provide assurance and verification that it is functional and remains robust.

The survey consists of two aspects: -

1. Inspection of SFRM anomalies and their severity levels
2. SFRM Thickness readings

8.1 Methodology

Figure 3 shows a typical floor plan of Euston Tower.

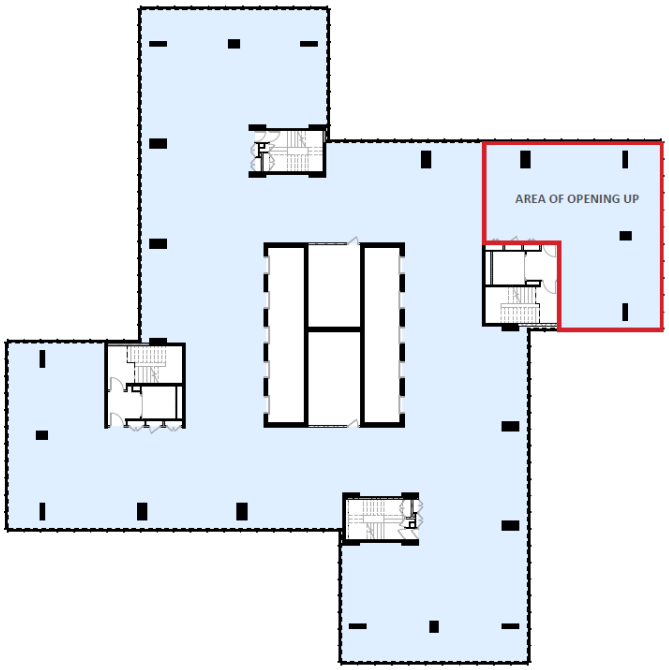


Figure 3: Existing typical floor plan. The spurs are known as North, East, South and West (image courtesy of 190925 ARUP Invasive Survey Report)

The scope of the survey includes the following: -

- On each level select one location in each of the four spurs
- Identify the locations selected
- General visual inspection of the SFRM at 4 locations levels 3-13 (11 floors)
- Close visual inspection of any anomalous areas identified
- Close visual inspection - measurement of the coating thickness using a needle depth gauge
- Any restrictions to the condition survey plan are noted accordingly

Anomalies are listed and categorised. The criteria are specific to a cement based SFRM applied to concrete structural/ compartmentation components the inside of a building. Five anomaly severity levels are used for condition assessment as shown in Table 4. It is of note that there is no standard to undertake this type of assessment. Instead, best practice industry principles have been adopted.

Table 4: Description of anomaly severity levels

Anomaly Severity Level	Description
1	Severe or immediate
2	Major
3	Significant
4	Minor
5	Acceptable

The severity levels presented in Table 4 are further clarified in Table 5.

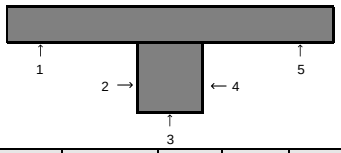
Table 5: PFP anomalies and their severity level

Anomaly Type	Anomaly Description		Severity	Implications	Possible Cause
Disbonded or Delaminated	Disbonded from substrate (extent ascertained by tap testing for hollow boss)	≤1m²	1	SFRM coatings should be sufficiently well bonded to the substrate to resist elastic deformation (flexure) and a degree of plastic deformation of the substrate in use and fire events	Poor surface preparation, dusty or contaminated substrate, spray application non conformance
		>1m²	3-5		
	Delaminated from previous spray pass/coat	≤1m²	1	Premature failure in fire event. Dropped object risk	Spray application non conformance
		>1m²	3-5		
Missing SFRM	Physical damage or areas where SFRM has been removed and not replaced	≤3000 mm²	1	Can cause localised hot spots in event of fire leading to premature failure of item protected	Mechanical damage or not replaced after removal
		>3000 mm²	3-5		
Repairs	Repair with different product		3	Performance of the detail may not be tested or certified	Non-conformance, original SFRM material obsolete or unknown
Cracking	≤3mm		1	Can cause localised hot spots in event of fire leading to premature failure of item protected. Note that for cracks <3mm you will get limited hot spots in the event of fire	Poor surface preparation, vibration, mechanical damage, or thermal expansion/cycling
	>3mm		3-5		
Remaining material < required thickness	≤10%loss		2	Reduced thickness of the PFP will, in case of fire, lead to faster temperature rise of the substrate, reducing the protective performance of the PFP.	Reduced thickness can be due to application non-conformance or mechanical damage
	>10% loss		3-5		
Appearance	Significant difference in appearance or colour to other areas of same SFRM		1-5	Fire rating may be compromised. CVI of PFP required to determine cause	Poor workmanship or spray application non conformance

