

BRE Cardington Steel Framed Building Fire Tests

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Foreword

BRE in collaboration with British Steel (now Tata Steel) conducted a series of large scale fire tests in the 1990s on a modern multi-storey composite steel framed building constructed within the BRE large scale test facility at Cardington near Bedford. The results from this ground breaking research project have enabled the development of performance based structural fire engineering and greatly improved the understanding of real buildings subject to real fires. Although the results have been disseminated in journals and conference proceedings the results from the two large scale fire tests conducted by BRE have never been fully available. The UK steel industry supported the dissemination of the detailed results from the four fire tests undertaken by Swinden Technology Centre for British Steel through publication on the web-based one stop shop for structural fire engineering hosted by the University of Manchester. The raw data from the two natural fire tests carried out by BRE has never been made publically available. Large scale fire test results are essential in validating software used for structural design purposes. It is hoped that the provision of the data from the BRE fire tests in a format that can be used by those involved in structural fire engineering design and research will be of benefit to the UK construction industry and facilitate the performance related design of structures subject to fire.

With support from the BRE Trust and Tata Steel it is now possible to make the data from the two BRE fire tests available to other research organisations involved in the development of fire safety engineering.

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Introduction

This document, the associated channel allocations and the accompanying data files have been prepared so that researchers in the field of fire safety engineering have access to the data logged during the two BRE fire tests on the steel framed building.

The format of the document is such that a general description of the location and construction of each test within the 8 storey building is provided followed by detailed drawings showing the location of each instrument. Each drawing refers to a data file containing the results from the tests. A channel allocation is provided for each test enabling researchers to identify each instrumentation location individually. The data files in Microsoft excel format can be freely accessed through the BRE web site.

The data files may be accessed through the following link (www.bre.co.uk) which will take the user through to the BRE web site. Table 2 relates the individual data files to the specific references within the channel allocations for each of the fire tests. Therefore by using the data files together with the channel allocations and the figures in this document users should be able to identify the specific location of each instrument used to record data from the fire tests.

The BRE 8 storey building

The experimental programme was conducted on the 8 storey steel framed building within the BRE's Large Building Test Facility (LBTF) at Cardington near Bedford (Photograph 1). The building was a composite steel and concrete structure designed to meet UK national design codes of the time (BS5950) and checked for compliance with the provisions of the Eurocode for the design of steel structures (BS EN 1993-1). The structure was a braced frame incorporating three stiff cores (a central lift shaft and two stairwells at either end of the building). The primary beam to column connections were partial depth end plates and the secondary connections were fin plates.

Composite action was achieved through shear studs welded through trapezoidal steel sheet decking onto both the primary and secondary beams. The slab was cast over the profiled steel sheet using lightweight concrete with a density of 1900kg/m³ to provide a maximum floor thickness of 130mm with reinforcement provided by an A142 anti-cracking mesh.

The structure was laid out in five 9m bays along the elevation and 6m-9m-6m bays across the building providing a total floor area in plan of 45m x 21m. For the purposes of standardization and to reduce fabrication and erection costs only four beam sections (254UB trimmers, 305UB ribs, 356UB and 610UB spine members) and three column sections (305UC x 198 & 118kg/m and 254UC x 89kg/m) were used. The internal columns were spliced twice within the height of the building whereas the edge columns were spliced only once. The general floor layout is shown in Figure 1.

Table 1 provides details of the floor loading for the building. The design imposed load was 2.5kN/m² on all floors other than the roof which was designed for a plant load of 7.5kN/m². The load was applied using 1.1 tonne sandbags spread uniformly over the floor area.

Load	Value (kN/m ²)
Composite slab	2.06
Steel sections	0.25
Raised floor	0.4
Services	0.25
Ceiling	0.15
Partitions	1.0
Imposed	0.83 (1/3 rd design load)

Table 1 Details of floor loading

The actual load applied during the fire tests was less than the design imposed load and was informed from survey data felt to be more representative than the nominal values taken from design standards¹. In all six tests, the applied loading was 2.663kN/m². This is equal to one third of the imposed load together with an allowance for the full weight of the raised floors, services, false ceilings and partitions. Although the purpose of the building was to facilitate research it was designed and built under normal commercial conditions and is therefore a 'real' building.

Fire tests

Information on the collaborative research project is available in design guidance published by the steel industry¹. Two major large scale fire tests were carried out by BRE as part of the original programme of research. The work was funded by the UK government. The two fire tests considered here are generally referred to as:

- BRE corner fire test
- BRE large compartment fire test

Corner fire test

File name	Type of instrument	Comments
Atmosphere.xls	T/C	Channels 214-234 in channel allocation
B1TEMP.xls	T/C	Channels 103-123 in channel allocation
B2TEMP.xls	T/C	Channels 124-144 in channel allocation
B3TEMP.xls	T/C	Channels 145-167 in channel allocation. 163 and 165-167 not present
B4TEMP.xls	T/C	Channels 168-190 in channel allocation
B5TEMP.xls	T/C	Channels 191-213 in channel allocation
C1TEMP.xls	T/C	Channels 1-22 in channel allocation
C2TEMP.xls	T/C	Channels 23-52 in channel allocation. 44-45 and 50-51 not present
C3TEMP.xls	T/C	Channels 53-82 in channel allocation. 72,74-75,79,81 not present
C4TEMP.xls	T/C	Channels 83-92 in channel allocation
C5TEMP.xls	T/C	Channels 93-102 in channel allocation. 99 and 102 not working.
SLABTEMP.xls	T/C	Channels 235-258 in channel allocation
OPPO.xls	T/C	Channels 250,256,259-260 in channel allocation
F1C1STRAIN.xls	strain gauge	Channels 261-275 in channel allocation
F1C2STRAIN.xls	strain gauge	Channels 277-291 in channel allocation
F1C3STRAIN.xls	strain gauge	Channels 293-307 in channel allocation
F1C4STRAIN.xls	strain gauge	Channels 309-323 in channel allocation
F1C6STRAIN.xls	strain gauge	Channels 325-339 in channel allocation
F1C7STRAIN.xls	strain gauge	Channels 341-355 in channel allocation
F1C8STRAIN.xls	strain gauge	Channels 357-371 in channel allocation
F2C1STRAIN.xls	strain gauge	Channels 373-387 in channel allocation
F2C2STRAIN.xls	strain gauge	Channels 389-403 in channel allocation
F2C3STRAIN.xls	strain gauge	Channels 405-419 in channel allocation
F2C4STRAIN.xls	strain gauge	Channels 421-435 in channel allocation
F2C6STRAIN.xls	strain gauge	Channels 437-451 in channel allocation
F2C7STRAIN.xls	strain gauge	Channels 453-467 in channel allocation
F2C8STRAIN.xls	strain gauge	Channels 469-483 in channel allocation
F2B6STRAIN.xls	strain gauge	Channels 485-507 in channel allocation

Large compartment fire test

File name	Comments
F1C1STRAIN.xls	Channels 1-7 in channel allocation
F1C2STRAIN.xls	Channels 9-15 in channel allocation
F1C3STRAIN.xls	Channels 17-23 in channel allocation
F1C4STRAIN.xls	Channels 25-31 in channel allocation
F1C5STRAIN.xls	Channels 33-39 in channel allocation
F1C6STRAIN.xls	Channels 41-47 in channel allocation
F1C7STRAIN.xls	Channels 49-55 in channel allocation
F1C8STRAIN.xls	Channels 57-63 in channel allocation
F1C9STRAIN.xls	Channels 65-71 in channel allocation
F1C10STRAIN.xls	Channels 73-79 in channel allocation
F1C12STRAIN.xls	Channels 81-87 in channel allocation
F1C13STRAIN.xls	Channels 89-95 in channel allocation
F2C1STRAIN.xls	Channels 97-103 in channel allocation
F2C2STRAIN.xls	Channels 105-111 in channel allocation
F2C3STRAIN.xls	Channels 113-119 in channel allocation
F2C4STRAIN.xls	Channels 121-127 in channel allocation
F2C5STRAIN.xls	Channels 129-135 in channel allocation
F2C6STRAIN.xls	Channels 137-143 in channel allocation
F2C7STRAIN.xls	Channels 145-151 in channel allocation
F2C8STRAIN.xls	Channels 153-159 in channel allocation
F2C9STRAIN.xls	Channels 161-167 in channel allocation
F2C10STRAIN.xls	Channels 169-175 in channel allocation
F2C12STRAIN.xls	Channels 177-183 in channel allocation
F2C13STRAIN.xls	Channels 185-191 in channel allocation
F3C1STRAIN.xls	Channels 193-199 in channel allocation
F3C2STRAIN.xls	Channels 201-207 in channel allocation
F3C3STRAIN.xls	Channels 209-215 in channel allocation
F3C4STRAIN.xls	Channels 217-223 in channel allocation

Corner fire test

F2B7STRAIN.xls	strain gauge	Channels 509-531 in channel allocation
F2B8STRAIN.xls	strain gauge	Channels 533-555 in channel allocation
F2B9STRAIN.xls	strain gauge	Channels 557-579 in channel allocation
F3C1STRAIN.xls	strain gauge	Channels 581-595 in channel allocation
F3C2STRAIN.xls	strain gauge	Channels 597-611 in channel allocation
F3C3STRAIN.xls	strain gauge	Channels 613-627 in channel allocation
F3C4STRAIN.xls	strain gauge	Channels 629-643 in channel allocation
F3C6STRAIN.xls	strain gauge	Channels 645-659 in channel allocation
F3C7STRAIN.xls	strain gauge	Channels 661-675 in channel allocation
F3C8STRAIN.xls	strain gauge	Channels 677-691 in channel allocation
F7C1STRAIN.xls	strain gauge	Channels 693-707 in channel allocation
F7C2STRAIN.xls	strain gauge	Channels 709-723 in channel allocation
F7C3STRAIN.xls	strain gauge	Channels 725-739 in channel allocation
F7C4STRAIN.xls	strain gauge	Channels 741-755 in channel allocation
F7C6STRAIN.xls	strain gauge	Channels 757-771 in channel allocation
F7C7STRAIN.xls	strain gauge	Channels 773-787 in channel allocation
F7C8STRAIN.xls	strain gauge	Channels 789-803 in channel allocation
RFSTRAIN.xls	strain gauge	Channels 805-835 in channel allocation
SLABSTR.xls	strain gauge	Channels 837-861 in channel allocation
CLINOM.DAT	clinometer	Channels 881-895 in channel allocation
LOAD.DAT	load cell	Channels 896-898 in channel allocation
SLABDEF.xls	displacement	Channels 893-895 and 901-920 in channel allocation
THERMO2.DAT	T/C	Channels 921-927 in channel allocation
INDIC.xls	T/C	Channels 928-936 in channel allocation
THERMO2.DAT	T/C	Channels 937-943, 945-953 in channel allocation
WALLTEMP.xls	T/C	Channels 956-957 in channel allocation
DISPLA1.DAT	displacement	Channels 961-984 in channel allocation

Large compartment fire test

F3C5STRAIN.xls	Channels 225-231 in channel allocation
F3C6STRAIN.xls	Channels 233-239 in channel allocation
F3C7STRAIN.xls	Channels 241-247 in channel allocation
F3C8STRAIN.xls	Channels 249-255 in channel allocation
F3C9STRAIN.xls	Channels 257-263 in channel allocation
F3C10STRAIN.xls	Channels 265-271 in channel allocation
F3C12STRAIN.xls	Channels 273-279 in channel allocation
F3C13STRAIN.xls	Channels 281-287 in channel allocation
RFSTRAIN.xls	Channels 289-299 in channel allocation
CSSTRAIN.xls	Channels 301-399 in channel allocation
ATMOS.xls	Channels 401-433 in channel allocation
SLABTEMP.xls	Channels 435-468 in channel allocation
C5TEMP.xls	Channels 470-473 in channel allocation
C6TEMP.xls	Channels 474-476 in channel allocation
C7TEMP.xls	Channels 477-479 in channel allocation
C8TEMP.xls	Channels 480-483 in channel allocation
C9TEMP.xls	Channels 484-487 in channel allocation
C13TEMP.xls	Channels 488-491 in channel allocation
B1TEMP.xls	Channels 492-495 in channel allocation
B6TEMP.xls	Channels 496-499 in channel allocation
B8TEMP.xls	Channels 500-503 in channel allocation
B9TEMP.xls	Channels 504-507 in channel allocation
B10TEMP.xls	Channels 508-511 in channel allocation
B12TEMP.xls	Channels 512-515 in channel allocation
B16TEMP.xls	Channels 516-519 in channel allocation
B21TEMP.xls	Channels 520-527 in channel allocation
B22TEMP.xls	Channels 528-535 in channel allocation
B23TEMP.xls	Channels 536-539 in channel allocation
B24TEMP.xls	Channels 540-547 in channel allocation
B25TEMP.xls	Channels 548-555 in channel allocation

Corner fire test

Large compartment fire test

WELDTEMP.xls	Channels 556-564 in channel allocation
TOPTEMP.xls	Channels 565-572 in channel allocation
JR.xls	Channels 573-579 in channel allocation
F7C6Strain.xls	Channels 581-587 in channel allocation
F7C7STRAIN.xls	Channels 589-595 in channel allocation
SLABDEF.xls	Channels 601-665 in channel allocation
WALLDEF.xls	Channels 681-686 in channel allocation
FLR4DEF.xls	Channels 687-695 in channel allocation
HANGTEMP.xls	Channels 701-709 in channel allocation
OPP.xls	Channels 710-713 in channel allocation
WALLTEMP	Channels 714-717 in channel allocation

Table 2 Channel numbers associated with specific data files (see channel allocations for instrument locations)

BRE corner fire test

Introduction

This test took place on the second floor of the building in a corner compartment bounded by gridlines E to F and 3 to 4 (see figure 1). Figure 2 is a three dimensional view of the compartment. For ease of reference the main steel members are identified according to the schematic shown in figure 3. This was extended to identify instrumentation adjacent to the compartment as shown in figure 4.

Compartment design

The choice of the third floor, that is fire on the second floor testing the third floor, as the location for the fire test was decided on to minimise the heat rise to the structural elements of the hangar itself and to facilitate observations during the test. The first and second floors were not typical of the building due to the presence of a central concourse. The location was also dictated by the need to ensure, as far as possible, the results of a test in one location do not adversely affect subsequent tests.

The compartment itself was created using fire resistant board (British Gypsum fireline) running between the columns forming the boundaries of the compartment. The internal column on gridline E3 was fully protected. Protection was also provided to the two external columns E4 and F4. The two remaining columns were outside the compartment, behind the shaft walling used to protect the stairwell at the Eastern end of the building. All column protection was achieved using British Gypsum Glasroc board. The secondary beam running through the centre of the compartment was completely unprotected. The presence of double glazed units formed the only protection to the edge beam running between gridlines E4 to F4 while the edge beam running between F4 and F3 was partially protected by the existing blockwork wall.

No attempt was made to provide any additional restraint to the boundary wall. The intention was to create a realistic compartment configuration representative of a corner office in a modern commercial building. No additional ventilation was provided and no attempt was made to artificially seal the compartment. One of the purposes of the test was to investigate the influence of the glazing on the development of the fire. The compartment is shown prior to ignition in Photographs 2 and 3.

Fire design

Twelve timber cribs were placed in the compartment. The fire load was 40kg/m² over a floor area of 54m² giving a total fire load of 2,160kg. Each crib was constructed from 200 sticks of 50mm x 50mm rough sawn softwood with ten sticks in each of 20 layers giving a crib height of 1 metre. The cribs were connected to one another using porous fibre board. Ignition was from a single point close to the stairwell.

Fire development

In the early stages fire development was governed by the lack of available oxygen for combustion. After an initial rise in temperature the fire died down and continued to smoulder until the fire

Service intervened to vent the compartment. A single pane of glass was removed resulting in a small increase in temperature followed by a decrease. A second pane was then removed leading to a sharp rise in temperature. Following flashover, the maximum atmosphere temperature exceeded 1000°C with corresponding unprotected steel temperatures in excess of 900°C. The maximum displacement of the floor slab was 270mm. Photograph 4 shows the external flaming from the windows following flashover while Photograph 5 shows the compartment after completion of the fire test with all combustible material consumed.

Instrumentation

The primary requirements of the instrumentation were to measure the temperature of the structural and non-structural components in the fire compartment, and of those components immediately outside the compartment; to measure the distribution of the internal forces in the members adjacent to the compartment; to measure the deflected shape of the floor, end wall and main structural members and to measure the heat transfer through the floor and walls of the compartment. In total some 1000 channels of data were recorded every two minutes for the duration of the test and at ten minute intervals overnight. The following sections will attempt to document the location and nature of the instruments and discuss some of the results in detail.

Temperature

In total 278 thermocouples were used to monitor the temperature of the steel columns and beams within the compartment, the temperature through the concrete slab and the atmosphere temperature within the compartment. Additional instruments were used to monitor the temperature immediately outside the compartment, the temperature of the hangar steelwork, indicative sections of unprotected steelwork suspended from the ceiling and the internal and external temperature of the gable wall.

Columns

The columns forming the boundaries of the compartment (C1 to C5 in figures 3 and 4) were extensively instrumented. Column C1 was instrumented in three locations as shown in figure 5 with a total of 22 thermocouples. In each case the dimension at the top of the section is from the connecting beam except where the deep 610 beam is framing in where the dimension is 100mm below the bottom of the deep beam. In either case the section B-B is half the overall distance between the floor slab and the underside of the deepest connecting beam.

When designing the compartment the original intention was to leave the columns unprotected except where the column was protected from the compartment construction itself. The extent and location of the thermocouples on the columns reflect this intention. Following the British Steel plane frame test¹ and the subsequent localised squash failure of the columns it was decided to protect the columns to ensure the structural integrity of the compartment. It is for this reason that there are such a large number of instruments on the protected columns.

The thermocouple locations for columns C2 and C3 are shown in figure 6. Because of the construction of the dado wall it was not possible to install thermocouples C2/22/23/28/29 or C3/22/23/28/29. Additionally thermocouple C3/20 was not installed. The thermocouple locations for columns C4 and C5 (behind the shaft walling) are shown in figures 7 and 8.

Beams

The locations for the thermocouples for beam B1 between gridlines E4 and F4 are shown in figure 9. Three sections along the beam were instrumented. Figures 10 to 13 show the locations for beams B2 to B5. Thermocouples B3/19 and B3/21, B3/22 and B3/23 were omitted as this part of the beam's cross-section lies wholly outside the compartment. For beams B4 and B5 the central instrumented cross-section was offset 200mm to the North to avoid beam B2 which frames into the web of both of these beams.

Atmosphere

A total of 21 thermocouples (A1-A21) were used to monitor the atmosphere temperature within the compartment. The locations are shown in plan in figure 14 and in section in figure 15.

Concrete slab

A total of 22 thermocouples (CS1-CS24) were used to monitor the temperature through the depth of the concrete slab. CS16 and CS22 have been omitted as they were felt to be surplus to requirements. The locations of the cut-outs in the slab are shown in plan in figure 16 while figure 17 shows the location of the instruments through the depth of the slab.

Miscellaneous

Four thermocouples were placed outside the compartment directly opposite the centre of the glazing at distances of 1m, 2.5m, 5m and 10m from the compartment to provide some information on the levels of radiated heat emanating from the window openings. The location is illustrated in figure 18. A number of thermocouples were used to measure the response of the Cardington hanger itself to the fire. Three thermocouples were suspended from the hanger roof, a further two instruments measured the response of the Perspex sheeting at the top of the hanger on both the north and east faces and two plate thermocouples were used to monitor the temperature of the loadbearing truss running opposite the compartment.

Three indicative column sections were hung from the ceiling of the compartment to provide information on the temperatures of unprotected sections within the compartment. The thermocouples (I1-I9) were located on both flanges and the web of each section.

Strain

Columns

The strain gauge specification for all steelwork is summarised in figure 19. The columns were gauged on the fire floor, the floor below, the floor above and the seventh floor. The measurement location along the column length is shown in figure 20 while figure 21 shows the cross-sectional locations for all steel sections. The gauge identification for all sections is the same. The first two alpha numeric characters refer to the floor level, the second two to the particular member and the final two to the cross-sectional location. Again all instruments are referenced to their particular channel allocation.

Beams

Each beam was gauged at three sections as shown in figure 19. The cross-sectional locations are shown in figure 21. Any deviation from these locations has been identified in the channel allocation provided.

Concrete slab

Thirteen concrete slab strain gauges (SCS1-SCS13) were mounted on the surface of the concrete in the positions and direction shown in figure 22.

Displacement

Concrete slab

A total of 23 1000mm displacement transducers were used to monitor the deflection of the concrete slab. These were located in the positions shown in figure 23.

Columns

Columns C1 and C2 (gridlines E3 and E4) were instrumented with 100mm displacement transducers to measure both major and minor axis deformations both laterally and axially as shown in figure 24. The results have not been processed but the original data file is provided.

Laser system

An innovative laser system was used to monitor the movement of the gable wall and associated steelwork at the eastern boundary of the compartment. The results from the system were logged separately from the rest of the data and so are not included in the channel allocation. Figure 25 shows the location of the targets used to monitor the movement of the wall. A data file is included but has not been accessed since the test was completed.

Rotation

A total of 12 clinometers (C1-C12) were used to measure the rotation of the connections within the compartment. The instruments on the columns were located on the web to measure major axis rotation while the instruments on the beams were located at mid-depth of the beam and approximately the depth of the section away from the connection. The location of the clinometers is shown in Figure 26. A data file is included but has not been accessed since the test was completed.

Miscellaneous

In addition to the instrumentation mentioned above two heat flux meters (DS1 and DS2) were placed in the plane of the window. Two heat flux meters, two steel billets and associated thermocouples (DOC1-DOC13) were installed in the floor slab by the University of Ulster to measure heat transfer through the floor. The location of the 50mm cored holes in the floor slab for the heat flux meters and steel billets are shown in figure 27.

Twelve timber cribs were placed within the compartment as shown in figure 28. The fire load was 40kg/m² over a floor area of 54m² giving a total fire load of 2160kg. Each crib was constructed from 200 sticks of 50mm x 50mm rough sawn softwood with 10 sticks in each of 20 layers giving a crib

height of 1metre. Three load cells (LC1-LC3) were used to monitor the mass weight loss of three of the twelve cribs. The location of the instrumented cribs is shown in figure 28.

