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The Temperatures Recorded in Five Indicative Assemblies Built into a Block-work Wall During a Natural Fire Test at BRE Cardington on November 4th. 1998

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1) Introduction

On November 4th. 1998 a natural fire test was carried out on a loaded asymmetric Slimdek floor beam assembly at the Building Research Establishments Large Building Test Facility situated at Cardington near Bedford. Details of the test are contained in a report [1] prepared by the BRE.

The principal purpose of the test was to investigate the performance of the Slimdek floor system when subjected to a severe fire. However, it also presented an opportunity to obtain data concerning the heat transfer characteristics of steel sections when built into block-work and concrete walls. Therefore, as part of the overall test programme, a series of indicative specimens were installed in one wall of the compartment. This technical memo gives details concerning the fabrication and instrumentation of the various specimens, together with the data recorded for each and any relevant observations. No attempt has been made to provide a detailed analysis of the data. This aspect of the work is currently on-going and will form the basis of a further report.

2) Test Compartment

The general layout of the 12 metre square test compartment is shown in Figure 1. The perimeter walls were constructed using Plasmor 'STRANLITE' block-work, the block dimensions being 440 x 215 x 190 mm, (length x depth x thickness). Some technical data relating to this product are given in Appendix 1.

3) Indicative Specimens (Instrumentation)

The indicative specimens consisted of the following :-

(a) Two identical 254 x 146 mm x 43 kg/m x 800 mm long UB sections which passed through the block-work wall with equal lengths of the section protruding both internally and externally. The thermocouple positions in the sections were as shown in Figures 2 and 3. Each specimen also had a thermocouple projecting from the lower flange to record the local furnace atmosphere temperature. All the thermocouples used were Class 1, 3 mm diameter Type 'K' and were located at the mid-thickness position in the steel element. The mean dimensions for the UB section were as shown in the following table.

		NOMINAL	ACTUAL
Depth of Section	D, mm	259.6	261.1
Width of Section	B, mm	147.3	146.8
Web Thickness	t, mm	7.3	7.34
Flange Thickness	T, mm	12.7	12.81
Root Radius	r, mm	7.6	not measured

(b) Two sets of identical steel bars, nominally 12.5, 25 and 80 mm diameter x 800 mm long which were cast into concrete blocks having the same length and depth as a Stranlite block. Two such blocks were produced, one being the same thickness as a Stranlite block, (i.e. 190 mm.), the other being 100 mm thick. The bars were situated with their centres at the mid-height of the blocks, the horizontal spacing between their centres being 150 mm as shown in Figure 4. The bars had equal lengths protruding on either side of the concrete.

The bar diameters were selected on the basis of their nominal section factors which are 320, 160 and 50 m^{-1} respectively. The section factor for a solid circular section is given by (4000/D), where D is the section diameter in mm. The measured mean diameters for the three bars were 12.64, 24.98 and 79.96 mm and hence the actual section factors were 316.46, 160.13 and 50.03 m^{-1} respectively.

The thermocouple positions in each of the six bars were as shown in Figures 5 and 6. Like the UB sections, thermocouples also projected from each of the 80 mm diameter pieces to record the local furnace atmosphere temperatures. The method employed for locating the thermocouples in the steel involved drilling a 3.1 mm diameter hole through the full vertical diameter of each section to within 1 mm of the bottom face. The thermocouples were then inserted into these holes. Since the hot junction of a 3 mm diameter thermocouple is located around 1.5 to 2.0 mm from its end the measurement positions in the bars were, therefore, all approximately 2.5 to 3.0 mm from the lowest point of the section.

(c) One of the Stranlite blocks used for constructing the compartment walls was instrumented as shown in Figure 7. The purpose of this was to obtain a horizontal thermal profile through the thickness of the block-work. Each 3 mm diameter thermocouple was inserted into a hole drilled down from the top surface to a depth of 70 mm.

4) Indicative Specimens (Construction)

All the indicative specimens were installed in the South facing wall of the compartment in the region between column C2 and the buttress pillar situated mid-way between that column and the corner column C1. They were located in the 3rd course of block-work down from the top. Figure 8 shows a general view of this being carried out.

The instrumented Stranlite block was located between the two 254 x 146 UB sections as shown in Figure 9. The lower flanges of these sections were placed in direct contact with the top of the 4th course down of block-work, i.e. with no mortar joint. The instrumented block and those on either side of the UB section webs were butted up tight so that the steel and block-work were in very close contact. Only the minimum amount of mortar necessary to effect a seal was applied to the ends of the blocks in contact with the UB webs. The lower flanges and webs of the sections were, in effect, substituted for the normal 10 mm mortar joints. Where the block-work came up against the root radii at the flange / web junctions it was very carefully chopped out so as to maintain as close a contact as possible between it and the steelwork.

The 100 and 190 mm thick concrete blocks were installed adjacent to each other, the faces on the fire exposed side being set flush with the surrounding compartment block-work as shown in Figure 10.

Figure 11 is a general view taken from inside the compartment showing all the indicative specimens mounted in the wall. Their horizontal and vertical positions are summarised in Table 1.

5) Thermal Data

The temperatures recorded in the various indicative specimens are presented in Tables 2 to 13. These contain the following information :-

Table 2	254 x 146 mm x 43 kg/m UB Section No. 1 Web positions W1 to W5 plus local atmosphere ATM1 (X36)
Table 3	254 x 146 mm x 43 kg/m UB Section No. 1 Lower flange positions F1 to F5
Table 4	254 x 146 mm x 43 kg/m UB Section No. 2 Web positions W6 to W10 plus local atmosphere ATM2 (X37)
Table 5	254 x 146 mm x 43 kg/m UB Section No. 2 Lower flange positions F6 to F10
Table 6	12.5 mm diameter bar set in the 100 mm thick concrete block. Positions X1 to X5 plus local atmosphere ATM3 (X16)
Table 7	25 mm diameter bar set in the 100 mm thick concrete block. Positions X11 to X15 plus local atmosphere ATM3 (X16)
Table 8	80 mm diameter bar set in the 100 mm thick concrete block. Positions X6 to X10 plus local atmosphere ATM3 (X16)
Table 9	12.5 mm diameter bar set in the 190 mm thick concrete block. Positions X17 to X22 plus local atmosphere ATM4 (X35)
Table 10	25 mm diameter bar set in the 190 mm thick concrete block. Positions X29 to X34 plus local atmosphere ATM4 (X35)
Table 11	80 mm diameter bar set in the 190 mm thick concrete block. Positions X23 to X28 plus local atmosphere ATM4 (X35)

Table 12 Horizontal profile in the Stranlite block.
Positions X38 to X42 plus mean of adjacent local atmospheres, ATM1, (X36), and ATM2, (X37)

Table 13 Local atmosphere data and mean values.