8.2 Inspection Assessment

Table 6: Assessment results

Minimum Inspection Activities / Requirements **Comments on the condition of the SFRM applied to floor slab and rib at the 4 selected inspection locations on each floor. The SFRM applied to the underside of the floor slab on each level was viewed from the floor below for example the underside of floor 13 was viewed from level 12** **The inspection checked at each location against all anomaly criteria, as listed in Section 8.1.**														
Minimum Inspection Requirements & Location Reference		Disbonded (DB)	Delaminated (DL)	Missing SFRM (CM)	Incompatible Repairs (IR)	Cracking (C)	Appearance (A)	Average thickness (mm)	Coating thickness measurement (mm) & Locations (stylised Section)					Comments
Item/ location	Severity Assessment	*≤1m² 1 >1m² 3-5*	*≤1m² 1 >1m² 3-5*	≤3000 1 >3000 3-5	3	≤3mm 1 *>3mm 3-5*	1-5	-	Slab 1	Rib 2	Rib 3	Rib 4	Slab 5	
Level 12 US/F13	North Spur							35	40	30	35	na	na	Plant room height and access restricted CVI
Level 12 US/F13	East Spur							45	45				45	No rib at location
Level 12 US/F13	South Spur							35	35				35	No rib at location
Level 12 US/F13	West Spur							27	25				30	No rib at location
Level 11 US/F12	North Spur							38	35	30	35	55	37	
Level 11 US/F12	East Spur							31	40	35	29	25	27	
Level 11 US/F12	South Spur							31	25	37	33	na	na	No access (na)
Level 11 US/F12	West Spur							40	35	35	50	na	na	No access (na) small patch repair
Level 10 US/F11	North Spur							38	40	40	36	na	42	No access (na)
Level 10 US/F11	East Spur							38	35	42	40	42	35	
Level 10 US/F11	South Spur						5	31	30	30	35	30	30	Heavy texture appearance
Level 10 US/F11	West Spur							33	40	30	32	na	31	No access (na)
Level 9 US/F10	North Spur							38	30	40	45	35	41	
Level 9 US/F10	East Spur							40	40	40	36	45	40	Grey coloured overspray
Level 9 US/F10	South Spur						5	38	47	28	40	43	36	Heavy texture appearance
Level 9 US/F10	West Spur						5	35	40	32	40	30	35	Heavy texture appearance
Level 8 US/F9	North Spur						5	36	30	30	43	33	46	Patch repair around hanger. Heavy texture
Level 8 US/F9	East Spur							38	43	35	38	35	37	Patch repair
Level 8 US/F9	South Spur					5		39	39	35	46	35	40	Large Patch repair, Minor crazing
Level 8 US/F9	West Spur							38	40	37	43	36	35	Large patch repair
Level 7US/F8	North Spur							30	30	25	33	26	35	Patch repair
Level 7US/F8	East Spur							43	40	43	45	40	47	
Level 7US/F8	South Spur						5	32	30	32	25	31	40	Heavy texture appearance
Level 7US/F8	West Spur							38	35	35	39	42	40	Patch repair
Level 6 US/F7	North Spur							33	35	31	35	35	30	
Level 6 US/F7	East Spur						5	45	44	45	47	41	46	Heavy texture appearance
Level 6 US/F7	South Spur							43	40	39	50	43	41	
Level 6 US/F7	West Spur			5				42	45	36	46	40	43	Minor scuff
Level 5 US/F6	North Spur							-	-	-	-	-	-	Occupied no access for CVI
Level 5 US/F6	East Spur							41	50	40	45	37	35	
Level 5 US/F6	South Spur							-	-	-	-	-	-	Occupied no access for CVI
Level 5 US/F6	West Spur							-	-	-	-	-	-	Occupied no access for CVI