Channel allocation

Chan. No.	Cable No.	location	comments	instrument	Figure No.
1	C1/1	column E3 top	web/flange junction S	t/c	5
2	C1/2	column E3 top	web S	t/c	5
3	C1/3	column E3 top	web N	t/c	5
4	C1/4	column E3 top	flange tip NE	t/c	5
5	C1/5	column E3 top	flange NE	t/c	5
6	C1/6	column E3 top	flange/web junction N	t/c	5
7	C1/7	column E3 top	flange NW	t/c	5
8	C1/8	column E3 top	flange tip NW	t/c	5
9	C1/9	column E3 middle	web/flange junction S	t/c	5
10	C1/10	column E3 middle	web S	t/c	5
11	C1/11	column E3 middle	web N	t/c	5
12	C1/12	column E3 middle	flange tip NE	t/c	5
13	C1/13	column E3 middle	flange NE	t/c	5
14	C1/14	column E3 middle	flange/web junction N	t/c	5
15	C1/15	column E3 middle	flange NW	t/c	5
16	C1/16	column E3 middle	flange tip NW	t/c	5
17	C1/17	column E3 bottom	web/flange junction S	t/c	5
18	C1/18	column E3 bottom	web S	t/c	5
19	C1/19	column E3 bottom	web N	t/c	5
20	C1/20	column E3 bottom	flange NE	t/c	5
21	C1/21	column E3 bottom	flange/web junction N	t/c	5
22	C1/22	column E3 bottom	flange NW	t/c	5
23	C2/1	column E4 top	flange tip SE	t/c	6
24	C2/2	column E4 top	flange SE	t/c	6
25	C2/3	column E4 top	web/flange junction S	t/c	6
26	C2/4	column E4 top	flange SW	t/c	6
27	C2/5	column E4 top	flange tip SW	t/c	6
28	C2/6	column E4 top	web	t/c	6
29	C2/7	column E4 top	flange NE	t/c	6
30	C2/8	column E4 top	flange/web junction N	t/c	6
31	C2/9	column E4 top	flange NW	t/c	6
32	C2/10	column E4 above wall	flange SE	t/c	6
33	C2/11	column E4 above wall	web/flange junction S	t/c	6
34	C2/12	column E4 above wall	flange SW	t/c	6
35	C2/13	column E4 above wall	web	t/c	6
36	C2/14	column E4 above wall	flange NE	t/c	6
37	C2/15	column E4 above wall	flange/web junction N	t/c	6
38	C2/16	column E4 above wall	flange NW	t/c	6

Chan. No.	Cable No.	location	comments	instrument	Figure No.
39	C2/17	column E4 below wall	flange tip SE	t/c	6
40	C2/18	column E4 below wall	flange SE	t/c	6
41	C2/19	column E4 below wall	web/flange junction S	t/c	6
42	C2/20	column E4 below wall	flange SW	t/c	6
43	C2/21	column E4 below wall	flange tip SW	t/c	6
46	C2/24	column E4 below wall	flange/web junction N	t/c	6
47	C2/25	column E4 bottom	flange SE	t/c	6
48	C2/26	column E4 bottom	web/flange junction S	t/c	6
49	C2/27	column E4 bottom	flange SW	t/c	6
52	C2/30	column E4 bottom	flange/web junction N	t/c	6
53	C3/1	column F4 top	flange tip SE	t/c	6
54	C3/2	column F4 top	flange SE	t/c	6
55	C3/3	column F4 top	web/flange junction S	t/c	6
56	C3/4	column F4 top	flange SW	t/c	6
57	C3/5	column F4 top	flange tip SW	t/c	6
58	C3/6	column F4 top	web	t/c	6
59	C3/7	column F4 top	flange NE	t/c	6
60	C3/8	column F4 top	flange/web junction N	t/c	6
61	C3/9	column F4 top	flange NW	t/c	6
62	C3/10	column F4 above wall	flange SE	t/c	6
63	C3/11	column F4 above wall	web/flange junction S	t/c	6
64	C3/12	column F4 above wall	flange SW	t/c	6
65	C3/13	column F4 above wall	web	t/c	6
66	C3/14	column F4 above wall	flange NE	t/c	6
67	C3/15	column F4 above wall	flange/web junction N	t/c	6
68	C3/16	column F4 above wall	flange NW	t/c	6
69	C3/17	column F4 below wall	flange tip SE	t/c	6
70	C3/18	column F4 below wall	flange SE	t/c	6
71	C3/19	column F4 below wall	web/flange junction S	t/c	6

Chan. No.	Cable No.	location	comments	instrument	Figure No.
73	C3/21	column F4 below wall	flange tip SW	t/c	6
76	C3/24	column F4 below wall	flange/web junction N	t/c	6
77	C3/25	column F4 bottom	flange SE	t/c	6
78	C3/26	column F4 bottom	web/flange junction S	t/c	6
80	C3/28	column F4 bottom	web S	t/c	6
82	C3/30	column F4 bottom	flange/web junction N	t/c	6
83	C4/1	column F3 top	web/flange junction S	t/c	7
84	C4/2	column F3 top	web	t/c	7
85	C4/3	column F3 top	flange NE	t/c	7
86	C4/4	column F3 top	flange/web junction N	t/c	7
87	C4/5	column F3 top	flange NW	t/c	7
88	C4/6	column F3 middle	web/flange junction S	t/c	7
89	C4/7	column F3 middle	web	t/c	7
90	C4/8	column F3 middle	flange NE	t/c	7
91	C4/9	column F3 middle	flange/web junction N	t/c	7
92	C4/10	column F3 middle	flange NW	t/c	7
93	C5/1	column E/F3 middle	web/flange junction S	t/c	8
94	C5/2	column E/F3 middle	web	t/c	8
95	C5/3	column E/F3 middle	flange NE	t/c	8
96	C5/4	column E/F3 middle	flange/web junction N	t/c	8
97	C5/5	column E/F3 middle	flange NW	t/c	8
98	C5/6	column E/F3 bottom	web/flange junction S	t/c	8
100	C5/8	column E/F3 bottom	flange NE	t/c	8
101	C5/9	column E/F3 bottom	flange/web junction N	t/c	8
103	B1/1	beam E4/F4 west	top flange N	t/c	9
104	B1/2	beam E4/F4 west	top flange/web junction	t/c	9
105	B1/3	beam E4/F4 west	top flange S	t/c	9
106	B1/4	beam E4/F4 west	web	t/c	9
107	B1/5	beam E4/F4 west	bottom flange N	t/c	9

Chan. No.	Cable No.	location	comments	instrument	Figure No.
108	B1/6	beam E4/F4 west	bottom flange/web junction	t/c	9
109	B1/7	beam E4/F4 west	bottom flange S	t/c	9
110	B1/8	beam E4/F4 middle	top flange N	t/c	9
111	B1/9	beam E4/F4 middle	top flange/web junction	t/c	9
112	B1/10	beam E4/F4 middle	top flange S	t/c	9
113	B1/11	beam E4/F4 middle	web	t/c	9
114	B1/12	beam E4/F4 middle	bottom flange N	t/c	9
115	B1/13	beam E4/F4 middle	bottom flange/web junction	t/c	9
116	B1/14	beam E4/F4 middle	bottom flange S	t/c	9
117	B1/15	beam E4/F4 east	top flange N	t/c	9
118	B1/16	beam E4/F4 east	top flange/web junction	t/c	9
119	B1/17	beam E4/F4 east	top flange S	t/c	9
120	B1/18	beam E4/F4 east	web	t/c	9
121	B1/19	beam E4/F4 east	bottom flange N	t/c	9
122	B1/20	beam E4/F4 east	bottom flange/web junction	t/c	9
123	B1/21	beam E4/F4 east	bottom flange S	t/c	9
124	B2/1	beam 3/4E-3/4F west	top flange N	t/c	10
125	B2/2	beam 3/4E-3/4F west	top flange/web junction	t/c	10
126	B2/3	beam 3/4E-3/4F west	top flange S	t/c	10
127	B2/4	beam 3/4E-3/4F west	web	t/c	10
128	B2/5	beam 3/4E-3/4F west	bottom flange N	t/c	10
129	B2/6	beam 3/4E-3/4F west	bottom flange/web junction	t/c	10
130	B2/7	beam 3/4E-3/4F west	bottom flange S	t/c	10
131	B2/8	beam 3/4E-3/4F middle	top flange N	t/c	10
132	B2/9	beam 3/4E-3/4F middle	top flange/web junction	t/c	10
133	B2/10	beam 3/4E-3/4F middle	top flange S	t/c	10
134	B2/11	beam 3/4E-3/4F middle	web	t/c	10
135	B2/12	beam 3/4E-3/4F middle	bottom flange N	t/c	10
136	B2/13	beam 3/4E-3/4F middle	bottom flange/web junction	t/c	10

Chan. No.	Cable No.	location	comments	instrument	Figure No.
137	B2/14	beam 3/4E-3/4F middle	bottom flange S	t/c	10
138	B2/15	beam 3/4E-3/4F east	top flange N	t/c	10
139	B2/16	beam 3/4E-3/4F east	top flange/web junction	t/c	10
140	B2/17	beam 3/4E-3/4F east	top flange S	t/c	10
141	B2/18	beam 3/4E-3/4F east	web	t/c	10
142	B2/19	beam 3/4E-3/4F east	bottom flange N	t/c	10
143	B2/20	beam 3/4E-3/4F east	bottom flange/web junction	t/c	10
144	B2/21	beam 3/4E-3/4F east	bottom flange S	t/c	10
145	B3/1	beam E3-F3 west	top flange N	t/c	11
146	B3/2	beam E3-F3 west	top flange/web junction	t/c	11
147	B3/3	beam E3-F3 west	top flange S	t/c	11
148	B3/4	beam E3-F3 west	web	t/c	11
149	B3/5	beam E3-F3 west	bottom flange tip N	t/c	11
150	B3/6	beam E3-F3 west	bottom flange N	t/c	11
151	B3/7	beam E3-F3 west	bottom flange/web junction	t/c	11
152	B3/8	beam E3-F3 west	bottom flange S	t/c	11
153	B3/9	beam E3-F3 west	bottom flange tip S	t/c	11
154	B3/10	beam E3-F3 middle	top flange N	t/c	11
155	B3/11	beam E3-F3 middle	top flange/web junction	t/c	11
156	B3/12	beam E3-F3 middle	top flange S	t/c	11
157	B3/13	beam E3-F3 middle	web	t/c	11
158	B3/14	beam E3-F3 middle	bottom flange N	t/c	11
159	B3/15	beam E3-F3 middle	bottom flange/web junction	t/c	11
160	B3/16	beam E3-F3 middle	bottom flange S	t/c	11
161	B3/17	beam E3-F3 east	top flange N	t/c	11
162	B3/18	beam E3-F3 east	top flange/web junction	t/c	11
164	B3/20	beam E3-F3 east	web	t/c	11
168	B4/1	beam E3-E4 north	top flange W	t/c	12
169	B4/2	beam E3-E4 north	top flange/web junction	t/c	12

Chan. No.	Cable No.	location	comments	instrument	Figure No.
170	B4/3	beam E3-E4 north	top flange E	t/c	12
171	B4/4	beam E3-E4 north	web	t/c	12
172	B4/5	beam E3-E4 north	bottom flange W	t/c	12
173	B4/6	beam E3-E4 north	bottom flange/web junction	t/c	12
174	B4/7	beam E3-E4 north	bottom flange E	t/c	12
175	B4/8	beam E3-E4 middle	top flange W	t/c	12
176	B4/9	beam E3-E4 middle	top flange/web junction	t/c	12
177	B4/10	beam E3-E4 middle	top flange E	t/c	12
178	B4/11	beam E3-E4 middle	web	t/c	12
179	B4/12	beam E3-E4 middle	bottom flange tip W	t/c	12
180	B4/13	beam E3-E4 middle	bottom flange W	t/c	12
181	B4/14	beam E3-E4 middle	bottom flange/web junction	t/c	12
182	B4/15	beam E3-E4 middle	bottom flange E	t/c	12
183	B4/16	beam E3-E4 middle	bottom flange tip E	t/c	12
184	B4/17	beam E3-E4 south	top flange W	t/c	12
185	B4/18	beam E3-E4 south	top flange/web junction	t/c	12
186	B4/19	beam E3-E4 south	top flange E	t/c	12
187	B4/20	beam E3-E4 south	web	t/c	12
188	B4/21	beam E3-E4 south	bottom flange W	t/c	12
189	B4/22	beam E3-E4 south	bottom flange/web junction	t/c	12
190	B4/23	beam E3-E4 south	bottom flange E	t/c	12
191	B5/1	beam F3-F4 north	top flange W	t/c	13
192	B5/2	beam F3-F4 north	top flange/web junction	t/c	13
193	B5/3	beam F3-F4 north	top flange E	t/c	13
194	B5/4	beam F3-F4 north	web	t/c	13
195	B5/5	beam F3-F4 north	bottom flange W	t/c	13
196	B5/6	beam F3-F4 north	bottom flange/web junction	t/c	13
197	B5/7	beam F3-F4 north	bottom flange E	t/c	13
198	B5/8	beam F3-F4 middle	top flange W	t/c	13

Chan. No.	Cable No.	location	comments	instrument	Figure No.
199	B5/9	beam F3-F4 middle	top flange/web junction	t/c	13
200	B5/10	beam F3-F4 middle	top flange E	t/c	13
201	B5/11	beam F3-F4 middle	web	t/c	13
202	B5/12	beam F3-F4 middle	bottom flange tip W	t/c	13
203	B5/13	beam F3-F4 middle	bottom flange W	t/c	13
204	B5/14	beam F3-F4 middle	bottom flange/web junction	t/c	13
205	B5/15	beam F3-F4 middle	bottom flange E	t/c	13
206	B5/16	beam F3-F4 middle	bottom flange tip E	t/c	13
207	B5/17	beam F3-F4 south	top flange W	t/c	13
208	B5/18	beam F3-F4 south	top flange/web junction	t/c	13
209	B5/19	beam F3-F4 south	top flange E	t/c	13
210	B5/20	beam F3-F4 south	web	t/c	13
211	B5/21	beam F3-F4 south	bottom flange W	t/c	13
212	B5/22	beam F3-F4 south	bottom flange/web junction	t/c	13
213	B5/23	beam F3-F4 south	bottom flange E	t/c	13
214	A1	SW corner of slab	300mm below ceiling	t/c	14/15
215	A2	W middle	300mm below ceiling	t/c	14/15
216	A3	NW corner	300mm below ceiling	t/c	14/15
217	A4	S middle	300mm below ceiling	t/c	14/15
218	A5	S middle	600mm below ceiling	t/c	14/15
219	A6	S middle	900mm below ceiling	t/c	14/15
220	A7	S middle	1200mm below ceiling	t/c	14/15
221	A8	S middle	1500mm below ceiling	t/c	14/15
222	A9	middle	300mm below ceiling	t/c	14/15
223	A10	middle	600mm below ceiling	t/c	14/15
224	A11	middle	900mm below ceiling	t/c	14/15
225	A12	middle	1200mm below ceiling	t/c	14/15
226	A13	middle	1500mm below ceiling	t/c	14/15
227	A14	N middle	300mm below ceiling	t/c	14/15

Chan. No.	Cable No.	location	comments	instrument	Figure No.
228	A15	N middle	600mm below ceiling	t/c	14/15
229	A16	N middle	900mm below ceiling	t/c	14/15
230	A17	N middle	1200mm below ceiling	t/c	14/15
231	A18	N middle	1500mm below ceiling	t/c	14/15
232	A19	SE corner	300mm below ceiling	t/c	14/15
233	A20	E middle	300mm below ceiling	t/c	14/15
234	A21	NE corner	300mm below ceiling	t/c	14/15
235	CS1	between surface and mesh	over crest	t/c	16/17
236	CS2	on mesh	over crest	t/c	16/17
237	CS3	on metal deck	over crest	t/c	16/17
238	CS4	between surface and mesh	over trough	t/c	16/17
239	CS5	on mesh	over trough	t/c	16/17
240	CS6	on metal deck	over trough	t/c	16/17
241	CS7	between surface and mesh	over crest	t/c	16/17
242	CS8	on mesh	over crest	t/c	16/17
243	CS9	on metal deck	over crest	t/c	16/17
244	CS10	between surface and mesh	over trough	t/c	16/17
245	CS11	on mesh	over trough	t/c	16/17
246	CS12	on metal deck	over trough	t/c	16/17
247	CS13	between surface and mesh	over crest	t/c	16/17
248	CS14	on mesh	over crest	t/c	16/17
249	CS15	on metal deck	over crest	t/c	16/17
250	OS1	opposite compartment	1m away	t/c	18
251	CS17	on mesh	over trough	t/c	16/17
252	CS18	on metal deck	over trough	t/c	16/17
253	CS19	between surface and mesh	over crest	t/c	16/17
254	CS20	on mesh	over crest	t/c	16/17
255	CS21	on metal deck	over crest	t/c	16/17
256	OS2	opposite compartment	2.5m away	t/c	18

Chan. No.	Cable No.	location	comments	instrument	Figure No.
257	CS23	on mesh	over trough	t/c	16/17
258	CS24	on metal deck	over trough	t/c	16/17
259	OS3	opposite compartment	5m away	t/c	18
260	OS4	opposite compartment	10m away	t/c	18
261	101	F1-C1-A	1st floor column E3 bottom SW flange	strain gauge	19/20/21
263	102	F1-C1-B	NW flange	strain gauge	19/20/21
265	103	F1-C1-C	NE flange	strain gauge	19/20/21
267	104	F1-C1-D	SE flange	strain gauge	19/20/21
269	105	F1-C1-E	top SW flange	strain gauge	19/20/21
271	106	F1-C1-F	NW	strain gauge	19/20/21
273	107	F1-C1-G	NE	strain gauge	19/20/21
275	108	F1-C1-H	SE	strain gauge	19/20/21
277	109	F1-C2-A	column E4 bottom SW	strain gauge	19/20/21
279	110	F1-C2-B	NW	strain gauge	19/20/21
281	111	F1-C2-C	NE	strain gauge	19/20/21
283	112	F1-C2-D	SE	strain gauge	19/20/21
285	113	F1-C2-E	top SW	strain gauge	19/20/21
287	114	F1-C2-F	NW	strain gauge	19/20/21
289	115	F1-C2-G	NE	strain gauge	19/20/21
291	116	F1-C2-H	SE	strain gauge	19/20/21
293	117	F1-C3-A	column F4 bottom SW	strain gauge	19/20/21
295	118	F1-C3-B	NW	strain gauge	19/20/21
297	119	F1-C3-C	NE	strain gauge	19/20/21
299	120	F1-C3-D	SE	strain gauge	19/20/21
301	121	F1-C3-E	top SW	strain gauge	19/20/21
303	122	F1-C3-F	NW	strain gauge	19/20/21
305	123	F1-C3-G	NE	strain gauge	19/20/21
307	124	F1-C3-H	SE	strain gauge	19/20/21

Chan. No.	Cable No.	location	comments	instrument	Figure No.
309	125	F1-C4-A	column F3 bottom SW	strain gauge	19/20/21
311	126	F1-C4-B	NW	strain gauge	19/20/21
313	127	F1-C4-C	NE	strain gauge	19/20/21
315	128	F1-C4-D	SE	strain gauge	19/20/21
317	129	F1-C4-E	top SW	strain gauge	19/20/21
319	130	F1-C4-F	NW	strain gauge	19/20/21
321	131	F1-C4-G	NE	strain gauge	19/20/21
323	132	F1-C4-H	SE	strain gauge	19/20/21
325	133	F1-C6-A	column D4 bottom SW	strain gauge	19/20/21
327	134	F1-C6-B	NW	strain gauge	19/20/21
329	135	F1-C6-C	NE	strain gauge	19/20/21
331	136	F1-C6-D	SE	strain gauge	19/20/21
333	137	F1-C6-E	top SW	strain gauge	19/20/21
335	138	F1-C6-F	NW	strain gauge	19/20/21
337	139	F1-C6-G	NE	strain gauge	19/20/21
339	140	F1-C6-H	SE	strain gauge	19/20/21
341	141	F1-C7-A	column D3 bottom SW	strain gauge	19/20/21
343	142	F1-C7-B	NW	strain gauge	19/20/21
345	143	F1-C7-C	NE	strain gauge	19/20/21
347	144	F1-C7-D	SE	strain gauge	19/20/21
349	145	F1-C7-E	top SW	strain gauge	19/20/21
351	146	F1-C7-F	NW	strain gauge	19/20/21
353	147	F1-C7-G	NE	strain gauge	19/20/21
355	148	F1-C7-H	SE	strain gauge	19/20/21
357	149	F1-C8-A	column E2 bottom SW	strain gauge	19/20/21
359	150	F1-C8-B	NW	strain gauge	19/20/21
361	151	F1-C8-c	NE	strain gauge	19/20/21
363	152	F1-C8-D	SE	strain gauge	19/20/21
365	153	F1-C8-E	top SW	strain gauge	19/20/21

Chan. No.	Cable No.	location	comments	instrument	Figure No.
367	154	F1-C8-F	NW	strain gauge	19/20/21
369	155	F1-C8-G	NE	strain gauge	19/20/21
371	156	F1-C8-H	SE	strain gauge	19/20/21
373	201	F2-C1-A	2nd floor column E3 bottom SW	strain gauge	19/20/21
375	202	F2-C1-B	NW	strain gauge	19/20/21
377	203	F2-C1-C	NE	strain gauge	19/20/21
379	204	F2-C1-D	SE	strain gauge	19/20/21
381	205	F2-C1-E	top SW	strain gauge	19/20/21
383	206	F2-C1-F	NW	strain gauge	19/20/21
385	207	F2-C1-G	NE	strain gauge	19/20/21
387	208	F2-C1-H	SE	strain gauge	19/20/21
389	209	F2-C2-A	column E4 bottom SW	strain gauge	19/20/21
391	210	F2-C2-B	NW	strain gauge	19/20/21
393	211	F2-C2-C	NE	strain gauge	19/20/21
395	212	F2-C2-D	Se	strain gauge	19/20/21
397	213	F2-C2-E	top SW	strain gauge	19/20/21
399	214	F2-C2-F	NW	strain gauge	19/20/21
401	215	F2-C2-G	NE	strain gauge	19/20/21
403	216	F2-C2-H	SE	strain gauge	19/20/21
405	217	F2-C3-A	column F4 bottom SW	strain gauge	19/20/21
407	218	F2-C3-B	NW	strain gauge	19/20/21
409	219	F2-C3-C	NE	strain gauge	19/20/21
411	220	F2-C3-D	SE	strain gauge	19/20/21
413	221	F2-C3-E	top SW	strain gauge	19/20/21
415	222	F2-C3-F	NW	strain gauge	19/20/21
417	223	F2-C3-G	NE	strain gauge	19/20/21
419	224	F2-C3-H	SE	strain gauge	19/20/21
421	225	F2-C4-A	column F3 bottom SW	strain gauge	19/20/21
423	226	F2-C4-B	NW	strain gauge	19/20/21

Chan. No.	Cable No.	location	comments	instrument	Figure No.
425	227	F2-C4-C	NE	strain gauge	19/20/21
427	228	F2-C4-D	SE	strain gauge	19/20/21
429	229	F2-C4-E	top SW	strain gauge	19/20/21
431	230	F2-C4-F	NW	strain gauge	19/20/21
433	231	F2-C4-G	NE	strain gauge	19/20/21
435	232	F2-C4-H	SE	strain gauge	19/20/21
437	233	F2-C6-A	column D4 bottom SW	strain gauge	19/20/21
439	234	F2-C6-B	NW	strain gauge	19/20/21
441	235	F2-C6-C	NE	strain gauge	19/20/21
443	236	F2-C6-D	SE	strain gauge	19/20/21
445	237	F2-C6-E	top SW	strain gauge	19/20/21
447	238	F2-C6-F	NW	strain gauge	19/20/21
449	239	F2-C6-G	NE	strain gauge	19/20/21
451	240	F2-C6-H	SE	strain gauge	19/20/21
453	241	F2-C7-A	column D3 bottom SW	strain gauge	19/20/21
455	242	F2-C7-B	NW	strain gauge	19/20/21
457	243	F2-C7-C	NE	strain gauge	19/20/21
459	244	F2-C7-D	SE	strain gauge	19/20/21
461	245	F2-C7-E	top Sw	strain gauge	19/20/21
463	246	F2-C7-F	NW	strain gauge	19/20/21
465	247	F2-C7-G	NE	strain gauge	19/20/21
467	248	F2-C7-H	SE	strain gauge	19/20/21
469	249	F2-C8-A	column E2 bottom SW	strain gauge	19/20/21
471	250	F2-C8-B	NW	strain gauge	19/20/21
473	251	F2-C8-C	NE	strain gauge	19/20/21
475	252	F2-C8-D	SE	strain gauge	19/20/21
477	253	F2-C8-E	top SW	strain gauge	19/20/21
479	254	F2-C8-F	NW	strain gauge	19/20/21
481	255	F2-C8-G	NE	strain gauge	19/20/21

Chan. No.	Cable No.	location	comments	instrument	Figure No.
483	256	F2-C8-H	SE	strain gauge	19/20/21
485	257	F2-B6-A	beam D4/E4 W lower flange N	strain gauge	19/20/21
487	258	F2-B6-B	upper flange N	strain gauge	19/20/21
489	259	F2-B6-C	upper flange S	strain gauge	19/20/21
491	260	F2-B6-D	lower flange S	strain gauge	19/20/21
493	261	F2-B6-E	middle, lower flange N	strain gauge	19/20/21
495	262	F2-B6-F	upper flange N	strain gauge	19/20/21
497	263	F2-B6-G	upper flange S	strain gauge	19/20/21
499	264	F2-B6-H	lower flange S	strain gauge	19/20/21
501	265	F2-B6-I	East lower flange N	strain gauge	19/20/21
503	266	F2-B6-J	upper flange N	strain gauge	19/20/21
505	267	F2-B6-K	upper flange S	strain gauge	19/20/21
507	268	F2-B6-L	lower flange S	strain gauge	19/20/21
509	269	F2-B7-A	beam D3/4-E3/4 West lower flange	strain gauge	19/20/21
511	270	F2-B7-B	upper flange N	strain gauge	19/20/21
513	271	F2-B7-C	upper flange S	strain gauge	19/20/21
515	272	F2-B7-D	lower flange S	strain gauge	19/20/21
517	273	F2-B7-E	middle lower flange N	strain gauge	19/20/21
519	274	F2-B7-F	upper flange N	strain gauge	19/20/21
521	275	F2-B7-G	upper flange S	strain gauge	19/20/21
523	276	F2-B7-H	lower flange S	strain gauge	19/20/21
525	277	F2-B7-I	East lower flange N	strain gauge	19/20/21
527	278	F2-B7-J	upper flange N	strain gauge	19/20/21
529	279	F2-B7-K	upper flange S	strain gauge	19/20/21
531	280	F2-B7-L	lower flange S	strain gauge	19/20/21
533	281	F2-B8-A	beam D3/E3 West lower flange N	strain gauge	19/20/21
535	282	F2-B8-B	Upper flange N	strain gauge	19/20/21
537	283	F2-B8-C	upper flange S	strain gauge	19/20/21