6) Commentary

All the thermocouples appear to have performed satisfactorily with the exception of two, both of which were located in the 190 mm thick concrete block. The thermocouples involved are X26 and X34 located in the 80 and 25 mm diameter steel bars respectively.

In the case of X34 the data recorded from the start of the test were erratic. Whilst some of the values may well be genuine it is difficult to be absolutely certain and so it has been decided to exclude all of them from the data presented here. After 123 minutes the data recorded at this position appears to be acceptable and it has therefore been retained in the released version. No specific reasons have been identified which would account for the initial erratic nature of the data or why it appears to have recovered later in the test. However, the most likely reason would seem to be a faulty connection somewhere in the mass of wiring to the logger.

In the case of X26 it will be noted that there is a gap in the recorded data between 83 and 254 minutes. Its presence is easier, (though very embarrassing), to explain, since this thermocouple was one of several which were connected with the polarities reversed between it and the extension cable to the data logger. This obviously results in all data being recorded on an increasingly negative scale until it exceeds the lower limit for which the data logger is calibrated, (about -200 Deg. C). The missing data are therefore where the temperatures were beyond the recordable range of the instrument and these data have to be considered as irretrievably lost. As the indicative specimen cooled down the values for X26 came back within the recordable range after 254 minutes.

A conversion routine has been established which allows the negative data obtained to be converted back to the positive values which would have been obtained had the thermocouple been wired correctly. It is confidently believed that this conversion routine is sufficiently accurate for the purposes of the present work. The values presented for X26 in Table 11 are those obtained after applying such a correction.

All the data presented in Tables 2 to 13 are available on a single floppy disk, (Excel spreadsheet), a copy of which is included with this document.

7) References

1) T. Lennon & D.B. Moore
"Full Scale Fire Test on a Slimdek Floor System"
Building Research Establishment Report No. TCR 30/99 November 1998

TABLE 1 **Dimensional Details Concerning the Positions of the Indicative Specimens Built into the South Wall of the Compartment**

Indicative Specimen Configuration	Vertical Distance from Top of Compartment Wall to Centre of Specimen, (mm)	Horizontal Distance from Web of Column C2 to c/l of Indicative Element, (mm)
1) 100 mm Thick Concrete Block		
12.5 mm diameter bar	**557.5**	**750**
25 mm diameter bar	**557.5**	**900**
80 mm diameter bar	**557.5**	**1050**
2) 190 mm Thick Concrete Block		
12.5 mm diameter bar	**557.5**	**1200**
25 mm diameter bar	**557.5**	**1350**
80 mm diameter bar	**557.5**	**1500**
3) 254 x 146 mm x 43 kg/m UB No. 1	**545** (To mid-height of Web)	**2025**
4) Stranlite Block	**520**	**2250**
5) 254 x 146 mm x 43 kg/m UB No. 2	**545** (To mid-height of Web)	**2475**

