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Lab Ref: 58570

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Originator: Harry Cursham

Project: Vivus #1

Samples: 2No products, Vivus#1 and 4:1 NHL, were to be investigated. Vivus#1 was a bagged product from Vivus Solutions Limited and the 4:1 NHL was a blend of sand and NHL.

Requirements: Samples of each mortar were produced, by hand-mixing, on the 25th October 2018 (Vivus#1) and the 1st November 2018 (4:1NHL) and a number of prism (40 x 40 x 160mm) samples manufactured to be tested for Flexural and Compressive Strength in general accordance with BS EN 1015-11 at specific ages up to, and including, 180 days. The samples were left open to the air throughout their curing life – both within the mould and after de-moulding.

A number of 'brick sandwiches' were manufactured on the 25th October 2018 using 2No, Vivus supplied, engineering bricks and a nominal 10mm 'filling/bed' of each mortar type. These 'brick sandwiches' were subjected to load cycling to 100, 200 and 800kN with deformation of the samples being monitored between each loading rate. This testing was carried out at specific intervals ranging from 2 hours after preparation to 180 days.

Kiwa CMT Testing

G. Peach AMICT
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Material details:Vivus#1 Mortar

9750g of Vivus#1 bagged mortar

2000ml of H₂O

4:1 NHL Mortar

850g NHL

4000g Sand

1000ml H₂O

Engineering Bricks

Dimensions - 215 x 102 x 65mm

Water Absorption - 4.89%

As received Density - 2330 kg/m³

Oven Dry Density - 2220 kg/m³

Saturated Density - 2375 kg/m³

Kiwa CMT**Vivus#1 Mortar Results:****Vivus #1 Flexural Strength and Compressive Strength (7 days)**

Ref	Cast Date	Test Date	Density (Kg/m ³)	Flexural Strength (N/mm ²)	Compressive Strength (N/mm ²)	Compressive Strength (N/mm ²)
V1 A	25.10.18	01.11.18	1669	0.27	0.52	0.49
V1 B	25.10.18	01.11.18	1696	0.16	0.55	0.54
		Av.	1683	0.22	Av.	0.53

Vivus #1 Flexural Strength and Compressive Strength (14 days)

Ref	Cast Date	Test Date	Density (Kg/m ³)	Flexural Strength (N/mm ²)	Compressive Strength (N/mm ²)	Compressive Strength (N/mm ²)
V1 C	25.10.18	08.11.18	1627	0.35	0.57	0.54
V1 D	25.10.18	08.11.18	1650	0.47	0.66	0.61
		Av.	1639	0.41	Av.	0.60

Vivus #1 Flexural Strength and Compressive Strength (28 days)

Ref	Cast Date	Test Date	Density (Kg/m ³)	Flexural Strength (N/mm ²)	Compressive Strength (N/mm ²)	Compressive Strength (N/mm ²)
V1 E	25.10.18	22.11.18	1663	0.36	0.84	1.00
V1 F	25.10.18	22.11.18	1649	0.44	1.24	0.98
		Av.	1656	0.40	Av.	1.01

Kiwa CMT**Vivus#1 Mortar Results:****Vivus #1 Flexural Strength and Compressive Strength (56 days)**

Ref	Cast Date	Test Date	Density (Kg/m ³)	Flexural Strength (N/mm ²)	Compressive Strength (N/mm ²)	Compressive Strength (N/mm ²)
V1 G	25.10.18	20.12.18	1654	0.67	0.93	1.02
V1 H	25.10.18	20.12.18	1656	0.74	0.91	1.12
		Av.	1655	0.71	Av.	1.00

Vivus #1 Flexural Strength and Compressive Strength (90 days)

Ref	Cast Date	Test Date	Density (Kg/m ³)	Flexural Strength (N/mm ²)	Compressive Strength (N/mm ²)	Compressive Strength (N/mm ²)
V1 J	25.10.18	23.01.19	1695	0.68	2.03	1.81
V1 K	25.10.18	23.01.19	1677	0.72	1.69	1.64
		Av.	1686	0.70	Av.	1.79

Vivus #1 Flexural Strength and Compressive Strength (180 days)

Ref	Cast Date	Test Date	Density (Kg/m ³)	Flexural Strength (N/mm ²)	Compressive Strength (N/mm ²)	Compressive Strength (N/mm ²)
V1 L	25.10.18	23.04.19	1670	0.56	1.86	1.81
V1 M	25.10.18	23.04.19	1673	0.64	1.92	1.89
		Av.	1672	0.60	Av.	1.87

Kiwa CMT**4:1 NHL Mortar Results:****NH Flexural Strength and Compressive Strength (7 days)**

Ref	Cast Date	Test Date	Density (Kg/m ³)	Flexural Strength (N/mm ²)	Compressive Strength (N/mm ²)	Compressive Strength (N/mm ²)
NH A	01.11.18	08.11.18	1725	0.35	0.89	0.88
NH B	01.11.18	08.11.18	1729	0.27	0.77	0.76
		Av.	1727	0.31	Av.	0.83

NH Flexural Strength and Compressive Strength (14 days)