Minimum Inspection Activities / Requirements Comments on the condition of the SFRM applied to floor slab and rib at the 4 selected inspection locations on each floor. The SFRM applied to the underside of the floor slab on each level was viewed from the floor below for example the underside of floor 13 was viewed from level 12 The inspection checked at each location against all anomaly criteria, as listed in Section 8.1.														
Minimum Inspection Requirements & Location Reference		Disbonded (DB)	Delaminated (DL)	Missing SFRM (CM)	Incompatible Repairs (IR)	Cracking (C)	Appearance (A)	Average thickness (mm)	Coating thickness measurement (mm) & Locations (stylised Section)  					Comments
Item/ location	Severity Assessment	*≤1m² 1 >1m² 3-5*	*≤1m² 1 >1m² 3-5*	≤3000 1 >3000 3-5	3	*≤3mm 1 >3mm 3-5*	1-5	-	Slab 1	Rib 2	Rib 3	Rib 4	Slab 5	
Level 4 US/F5	North Spur							45	35	48	47	50	45	
Level 4 US/F5	East Spur			1				40	34	42	40	37	45	CM; large area removed for CVI by others – see Figure 10 and Figure 11
Level 4 US/F5	South Spur					5		46	40	40	45	50	55	C&DB; cracking 300x300
Level 4 US/F5	West Spur							43	45	33	50	40	46	Area sprayed with a white paint coating
Level 3 US/F4	North Spur						5	36	32	38	42	34	32	Large rib, heavy texture appearance
Level 3 US/F4	East Spur					5	5	36	35	30	44	35	35	C; heavy texture appearance
Level 3 US/F4	South Spur						5	37	46	45	35	35	25	Heavy texture appearance
Level 3 US/F4	West Spur					5		44	30	45	55	45	47	C
Level 2 US/F3	North Spur							-	-	-	-	-	-	Floor height prevented access CVI
Level 2 US/F3	East Spur							-	-	-	-	-	-	Floor height prevented access CVI
Level 2 US/F3	South Spur							-	-	-	-	-	-	Floor height prevented access CVI
Level 2 US/F3	West Spur							-	-	-	-	-	-	Floor height prevented access CVI

8.3 Associated Images

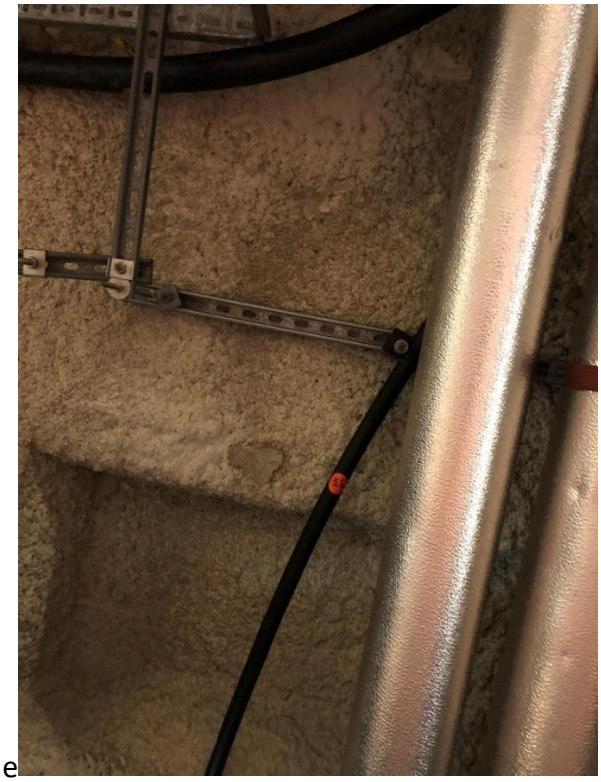


Figure 4: Minor patch repair

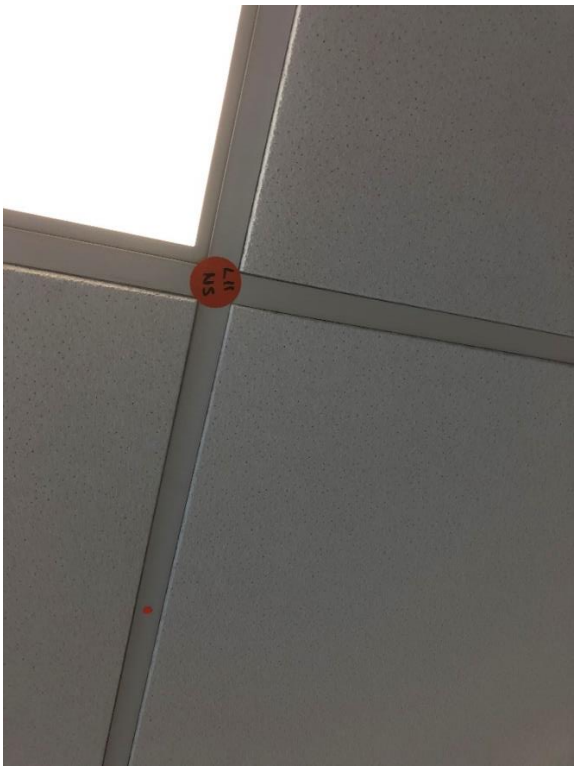


Figure 5: Adhesive label identifying the inspective location (L11 NS)