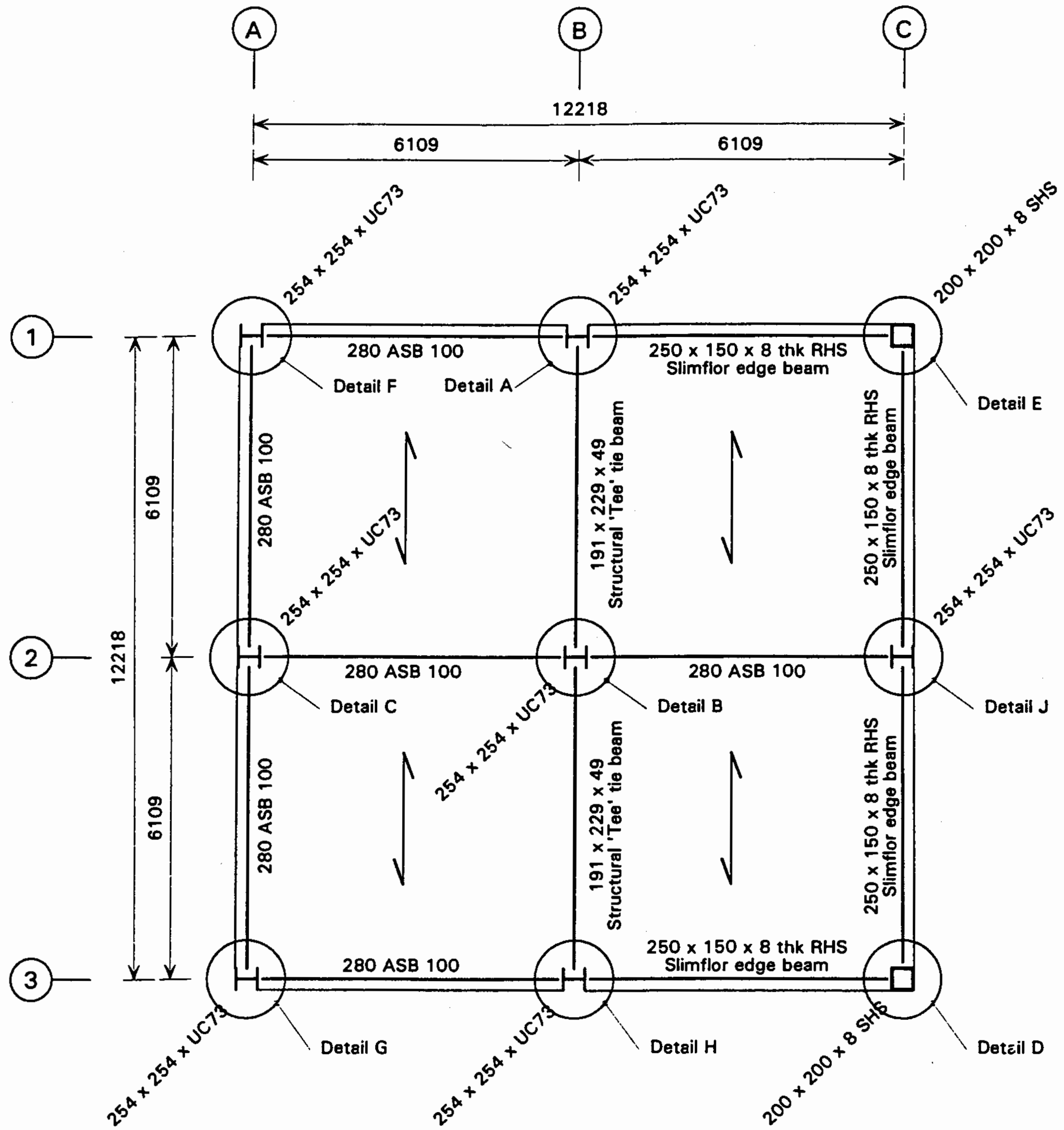


Fig. 1 General Layout of the 12 metre Square Test Compartment (Reproduced from SCI Drawing No. BCF791-1-01)

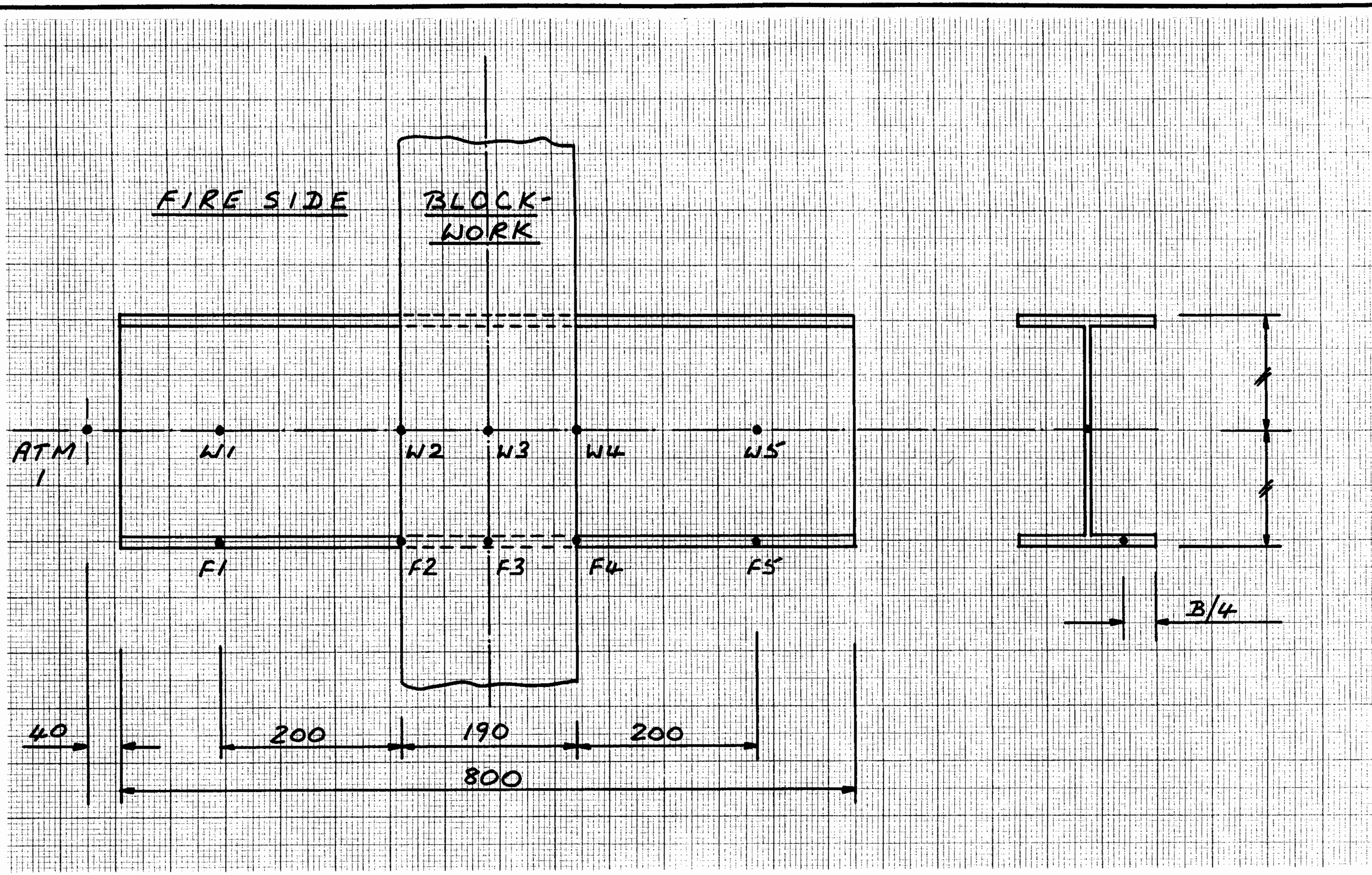


Fig. 2 Thermocouple Positions in the 254 x 146 mm x 43 kg/m UB Built into the Block-Work Perimeter Wall (Indicative Specimen No. 1)