Ref	Cast Date	Test Date	Density (Kg/m ³)	Flexural Strength (N/mm ²)	Compressive Strength (N/mm ²)	Compressive Strength (N/mm ²)
NH C	01.11.18	15.11.18	1716	0.59	1.13	1.13
NH D	01.11.18	15.11.18	1698	0.47	1.04	1.10
		Av.	1707	0.53	Av.	1.10

NH Flexural Strength and Compressive Strength (28 days)

Ref	Cast Date	Test Date	Density (Kg/m ³)	Flexural Strength (N/mm ²)	Compressive Strength (N/mm ²)	Compressive Strength (N/mm ²)
NH E	01.11.18	29.11.18	1739	0.35	0.96	1.10
NH F	01.11.18	29.11.18	1729	0.61	1.01	1.16
		Av.	1734	0.48	Av.	1.06

Kiwa CMT**4:1 NHL Mortar Results:****NH Flexural Strength and Compressive Strength (56 days)**

Ref	Cast Date	Test Date	Density (Kg/m ³)	Flexural Strength (N/mm ²)	Compressive Strength (N/mm ²)	Compressive Strength (N/mm ²)
NH G	01.11.18	27.12.18	1735	0.63	1.24	1.24
NH H	01.11.18	27.12.18	1762	0.51	1.13	1.27
		Av.	1749	0.57	Av.	1.22

NH Flexural Strength and Compressive Strength (90 days)

Ref	Cast Date	Test Date	Density (Kg/m ³)	Flexural Strength (N/mm ²)	Compressive Strength (N/mm ²)	Compressive Strength (N/mm ²)
NH J	01.11.18	30.01.19	1769	0.92	1.19	1.24
NH K	01.11.18	30.01.19	1778	0.96	1.35	1.30
		Av.	1774	0.94	Av.	1.27

NH Flexural Strength and Compressive Strength (180 days)

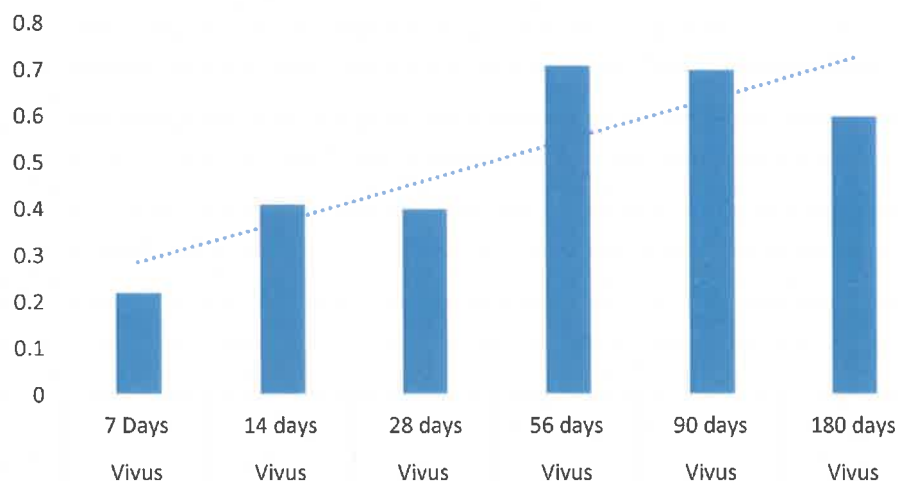
Ref	Cast Date	Test Date	Density (Kg/m ³)	Flexural Strength (N/mm ²)	Compressive Strength (N/mm ²)	Compressive Strength (N/mm ²)
NH L	01.11.18	30.04.19	1734	0.80	2.14	2.06
NH M	01.11.18	30.04.19	1794	0.76	2.17	2.03
		Av.	1764	0.78	Av.	2.10

Kiwa CMT**Summary Table of Results Vivus/NH**

	Vivus	Vivus	Vivus	Vivus	Vivus	Vivus	NH	NH	NH	NH	NH	NH
Ref	7 Days	14 days	28 days	56 days	90 days	180 days	7 Days	14 days	28 days	56 days	90 days	180 days
	Av.	Av.	Av.	Av.	Av.	Av.	Av.	Av.	Av.	Av.	Av.	Av.
Density (Kg/m ³)	1683	1639	1656	1655	1686	1672	1727	1707	1734	1749	1774	1764
Flexural Strength (N/mm ²)	0.22	0.41	0.40	0.71	0.70	0.60	0.31	0.53	0.48	0.57	0.94	0.78
Compressive Strength (N/mm ²)	Av.	Av.	Av.	Av.	Av.	Av.	Av.	Av.	Av.	Av.	Av.	Av.
Compressive Strength (N/mm ²)	0.53	0.60	1.01	1.00	1.79	1.87	0.83	1.10	1.06	1.22	1.27	2.10

