ST0597-3

Formblock Construction Report and Design Recommendations

(this report replaces report ST0597-1

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Formblock Construction Report

1. CLIENT

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2. OBJECTIVE

To evaluate the extent to which blockfill will flow into the Formblock block wall cavity and compact around the reinforcing bars, and from this to comment on the appropriate design procedures to be used with the system.

3. SCOPE

On 7th December 2004 a set of three Formblock block walls was constructed in the BRANZ Structures Laboratory for face load testing. This testing is reported elsewhere as BRANZ Report ST 0597.

A further set of three walls were cast on 7th January 2005 for structural testing and at the same time as these block walls were cast, a fourth wall was cast to be used to evaluate the constructability of the wall and in particular the flow of the blockfill in the wall cavity and the penetration of blockfill into the horizontal "dry" joints between the stacked blocks.

4. BLOCKFILL

The blockfill was supplied by Allied Concrete Upper Hutt under the direction of Stevenson Ready Mixed Concrete Ltd staff from Auckland. The Formblock mix design from the Australian literature specifies a superplasticised greater than 20 MPa mix with a slump of 200-250 mm. Such a slump is considered by BRANZ to be too large to be appropriately measured using the slump test. A more appropriate test is the determination of spread of concrete test (NZS 3112:Part1:1986). NZS 4210, Masonry construction and materials, also states (C2.3.2.1)] that "grout infill (blockfill) must have characteristics of flow which are considerably different from those of concrete. While the slump test is an appropriate test for measuring characteristics of concrete, it is technically inappropriate for grout." The mix is designed with an expansive admixture to offset plastic settlement.

A spread measurement and compression blocks were taken by BRANZ for both pours and the results are presented in Table 1. The spread and compression tests were carried out in accordance with NZS 3112. All compression cylinders were wet conditioned up until test.

Blockfill Mix	Mix 1 Poured 7/12/2004	Mix 2 Poured 7/1/2005
Spread	450mm average	550mm
7 day Compression	17.0 MPa	-
28 Day Compression	22.0 MPa	22.0 MPa
Compression at Test	23.5 MPa at 62 days	22.5 MPa at 31 days

Table 1: Concrete Blockfill Test Results

The workability of the blockfill for the first pour was too low and this had repercussions for the penetration of the blockfill into the wall cavity. The concrete mix was adjusted by the Stevensons staff for the second pour which resulted in an improvement in the workability.

The target strength for a 20 MPa mix in accordance with NZS 3104 “Specification for Concrete Production” is 24.0 MPa at 28 days. The measured 28 day strength for both pours was above the specified strength but slightly below the target 28 day strength.

5. WALL CASTING

Comment on the construction process is limited in the remainder of this report to the performance of the second pour, because it was agreed that the mix used in the first pour was unsuitable and would therefore never be specified.

Wall 2, poured on 7th January, was 2.4 metres high by 1.6 metres wide. It had two D12 vertical bars only, 800 mm apart.

The vertical bars were used as rodding to assist the flow of the blockfill through the wall cavity.

Wall 2 was soaked prior to concreting to minimise water absorption from the mix at the time that the blockfill was poured.

The blockfill in Wall 2 had good workability, as indicated by the increased spread of the mix, and there was no noticeable plastic settlement.

6. EVALUATION OF ADHERENCE OF BLOCKFILL TO MASONRY SHELL

6.1 Wall 2

As stated in Section 4, Wall 2 had a more workable blockfill and the wall was soaked prior to the pour.

Two 600mm square sections were cut from the middle of the wall. A longitudinal section was also cut off the side of the wall. Figures 1 to 3 show these cut cross-sections.

All cross-sections show good compaction in the Formblock cavity and a close-knit bond between the blockfill and the masonry shell.

A close inspection of the horizontal “dry” joints between the blocks also revealed that the blockfill had seeped into the space between the blocks, effectively filling the gap to the outer edge of the contact area.

Figure 1 – Cut longitudinal section of wall 2

Figure 2 – Close up of cut wall.