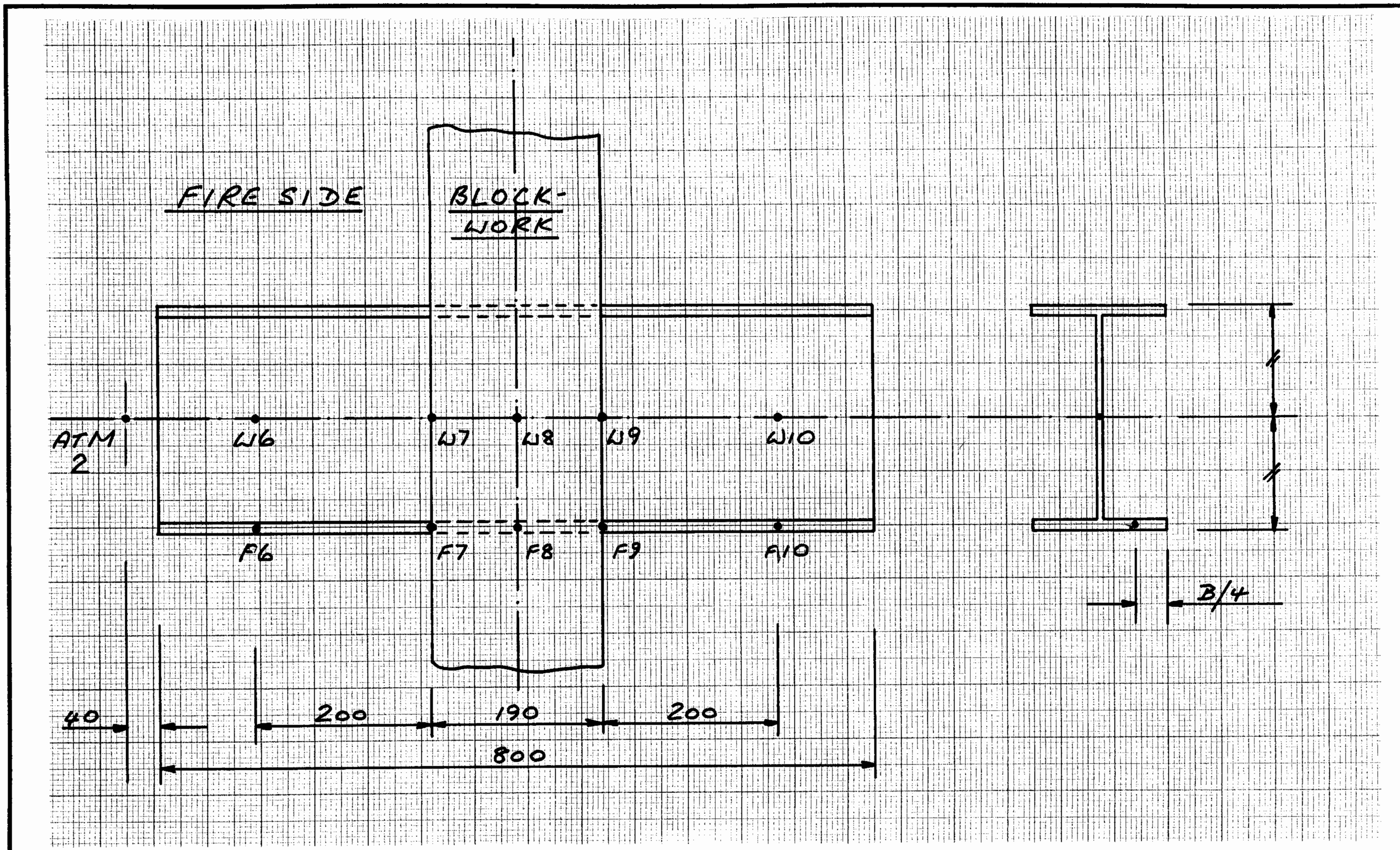


Fig. 3 Thermocouple Positions in the 254 x 146 mm x 43 kg/m UB Built into the Block-Work Perimeter Wall (Indicative Specimen No. 2)