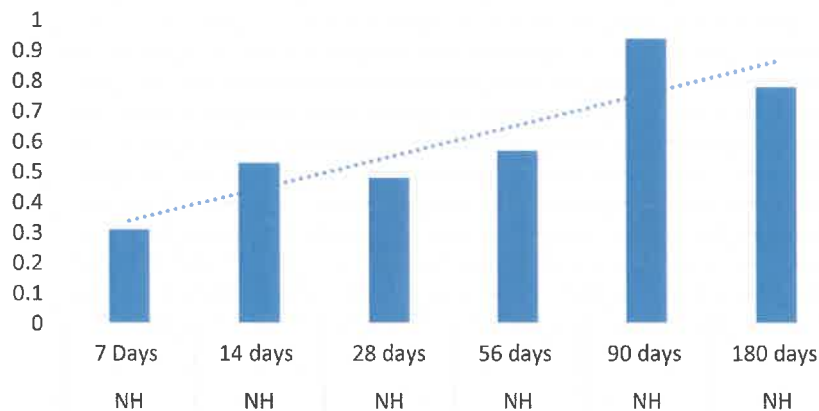
Flexural Strength VIVUS Table

	Vivus	Vivus	Vivus	Vivus	Vivus	Vivus
	7 Days	14 days	28 days	56 days	90 days	180 days
Flexural Strength (N/mm ²)	0.22	0.41	0.40	0.71	0.70	0.60

Flexural Strength (N/mm²)

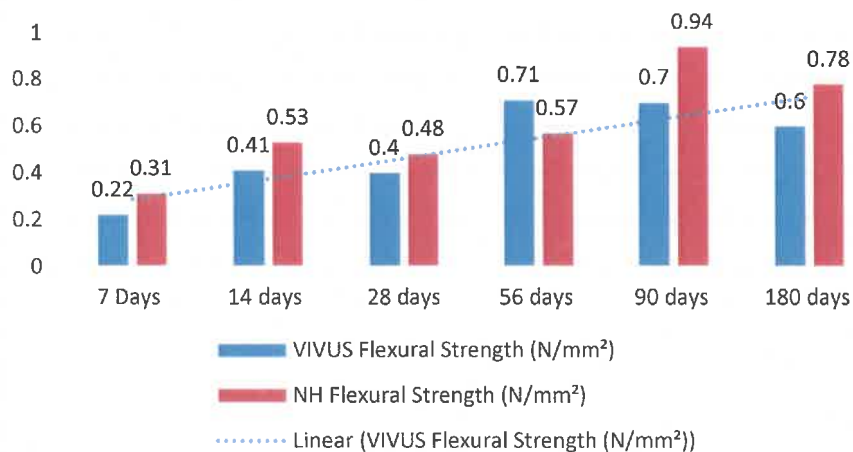
Kiwa CMT**Summary: Flexural Strength NH Table**

	NH	NH	NH	NH	NH	NH
	7 Days	14 days	28 days	56 days	90 days	180 days
Flexural Strength (N/mm ²)	0.31	0.53	0.48	0.57	0.94	0.78

Flexural Strength (N/mm²)**Combined Table VIVUS/NH**

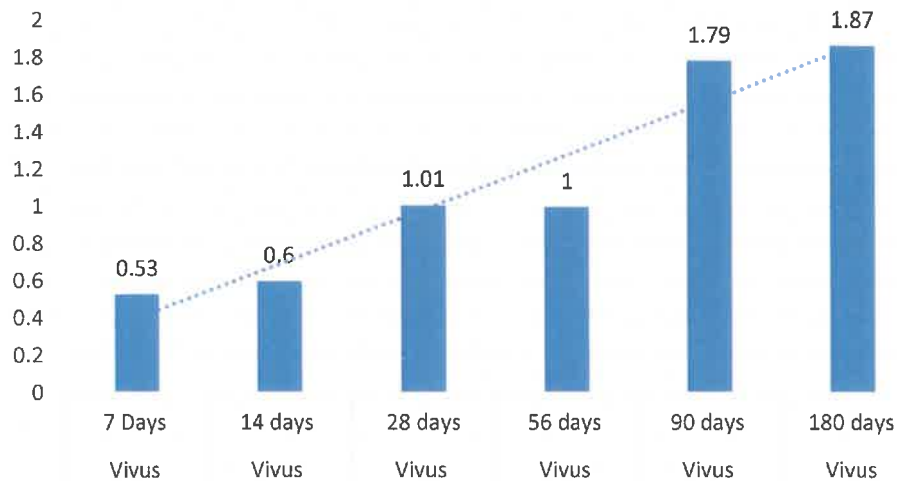
	7 Days	14 days	28 days	56 days	90 days	180 days
VIVUS Flexural Strength (N/mm ²)	0.22	0.41	0.40	0.71	0.70	0.60
NH Flexural Strength (N/mm ²)	0.31	0.53	0.48	0.57	0.94	0.78