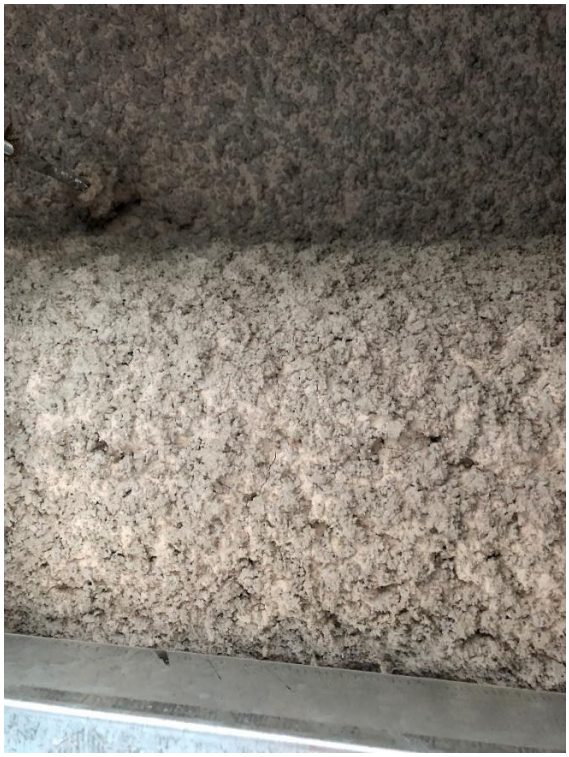


Figure 6: Heavy texture appearance

Figure 7: Small patch repair

Figure 8: Large patch repair

Figure 9: Needle gauge coating thickness measurement to slab rib

Figure 10: Level 4 East spur – large area of SFRM removed for CVI by others as part of the structural investigation

Figure 11: Level 4 East spur showing the cohesive failure of the SFRM on removal with mechanical tools – indicating good adhesion

9 FINDINGS AND SUMMARY

The survey results presented in Table 6 found one anomaly level 1 (severe or immediate) where McGee (see reference in Table 1) had carried out "*insulation breakout as part of Euston Tower site investigations*". For this area, the manufacturer of the product should be able to provide a standard repair procedure which a recognised specialist contractor will incorporate into a method statement.

All other anomalies assessments were categorised as '5', i.e., acceptable.

The average thickness of the SFRM ranged from 27mm to 46mm.

It is common practice to use SFRM materials to upgrade concrete components in buildings. Promat provide guidance on the use of MANDOLITE® CP2 to upgrade the insulation requirement of concrete soffits and compensate for lack of concrete cover. An extract of the relevant thicknesses is shown in Figure 12, while the full datasheet is provided in Appendix C of this document.

TABLE 1

Thickness of Cafco MANDOLITE® CP2 (in mm) required to upgrade the fire insulation requirements for concrete soffits

Existing Slab Thickness (mm)	Total Required Fire Resistance to BS476:Part 21 (minutes)					
	30	60	90	120	180	240
75		9.5	15	20	29	37
80		8	13	18	27	35
90		8	9.5	14	23	31
100			8	10	19	27
110				9.5	15	23
120				8	11	19
130					9.5	15
140					8	11
150						9.5
165						8

TABLE 2

Thickness of Cafco MANDOLITE® CP2 (in mm) required to compensate for lack of concrete cover to reinforcement

Existing Cover (mm)	Total Required Fire Resistance to BS476:Part 21 (minutes)					
	30	60	90	120	180	240
10	9.5	9.5	9.5	13	18	22
15	8	8	9.5	11	16	20
20		8	8	9.5	14	18
25			8	8	12	16
30				8	10	14
40					8	10
50					8	9.5
60						8

Figure 12: Excepts from [4] Promat Cafco MANDOLITE® CP2 technical Data Sheet TDS136

In can be seen in the tables above, the minimum measured thickness of MANDOLITE CP2 of 27mm would be sufficient to upgrade the insulation requirement of concrete soffits and compensate for lack of concrete cover to reinforcement for 120 minutes fire resistance.