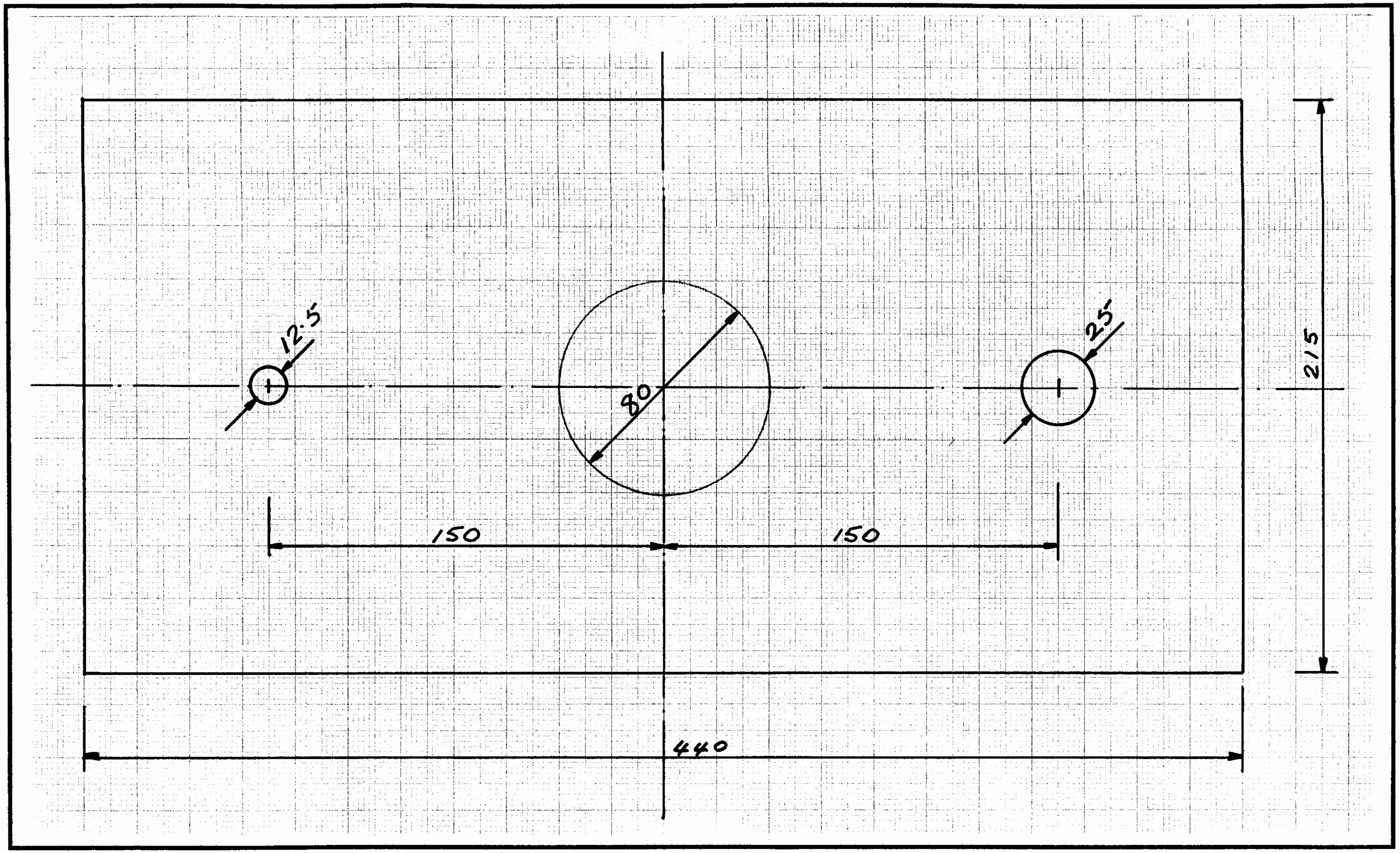


Fig. 4 Positions of the Steel Bars Cast in the 100 mm & 190 mm Thick Concrete Blocks (View from Non-Fire Side)

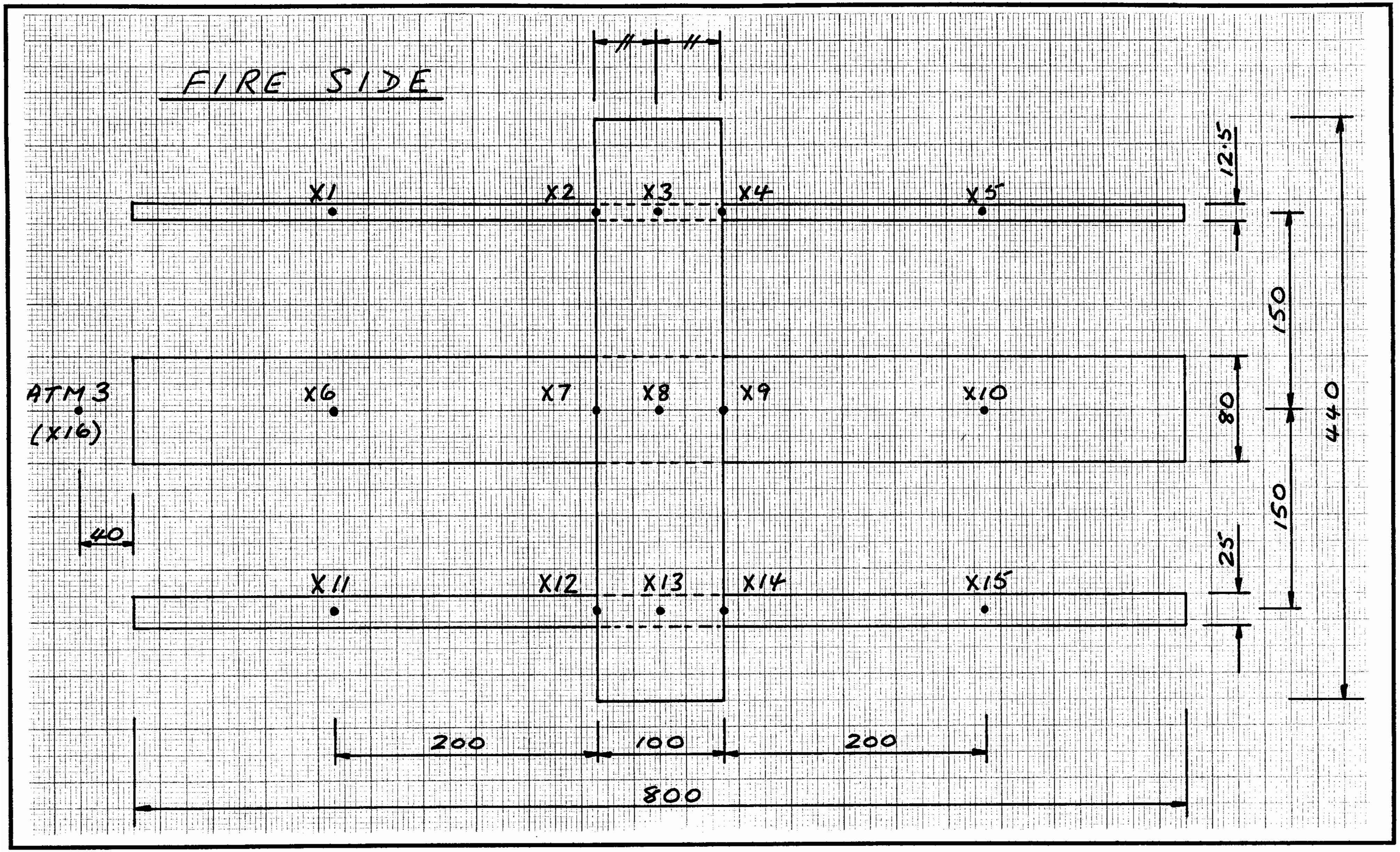


Fig. 5 Thermocouple Positions in the Steel Bars Cast in the 100 mm Thick Concrete Block (Plan View)