Flexural Strength Combined

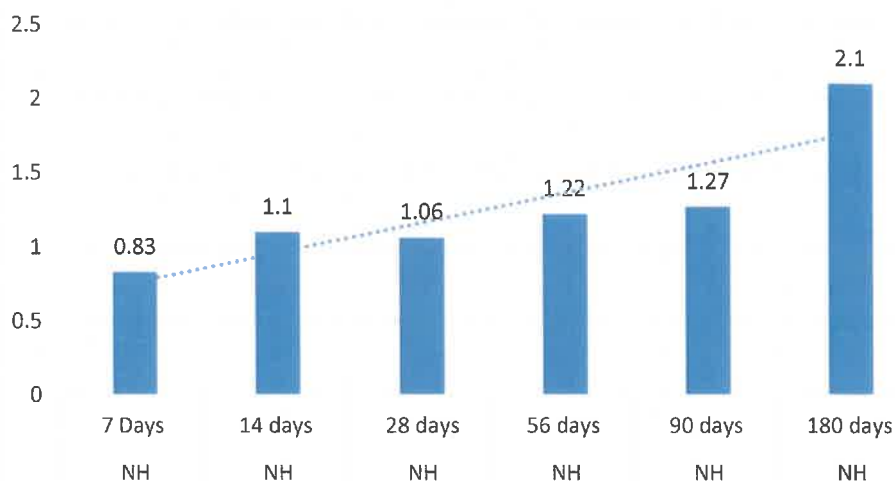


Compressive Strength VIVUS

	Vivus	Vivus	Vivus	Vivus	Vivus	Vivus
	7 Days	14 days	28 days	56 days	90 days	180 days
Compressive Strength (N/mm ²)	0.53	0.60	1.01	1.00	1.79	1.87

Compressive Strength (N/mm²)**Compressive Strength NH**

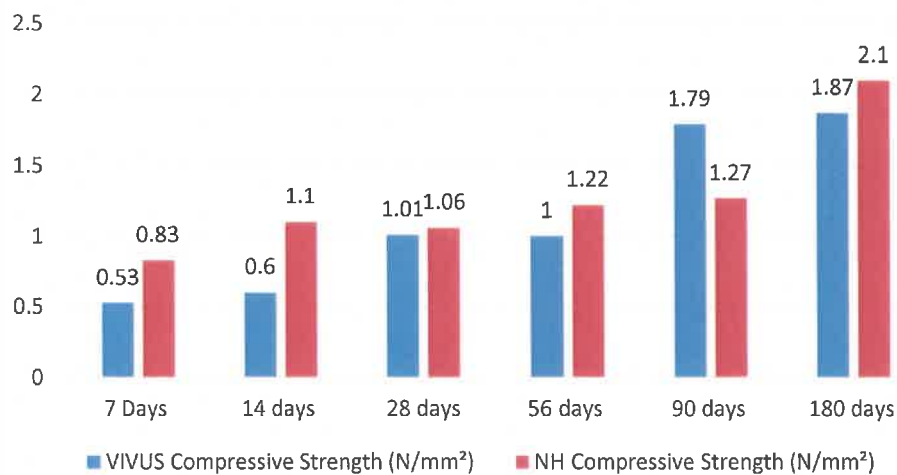
	NH	NH	NH	NH	NH	NH
	7 Days	14 days	28 days	56 days	90 days	180 days
Compressive Strength (N/mm ²)	0.83	1.10	1.06	1.22	1.27	2.10

Compressive Strength (N/mm²)

Compressive Test Combined VIVUS/NH

	7 Days	14 days	28 days	56 days	90 days	180 days
VIVUS Compressive Strength (N/mm²)	0.53	0.60	1.01	1.00	1.79	1.87
NH Compressive Strength (N/mm²)	0.83	1.10	1.06	1.22	1.27	2.10

Compressive Strength Combined



Behaviour of mortar under loading

In order to evaluate how the mortars, in both the relatively fresh and hardened state, would behave when laid, brick-bonded and subjected to loading, numerous samples were created using 2No engineering bricks and a nominal 10mm bed of each mortar bonding the 2No bricks.

This test is not governed by any standard, known to ourselves, and was used to attempt to demonstrate a 'quicker build rate' between the Vivus #1 and 4:1 NHL mortars.

The original height of the samples were measured at 4 points and the samples then subjected to 3No load increments of 100kN (10.2T), 200kN (20.4T) and 800kN (81.6T) equivalent, based on the surface area of the brick test surfaces, to 4.6, 9.2 and 36.5 N/mm² respectively. After each incremental loading the samples were re-measured before applying the next load.

Individual samples were produced for testing/loading at 2 hours, 24 hours, 4 days, 28 days, 56 days and 180 days.

Results in mm from original measurements.

Vivus #1

V1 (2 Hours)	Point A	Point B	Point C	Point D
100 KN	-0.5	-0.5	-1.0	-0.5
200 KN	-0.5	-1.0	-1.0	-1.0
800 KN	-0.5	-1.0	-1.5	-1.0

Mortar being expelled from the bedding joint at 180KN

V1 (24 Hours)	Point A	Point B	Point C	Point D
100 KN	-0.5	-0.5	0.0	0.0
200 KN	-1.0	-1.0	-0.5	0.0
800 KN	-1.0	-1.0	-0.5	-0.5

Mortar being expelled from the bedding joint at 60KN

V1 (4 Days)	Point A	Point B	Point C	Point D
100 KN	-0.5	-1.0	-0.5	0.0
200 KN	-0.5	-1.0	-0.5	-0.5
800 KN	-0.5	-1.0	-0.5	-0.5

Mortar being expelled from the bedding joint at 55KN

Vivus #1 (contd.)