Chan. No.	Cable No.	location	comments	instrument	Figure No.
539	284	F2-B8-D	lower flange S	strain gauge	19/20/21
541	285	F2-B8-E	middle lower flange N	strain gauge	19/20/21
543	286	F2-B8-F	upper flange N	strain gauge	19/20/21
545	287	F2-B8-G	upper flange S	strain gauge	19/20/21
547	288	F2-B8-H	lower flange S	strain gauge	19/20/21
549	289	F2-B8-I	East lower flange N	strain gauge	19/20/21
551	290	F2-B8-J	upper flange N	strain gauge	19/20/21
553	291	F2-B8-K	upper flange S	strain gauge	19/20/21
555	292	F2-B8-L	lower flange S	strain gauge	19/20/21
557	293	F2-B9-A	beam E2/F3 South lower flange W	strain gauge	19/20/21
559	294	F2-B9-B	upper flange W	strain gauge	19/20/21
561	295	F2-B9-C	upper flange E	strain gauge	19/20/21
563	296	F2-B9-D	lower flange E	strain gauge	19/20/21
565	297	F2-B9-E	middle lower flange W	strain gauge	19/20/21
567	298	F2-B9-F	upper flange W	strain gauge	19/20/21
569	299	F2-B9-G	upper flange E	strain gauge	19/20/21
571	2100	F2-B9-H	lower flange E	strain gauge	19/20/21
573	2101	F2-B9-I	North lower flange W	strain gauge	19/20/21
575	2102	F2-B9-J	upper flange W	strain gauge	19/20/21
577	2103	F2-B9-K	upper flange E	strain gauge	19/20/21
579	2104	F2-B9-L	lower flange E	strain gauge	19/20/21
581	301	F3-C1-A	3rd floor column E3 bottom SW	strain gauge	19/20/21
583	302	F3-C1-B	NW	strain gauge	19/20/21
585	303	F3-C1-C	NE	strain gauge	19/20/21
587	304	F3-C1-D	SE	strain gauge	19/20/21
589	305	F3-C1-E	top SW	strain gauge	19/20/21
591	306	F3-C1-F	NW	strain gauge	19/20/21
593	307	F3-C1-G	NE	strain gauge	19/20/21
595	308	F3-C1-H	SE	strain gauge	19/20/21

Chan. No.	Cable No.	location	comments	instrument	Figure No.
597	309	F3-C2-A	column E4 bottom SW	strain gauge	19/20/21
599	310	F3-C2-B	NW	strain gauge	19/20/21
601	311	F3-C2-C	NE	strain gauge	19/20/21
603	312	F3-C2-D	SE	strain gauge	19/20/21
605	313	F3-C2-E	top SW	strain gauge	19/20/21
607	314	F3-C2-F	NW	strain gauge	19/20/21
609	315	F3-C2-G	NE	strain gauge	19/20/21
611	316	F3-C2-H	SE	strain gauge	19/20/21
613	317	F3-C3-A	column F4 bottom SW	strain gauge	19/20/21
615	318	F3-C3-B	Nw	strain gauge	19/20/21
617	319	F3-C3-C	NE	strain gauge	19/20/21
619	320	F3-C3-D	SE	strain gauge	19/20/21
621	321	F3-C3-E	top SW	strain gauge	19/20/21
623	322	F3-C3-F	NW	strain gauge	19/20/21
625	323	F3-C3-G	NE	strain gauge	19/20/21
627	324	F3-C3-H	SE	strain gauge	19/20/21
629	325	F3-C4-A	column F3 bottom SW	strain gauge	19/20/21
631	326	F3-C4-B	NW	strain gauge	19/20/21
633	327	F3-C4-C	NE	strain gauge	19/20/21
635	328	F3-C4-D	SE	strain gauge	19/20/21
637	329	F3-C4-E	top SW	strain gauge	19/20/21
639	330	F3-C4-F	NW	strain gauge	19/20/21
641	331	F3-C4-G	NE	strain gauge	19/20/21
643	332	F3-C4-H	SE	strain gauge	19/20/21
645	333	F3-C6-A	column D4 bottom SW	strain gauge	19/20/21
647	334	F3-C6-B	NW	strain gauge	19/20/21
649	335	F3-C6-C	NE	strain gauge	19/20/21
651	336	F3-C6-D	SE	strain gauge	19/20/21
653	337	F3-C6-E	top SW	strain gauge	19/20/21

Chan. No.	Cable No.	location	comments	instrument	Figure No.
655	338	F3-C6-F	NW	strain gauge	19/20/21
657	339	F3-C6-G	NE	strain gauge	19/20/21
659	340	F3-C6-H	SE	strain gauge	19/20/21
661	341	F3-C7-A	column D3 bottom SW	strain gauge	19/20/21
663	342	F3-C7-B	NW	strain gauge	19/20/21
665	343	F3-C7-C	NE	strain gauge	19/20/21
667	344	F3-C7-D	SE	strain gauge	19/20/21
669	345	F3-C7-E	top SW	strain gauge	19/20/21
671	346	F3-C7-F	NW	strain gauge	19/20/21
673	347	F3-C7-G	NE	strain gauge	19/20/21
675	348	F3-C7-H	SE	strain gauge	19/20/21
677	349	F3-C8-A	column E2 bottom SW	strain gauge	19/20/21
679	350	F3-C8-B	NW	strain gauge	19/20/21
681	351	F3-C8-C	NE	strain gauge	19/20/21
683	352	F3-C8-D	SE	strain gauge	19/20/21
685	353	F3-C8-E	top SW	strain gauge	19/20/21
687	354	F3-C8-F	NW	strain gauge	19/20/21
689	355	F3-C8-G	NE	strain gauge	19/20/21
691	356	F3-C8-H	SE	strain gauge	19/20/21
693	701	F7-C1-A	7th floor column E3 bottom SW	strain gauge	19/20/21
695	702	F7-C1-B	NW	strain gauge	19/20/21
697	703	F7-C1-C	NE	strain gauge	19/20/21
699	704	F7-C1-D	SE	strain gauge	19/20/21
701	705	F7-C1-E	Top SW	strain gauge	19/20/21
703	706	F7-C1-F	NW	strain gauge	19/20/21
705	707	F7-C1-G	NE	strain gauge	19/20/21
707	708	F7-C1-H	SE	strain gauge	19/20/21
709	709	F7-C2-A	column E4 bottom SW	strain gauge	19/20/21
711	710	F7-C2-B	NW	strain gauge	19/20/21

Chan. No.	Cable No.	location	comments	instrument	Figure No.
713	711	F7-C2-C	NE	strain gauge	19/20/21
715	712	F7-C2-D	SE	strain gauge	19/20/21
717	713	F7-C2-E	top SW	strain gauge	19/20/21
719	714	F7-C2-F	NW	strain gauge	19/20/21
721	715	F7-C2-G	NE	strain gauge	19/20/21
723	716	F7-C2-H	SE	strain gauge	19/20/21
725	717	F7-C3-A	column F4 bottom SW	strain gauge	19/20/21
727	718	F7-C3-B	NW	strain gauge	19/20/21
729	719	F7-C3-C	NE	strain gauge	19/20/21
731	720	F7-C3-D	SE	strain gauge	19/20/21
733	721	F7-C3-E	top SW	strain gauge	19/20/21
735	722	F7-C3-F	NW	strain gauge	19/20/21
737	723	F7-C3-G	NE	strain gauge	19/20/21
739	724	F7-C3-H	SE	strain gauge	19/20/21
741	725	F7-C4-A	column F3 bottom SW	strain gauge	19/20/21
743	726	F7-C4-B	NW	strain gauge	19/20/21
745	727	F7-C4-C	NE	strain gauge	19/20/21
747	728	F7-C4-D	SE	strain gauge	19/20/21
749	729	F7-C4-E	top SW	strain gauge	19/20/21
751	730	F7-C4-F	NW	strain gauge	19/20/21
753	731	F7-C4-G	NE	strain gauge	19/20/21
755	732	F7-C4-H	SE	strain gauge	19/20/21
757	733	F7-C6-A	column D4 bottom SW	strain gauge	19/20/21
759	734	F7-C6-B	NW	strain gauge	19/20/21
761	735	F7-C6-C	NE	strain gauge	19/20/21
763	736	F7-C6-D	SE	strain gauge	19/20/21
765	737	F7-C6-E	top SW	strain gauge	19/20/21
767	738	F7-C6-F	NW	strain gauge	19/20/21
769	739	F7-C6-G	NE	strain gauge	19/20/21

Chan. No.	Cable No.	location	comments	instrument	Figure No.
771	740	F7-C6-H	SE	strain gauge	19/20/21
773	741	F7-C7-A	column D3 bottom SW	strain gauge	19/20/21
775	742	F7-C7-B	NW	strain gauge	19/20/21
777	743	F7-C7-C	NE	strain gauge	19/20/21
779	744	F7-C7-D	SE	strain gauge	19/20/21
781	745	F7-C7-E	top SW	strain gauge	19/20/21
783	746	F7-C7-F	NW	strain gauge	19/20/21
785	747	F7-C7-G	NE	strain gauge	19/20/21
787	748	F7-C7-H	SE	strain gauge	19/20/21
789	749	F7-C8-A	column D2 bottom SW	strain gauge	19/20/21
791	750	F7-C8-B	NW	strain gauge	19/20/21
793	751	F7-C8-C	NE	strain gauge	19/20/21
795	752	F7-C8-D	SE	strain gauge	19/20/21
797	753	F7-C8-E	top SW	strain gauge	19/20/21
799	754	F7-C8-F	NW	strain gauge	19/20/21
801	755	F7-C8-G	NE	strain gauge	19/20/21
803	756	F7-C8-H	SE	strain gauge	19/20/21
805	SR1	F2-R1	SW cut out mesh	strain gauge	
807	SR2	F2-R2	SW cut out mesh	strain gauge	
809	SR3	F2-R3	W cut out mesh	strain gauge	
811	SR4	F2-R4	NW cut out mesh	strain gauge	
813	SR5	F2-R5	NW cut out mesh	strain gauge	
815	SR6	F2-R6	1/4 point	strain gauge	
817	SR7	F2-R7	1/4 point	strain gauge	
819	SR8	F2-R8	S middle	strain gauge	
821	SR9	F2-R9	middle	strain gauge	
823	SR10	F2-R10	middle	strain gauge	
825	SR11	F2-R11	N middle	strain gauge	
827	SR12	F2-R12	N middle	strain gauge	

Chan. No.	Cable No.	location	comments	instrument	Figure No.
829	SR13	F2-R13	SE	strain gauge	
831	SR14	F2-R14	E middle	strain gauge	
833	SR15	F2-R15	NE	strain gauge	
835	SR16	F2-R16	NE	strain gauge	
837	CSS1	SW corner	300mm from C.L.	strain gauge	22
839	CSS2	SW	500mm from C. L.	strain gauge	22
841	CSS3	SW	750mm from C. L.	strain gauge	22
843	CSS4	SW	1/4 point	strain gauge	22
845	CSS5	W	middle	strain gauge	22
847	CSS6	NW	1/4 point	strain gauge	22
849	CSS7	NW corner	750mm from C. L.	strain gauge	22
851	CSS8	SW corner	500mm from C. L.	strain gauge	22
853	CSS9	SW	1/4 point	strain gauge	22
855	CSS10	S	middle	strain gauge	22
857	CSS11	middle	middle	strain gauge	22
859	CSS12	SE	1/4 point	strain gauge	22
861	CSS13	SE corner	1125mm from C. L.	strain gauge	22
881	C1	column C1 (E3)	web	clinometer	26
882	C2	beam E3-E4	B4 S	clinometer	26
883	C3	beam E3-E4	B4 N	clinometer	26
884	C4	column C2 (E4)	web	clinometer	26
885	C5	beam E4-F4	B1 W	clinometer	26
886	C6	beam E4-F4	B1 E	clinometer	26
887	C7	column C3 (F4)	web	clinometer	26
888	C8	beam F4-F3	B5 N	clinometer	26
889	C9	beam F4-F3	B5 S	clinometer	26
890	C10	column C4 (F3)	web	clinometer	26
891	C11	beam F3-E3	B3 E	clinometer	26
892	C12	beam F3-E3	B3 W	clinometer	26

Chan. No.	Cable No.	location	comments	instrument	Figure No.
893	PKB1	diagonal SE-NW	1/4 point	displacement	23
894	PKB2	diagonal SW-NE	1/4 point	displacement	23
895	PKB3	E to W	CL-F3-F4	displacement	23
896	LC1	NE corner		load cell	
897	LC2	SW corner		load cell	
898	LC3	middle		load cell	
901	D1	E to W	on CL E3-E4	displacement	23
902	D2	E to W	300mm from previous	displacement	23
903	D3	E to W	300mm from previous	displacement	23
904	D4	E to W	300mm from previous	displacement	23
905	D5	E to W	300mm from previous	displacement	23
906	D6	E to W	300mm from previous	displacement	23
907	D7	diagonal SW-NE	1/4 point	displacement	23
908	D8	E to W	1/4 point	displacement	23
909	D9	diagonal SE-NW	1/4 point	displacement	23
910	D10	E to W	3/8 point	displacement	23
911	D11	S to N	on C. L. E3-F3	displacement	23
912	D12	S to N	200mm from previous	displacement	23
913	D13	S to N	200mm from previous	displacement	23
914	D14	S to N	200mm from previous	displacement	23
915	D15	S to N	200mm from previous	displacement	23
916	D16	S to N	200mm from previous	displacement	23
917	D17	S to N	1/4 point	displacement	23
918	D18	S to N	3/8 point	displacement	23
919	D19	centre	centre	displacement	23
920	D20	S to N	CL E4-F4	displacement	23
921	high	hangar window	N	t/c	
922	medium	hangar window	E	t/c	
923	100/101	hangar roof		t/c	

Chan. No.	Cable No.	location	comments	instrument	Figure No.
924	100/102	hangar roof		t/c	
925	100/103	hangar roof		t/c	
926	front	hangar truss	front of protection	t/c	
927	back	hangar truss	behind protection	t/c	
928	I1	indicative 1 flange	NW of compartment close to window	t/c	Photo. 2
929	I2	flange		t/c	Photo. 2
930	I3	web		t/c	Photo. 2
931	I4	flange	NE of compartment close to window	t/c	Photo. 2
932	I5	flange		t/c	Photo. 2
933	I6	web		t/c	Photo. 2
934	I7	flange	SW of compartment away from window	t/c	Photo. 2
935	I8	flange		t/c	Photo. 2
936	I9	web		t/c	Photo. 2
937	DOC1		University of Ulster		
938	DOC2		University of Ulster		
939	DOC3		University of Ulster		
940	DOC4		University of Ulster		
941	DOC5		University of Ulster		
942	DOC6		University of Ulster		
943	DOC7		University of Ulster		
945	DOC9		University of Ulster		
946	DOC10		University of Ulster		
947	DOC11		University of Ulster		
948	DOC12		University of Ulster		
949	DOC13		University of Ulster		
950	DOC14		University of Ulster		
951	DOC15		University of Ulster		

Chan. No.	Cable No.	location	comments	instrument	Figure No.
952	DOC16	heat flux	through slab	heat flux	
953	DOC8	heat flux	through slab	heat flux	
954	DS1	heat flux	in plane of window	heat flux	
955	DS2	heat flux	in plane of window	heat flux	
956	Y1	inside gable wall		t/c	
957	Y2	outside gable wall		t/c	
961	D24	column C1 (E3)	axial N-S	displacement	24
962	D25	column C1 (E3)	axial E-W	displacement	24
963	D26	column C1 (E3)	major axis L/6 from top	displacement	24
964	D27	column C1 (E3)	major axis L/3 from top	displacement	24
965	D28	column C1 (E3)	major axis L/2	displacement	24
966	D29	column C1 (E3)	major axis 2L/3 from top	displacement	24
967	D30	column C1 (E3)	major axis 5L/6 from top	displacement	24
968	D31	column C1 (E3)	minor axis L/6 from top	displacement	24
969	D32	column C1 (E3)	minor axis L/3 from top	displacement	24
970	D33	column C1 (E3)	minor axis L/2	displacement	24
971	D34	column C1 (E3)	minor axis 2L/3 from top	displacement	24
972	D35	column C1 (E3)	minor axis 5L/6 from top	displacement	24
973	D36	column C2 (E4)	axial N-S	displacement	24
974	D37	column C2 (E4)	axial E-W	displacement	24
975	D38	column C2 (E4)	major axis L/6 from top	displacement	24
976	D39	column C2 (E4)	major axis L/3 from top	displacement	24
977	D40	column C2 (E4)	major axis L/2	displacement	24
978	D41	column C2 (E4)	major axis 2L/3 from top	displacement	24
979	D42	column C2 (E4)	major axis 5L/6 from top	displacement	24
980	D43	column C2 (E4)	minor axis L/6 from top	displacement	24
981	D44	column C2 (E4)	minor axis L/3 from top	displacement	24
982	D45	column C2 (E4)	minor axis L/2	displacement	24
983	D46	column C2 (E4)	minor axis 2L/3 from top	displacement	24

Chan. No.	Cable No.	location	comments	instrument	Figure No.
984	D47	column C2 (E4)	minor axis 5L/6 from top	displacement	24

References

1. Newman G M, Robinson J T and Bailey C G, Fire Safe Design: A new approach to multi-storey steel-framed buildings (Second Edition), SCI Publication P288, The Steel Construction Institute, Ascot, 2006
2. Mitchell G and Woodgate R, Floor Loadings in Office Buildings - the Results of a Survey, Current Paper, BRE 1971



Photograph 1 Composite steel framed building inside the Large Building Test Facility at Cardington



Photograph 2 Corner fire test prior to ignition – view from inside



Photograph 3 Corner fire test prior to ignition – view from outside



Photograph 4 BRE Corner fire test



Photograph 5 Corner fire compartment post-test

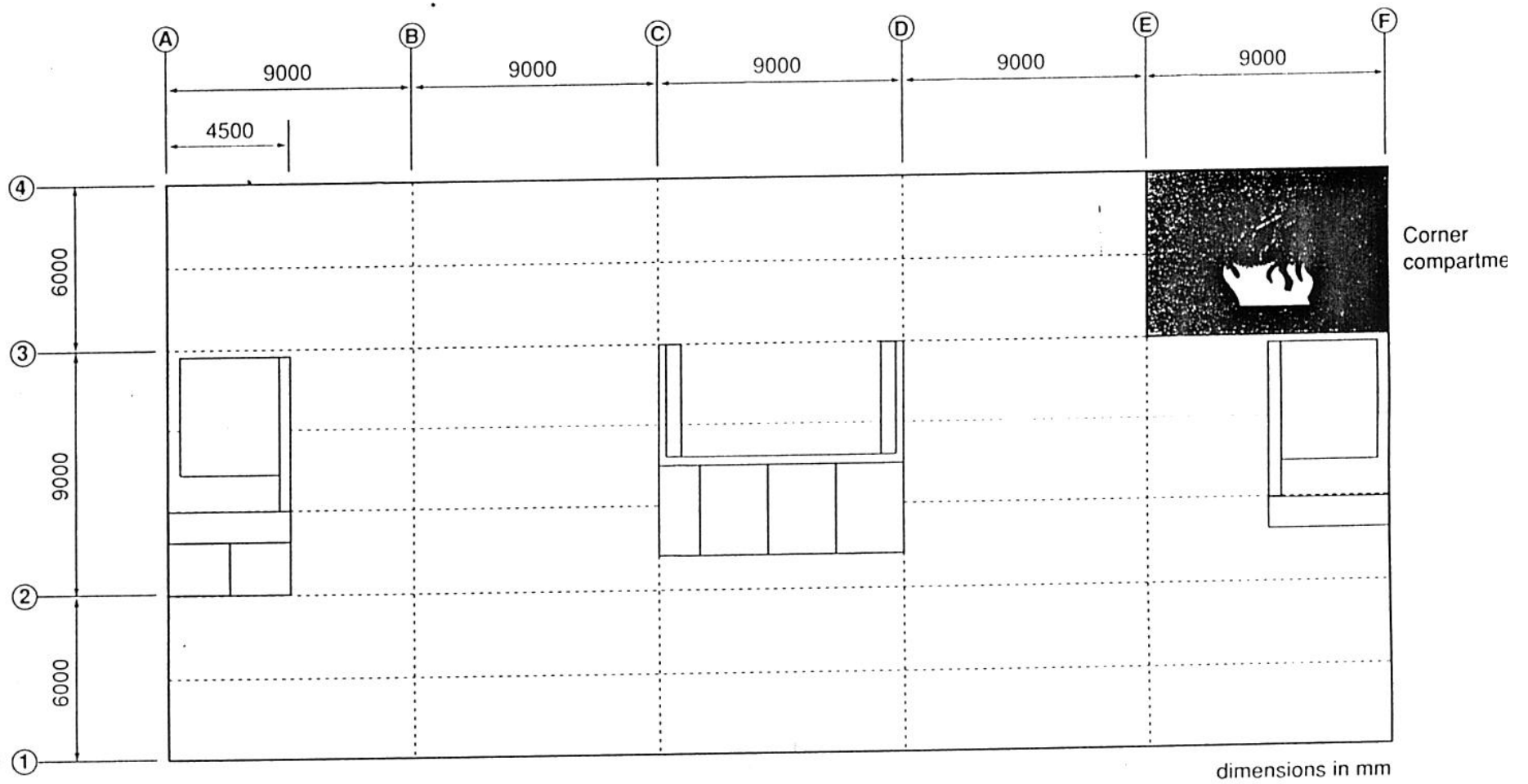


Figure 1 General floor plan showing gridline locations and location of test compartment