10 APPENDIX A: MANCHESTER BUILDING AND TESTING LABORATORIES REPORT

Manchester Building and Testing Laboratories Limited

Consultant Analytical Investigation Laboratories
Materials Testing Service

Priory Grange, Watling Street, Old Roman Road
Affetside Bury, Manchester BL8 3QJ
Telephone & Fax : 01204-886677
Email : mbtlabs@btinternet.com
Web site : www.mbtlabs.co.uk
www.mbtl.co.uk

18 February 2021

Re: 3 Samples submitted for analysis

Dear Eddie,

Please find written confirmation of test results as discussed for samples submitted.
Your reference :- SFRM Investigation Chemical Analysis & Physical Properties.

Introduction

Three separate samples of Sprayed Fire-Resistive Material were further submitted for density measurement and binder typing with as-received weights as follows:-

A - 87.1 grams
B - 61.8 grams
C - 58.6 grams

Directors: Brian Timperley, F.C.S., J. Timperley, S.R.Ch.
Manchester Building and Testing Laboratories Ltd. is a limited company registered in England and Wales.
Company No. 00954353. Registered office: 114 Drake St, Rochdale, Lancs, OL16 1PN.

Test Results and Conclusions

Test results of sample submitted

	ASTM C642-13
% Water Absorption of Sample 24 Hours Cold	173.42 %
% Water Absorption of Sample Saturated	216.39 %
Dry Bulk Density of Sample in KG/m^3	386
Bulk Density after Cold Immersion KG/m^3	1056
Saturated Bulk Density of Sample in KG/m^3	1223
Apparent Specific Gravity of Sample	2.36
Percentage Volume of Voids in Sample	83.6
Saturation Coefficient	0.80

The as-received mass of the main sample was 87.1 grams and all three samples were conditioned at 43°C and ≤60% RH to virtual constant weight at 8-hour intervals.

The minimum volume for testing density is 0.35 litres for an alternative referee-standard test method for density in hardened concrete with strict reference to ASTM C642-13.

The chemical analysis with strict reference to BS 4551:2005+A2:2013 indicated that the major binding agent was found to be based largely on Ordinary Portland Cement.

The analysis also indicated that significantly higher aluminium content (as Al_2O_3) when compared to the iron content (as Fe_2O_3) and higher silica contents (as SiO_2) tended to indicate that the majority of the lightweight aggregate could be mainly based on Perlite.

Sulphur trioxide (SO_3) is low eliminating the binder being based on calcium sulphate ($CaSO_4$). It is more in line with the ($CaSO_4$) being added to ordinary Portland cement to prevent flash-set.

The dry bulk density of the three different samples

A - 385 kg/m^3

B - 400 kg/m^3

C - 370 kg/m^3

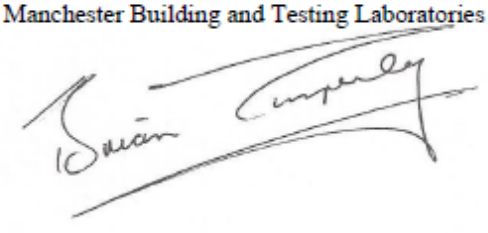
The dry bulk density of the sample A carried out by the alternative referee test method ASTMC642-13 in the previous table. Sample 'D' shows remarkably good correlation with sample 'A' by two different methods, 'D' being a 'referee' displacement method.

D - 386 kg/m^3

Confirmatory measurement methods appear to be in very good correlation to the displacement methods.

Note that the same ASTM analytical specification indicates a huge 83.6% voids, presumably mainly due to the lightweight aggregate.

Manchester Building and Testing Laboratories Limited



Brian Timperley.

11 APPENDIX B: SGS INTRON LABORATORY – CERTIFICATE OF ANALYSIS

SGS INTRON Laboratory
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tel: +31 (0) 88 - 2 145 204

Certificate Of Analysis

PFP Specialists Ltd
attn. Mr. J.V. Dunk
Willowbrook, The Street, Preston St Mary
C0109NG SUFFOLK
UNITED KINGDOM

Date	:	09-03-2021
Subject	:	Results laboratory testing sprayed fire-resistive material (SFRM)
Your Code	:	No reference supplied
Laboratory Number	:	204727
Sampling	:	By client
Period of Investigation	:	03-02-2021 until 22-02-2021

SAMPLE DATA

Sample No	Sample Type	Sample Code	Date of Acceptance
1	SFRM	ET21012021	03-02-2021
2	SFPM	MM25-2212021	03-02-2021
3	SFRM	RCP2 21012021 (Reference)	25-01-2021

METHODS

Analyses		Used method	Q	S
Visual assessment	Optical microscopy	SGS INTRON		
Identification	Infrared spectrometry (ATR/FTIR)	SGS INTRON		
Identification and quantification	XRD	In house method		s

'Q = ISO 17025 accredited, s = subcontracted, Qs = ISO 17025 accredited subcontractor

SUMMARY RESULTS COMPOSITION

The two samples (1 and 3) consist of a Portland cement-based material. In both samples fire retardant minerals like Hydrophlogopite, Phlogopite and Vermiculite are present. The quantities can not be determined without further testing. There is always the possibility that the samples are inhomogenous.