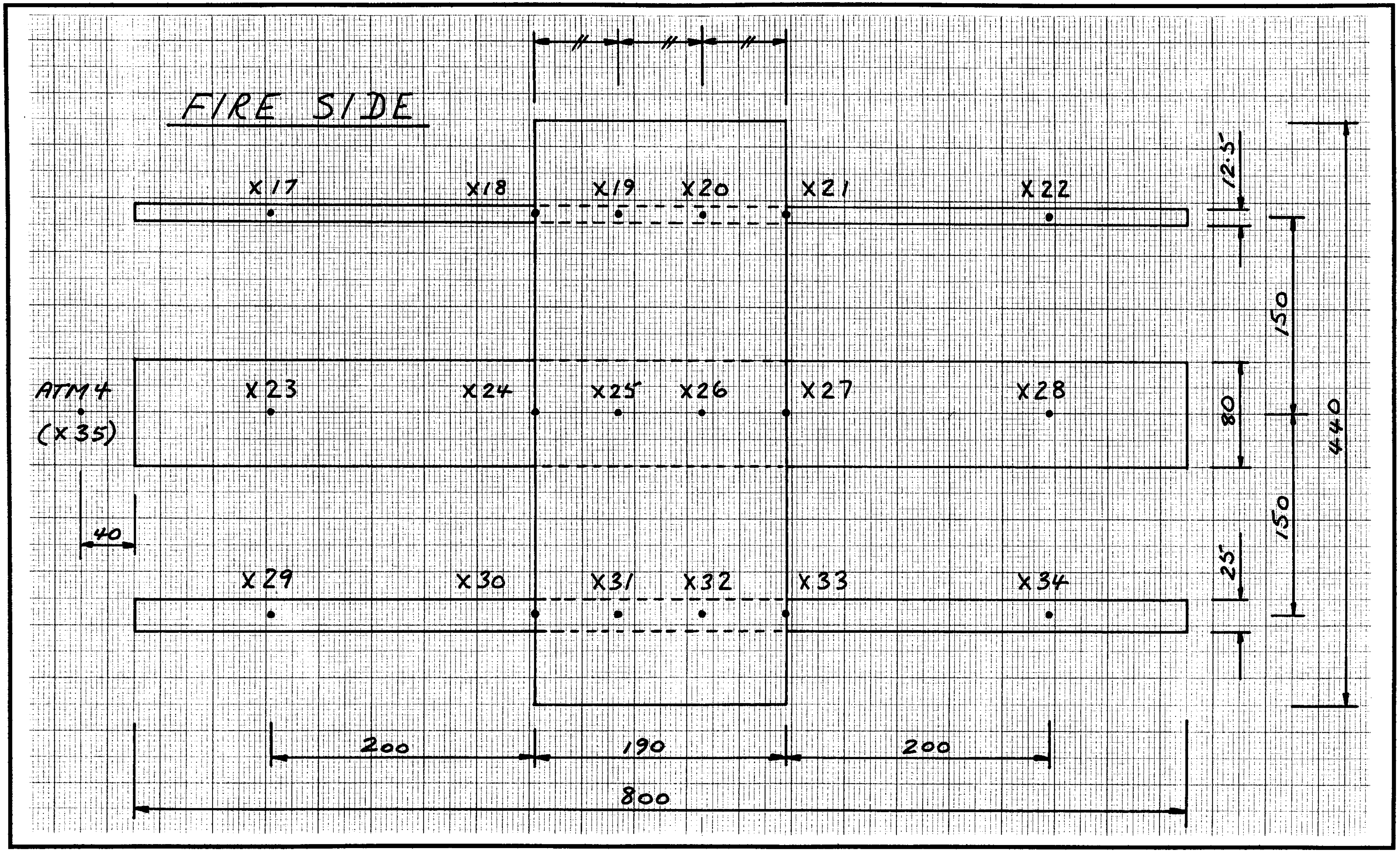


Fig. 6 **Thermocouple Positions in the Steel Bars Cast in the 190 mm Thick Concrete Block (Plan View)**