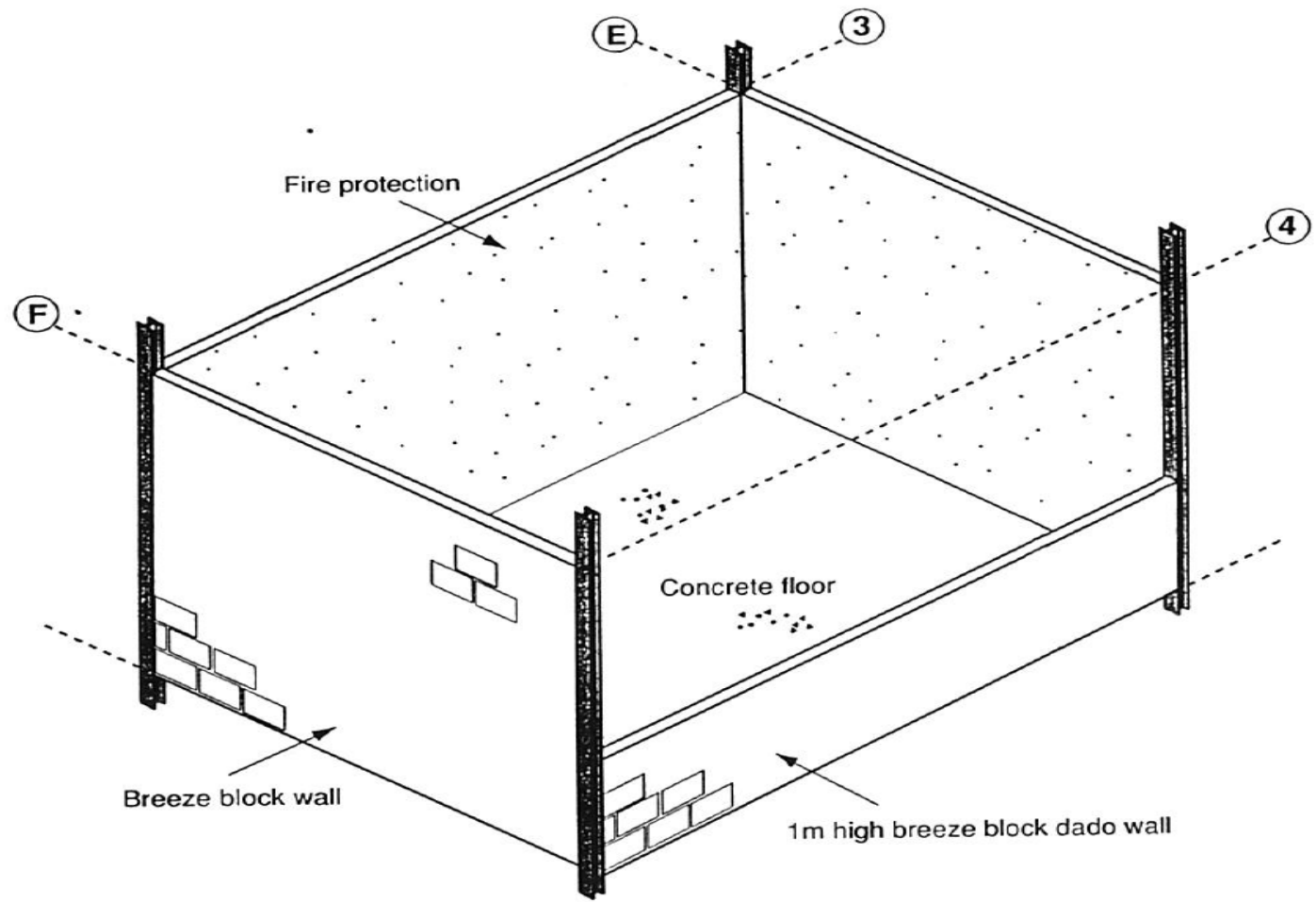


Figure 2 Three dimensional view of the fire compartment

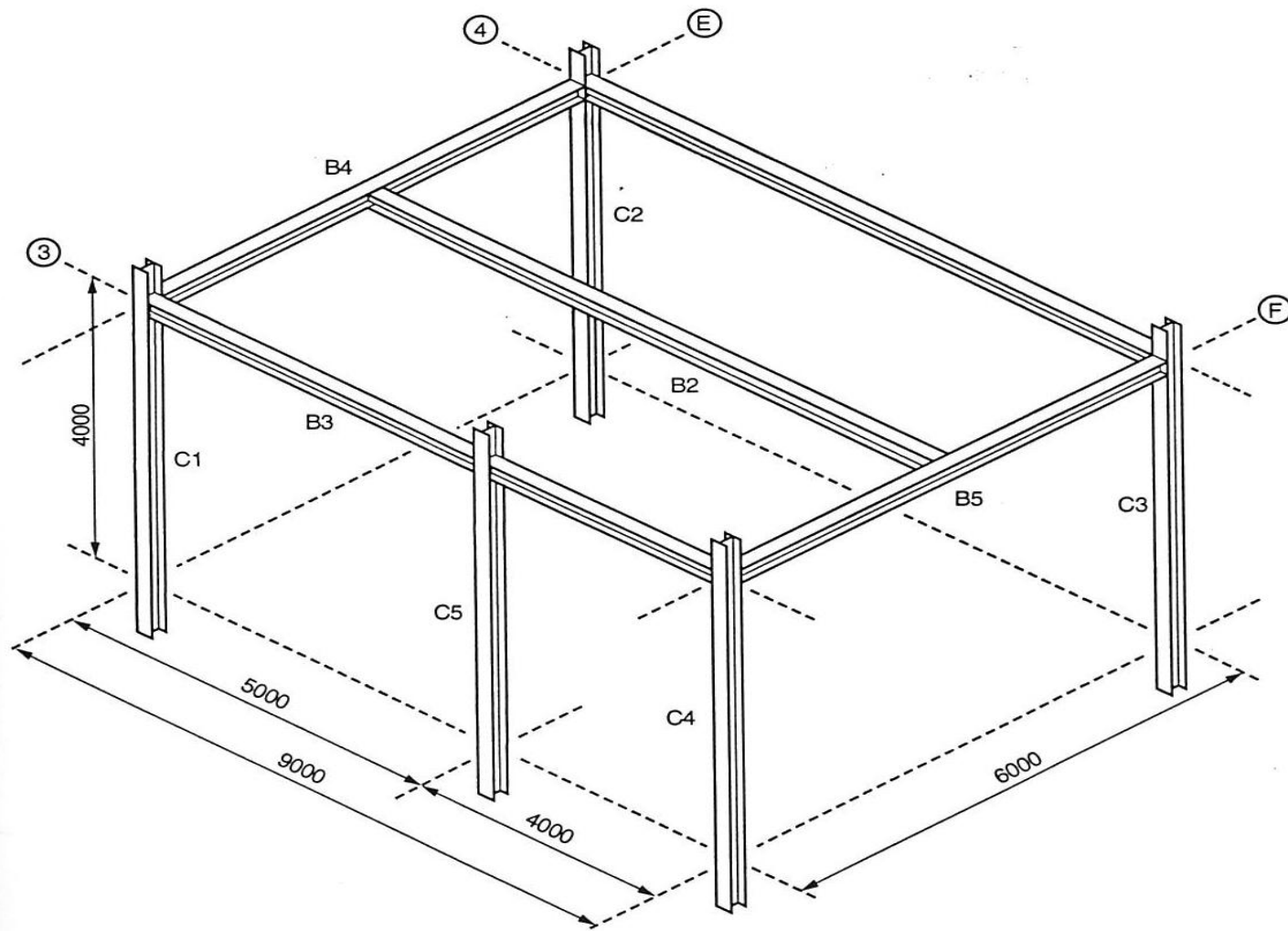


Figure 3 Location of beams and columns forming the boundaries of the fire compartment

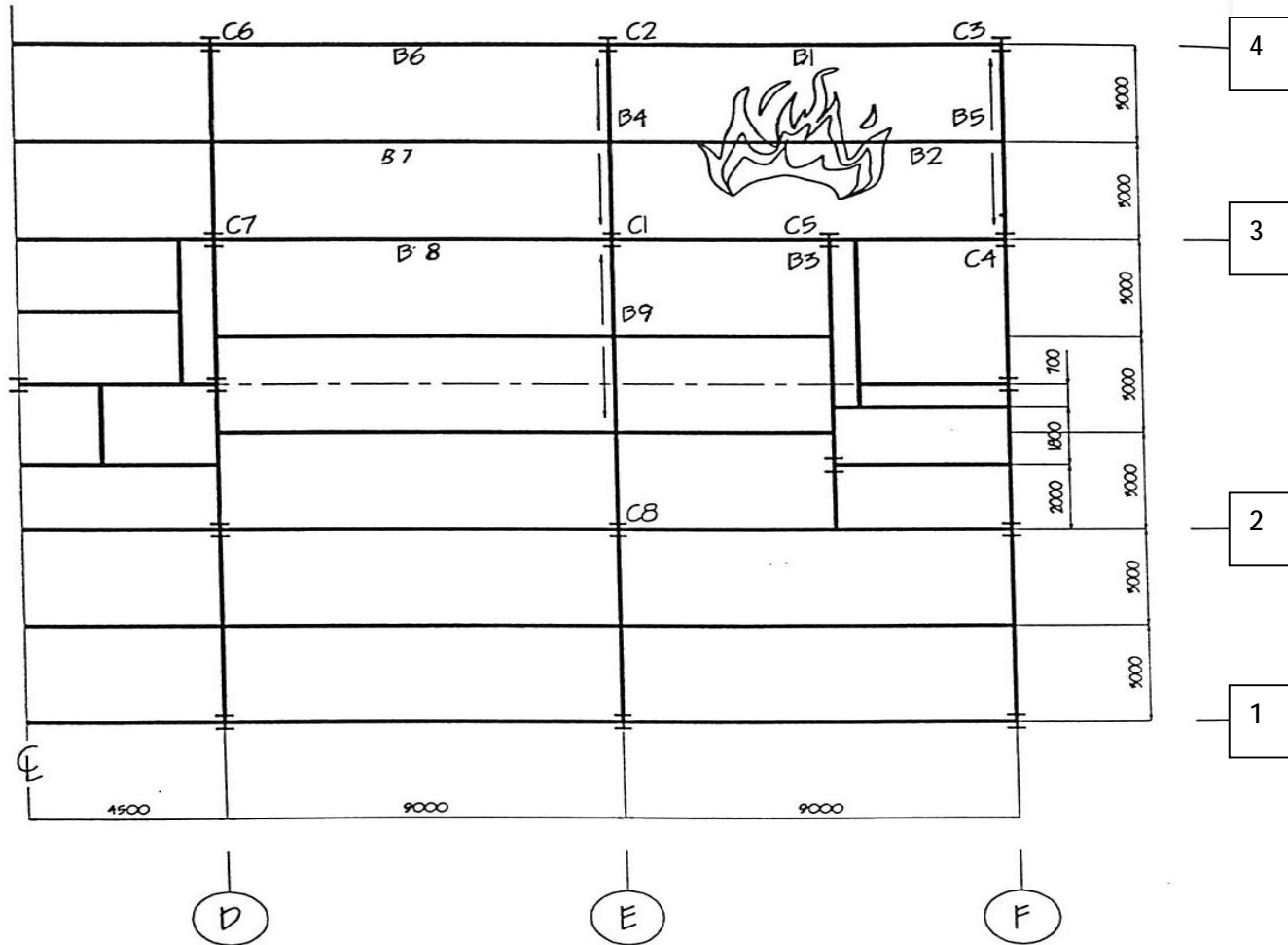


Figure 4 Plan of 2nd-3rd floor steel

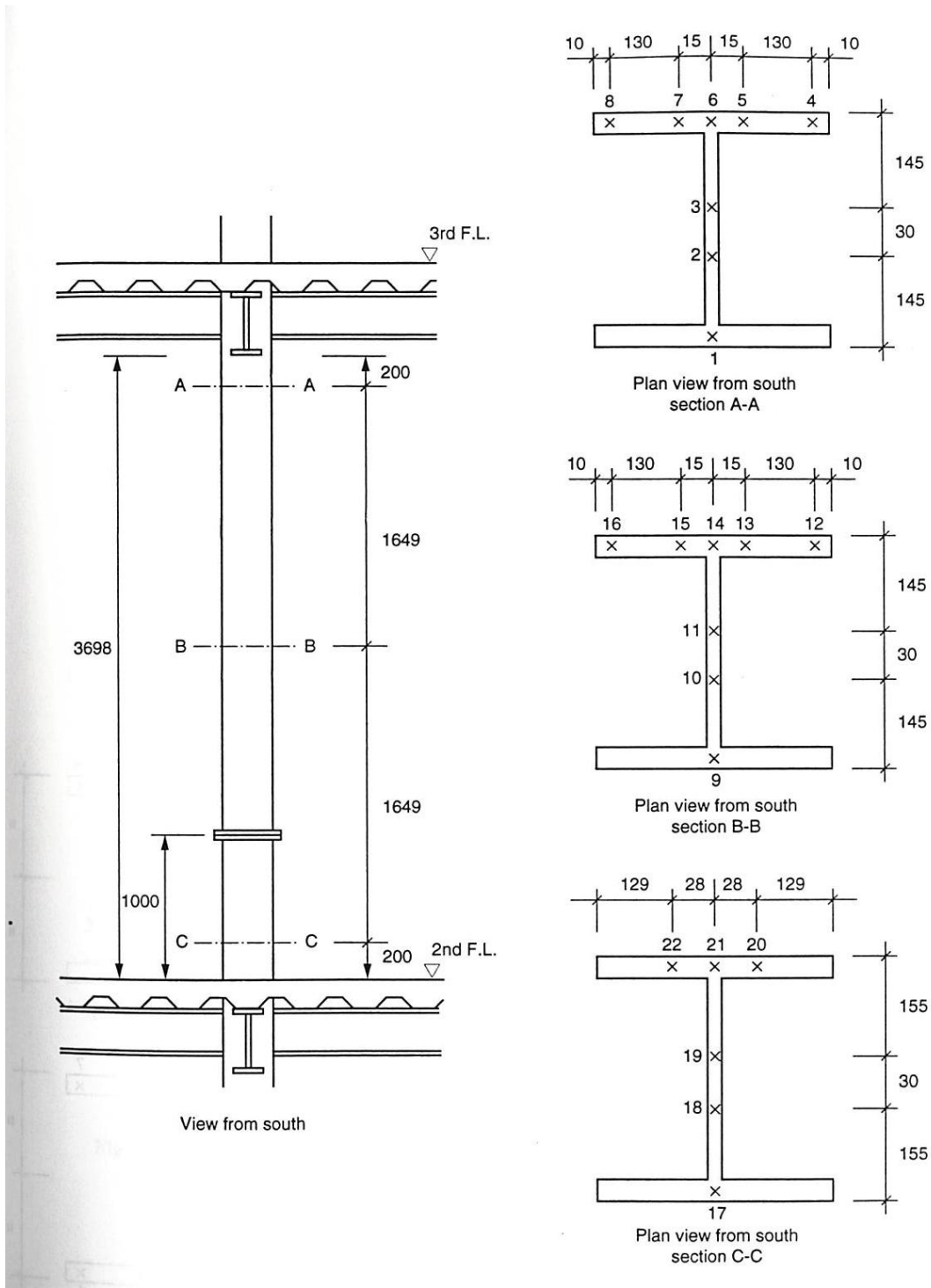


Figure 5 Thermocouple locations for column C1 (E3) – associated data file C1TEMP.xls

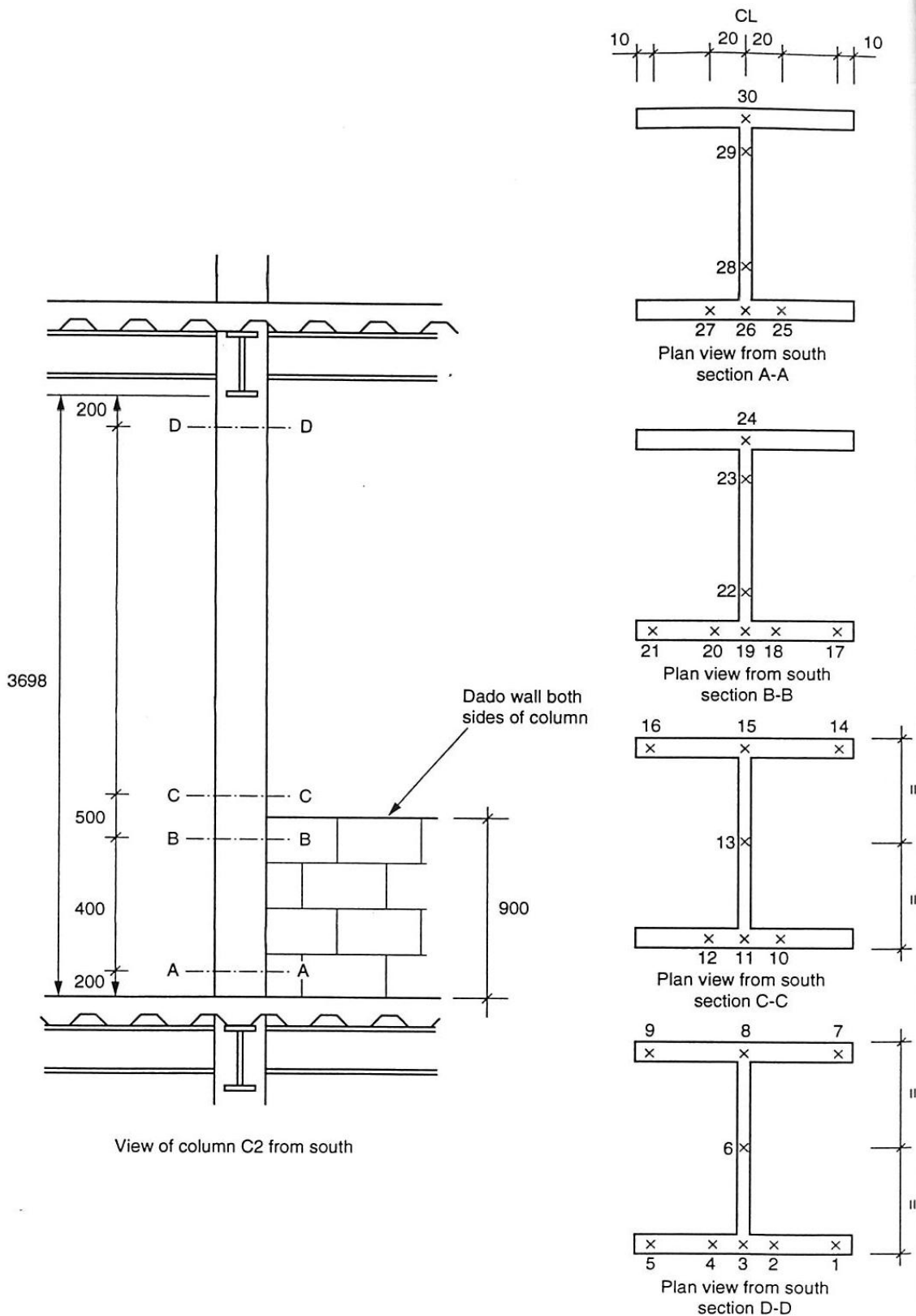


Figure 6 Thermocouple locations for columns C2 and C3 (E4 and F4) – associated data files C2TEMP.xls and C3TEMP.xls

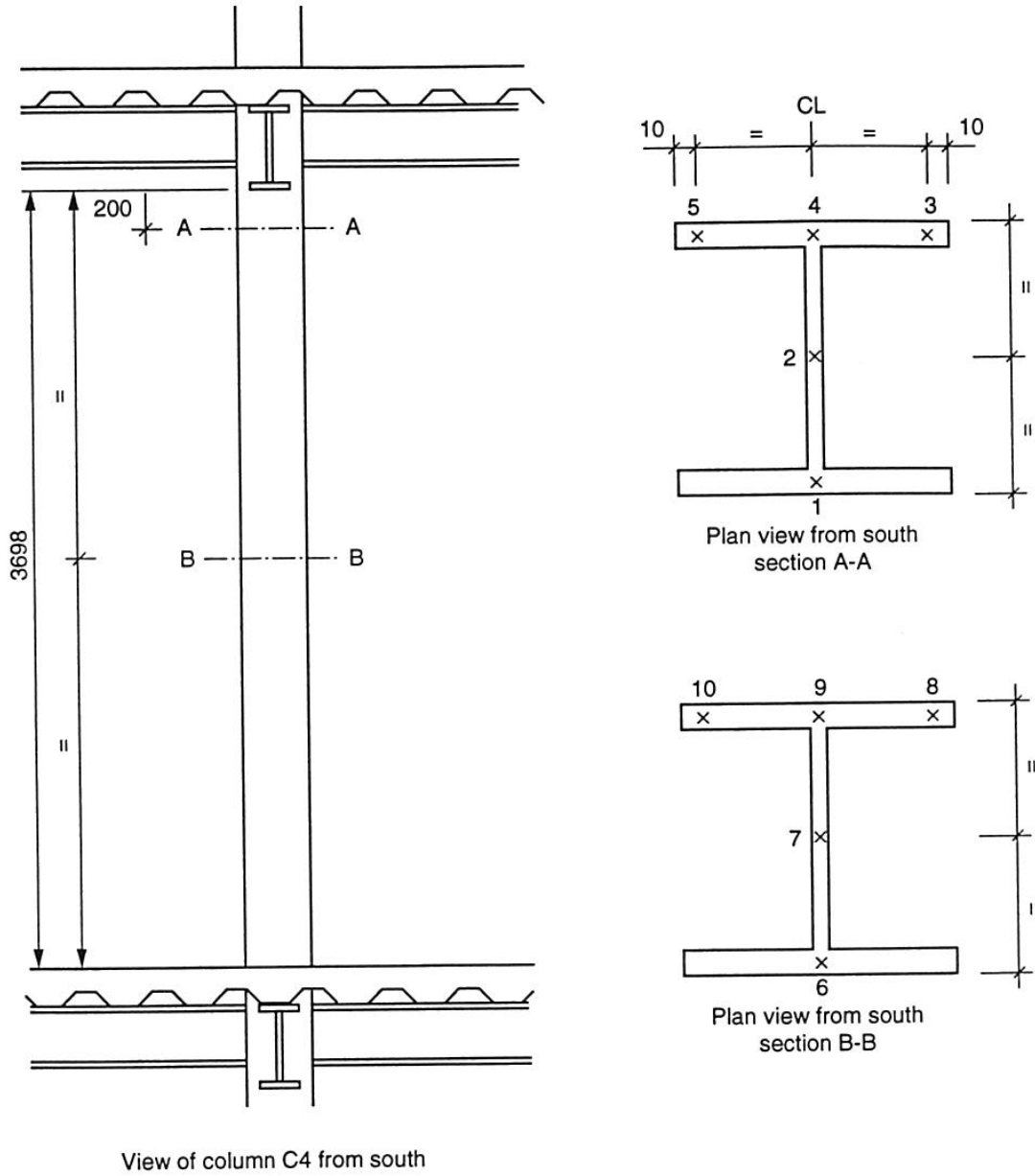


Figure 7 Thermocouple locations for column C4 (F3) – associated data file C4TEMP.xls

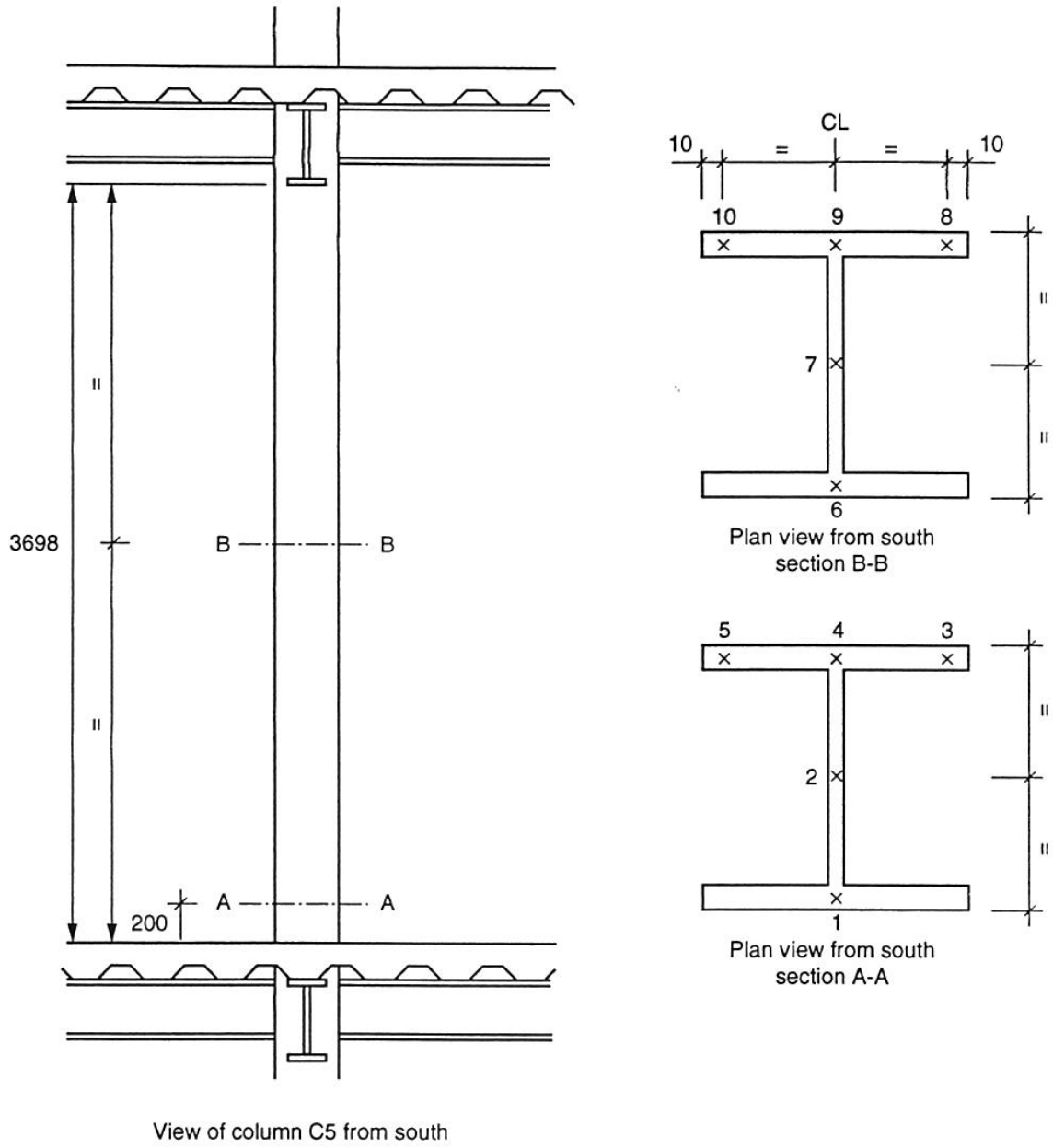


Figure 8 Thermocouple locations for column C5 (E/F3) – associated data file C5TEMP.xls