V1 (28 Days)	Point A	Point B	Point C	Point D
100 KN	0.0	0.0	0.0	-1.0
200 KN	0.0	0.0	0.0	-1.0
800 KN	0.0	-0.5	-0.5	-1.5

Mortar being expelled from the bedding joint at 120KN. Bond between Brick and Mortar Joint separated following application of 800KN load.

V1 (56 days)	Point A	Point B	Point C	Point D
100 KN	0.0	0.0	0.0	-0.5
200 KN	-0.5	-0.5	-1.0	-0.5
800 KN	-0.5	-0.5	-1.0	-0.5

Mortar being expelled from the bedding joint at 120KN. Bond between Brick and Mortar Joint separated following application of 800KN load.

V1 (180 Days)	Point A	Point B	Point C	Point D
100 KN	0.0	0.0	-0.5	-0.5
200 KN	-0.5	-0.5	-0.5	-0.5
800 KN	-0.5	-0.5	-0.5	-0.5

Mortar being expelled from the bedding joint at 130KN. Bond between Brick and Mortar Joint separated following application of 800KN load.

4:1 NHL Mortar

NH (2 Hours)	Point A	Point B	Point C	Point D
100 KN	0.0	0.0	-1.0	-0.5
200 KN	-1.0	0.0	-1.0	-0.5
800 KN	-1.5	0.0	-1.0	-1.0

Mortar being expelled from the bedding joint at 60KN

NH (24 Hours)	Point A	Point B	Point C	Point D
100 KN	0.0	-0.5	0.0	0.0
200 KN	0.0	-0.5	-0.5	-0.5
800 KN	-0.5	-0.5	-0.5	-1.0

Mortar being expelled from the bedding joint at 40KN. Brick cracked at 800KN

4:1 NHL Mortar (contd)

NH (4 Days)	Point A	Point B	Point C	Point D
100 KN	-0.5	-1.0	-0.5	-0.5
200 KN	-1.0	-1.0	-1.0	-0.5
800 KN	-1.0	-1.0	-1.0	-0.5

Mortar being expelled from the bedding joint at 30KN. Brick cracked at 800KN

NH (28 Days)	Point A	Point B	Point C	Point D
100 KN	0.0	-0.5	-0.5	0.0
200 KN	-0.5	-1.0	-0.5	0.0
800 KN	-0.5	-1.0	-1.0	-0.5

Mortar being expelled from the bedding joint at 150KN. Bond not separated but severe edge degradation of mortar after 800KN loading

NH (56 Days)	Point A	Point B	Point C	Point D
100 KN	0.0	-0.5	-0.5	-0.5
200 KN	-0.5	-1.0	-1.0	-1.0
800 KN	-1.0	-1.0	-1.0	-1.0

Mortar being expelled from the bedding joint at 140KN. Bond not separated but severe edge degradation of mortar after 800KN loading

NH (180 Days)	Point A	Point B	Point C	Point D
100 KN	0.0	-0.5	0.0	-0.5
200 KN	-0.5	-1.0	-0.5	-1.0
800 KN	-0.5	-1.0	-0.5	-1.0

Mortar being expelled from the bedding joint at 160KN. Bond not separated but severe edge degradation of mortar after 800KN loading

Kiwa CMT**Summary Table: Vivus/NH**

TOTAL EXPULSION OF MORTAR	100 KN	200 KN	800 KN	TOTAL		100 KN	200 KN	800 KN	TOTAL	Variance VIVUS	Variance NH
Vivus (2 Hours)	-2.5	-3.5	-4	-10	NH (2 Hours)	-1.5	-2.5	-3.5	-7.5	-2.5	0
Vivus (24Hours)	-2	-2.5	-2.5	-6.5	NH (24 Hours)	-2.5	-3.5	-3.5	-4.5	-2	0
Vivus (4 days)	-2	-2.5	-2.5	-7	NH (4 days)	-2.5	-3.5	-3.5	-9.5	0	-2.5
Vivus (28 days)	-1	-1	-2.5	-4.5	NH (28 days)	-1	-2	-3	-6	0	-1.5
Vivus (56 days)	-0.5	-2.5	-2.5	-5.5	NH (56 days)	-1.5	-3.5	-4	-9	0	-3.5
Vivus (180 days)	-1	-2	-2	-5	NH (180 days)	-1	-3	-3	-7	0	-2