Author: ing. S.P.M.L. Benders, projectmanager
Authorisation: H.P.H. Creemers, accountmanager

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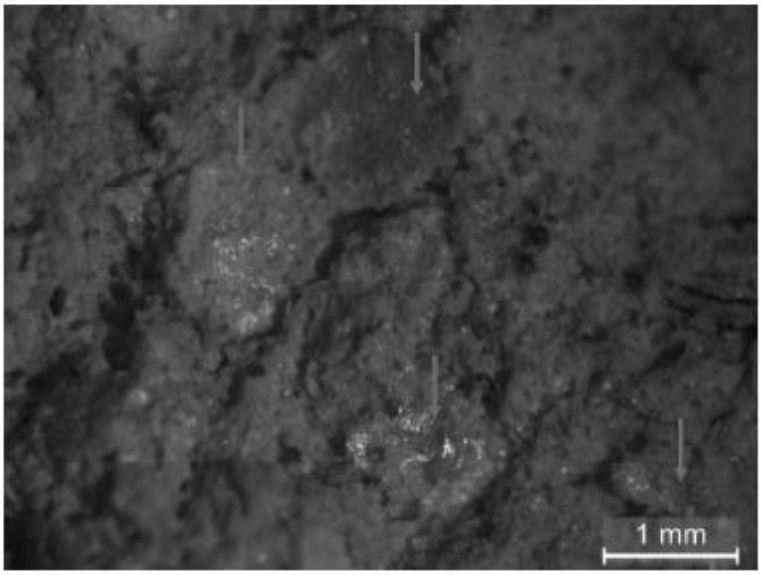
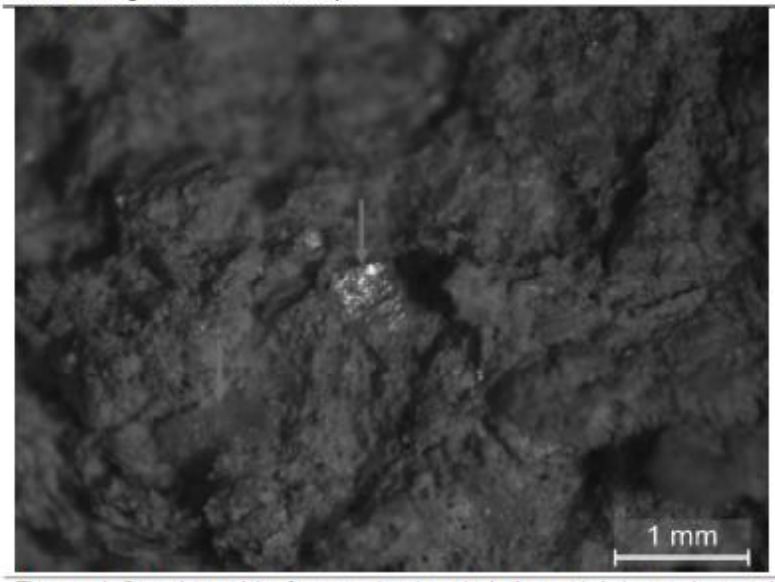
SGS

RESULTS OPTICAL MICROSCOPY



The sample 1 consists mainly of a grey colored matrix. In the matrix beige pearlescent plate like grains are embedded (some marked with a red arrow). The layers are easily pulled apart with a scalpel. It looks like a mica. These grains have a round shape.



The sample 3 consists mainly of a grey colored matrix. In the matrix beige pearlescent plate like grains are embedded (some marked with a red arrow). The layers are easily pulled apart with a scalpel. It looks like a mica. These grains have a angular shape.

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RESULTS & OPINION/INTERPREATATIE ATR/FTIR ANALYSIS

The results of the ATR/FTIR analysis are depicted in the image below.