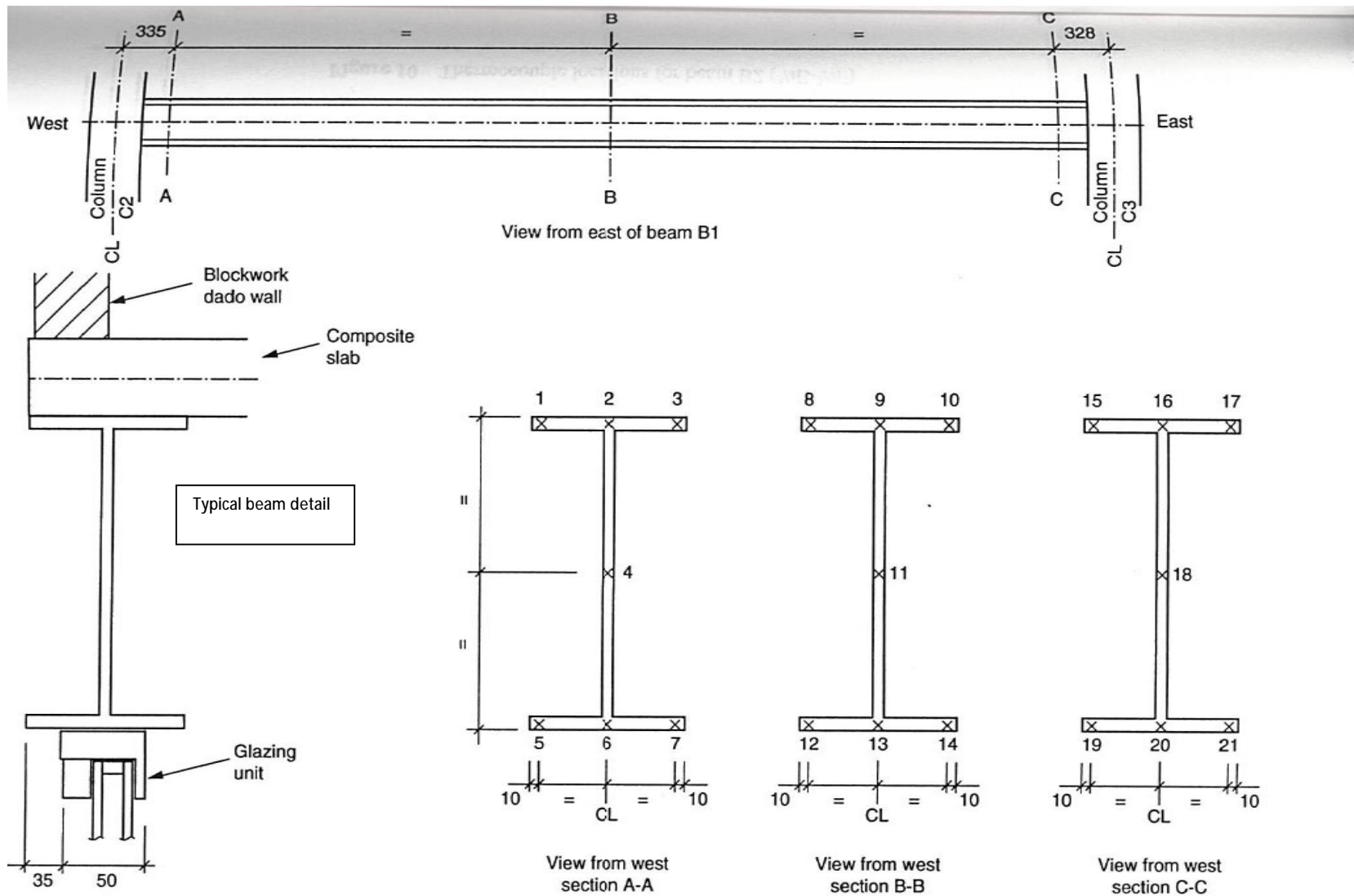
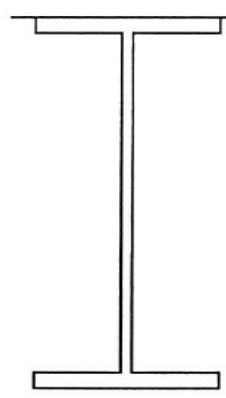
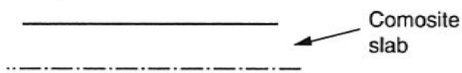
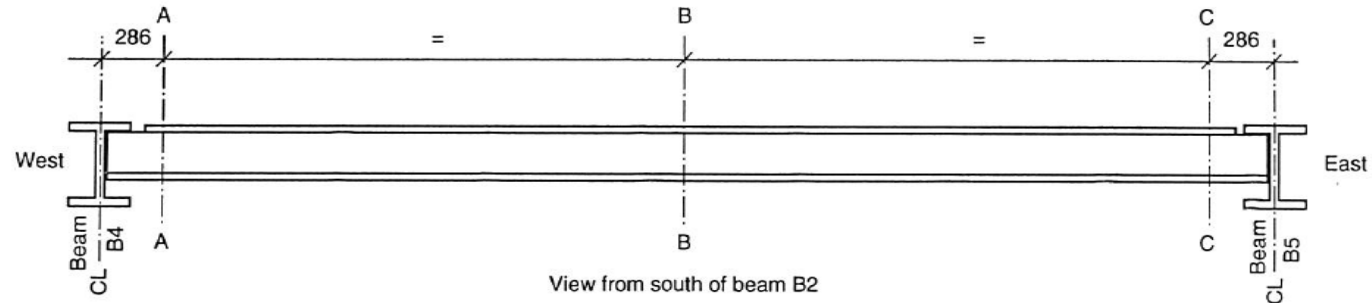
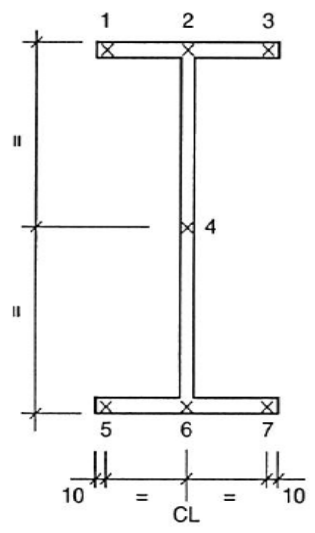


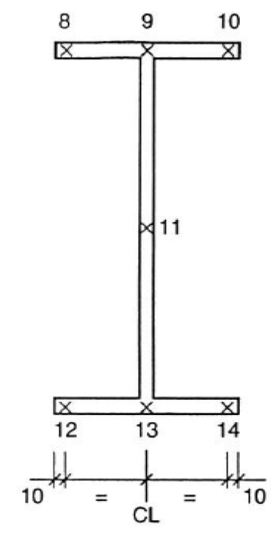
Figure 9 Thermocouple locations for beam B1 (E4-F4) – associated data file B1TEMP.xls



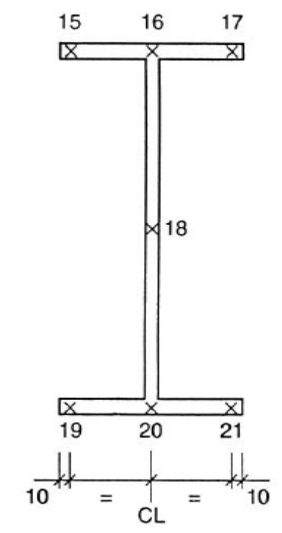
Typical beam detail



View from west section A-A



View from west section B-B



View from west section C-C

Figure 10 Thermocouple locations for beam B2 (3/4E – 3/4F) – associated data file B2TEMP.xls

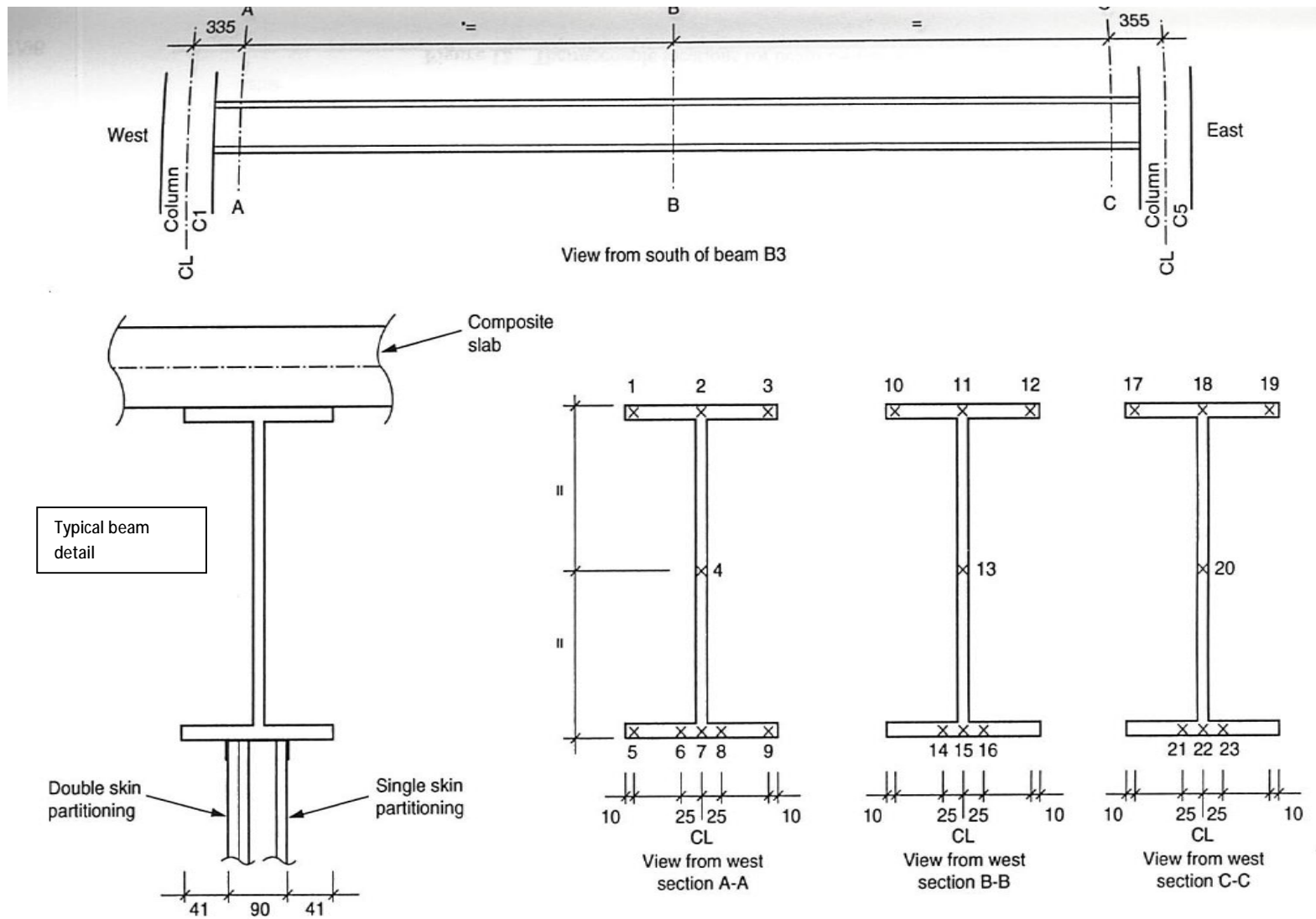


Figure 11 Thermocouple locations for beam B3 (E3-F3) – associated data file B3TEMP.xls

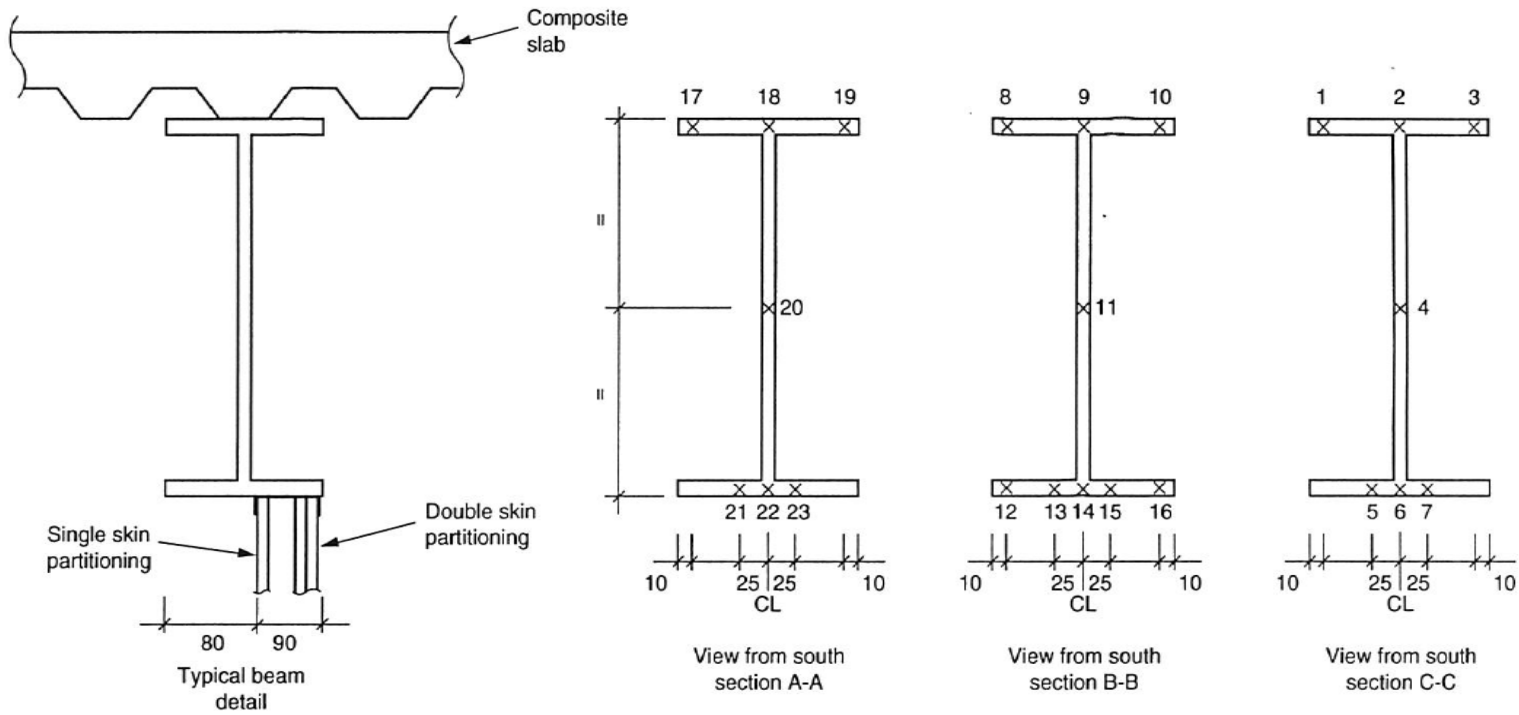
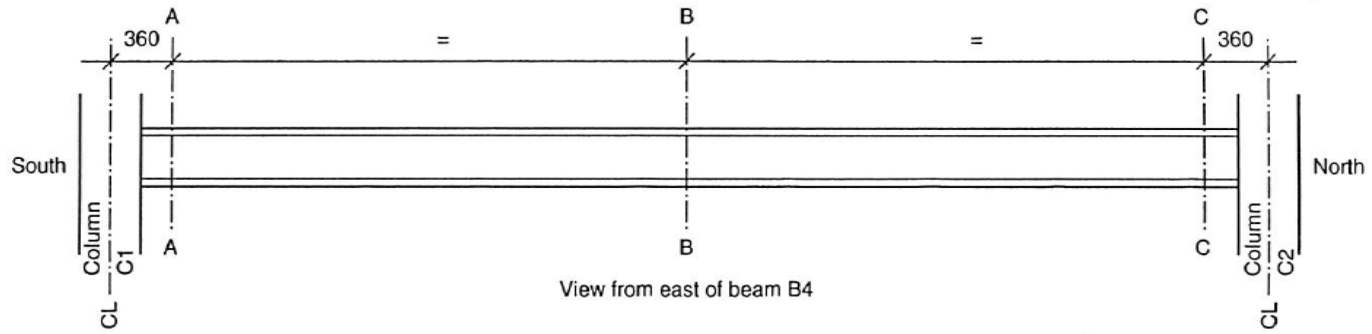


Figure 12 Thermocouple locations for beam B4 (E3-E4) – associated data file B4TEMP.xls

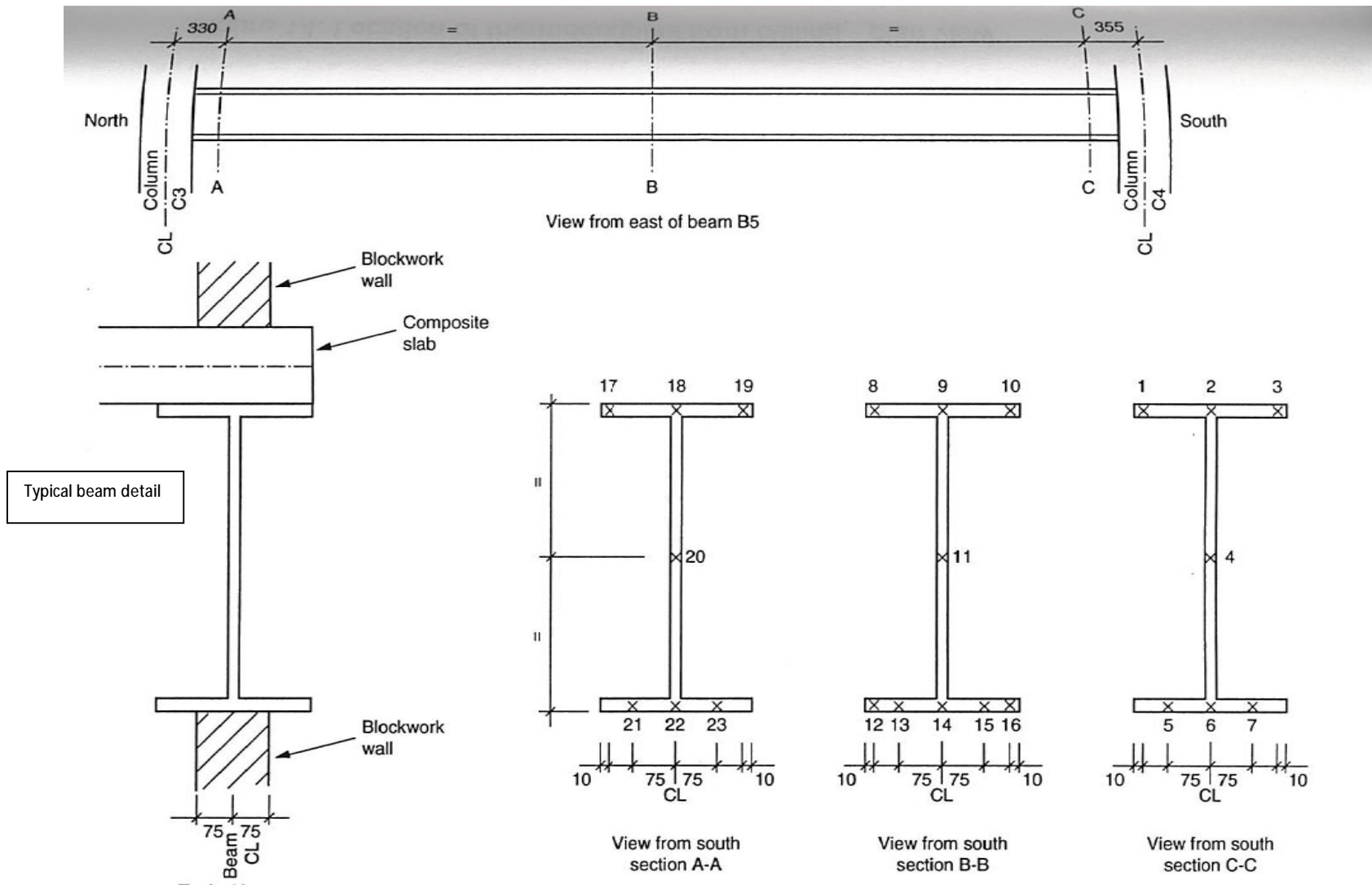


Figure 13 Thermocouple locations for beam B5 (F3-F4) – associated data file B5TEMP.xls

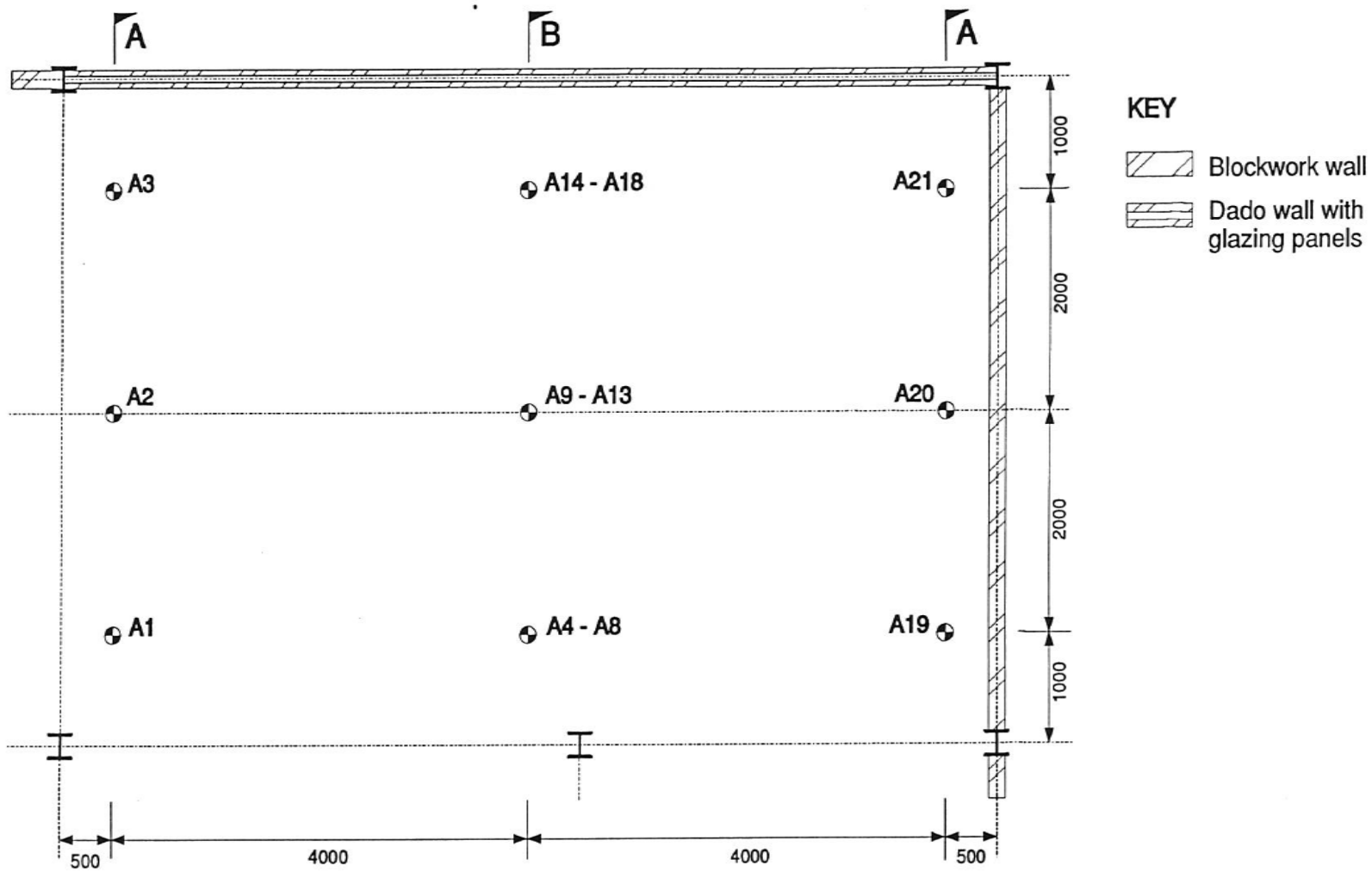
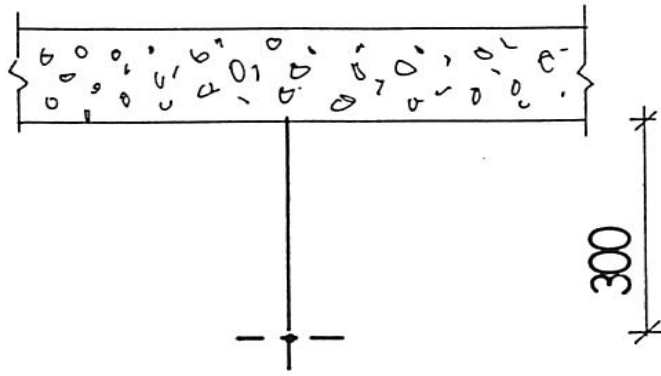
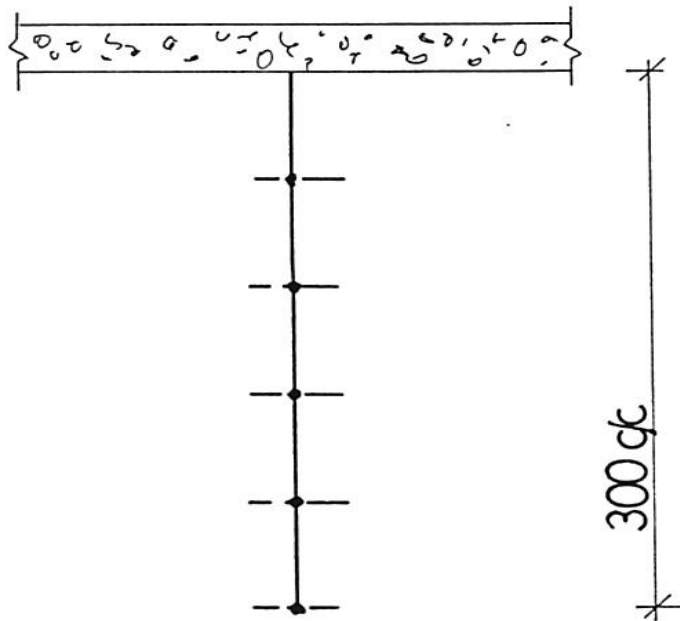