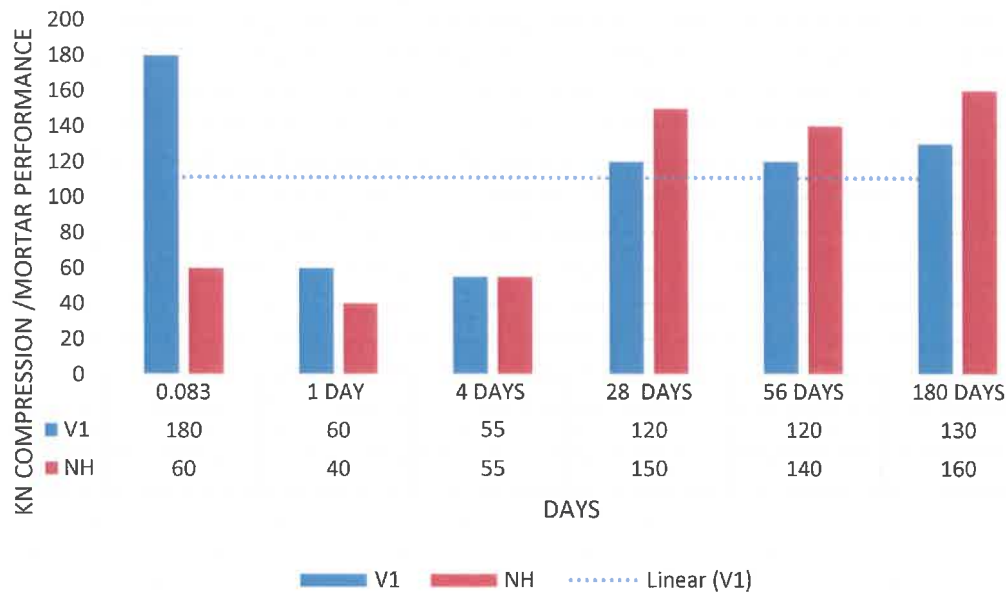
Observations:

There is not a substantial difference between the two mixes overall.
 Vivus1 becomes retains more mortar after 24 hours and does not lose as much mortar overall as compared to NH after 4 days.

Summary of Expulsion of Mortar Test Vivus/NH

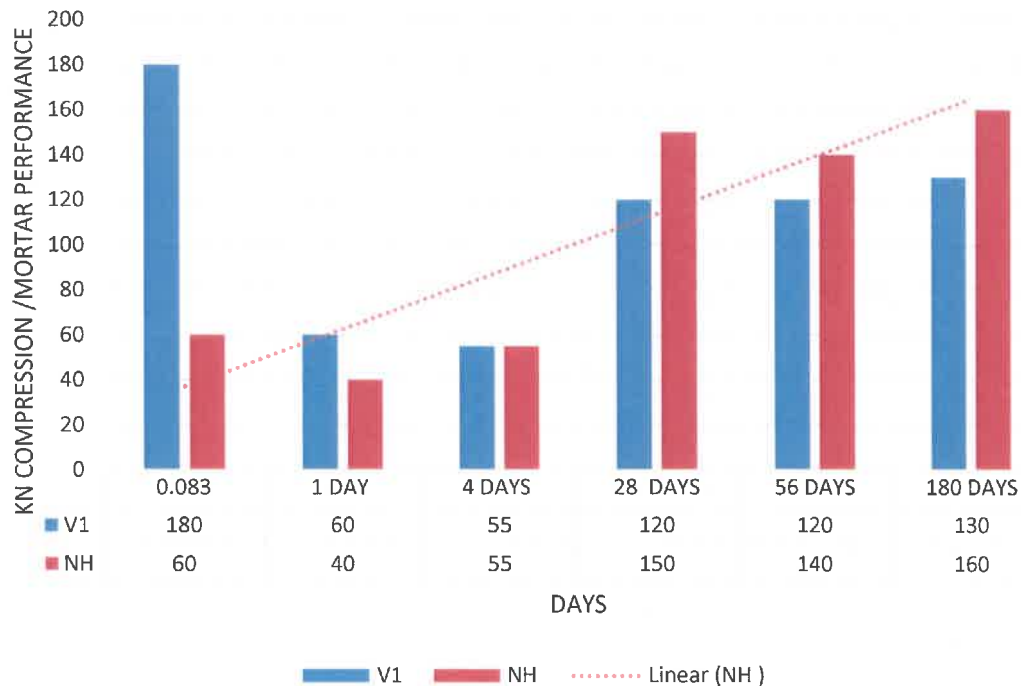
	0.083 (2 Hrs)	1 DAY	4 DAYS	28 DAYS	56 DAYS	180 DAYS
V1 (KN)	180	60	55	120	120	130
NH (KN)	60	40	55	150	140	160

MORTAR RETENTION AFTER KN COMPRESSION

**Observation:**

- (i) This table (Mortar Retention after Compression) shows that Vivus requires more compression as compared to NH before expulsion of mortar from the mortar bed from the beginning of build/laying of bricks (and then reaches parity with NH on day 4) VIVUS allows for a much faster building rate through heavier load (more brick courses per diem) and less down time for the bricklayers saving site costs.
- (ii) Note the trendline is constant whilst below NH requires more days to improve.
- (iii) Parity with NH by day 4.

MORTAR RETENTION AFTER KN COMPRESSION

**Observation:**

NH Improves over time, however it is significantly less than Vivus during the first 4 days.

Expulsion of Mortar: Comparison Vivus/NH under different loadings.