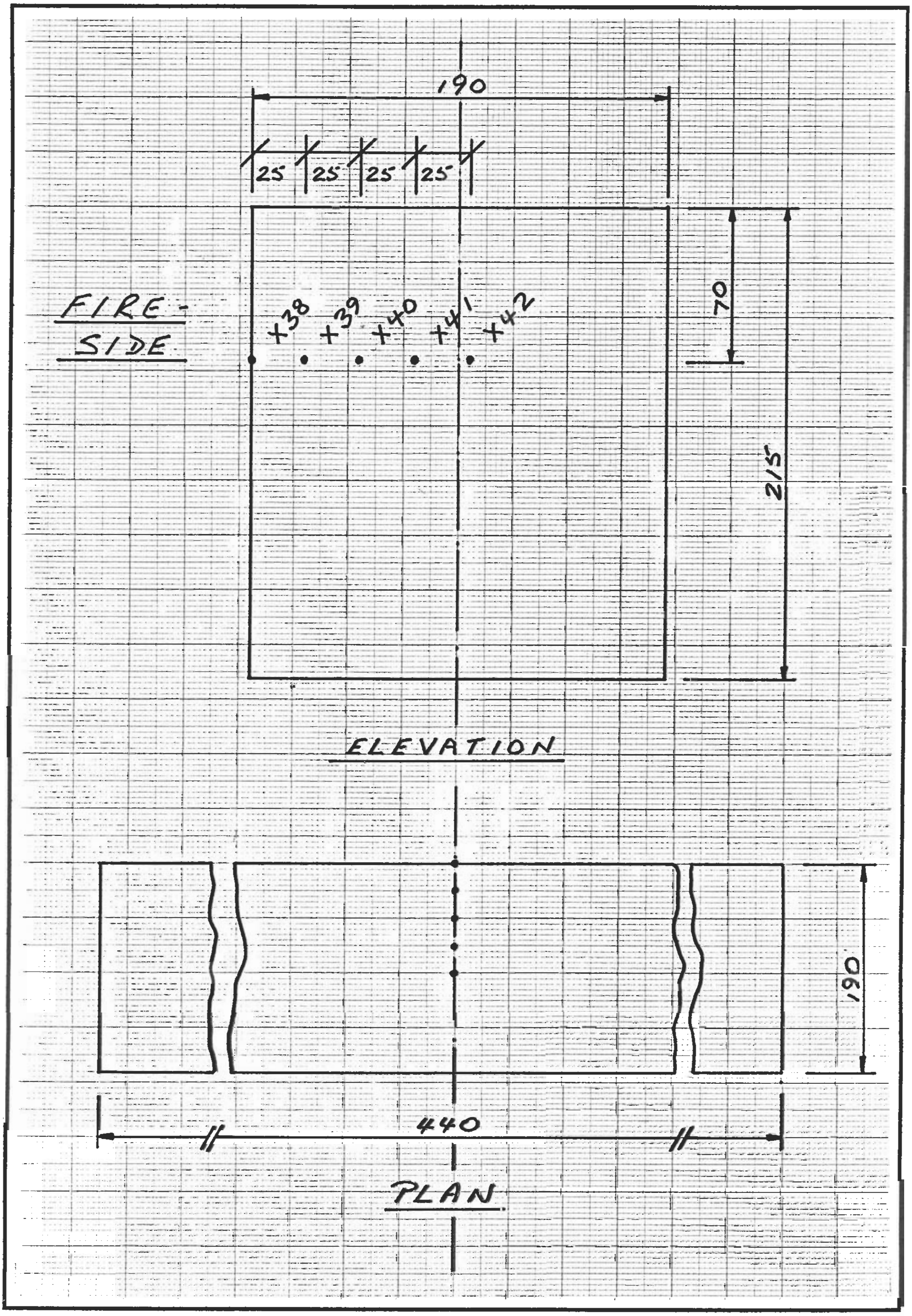


Fig. 7 **Thermocouple Positions in the Stranlite Block**

Fig. 8 General View Showing the Indicative Specimens Being Built into the Compartment Wall

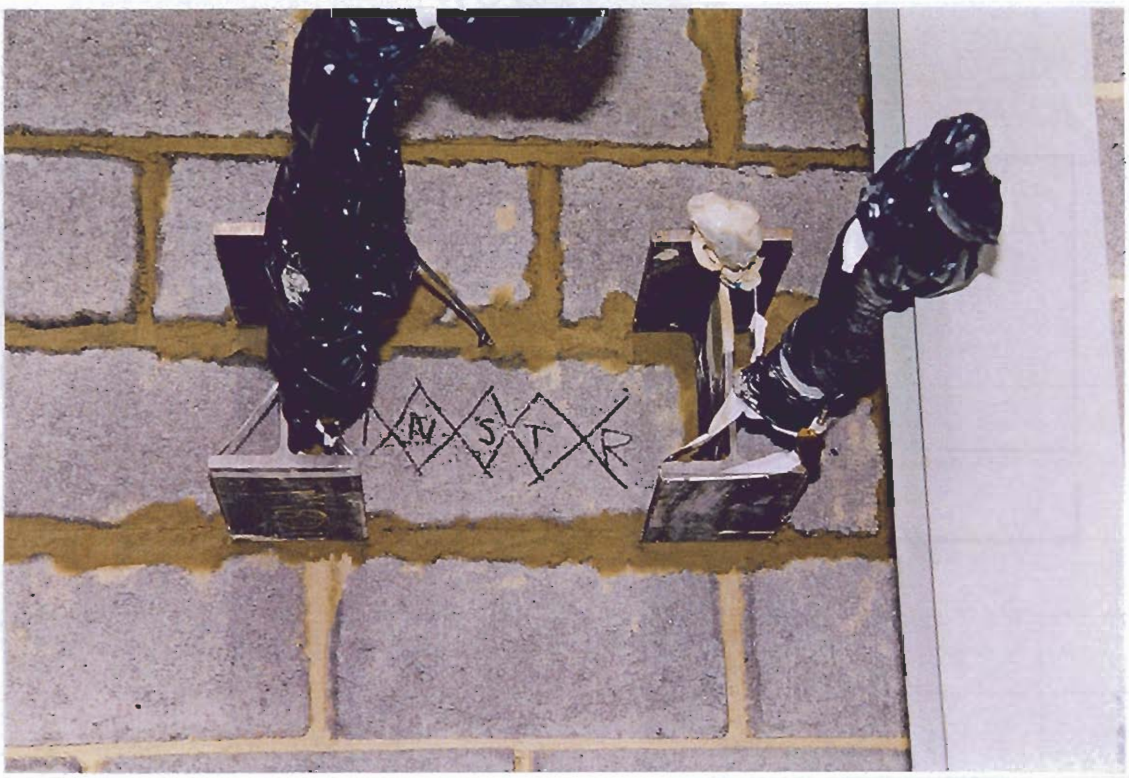


Fig. 9 Instrumented Stranlite Block Between the Two UB Sections (Compartment Exterior View)

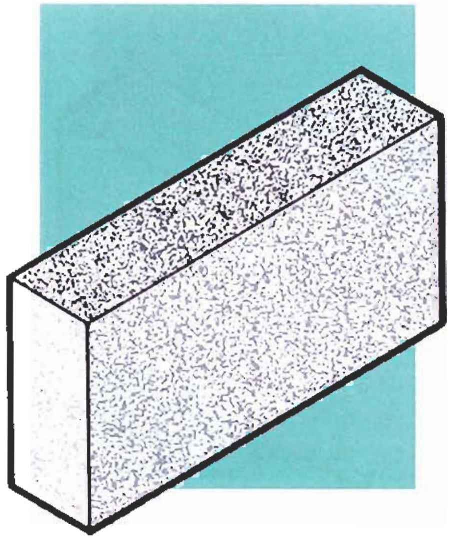
Fig. 10 Steel Bars Set in 100 and 190 mm Thick Concrete Blocks (Compartment Interior View, 190 mm Block on Left)

Fig. 11 General View Showing all The Indicative Specimens (Compartment Interior View)

APPENDIX 1

TECHNICAL DATA CONCERNING PLASMOR

"STRANLITE" BLOCK-WORK



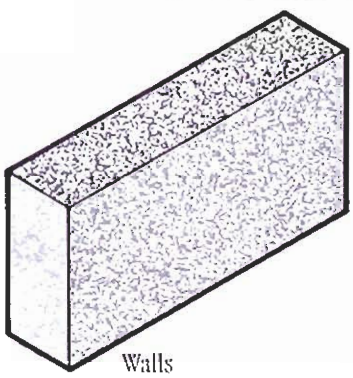
CI/SfB			Ff4	01.5.97

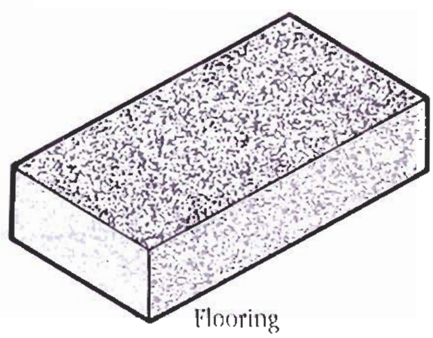
STRANLITE®
High quality lightweight concrete blocks for walls, floors and foundations.