Figure 14 Location of thermocouples from ceiling – plan view – associated data file Atmosphere.xls



SECTION A



SECTION B

Figure 15 Location of thermocouples from ceiling – elevation view – associated data file Atmosphere.xls

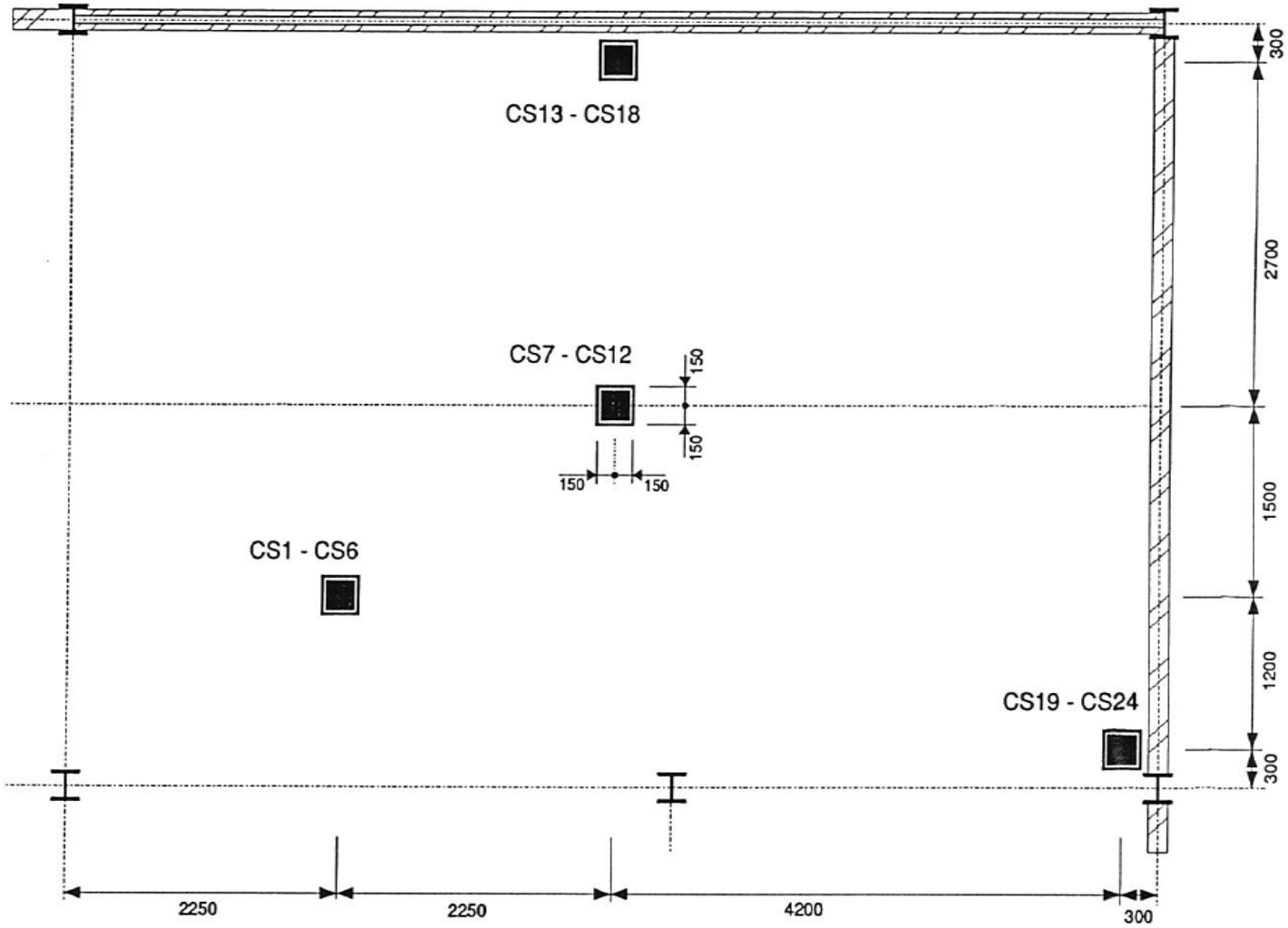


Figure 16 Instrumented cut-outs 3rd floor – associated data file SLABTEMP.xls

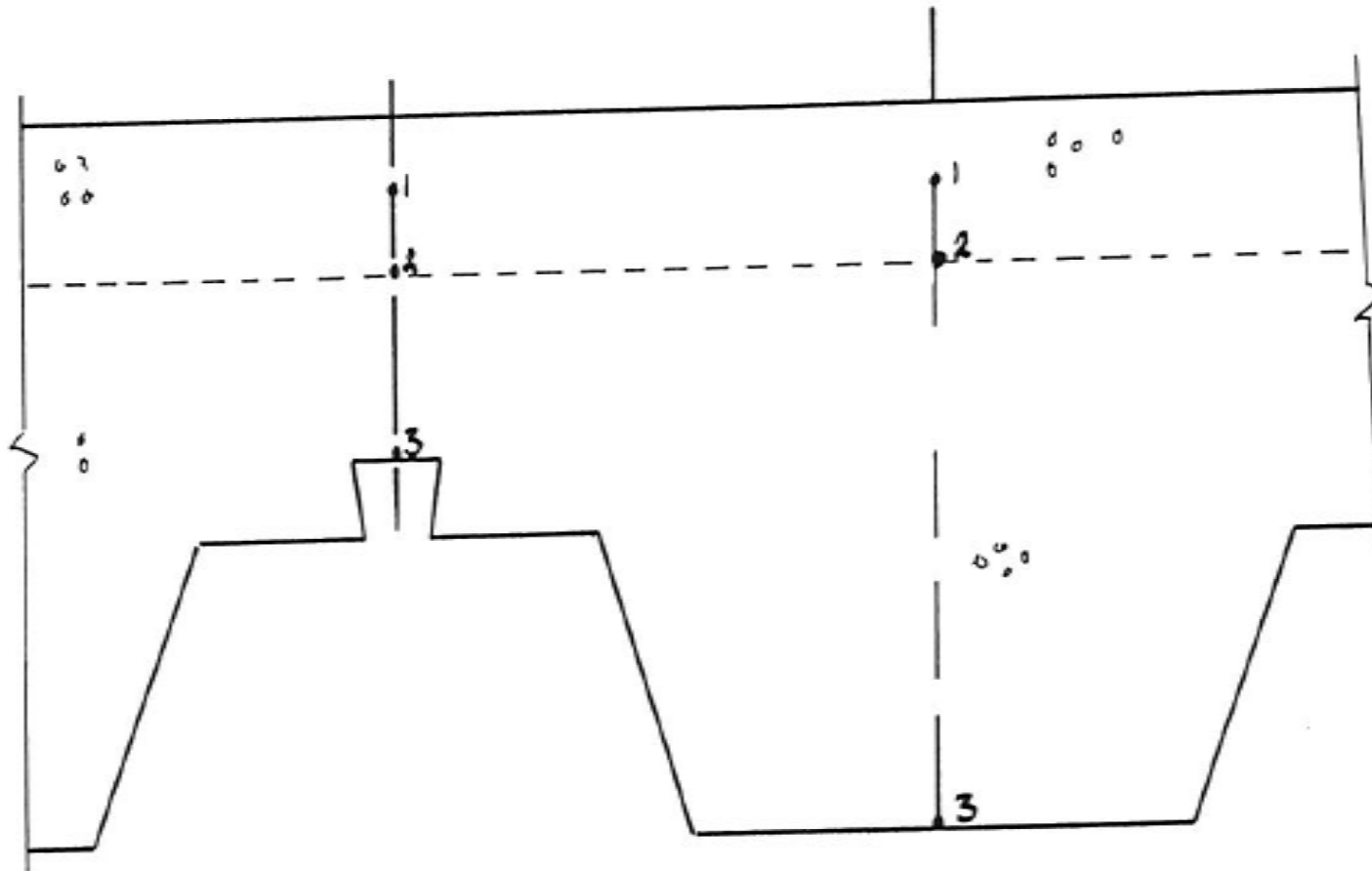


Figure 17 Concrete slab thermocouple positions – associated data file SLABTEMP.xls

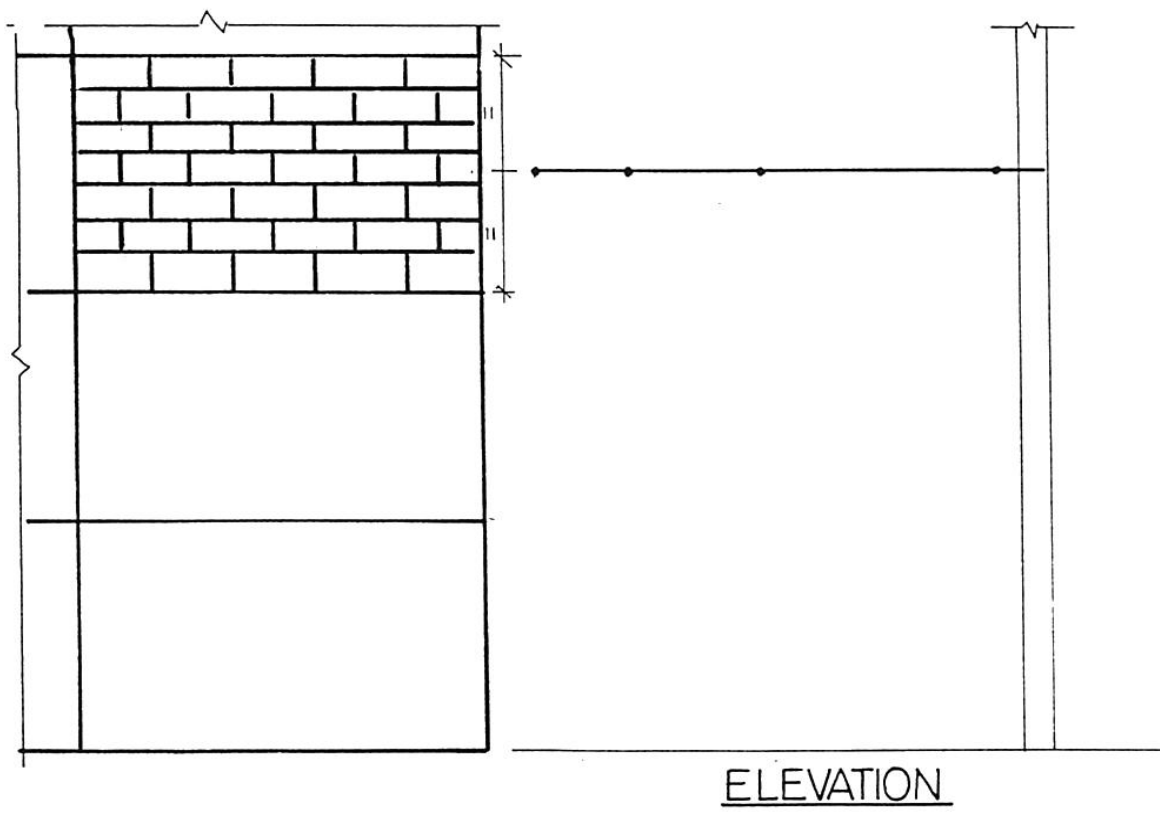
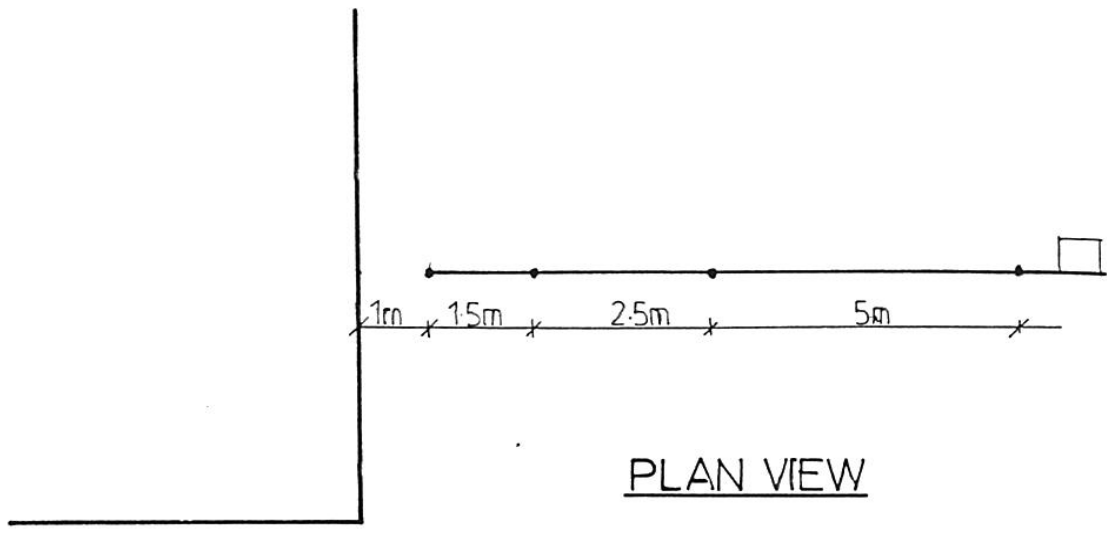


Figure 18 Thermocouple positions away from the compartment – associated data file OPPO.xls

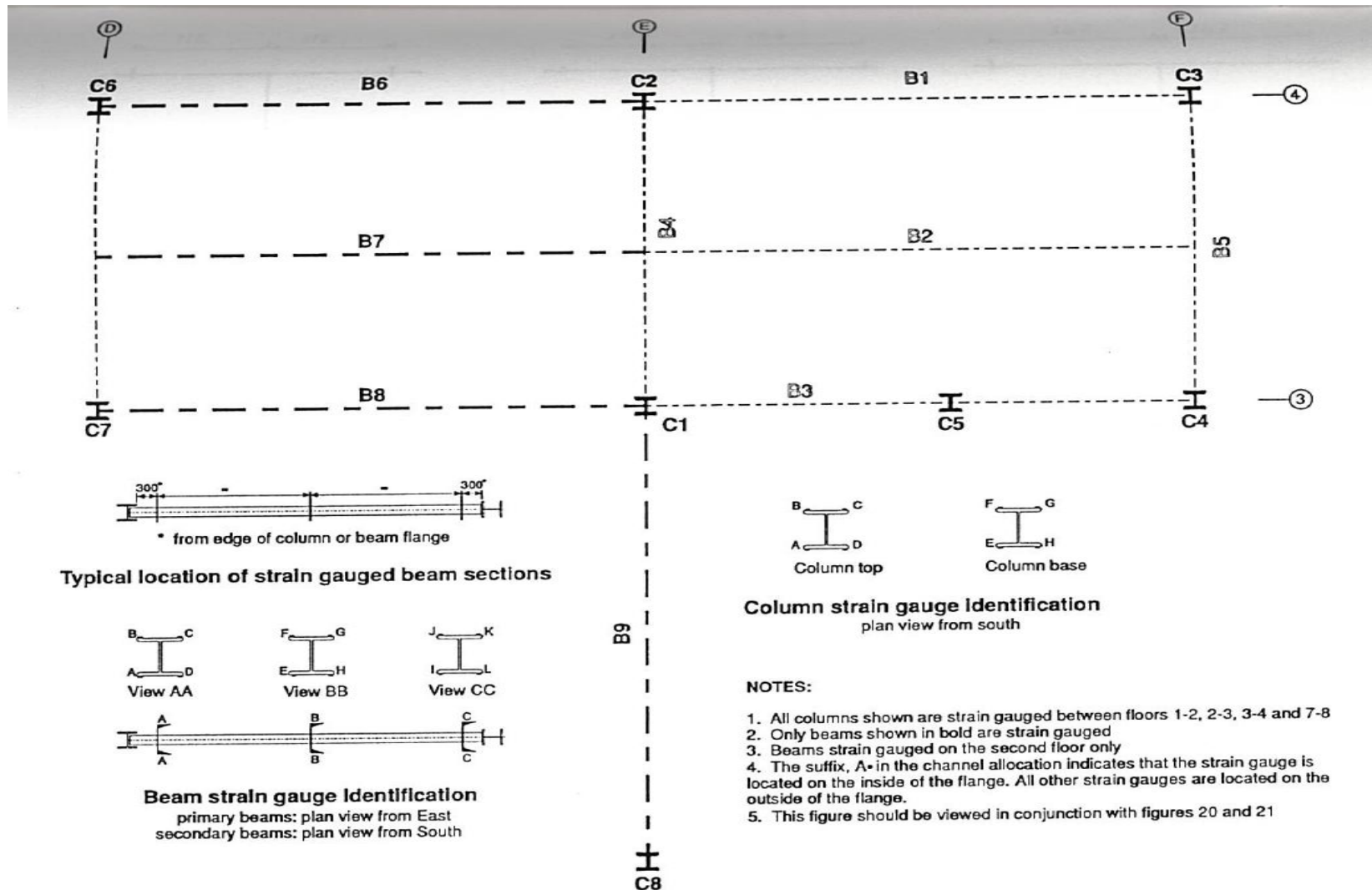
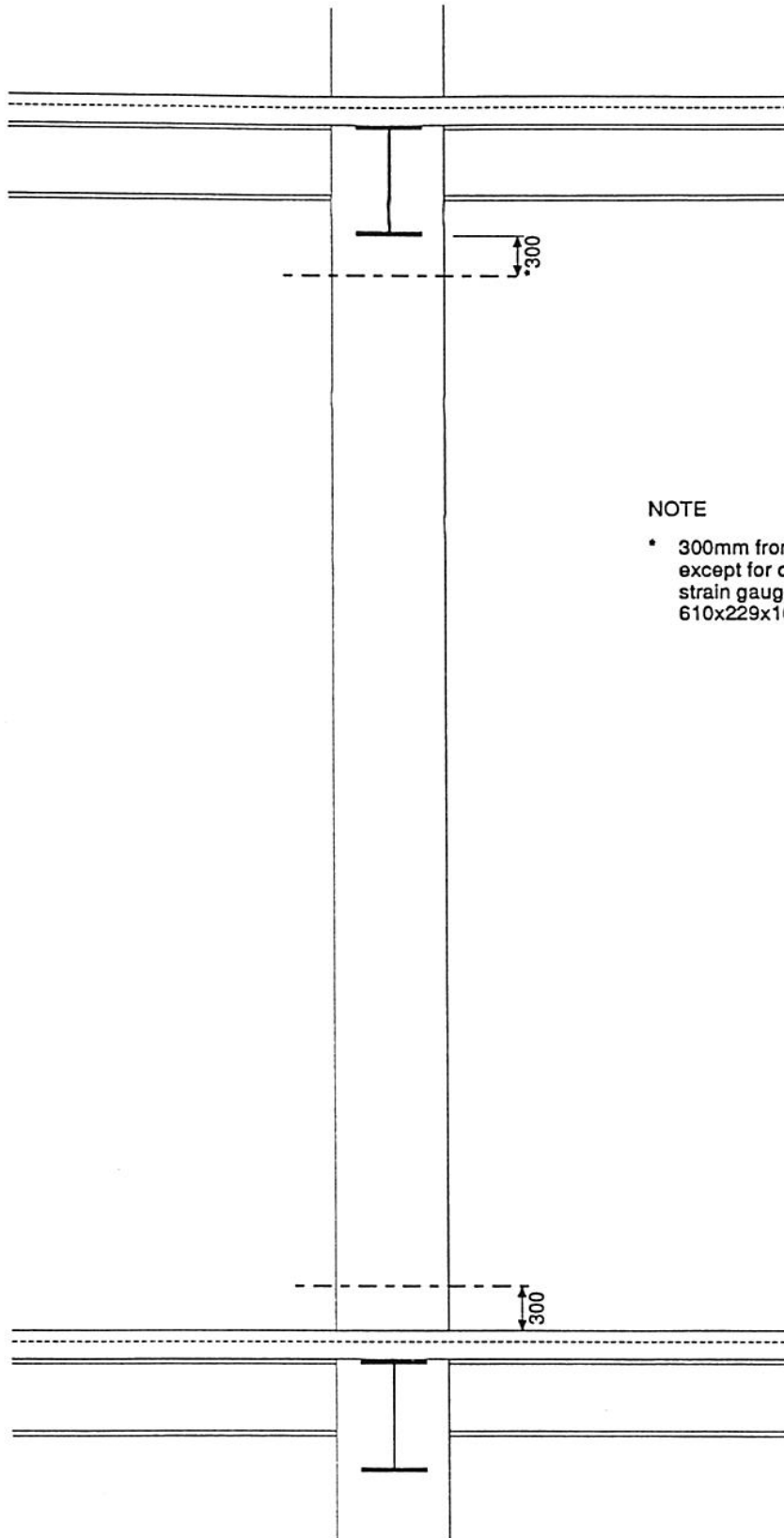


Figure 19 Strain gauge location and identification – for associated data files refer to location description in the channel allocation (eg. F1C1STRAIN.xls for column C1 strains at first floor level)



NOTE

- * 300mm from underside of deepest beam except for columns C1 and C8 where strain gauges are 100mm below the 610x229x101 UB.