EXPULSION OF MORTAR	2HRS	1 DAY	4 DAYS	28 DAYS	56 DAYS	180 DAYS
Vivus 100KN	-2.5	-2	-2	-2	-1	-0.5
Vivus 200KN	-3.5	-2.5	-2.5	-1	-2.5	-2
Vivus 800KN	-4	-2.5	-2.5	-2.5	-2.5	-2
EXPULSION OF MORTAR	2 HRS	1 DAY	4 DAYS	28 DAYS	56 DAYS	180 DAYS
NH 100KN	-1.5	-2.5	-2.5	-1	-1.5	-1
NH 200KN	-2.5	-3.5	-3.5	-2	-3.5	-3
NH 800KN	-3.5	-3.5	-3.5	-3	-4	-3

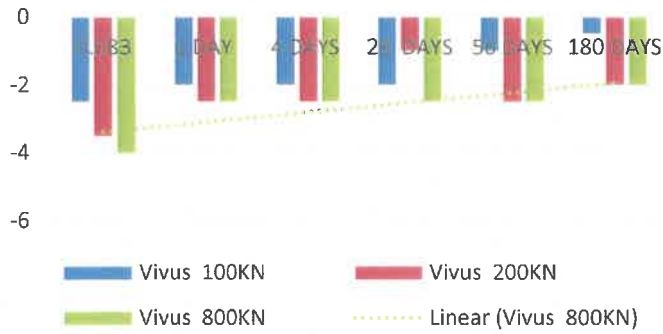
Observation:

From the Charts it is possible to note that Vivus is not expelled from the bricks in the same amounts as NH and continues to reduce over time. It is also notable that under 800KN and 200KN loading Vivus is significantly better than NH.

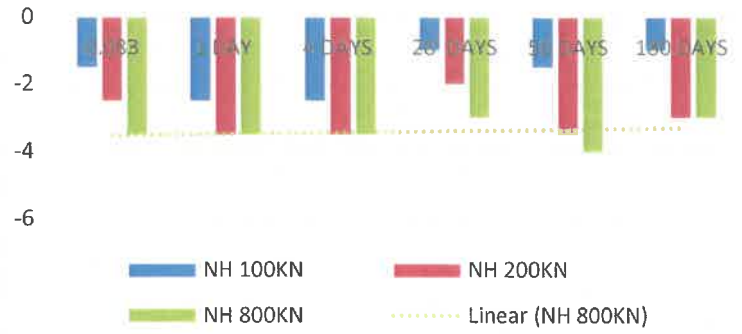
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EXPULSION OF MORTAR- VIVUS



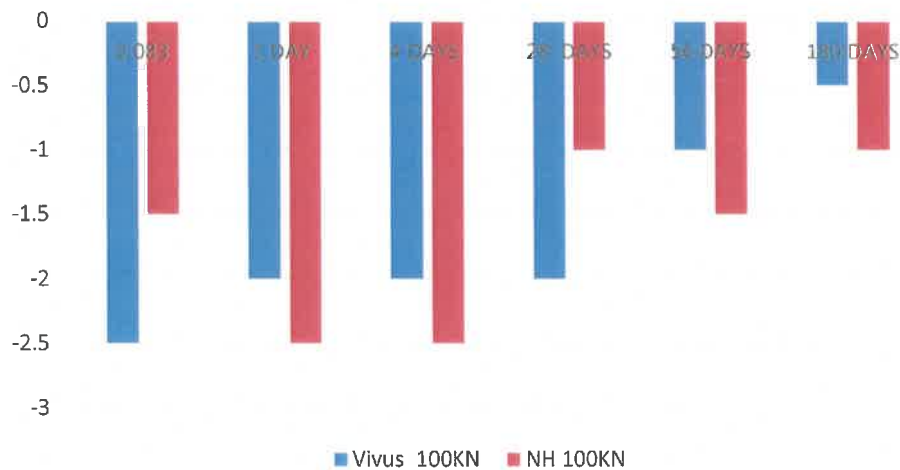
EXPULSION OF MORTAR- NH



Expulsion of Mortar :100 KN Loading

EXPULSION OF MORTAR	2HR	1 DAY	4 DAYS	28 DAYS	56 DAYS	180 DAYS
Vivus 100KN	-2.5	-2	-2	-2	-1	-0.5
NH 100KN	-1.5	-2.5	-2.5	-1	-1.5	-1