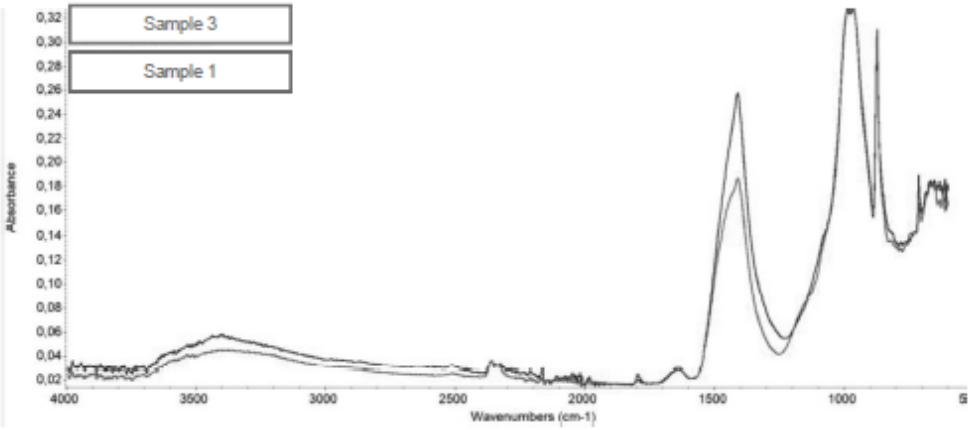

Image: ATR-FTIR spectrum of the two samples

The ATR/FTIR spectrum of the two samples are identical. The two samples consist of a Portland based cement. The reference spectrum of Portland cement is not depicted. In general quantities in lower concentrations than 10 % of unknow components cannot be detected with ATR/FTIR.

RESULTS XRD ALALYSIS

The results of the XRD analysis are presented in the image below.

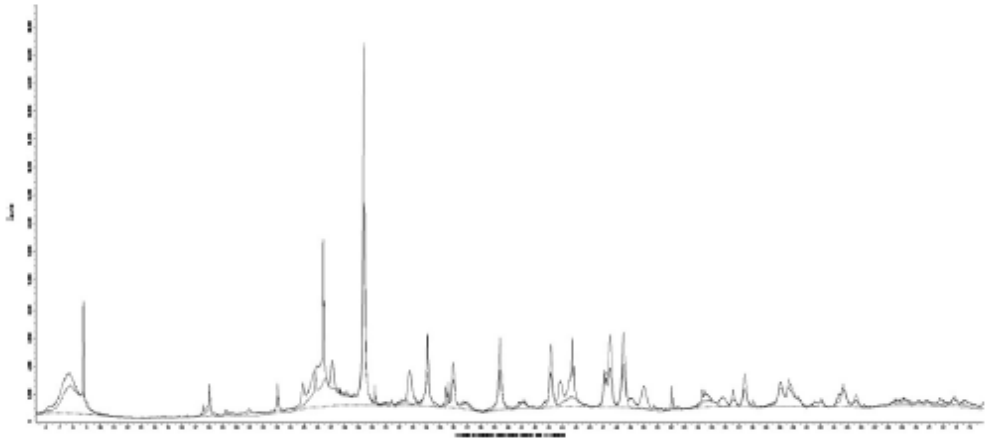

Image: Results XRD analysis, overlay of the two XRD spectra of the two samples.

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Sample 1 & 3 consists of:

Sample 1	Sample 3
C: Calcite	C: Calcite
H: Hydrophlogopite	H: Hydrophlogopite
P: Phlogopite	P: Phlogopite
Po: Portlandite	Po: Portlandite.
V: Vermiculite	V: Vermiculite
Va: Vaterite	

The quantities of minerals differ in the two samples. However fire retardant minerals like Hydrophlogopite, Phlogopite and Vermiculite are present in both samples. Both their amount differs. A quantification is without further testing not possible. There is always the possibility that the samples are inhomogenous.

INFORMATION ON THE SUITABILITY OF THE SAMPLES FOR ANALYSIS

According to international regulation (NEN-EN-ISO/IEC 17025) SGS INTRON is obliged to control if the samples are suitable for the intended analyses and should ensure that the samples do not degrade before the content is determined. It is requested that the suppliers of samples deliver the samples packed and, if applicable, conserved in a manner that is suitable for the intended analyses.

DISCLAIMER

- This report may only be reproduced in its entirety without the written permission of the SGS INTRON laboratory.
- The results are only related to the investigated samples.
- The scope of the NEN-EN-ISO/IEC 17025 accreditation includes all results associated with analyzes that are marked with a Q for analysis methods.
- The uncertainty of measurement of the reported results and other performance data can be requested at SGS INTRON.
- On request, a list of accredited analysis methods can be requested, which describes the relationship (compliant, equivalent, own method) with the underlying standard.