Figure 20 Strain gauged sections, columns C1-C4 and C6-C8

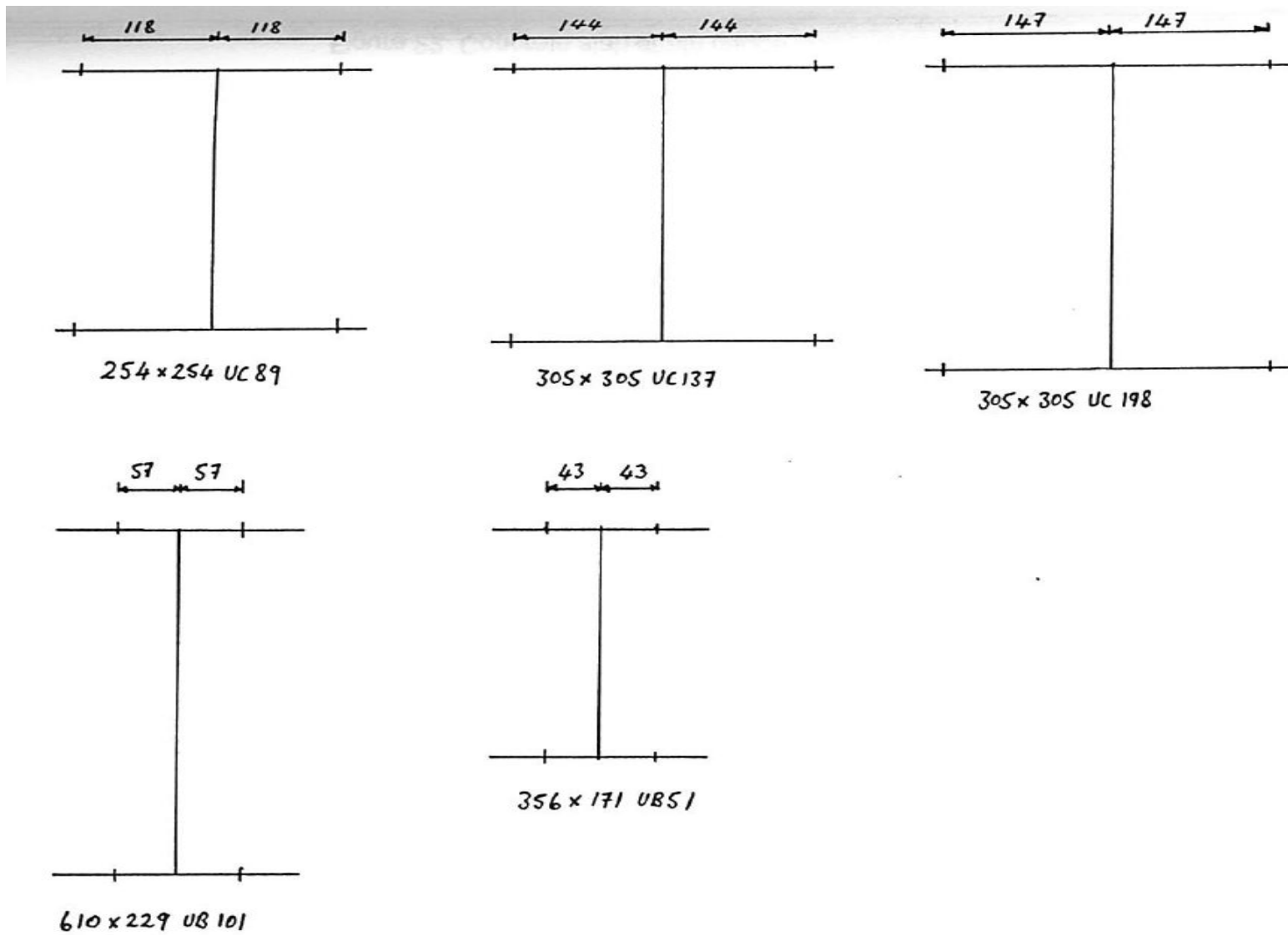


Figure 21 Strain gauge locations for individual beam and column sections

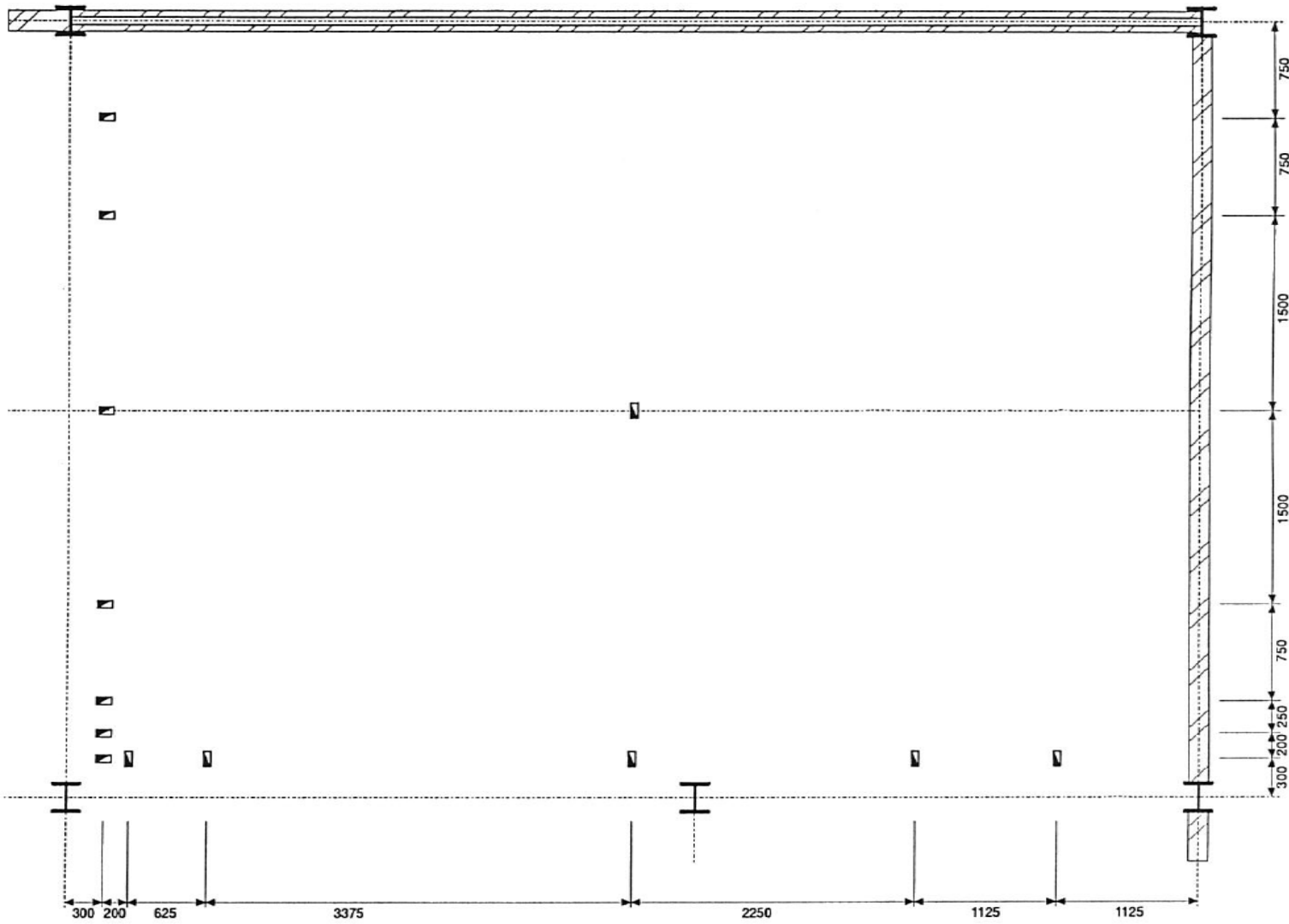


Figure 22 Concrete slab strain gauge locations – associated data files SLABSTR.xls (for surface gauges) and RFSTRAIN.xls for reinforcement

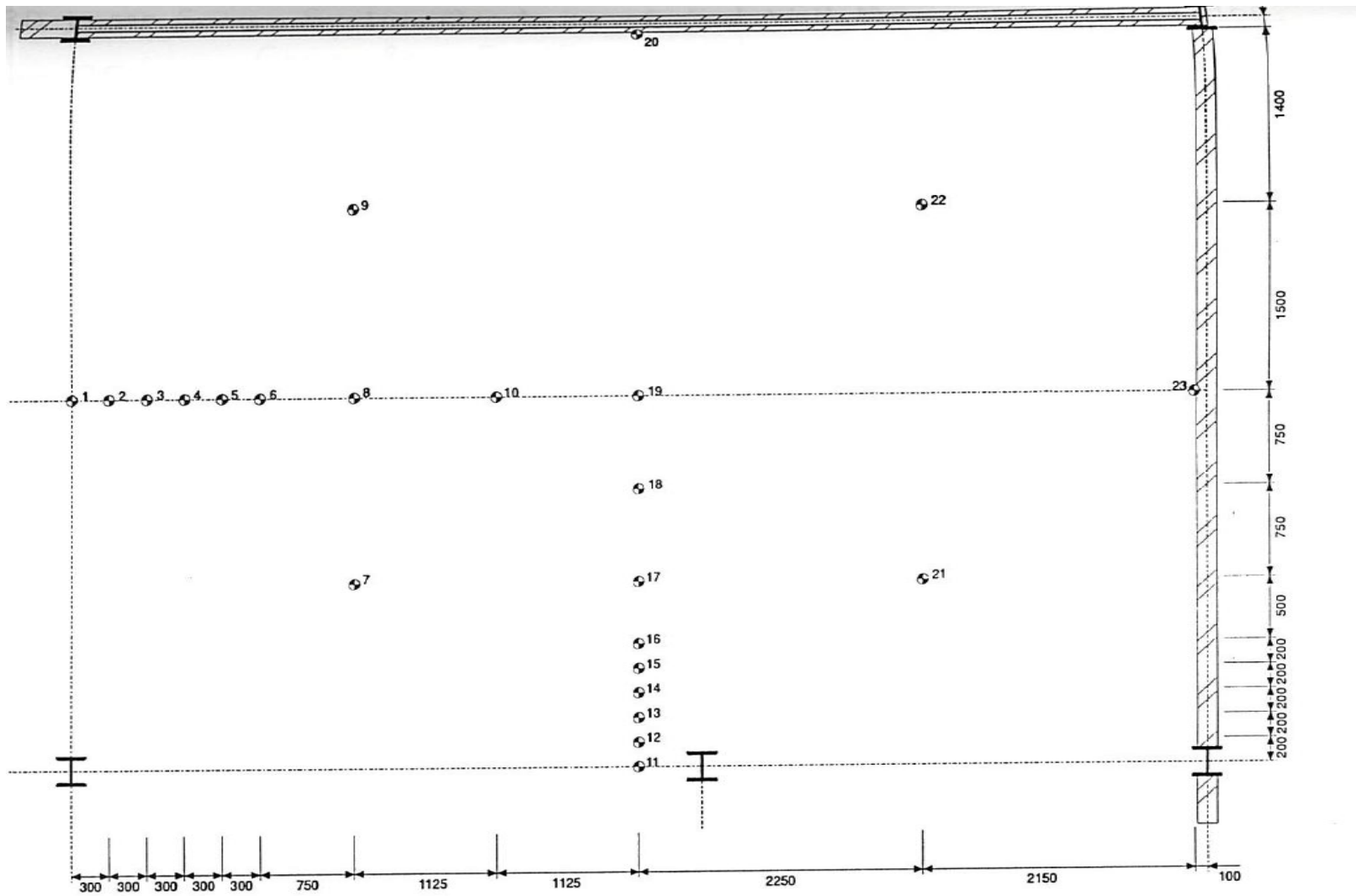


Figure 23 Third floor slab displacements – associated data file SLABDEF.xls

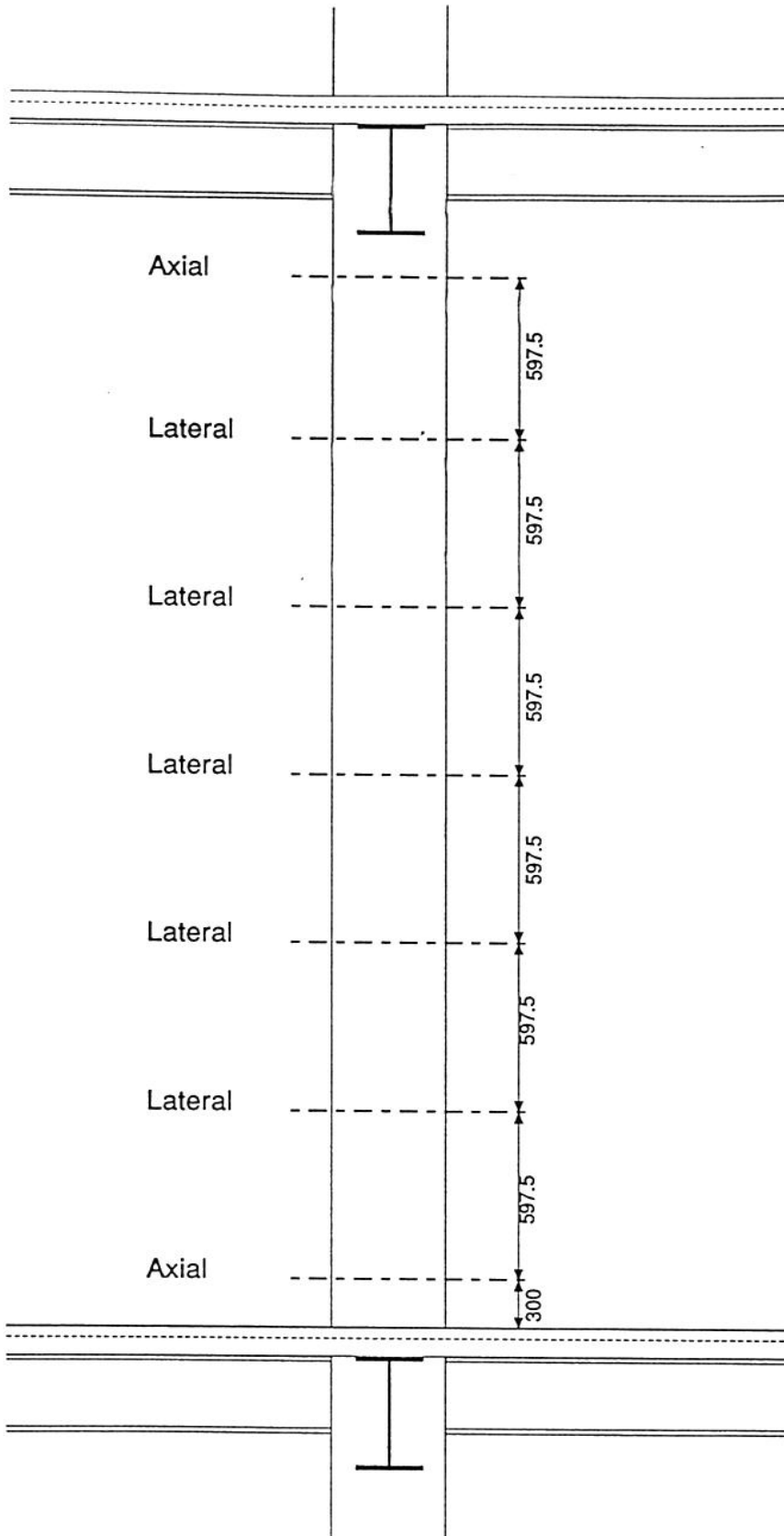


Figure 24 Lateral and axial displacement positions, columns C1 and C2 (associated data file DISPLA1.DAT – MS DOS)

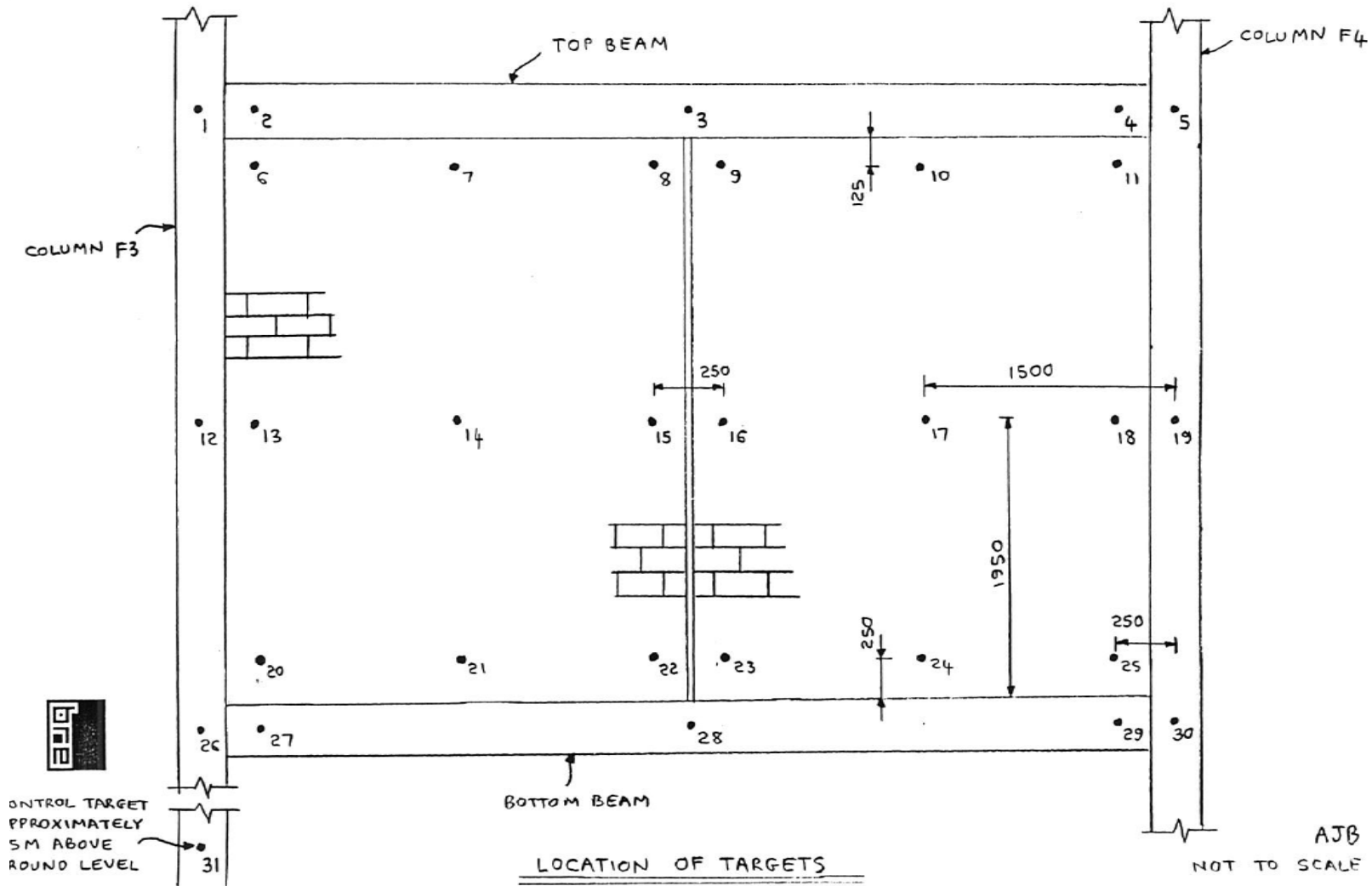


Figure 25 3D Laser system monitoring of end wall movement during the BRE corner fire test – associated data file 3DLASER.BBC

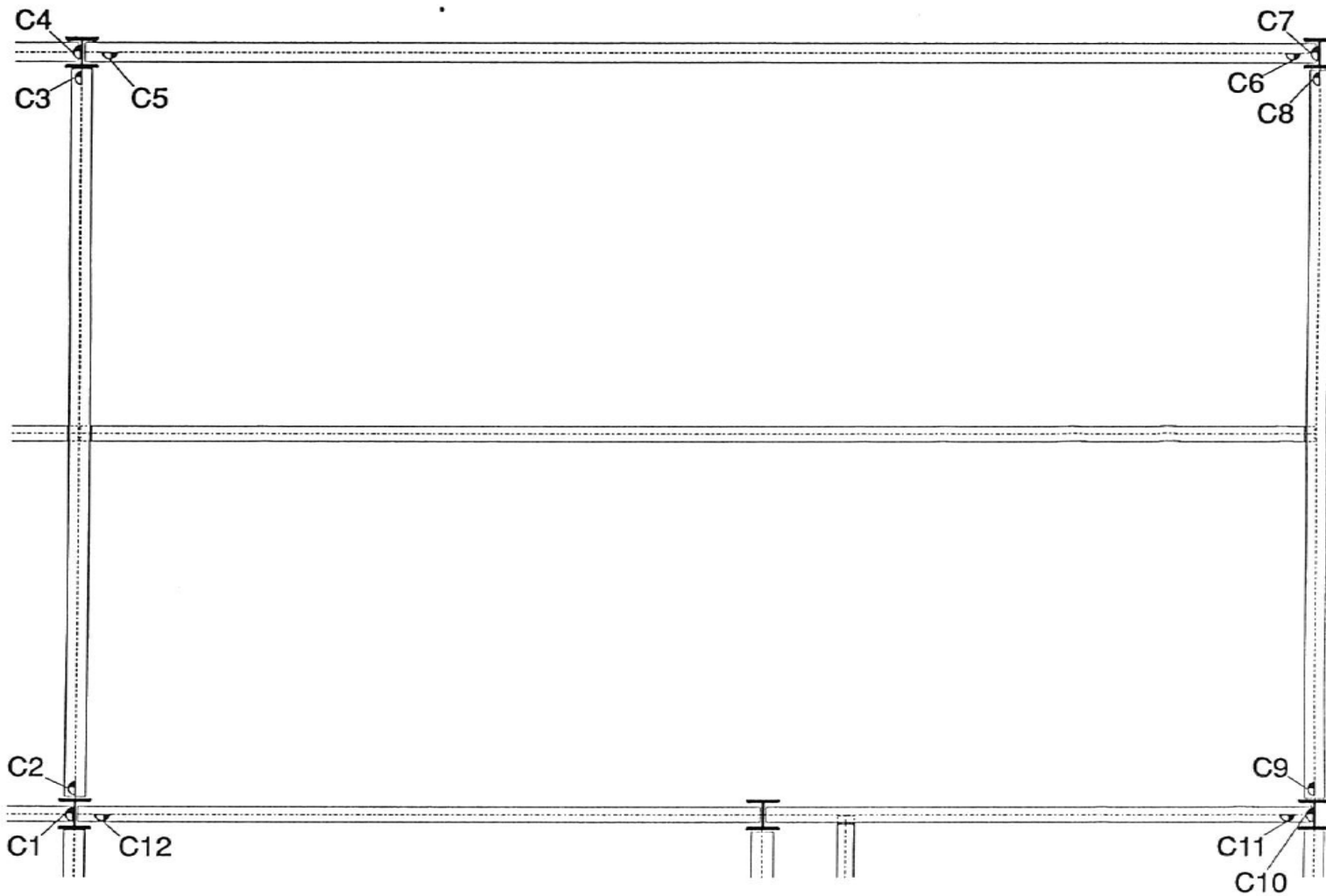
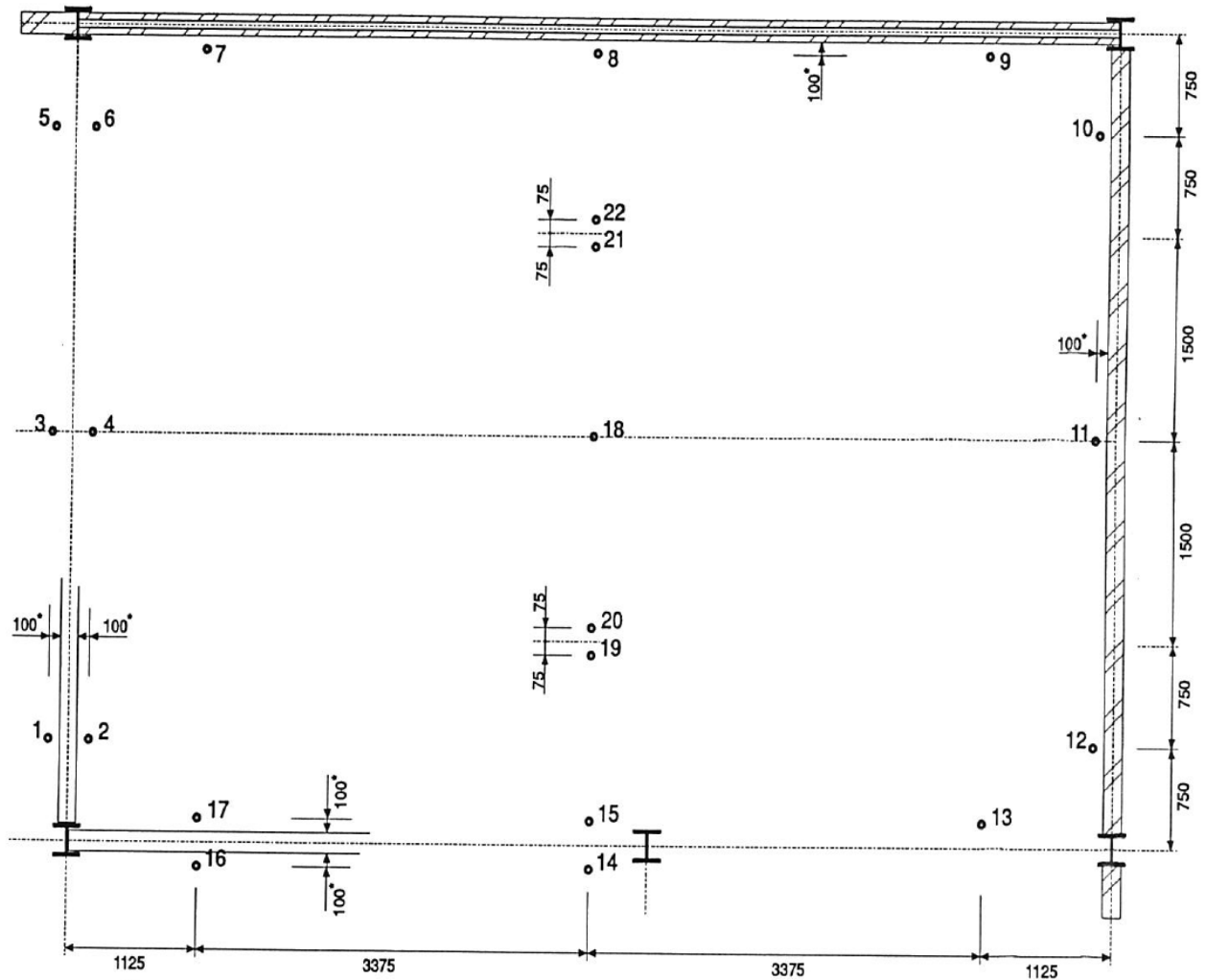


Figure 26 Rotation gauge positions (associated data file CLINOM.DAT – MS DOS)



NOTES
 * Dimension from flange of beam
 Holes 1 - 18, 32mm dia.; holes 19 - 22, 50mm dia.