100KN Loading VIVUS vs NH

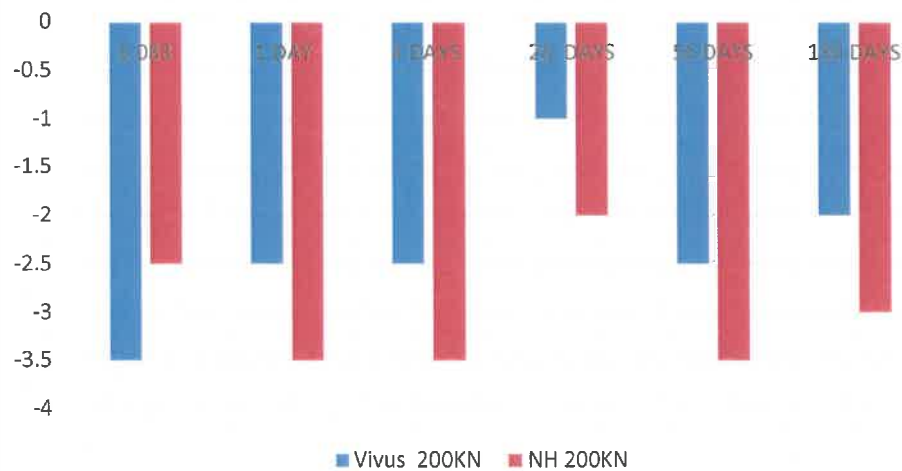


**Note: Vivus remains constant from 1 day to 28 days.
NH from 1 to 4 days**

Expulsion of Mortar : 200 KN Loading

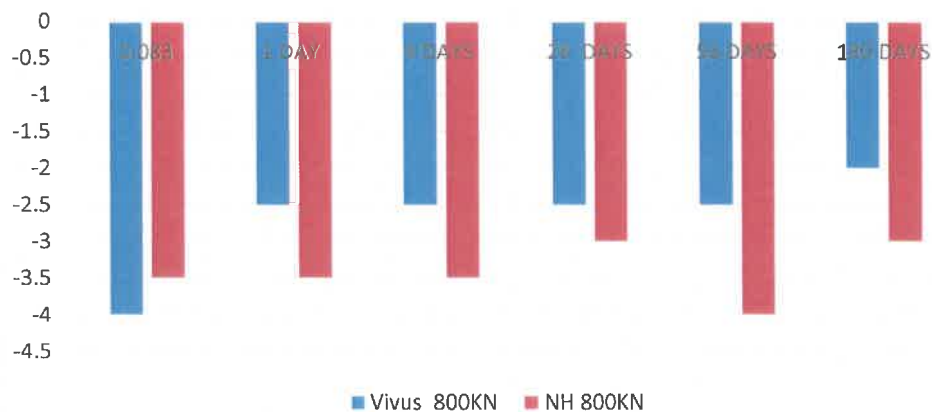
EXPULSION OF MORTAR	2HR	1 DAY	4 DAYS	28 DAYS	56 DAYS	180 DAYS
Vivus 200KN	-3.5	-2.5	-2.5	-1	-2.5	-2
NH 200KN	-2.5	-3.5	-3.5	-2	-3.5	-3

200KN Loading Vivus vs NH

**Expulsion of Mortar : 800 KN Loading**

EXPULSION OF MORTAR	2HR	1 DAY	4 DAYS	28 DAYS	56 DAYS	180 DAYS
Vivus 800KN	-4	-2.5	-2.5	-2.5	-2.5	-2
NH 800KN	-3.5	-3.5	-3.5	-3	-4	-3

800KN Loading Vivus vs NH



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Observation: Vivus more constant overall

Observation: Mortar Failure and some examples of Engineering Brick failure.

VIVUS

It was observed that using VIVUS the engineering bricks remained intact and the mortar did not degrade.

NH Mortar

Further, it was observed that using NH mortar some of the engineering bricks failed at 800KN loading as well as the mortar.

The severe edge degradation of NH mortar under compression suggests that the mortar failed throughout. Indeed, it was noted and photographed.

MORTAR	LOAD	VIVUS
V1 (2 Hours)	180KN	Mortar being expelled from the bedding joint at 180KN
V1 (24 Hours)	60KN	Mortar being expelled from the bedding joint at 60KN
V1 (4 Days)	55KN	Mortar being expelled from the bedding joint at 55KN
V1 (28 Days)	120KN	Mortar being expelled from the bedding joint at 120KN.
V1 (28 Days)	800KN	Bond between Brick and Mortar Joint separated following application of 800KN load.
V1 (56 days)	120KN.	Mortar being expelled from the bedding joint at 120KN.
V1 (56 days)	800KN	Bond between Brick and Mortar Joint separated following application of 800KN load
V1 (180 Days)	130KN	Mortar being expelled from the bedding joint at 130KN
V1 (180 Days)	800KN	Bond between Brick and Mortar Joint separated following application of 800KN load

MORTAR	LOAD	NH
NH (2 Hours)	60KN	Mortar being expelled from the bedding joint at 60KN
NH (24 Hours)	40KN	Mortar being expelled from the bedding joint at 40KN
NH (24 Hours)	800KN	Brick cracked at 800KN
NH (4 Days)	55KN	Mortar being expelled from the bedding joint at 55KN
NH (4 Days)	800KN	Brick cracked at 800KN
NH (28 Days)	150KN	Mortar being expelled from the bedding joint at 150KN.
NH (28 Days)	800KN	Bond not separated but severe edge degradation of mortar after 800KN loading
NH (56 days)	140KN.	Mortar being expelled from the bedding joint at 140KN.
NH (56 days)	800KN	Bond not separated but severe edge degradation of mortar after 800KN loading
NH (180 Days)	160KN	Mortar being expelled from the bedding joint at 160KN
NH (180 Days)	800KN	Bond not separated but severe edge degradation of mortar after 800KN loading

Important:

Please note that these test results only pertain to the samples tested and the materials used in this project. It does not infer compliance with any future batches or brick types used. Changes in raw materials, mixing techniques, fluctuating temperatures and humidity have not been examined in this study.

Kiwa CMT Testing



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