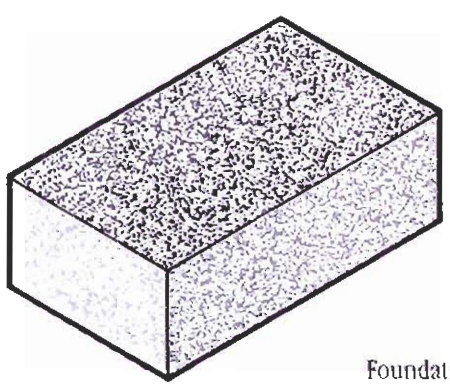
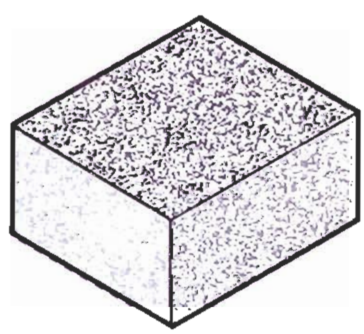
S T R A N L I T E®

A range of lightweight blocks for all general walling, floors and foundation situations.

PRODUCT TYPES


Walls


Flooring



Foundation

AGLITE®
Low density loadbearing aggregate block, introduced in response to the new challenges in building performance

FIBOLITE®
Ultra lightweight concrete blocks with superior fixability, robustness and low shrinkage

THERMALBOND®
The most effective way to ensure that walls meet all thermal requirements.

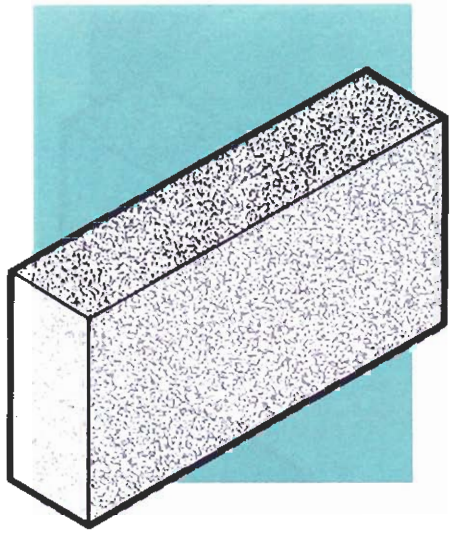
ARCHITECTURAL MASONRY
Unsurpassed masonry quality, with an extensive range of complementary specials for "bespoke" projects

PLASCON
A dense concrete general purpose building block, in open, and close textures, made to exceptionally high standards.

PLASPAVE®
Concrete block paving for commercial, residential and industrial landscapes.

SPECIAL PRODUCTS
A range of concrete products purpose designed for building specialists.

Plasmor
BUILDING · A BETTER WAY



STRANLITE LIGHTWEIGHT BLOCKS

A range of lightweight loadbearing blocks that are manufactured from Ordinary Portland cement, selected aggregates including graded Furnace Bottom and also Pulverised Fuel Ash.

The blocks are plain ended and grey in colour and are available in a wide range of sizes and strengths. There are two textures, Standard and Paintgrade.

THE BENEFITS OF USING STRANLITE LIGHTWEIGHT BLOCKS

A comprehensive range to handle all common walling situations.

A range that allows the specifier/builder to select depending upon the walls required performance.

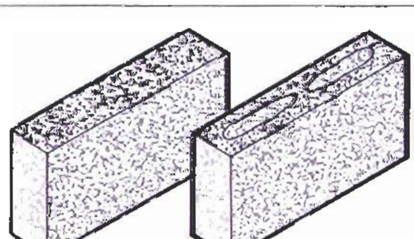
Ideal for plastering, rendering, tiling or application of heavy duty fabrics.

USES

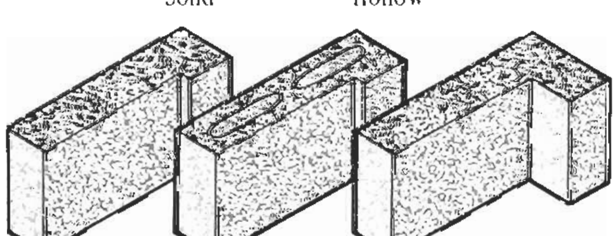
External walls–outer and inner leaf

Internal Partitions	Walls below ground level
Internal Loadbearing Walls	Reinforced Walls
Party Walls/Flanking Walls	Semi-exposed Walls

PRODUCT TYPES



Solid Hollow

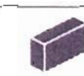
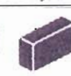
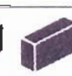
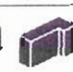
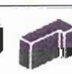
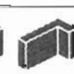
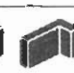


Reveal Hollow Reveal Quoin

METRIC SIZES AND TYPES

Co-ordinating Size	450mm × 225mm
Actual Size	440mm × 215mm

STRANLITE LIGHTWEIGHT BLOCKS

MM	75	90	100	140	190	215
SOLID						
HOLLOW						
REVEAL (50mm)*						
REVEAL (75mm)*						
REVEAL HOLLOW (50mm)*						
QUOIN						

*Width of Cavity Closing

PROPERTIES AND PERFORMANCE

Drying Shrinkage	0.02 %
Thermal Conductivity	0.42W/m°C
Manufacture and Authority	BS6073: Part 1 1981
Approx Density	1375 kg/m³
Compressive Strengths	4.2 N/mm² 7.0 N/mm² 10.5 N/mm²
Sound Insulation	Excellent. Satisfies party wall and flanking wall requirements of the Building Regulations.
Fire Resistance	Class 1 Aggregate BS5628
Thermal Insulation	Blocks require additional insulation to meet thermal regulations
Pack Sizes*	75mm in 12.0m² 140mm in 6.4m 90mm in 10.4m² 190mm in 4.8m² 100mm in 9.6m² 215mm in 4.0m²

*Pack size may vary, please check with your local Divisional Office.