12 APPENDIX C: CAFCO MANDOLITE®-CP2 TECHNICAL DATA SHEET

Promat

Cafco MANDOLITE® CP2 to Upgrade the Fire Resistance of Concrete and Composite Soffits

Technical Data Sheet_136
April 2017 (Page 1 of 2)

INTRODUCTION

Concrete slabs and steel and concrete composite slabs have an inherent amount of fire resistance, dependant upon their construction. However there are times where this fire resistance needs to be upgraded (for example, from 1 to 2 hours). This is usually due to insufficient cover to the reinforcement or the thickness of the slab will not provide the required level of fire insulation. The information on this TDS covers upgrades to BS476:Part 21.

For this application Promat recommend the use of Cafco MANDOLITE® CP2, a spray- applied, factory controlled, premix of vermiculite and cement.

1. UPGRADING CONCRETE SOFFITS

The thickness of Cafco MANDOLITE® CP2 required to upgrade the fire resistance depends on the following factors.

1. Thickness of the concrete slab
2. Cover to the steel reinforcement
3. Total period of fire resistance required

Tables 1 and 2 should be read together and the additional amount of Cafco MANDOLITE® CP2, required to upgrade the thickness or cover to the reinforcement, determined. The higher of the amounts should be used to ensure that both criteria are met. The minimum thickness of Cafco MANDOLITE® CP2 which can practically be applied is 8mm.

TABLE 1

Thickness of Cafco MANDOLITE® CP2 (in mm) required to upgrade the fire insulation requirements for concrete soffits

Existing Slab Thickness (mm)	Total Required Fire Resistance to BS476:Part 21 (minutes)					
	30	60	90	120	180	240
75		9.5	15	20	29	37
80		8	13	18	27	35
90		8	9.5	14	23	31
100			8	10	19	27
110				9.5	15	23
120				8	11	19
130					9.5	15
140					8	11
150						9.5
165						8

TABLE 2

Thickness of Cafco MANDOLITE® CP2 (in mm) required to compensate for lack of concrete cover to reinforcement

Existing Cover (mm)	Total Required Fire Resistance to BS476:Part 21 (minutes)					
	30	60	90	120	180	240
10	9.5	9.5	9.5	13	18	22
15	8	8	9.5	11	16	20
20		8	8	9.5	14	18
25			8	8	12	16
30				8	10	14
40					8	10
50					8	9.5
60						8

AUTHORITY: WARRES 52925, WF AR 328526, SCI/RT/316, BS 8110-2 SECTION 4

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technical.promat@etexbp.co.uk | www.promat.co.uk

etex building performance

continued

EXAMPLE

A concrete slab which is 110mm thick with 15mm cover to the reinforcement requires upgrading to 120 minutes.

From Table 1 an additional 9.5mm is required and, from Table 2, an additional 11mm is required. Therefore 11mm of Cafco MANDOLITE® CP2 is required for the upgrade.

2. UPGRADING STEEL AND CONCRETE COMPOSITE SLABS

The application of 18mm Cafco MANDOLITE® CP2 to an existing 1 hour rated steel and concrete floor will upgrade the fire resistance to 4 hours. This can be used on both open and re-entrant profile steel sheets.

SUBSTRATE PREPARATION

Substrates need to be clean and free from dust, debris, release agents, contaminants and impurities. Steel substrates also need to be free from oil, grease or anything that could prevent good adhesion.

If the applicator finds "contamination", local degreasing may be required and if it is more extensive, the entire substrate may need to be degreased and allowed to dry before application.

When used in construction specifications (cellulosic fire risk) where Cafco MANDOLITE® CP2 is to be applied onto clean concrete or clean bare steel in good condition, the use of a keycoat and mesh reinforcement is not required. For application to galvanized steel, mesh reinforcement is not required but a keycoat is.

For soffits in poor condition or those that have been painted or cannot successfully be cleaned, expanded metal lathing (BB264 or equal), or Riblath 271, must be fixed to the soffit to provide an independent support for the Cafco MANDOLITE® CP2. The minimum thickness of Cafco MANDOLITE® CP2 that can be successfully applied to expanded metal lathing is 13mm and this thickness is measured "proud of lath"

For more information regarding keycoats and application to expanded metal lathing please contact the Etex Building Performance technical team or refer to the Cafco MANDOLITE® CP2 Application Manual.

Etex Building Performance Limited
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