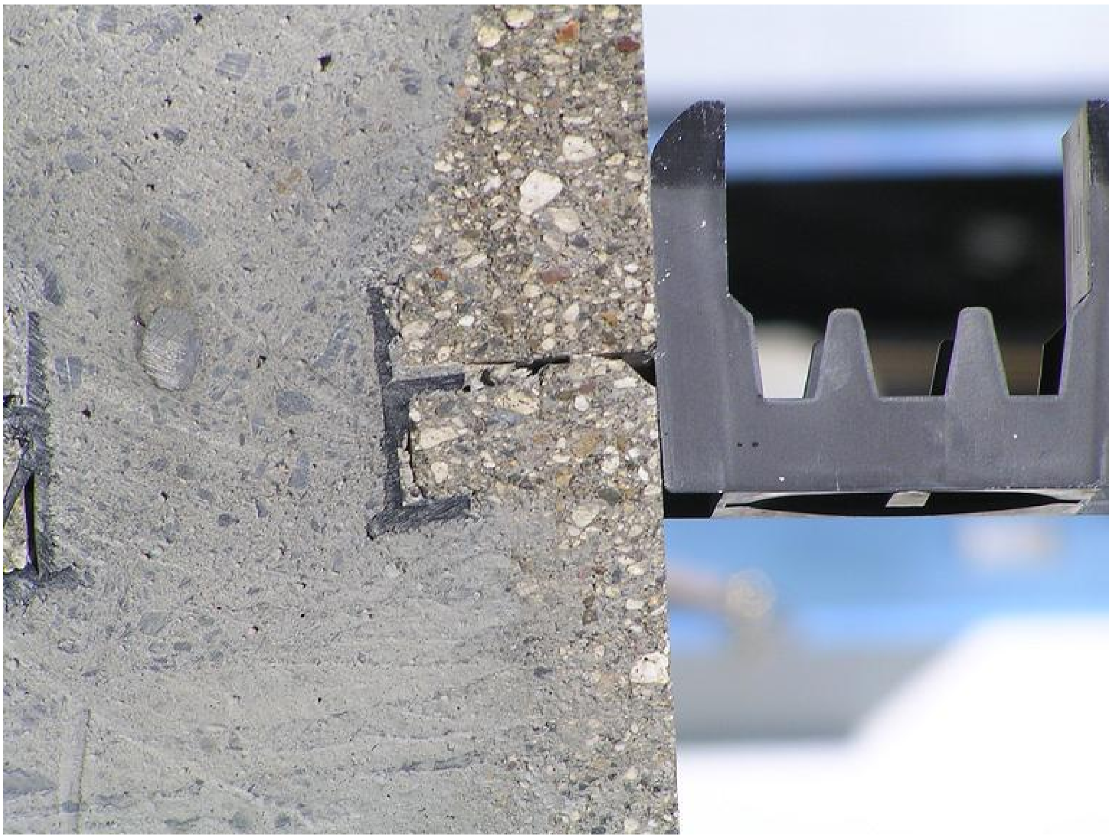

Figure 3 – Close up showing plastic bridge

7. STARTER BAR SPLICES

Plastic chairs are used to locate the block layers with respect to each other (see Figure 3). The vertical reinforcing steel passes through the chairs. The bottom two courses of blocks will each have a horizontal bar in normal construction, placed in the locator slots, one on each side of the chair. This serves to locate the vertical bar in the centre (±12 mm) of the wall. In the along wall direction, the starter bar is expected to be in the correct position. The main vertical bars form non-contact lap splices with the starter bars. The maximum misalignment of the vertical steel is 50 mm if the starter bar is not accurately placed and 25 mm if accurately placed. Thus, the lap length for D12 starter bars must be set at 400 mm.

8. CONCLUSIONS

8.1 Construction

Based on the examination of the Formblock walls cast at BRANZ coincidental with the structural testing programme, BRANZ recommends that presoaking of the masonry shells should always be carried out immediately prior to filling the cavity with blockfill.

It appeared that a blockfill spread of 550mm was sufficient to ensure adequate flow of the blockfill within the cavity and to ensure adequate seepage between the dry stacked block joints to fill the joint and form a bond with the masonry shell. A spread of 550 mm should be specified in the literature.

While the details are not reported here, the wall cast in December was 3 m high and demonstrated that walls up to 3 m high could be filled satisfactorily with blockfill with rodding provided by the vertical bars.

Non-contact lap splices between vertical bars and the corresponding starter bars are acceptable with Formblock walls, given that they are constrained within the plastic chairs used to maintain alignment of the blocks. D12 starter bars must lap the main vertical steel over a minimum length of 400 mm. For walls that span vertically under face loading, the horizontal bars must be placed alternately on either side of the vertical bars to maintain the vertical bar at a position near the centre of the wall.

Because the walls are dry stacked, there are no mortar droppings and because the bars are non-contact spliced, there is no need to provide clean-out/access ports at the bottom of the walls.

8.2 Design

The Formblock system is expected to be predominantly designed as an elastically responding system. The provisions contained in NZS 4230:2004 will be applicable, with the following modifications.

With reference to test report ST0597-2, the following design procedures may be used with the Formblock system.

For the design of Formblock walls for face loading, the bending strength may be calculated using the formula:

$M = \phi A_s f_y (D-7-a/2)$

Where

M	=	out-of-plane bending strength
ϕ	=	capacity reduction factor (=0.85)
A_s	=	area of vertical steel
f_y	=	yield strength of the reinforcing steel
D	=	half the block thickness
7	=	the width of the chamfer on the outside of the block
a	=	$(A_s f_y) / (0.85 f'_m b)$
f'_m	=	characteristic masonry strength, 12 MPa
b	=	the length of the wall

For the design of elastically responding gravity loadbearing walls, where the axial load is centred within the middle third of the wall, the nominal axial strength may be calculated using the following formula:

$N_{nw} = 0.5 f'_m A_g [1-(L_n/40d)^2]$

Where

N_{nw}	=	nominal axial load strength
f'_m	=	characteristic masonry strength, 12 MPa
A_g	=	gross area of the section (= wall horizontal length x d)
L_n	=	clear vertical distance between lines of effective horizontal support
d	=	the contact thickness of the Formblock wall (= 190 – 2 x 7)

For in-plane shear loading, the shear strength may be calculated as follows:

Use the provisions for shear strength contained in chapter 10 of NZS 4230:2004, where b_w = 176 mm (= 190 – 2 x 7).

GJB NPL