Figure 27 Position of holes cored in the composite slab

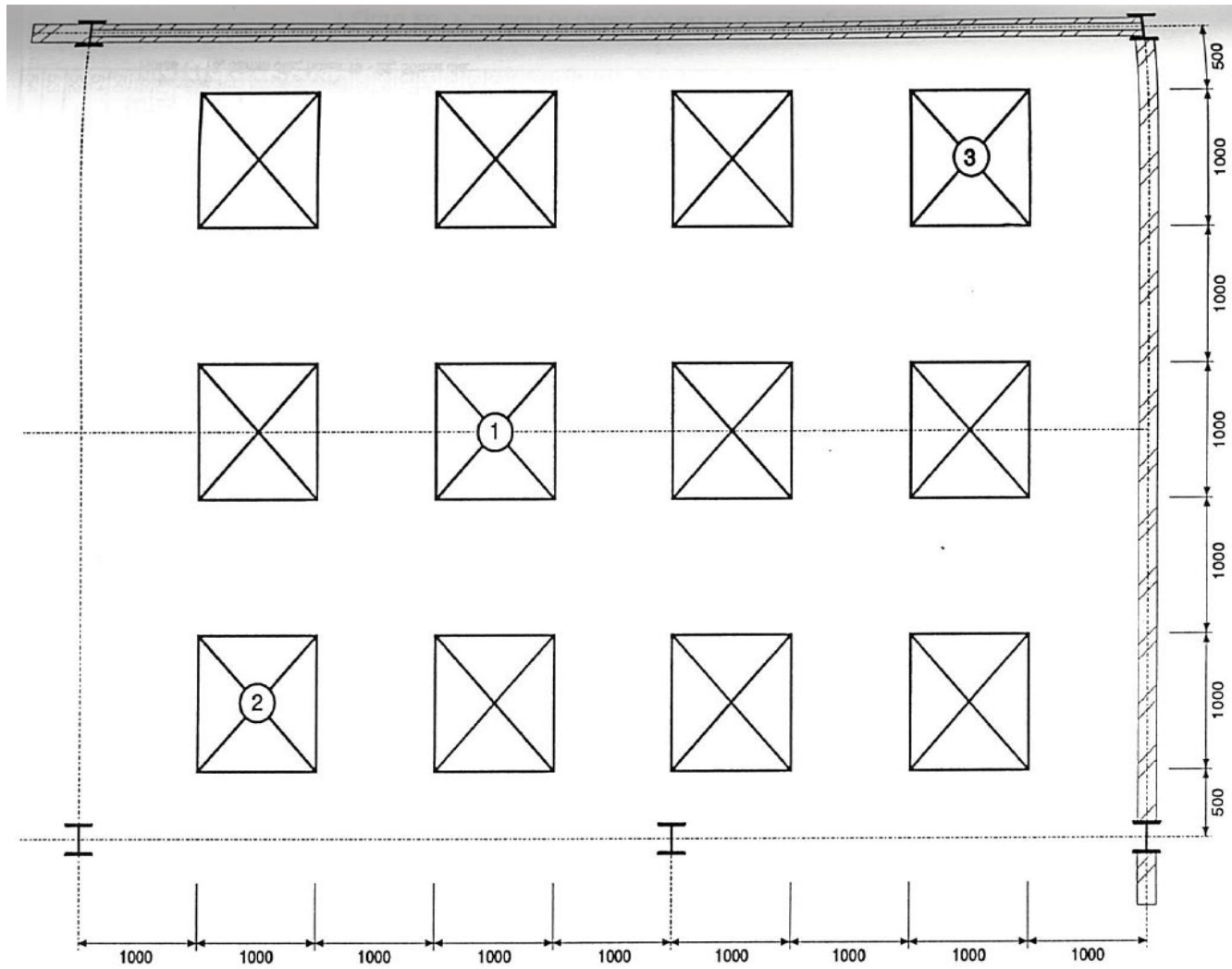


Figure 28 Crib layout and location of load cells to monitor mass loss – associated data file LOAD.dat – MS DOS

Large compartment fire test

Introduction

The fire took place on the second floor of the eight-storey building in a compartment bounded by gridlines A to C and 1 to 4 as shown in Figure 29. To avoid confusion the fire was on the second floor but from a structural point of view the focus of attention was on the third floor.

Compartment design

The compartment was designed to represent a modern open-plan office with overall dimensions of 18m x 21m. The fire load of 40kg/m² was provided by timber cribs arranged uniformly over the floor area. The distribution of the fire load was different to the corner test with each crib containing more timber and the distance between the cribs being greater than for the corner test (see figures 57 and 58 and photograph 6 for details). This, together with the ventilation condition (see below) had an impact on the development of the fire. The compartment was constructed by erecting a fire-resistant wall across the full width of the building and by constructing additional protection to the lift shaft. Double glazing was installed on two sides of the building with the middle third of the original open area left unglazed to allow sufficient initial ventilation to allow the fire to develop. All of the steel beams including the perimeter beams were left unprotected while both the internal and edge columns were protected up to and including the connections. Photograph 6 shows the inside of the compartment prior to ignition.

Fire development

The ventilation conditions and the crib design had a significant impact on the development of the fire. There was an initial rapid rise in temperature as the glazing was destroyed. The extent of the open area and the presence of a cross draft through the building resulted in a fire of long duration but reduced the maximum temperatures generated. The maximum atmosphere temperature was approximately 760°C with steelwork temperatures approaching 700°C. The maximum recorded displacement of the floor slab was over 550mm. The steady burning phase is illustrated in Photograph 7 while Photograph 8 shows the deflection of the beams and the floor slab in the latter stages of the fire.

Instrumentation

Temperature

Approximately 200 thermocouples were used to monitor the temperature of the steel columns and beams within the compartment, the temperature through the concrete slab and the atmosphere temperature within the compartment. Additional instruments were used to monitor the temperature immediately outside the compartment, the temperature of the hangar steelwork, and the internal and external temperature of the gable wall.

Atmosphere

A total of 33 thermocouples (A1-A33, channels 401-433) were used to measure the atmosphere temperatures within the compartment. Their locations are shown in figures 30 and 31.

Concrete slab

A total of 36 thermocouples (C1-C36, channels 434-469) were used to measure the temperature profile through the depth of the slab at six different locations. The position of the instruments is shown in figures 32 and 33.

Columns

The columns with and around the compartment are identified from figure 34. Columns C5-C9 and C13 were instrumented (C5/1 to C13/4, channels 470-491). Columns C5, C8, C9 and C13 are edge columns and four thermocouples were used on each member at a section 1.7m from the floor slab. Columns C6 and C7 are the only internal columns in the fire compartment. They were instrumented with three thermocouples at a section 1.7m from the floor slab. Cross-sectional locations for column C5 are shown in figure 35. Cross-sectional locations for columns C6 and C7 are shown in figure 36. Thermocouple locations for columns C8 and C13 are shown in figure 37 while figure 38 shows the thermocouple locations for column C9.

In total twenty two thermocouples were used to measure the temperature of the protected columns within the compartment. In addition to the instruments mentioned above a single thermocouple, used for temperature compensation is located adjacent to the weldable strain gauges (W1 to W9, channels 556 to 564). Their location is shown in figure 39. In order to ascertain the magnitude of the longitudinal thermal gradient, which was found to be significant in the previous test, an additional thermocouple was located towards the top of each of the instrumented column sections (T1 to T8, channels 565 to 572). Their locations are shown in figure 40.

Beams

The secondary beams running from east to west within the compartment are identified from figure 41. Beams B1, B6, B8-B10, B12 and B16 within the compartment were instrumented. Each beam had four thermocouples located in the centre of the span in the cross-sectional locations indicated in figure 42. A total of 28 thermocouples were used to measure the temperature of the secondary beams (B1/1 to B12/4, channels 492 to 515).

The primary beams running from north to south within the compartment are identified from figure 43. Beams B21-B25 within the compartment were instrumented. Beam 23 had four thermocouples located at the centre of the span. The remaining beams were instrumented at two sections: in the centre of the span and close to the connection. In each case the cross-sectional locations are illustrated in figure 44. Where an intermediate secondary beam is framing into the web of the primary beam (all beams with the exception of the central deep beam B22) the central instrumented location is offset 200mm from the flange of the secondary beam and to the south of that beam. In each case where there is an instrumented location close to the connection this was similarly offset 200mm from the flange of the column. In each case these instrumented sections are to the north end of the beam.

Miscellaneous

Four thermocouples were placed outside the compartment directly opposite the centre of the glazed area to the north of the building at distances of 1m, 2.5m, 5m and 10m from the compartment. The location is illustrated in figure 45. A number of additional thermocouples were used to measure the response of the hangar itself. Three thermocouples were suspended from the hangar roof, a further two thermocouples measured the response of the Perspex sheeting at the top of the hangar to the north side of the compartment and two plate thermometers were used to monitor the temperature of the loadbearing truss running opposite the northern edge of the compartment. The locations of the thermocouples measuring the response of the hangar to the fire are illustrated in figure 46.

Seven thermocouples (JR1 to JR7, channels 573 to 579) were used to monitor the heat transferred through the fire resistant partition. Their locations are shown in figures 47 and 48.

Strain

Steelwork

No beams were strain gauged for this test and all columns were instrumented at a single section. The columns are identified according to figure 49. Cross-sectional locations are shown in figure 50. Columns C1-C12 were gauged at one section only on floors 1,2 and 3. Second floor gauges on C5-C9 and C13 are high temperature weldable strain gauges. Columns on floor 1 are in all cases gauged at the mid-height of the column. On floor 2 those columns mentioned above as having weldable gauges were instrumented 500mm from the surface of the concrete slab, the remaining columns being gauged at mid-height. On floor 3 the external columns were gauged at 1000mm from the surface of the concrete slab for reasons of accessibility, the remaining columns were gauged at mid-height.

The total number of strain gauges is therefore 3 floors by 12 columns by 4 gauges per section = 144 gauges, of which 6 columns by 4 gauges = 24 are weldables. Each section where high temperature gauges are used has a single thermocouple associated with it to allow for subsequent temperature compensation. The first floor gauges are identified in the channel allocation from F1-C1-A to F1-C13-D, channel numbers 1 to 95. The second floor gauges are indicated by locations F2-C1-A to F2-C13-D, channel numbers 97 to 191 while the third floor gauges are identified by locations F3-C1-A to F3-C13-D, channel numbers 193 to 287.

An additional four strain gauges were located at mid-height of the two internal columns on the seventh floor on gridline B.

Reinforcing mesh

Figure 51 shows the position and direction of the gauges located on the reinforcement in pre-prepared cut-outs in the composite slab (F3-R1 to F3-R6, channel numbers 289 to 299).

Concrete slab

Figure 52 shows the location and direction of the fifty gauges used to measure slab strain (S1 to S50, channel numbers 301 to 399).

Displacement

Concrete slab

Figures 53 and 54 show the location of the fifty displacement transducers monitoring the movement of the floor slab (D1 to D50, channels 601 to 650). In order to ascertain the absolute movement of the third floor a number of additional displacement transducers were located on the fourth floor in the positions shown in figure 55.

Fire wall

Six displacement transducers were used to measure the deformation of the fire wall. Measurements were taken at each of the two locations: to the south of column C3 and to the north of column C2. In each case measurements were made at quarter height, mid-height and three quarter height up the wall. During the fire displacement of the floor slabs and the secondary beams passing through the compartment wall led to a collapse of the wall as illustrated in Photographs 9-11.

Laser system

An innovative laser system was used to measure the movement of the two masonry panels exposed to fire from the inside. In total 83 targets were monitored for the duration of the test. The location of the targets is shown in figure 56.

Crib design

A total of 42 timber cribs were built in the compartment in the locations shown in figure 57. Each crib was constructed from 10 layers of grouped sticks and six layers of individual sticks at a spacing of 1:1 as shown in figure 58. The cribs were designed to give an early flashover, a steady burning time of forty minutes and total test duration of 80 minutes.

Additional data

Additional measurements were made on behalf of the University of Ulster and the Fire Research Station including heat flux and temperature data. No information is available on the specific location of the instruments. The data files are available as DOC.xls and FRS.xls respectively.

Channel allocation

Chan. No.	Cable No.	location	comments	Figure No.
1	101	F1-C1-A	strain gauge	49/50
3	102	B	strain gauge	49/50
5	103	C	strain gauge	49/50
7	104	D	strain gauge	49/50
9	105	F1-C2-A	strain gauge	49/50
11	106	B	strain gauge	49/50

13	107	C	strain gauge	49/50
15	108	D	strain gauge	49/50
17	109	F1-C3-A	strain gauge	49/50
19	110	B	strain gauge	49/50
21	111	C	strain gauge	49/50
23	112	D	strain gauge	49/50
25	113	F1-C4-A	strain gauge	49/50
27	114	B	strain gauge	49/50
29	115	C	strain gauge	49/50
31	116	D	strain gauge	49/50
33	117	F1-C5-A	strain gauge	49/50
35	118	B	strain gauge	49/50
37	119	C	strain gauge	49/50
39	120	D	strain gauge	49/50
41	121	F1-C6-A	strain gauge	49/50
43	122	B	strain gauge	49/50
45	123	C	strain gauge	49/50
47	124	D	strain gauge	49/50
49	125	F1-C7-A	strain gauge	49/50
51	126	B	strain gauge	49/50
53	127	C	strain gauge	49/50
55	128	D	strain gauge	49/50
57	129	F1-C8-A	strain gauge	49/50
59	130	B	strain gauge	49/50
61	131	C	strain gauge	49/50
63	132	D	strain gauge	49/50
65	133	F1-C9-A	strain gauge	49/50
67	134	B	strain gauge	49/50
69	135	C	strain gauge	49/50
71	136	D	strain gauge	49/50
73	137	F1-C10-A	strain gauge	49/50
75	138	B	strain gauge	49/50
77	139	C	strain gauge	49/50
79	140	D	strain gauge	49/50
81	145	F1-C12-A	strain gauge	49/50
83	146	B	strain gauge	49/50
85	147	C	strain gauge	49/50
87	148	D	strain gauge	49/50
89	149	F1-C13-A	strain gauge	49/50
91	150	B	strain gauge	49/50
93	151	C	strain gauge	49/50
95	152	D	strain gauge	49/50
97	201	F2-C1-A	strain gauge	49/50
99	202	B	strain gauge	49/50
101	203	C	strain gauge	49/50
103	204	D	strain gauge	49/50
105	205	F2-C2-A	strain gauge	49/50
107	206	B	strain gauge	49/50

109	207	C	strain gauge	49/50
111	208	D	strain gauge	49/50
113	209	F2-C3-A	strain gauge	49/50
115	210	B	strain gauge	49/50
117	211	C	strain gauge	49/50
119	212	D	strain gauge	49/50
121	213	F2-C4-A	strain gauge	49/50
123	214	B	strain gauge	49/50
125	215	C	strain gauge	49/50
127	216	D	strain gauge	49/50
129	217	F2-C5-A	strain gauge	49/50
131	218	B	strain gauge	49/50
133	219	C	strain gauge	49/50
135	220	D	strain gauge	49/50
137	221	F2-C6-A	strain gauge	49/50
139	222	B	strain gauge	49/50
141	223	C	strain gauge	49/50
143	224	D	strain gauge	49/50
145	225	F2-C7-A	strain gauge	49/50
147	226	B	strain gauge	49/50
149	227	C	strain gauge	49/50
151	228	D	strain gauge	49/50
153	229	F2-C8-A	strain gauge	49/50
155	230	B	strain gauge	49/50
157	231	C	strain gauge	49/50
159	232	D	strain gauge	49/50
161	233	F2-C9-A	strain gauge	49/50
163	234	B	strain gauge	49/50
165	235	C	strain gauge	49/50
167	236	D	strain gauge	49/50
169	237	F2-C10-A	strain gauge	49/50
171	238	B	strain gauge	49/50
173	239	C	strain gauge	49/50
175	240	D	strain gauge	49/50
177	245	F2-C12-A	strain gauge	49/50
179	246	B	strain gauge	49/50
181	247	C	strain gauge	49/50
183	248	D	strain gauge	49/50
185	249	F2-C13-A	strain gauge	49/50
187	250	B	strain gauge	49/50
189	251	C	strain gauge	49/50
191	252	D	strain gauge	49/50
193	301	F3-C1-A	strain gauge	49/50
195	302	B	strain gauge	49/50
197	303	C	strain gauge	49/50
199	304	D	strain gauge	49/50
201	305	F3-C2-A	strain gauge	49/50
203	306	B	strain gauge	49/50

205	307	C	strain gauge	49/50
207	308	D	strain gauge	49/50
209	309	F3-C3-A	strain gauge	49/50
211	310	B	strain gauge	49/50
213	311	C	strain gauge	49/50
215	312	D	strain gauge	49/50
217	313	F3-C4-A	strain gauge	49/50
219	314	B	strain gauge	49/50
221	315	C	strain gauge	49/50
223	316	D	strain gauge	49/50
225	317	F3-C5-A	strain gauge	49/50
227	318	B	strain gauge	49/50
229	319	C	strain gauge	49/50
231	320	D	strain gauge	49/50
233	321	F3-C6-A	strain gauge	49/50
235	322	B	strain gauge	49/50
237	323	C	strain gauge	49/50
239	324	D	strain gauge	49/50
241	325	F3-C7-A	strain gauge	49/50
243	326	B	strain gauge	49/50
245	327	C	strain gauge	49/50
247	328	D	strain gauge	49/50
249	329	F3-C8-A	strain gauge	49/50
251	330	B	strain gauge	49/50
253	331	C	strain gauge	49/50
255	332	D	strain gauge	49/50
257	333	F3-C9-A	strain gauge	49/50
259	334	B	strain gauge	49/50
261	335	C	strain gauge	49/50
263	336	D	strain gauge	49/50
265	337	F3-C10-A	strain gauge	49/50
267	338	B	strain gauge	49/50
269	339	C	strain gauge	49/50
271	340	D	strain gauge	49/50
273	345	F3-C12-A	strain gauge	49/50
275	346	B	strain gauge	49/50
277	347	C	strain gauge	49/50
279	348	D	strain gauge	49/50
281	349	F3-C13-A	strain gauge	49/50
283	350	B	strain gauge	49/50
285	351	C	strain gauge	49/50
287	352	D	strain gauge	49/50
289	F3-R1	cut out 1	NW corner 1/4 point	51
291	F3-R2	cut out 2	SW corner 1/4 point	51
293	F3-R3	cut out 3	N middle	51
295	F3-R4	cut out 4	middle	51
297	F3-R5	cut out 5	NE corner 1/4 point	51
299	F3-R6	cut out 6	SE corner 1/4 point	51

301	S1	F3-S1	from gridline C1 200mm spacing	52
303	S2	F3-S2		52
305	S3	F3-S3		52
307	S4	F3-S4		52
309	S5	F3-S5		52
311	S6	F3-S6		52
313	S7	F3-S7		52
315	S8	F3-S8		52
317	S9	F3-S9		52
319	S10	F3-S10		52
321	S11	F3-S11	from gridline B1 200mm spacing	52
323	S12	F3-S12		52
325	S13	F3-S13		52
327	S14	F3-S14		52
329	S15	F3-S15		52
331	S16	F3-S16		52
333	S17	F3-S17		52
335	S18	F3-S18		52
337	S19	F3-S19		52
339	S20	F3-S20		52
341	S21	F3-S21	from gridline C4 200mm spacing	52
343	S22	F3-S22		52
345	S23	F3-S23		52
347	S24	F3-S24		52
349	S25	F3-S25		52
351	S26	F3-S26		52
353	S27	F3-S27		52
355	S28	F3-S28		52
357	S29	F3-S29		52
359	S30	F3-S30		52
361	S31	F3-S31	from gridline B4 200mm spacing	52
363	S32	F3-S32		52
365	S33	F3-S33		52
367	S34	F3-S34		52
369	S35	F3-S35		52
371	S36	F3-S36		52
373	S37	F3-S37		52
375	S38	F3-S38		52
377	S39	F3-S39		52
379	S40	F3-S40		52
381	S41	F3-S41	boundary wall from C1-C2	52
383	S42	F3-S42		52
385	S43	F3-S43		52
387	S44	F3-S44	boundary wall from C3-C4	52
389	S45	F3-S45		52
391	S46	F3-S46		52
393	S47	F3-S47	between B and C	52
395	S48	F3-S48		52

397	S49	F3-S49		52
399	S50	F3-S50		52
401	A1	NE corner 300mm from ceiling	atmosphere thermocouple	30/31
402	A2	NE corner 600mm from ceiling	atmosphere thermocouple	30/31
403	A3	NE corner 900mm from ceiling	atmosphere thermocouple	30/31
404	A4	E middle 300mm from ceiling	atmosphere thermocouple	30/31
405	A5	E middle 600mm from ceiling	atmosphere thermocouple	30/31
406	A6	E middle 900mm from ceiling	atmosphere thermocouple	30/31
407	A7	SE corner 300mm from ceiling	atmosphere thermocouple	30/31
408	A8	SE corner 600mm from ceiling	atmosphere thermocouple	30/31
409	A9	SE corner 900mm from ceiling	atmosphere thermocouple	30/31
410	A10	N middle 300mm from ceiling	atmosphere thermocouple	30/31
411	A11	N middle 600mm from ceiling	atmosphere thermocouple	30/31
412	A12	N middle 900mm from ceiling	atmosphere thermocouple	30/31
413	A13	N middle 1200mm from ceiling	atmosphere thermocouple	30/31
414	A14	N middle 1500mm from ceiling	atmosphere thermocouple	30/31
415	A15	middle 300mm from ceiling	atmosphere thermocouple	30/31
416	A16	middle 600mm from ceiling	atmosphere thermocouple	30/31
417	A17	middle 900mm from ceiling	atmosphere thermocouple	30/31
418	A18	middle 1200mm from ceiling	atmosphere thermocouple	30/31
419	A19	middle 1500mm from ceiling	atmosphere thermocouple	30/31
420	A20	S middle 300mm from ceiling	atmosphere thermocouple	30/31
421	A21	S middle 600mm from ceiling	atmosphere thermocouple	30/31
422	A22	S middle 900mm from ceiling	atmosphere thermocouple	30/31
423	A23	S middle 1200mm from ceiling	atmosphere thermocouple	30/31
424	A24	S middle 1500mm from ceiling	atmosphere thermocouple	30/31
425	A25	NW corner 300mm from ceiling	atmosphere thermocouple	30/31
426	A26	NW corner 600mm from ceiling	atmosphere thermocouple	30/31
427	A27	NW corner 900mm from ceiling	atmosphere thermocouple	30/31
428	A28	W middle 300mm from ceiling	atmosphere thermocouple	30/31
429	A29	W middle 600mm from ceiling	atmosphere thermocouple	30/31
430	A30	W middle 900mm from ceiling	atmosphere thermocouple	30/31
431	A31	SW corner 300mm from ceiling	atmosphere thermocouple	30/31
432	A32	SW corner 600mm from ceiling	atmosphere thermocouple	30/31
433	A33	SW corner 900mm from ceiling	atmosphere thermocouple	30/31
435	C2	decking	over crest	32/33
436	C3	mesh	over trough	32/33
437	C4	mesh	over crest	32/33
438	C5	concrete	over trough	32/33
439	C6	concrete	over crest	32/33
440	C7	SW decking	over trough	32/33
441	C8	decking	over crest	32/33
442	C9	mesh	over trough	32/33
443	C10	mesh	over crest	32/33
444	C11	concrete	over trough	32/33
445	C12	concrete	over crest	32/33
446	C13	N middle decking	over trough	32/33
447	C14	decking	over crest	32/33

448	C15	mesh	over trough	32/33
449	C16	mesh	over crest	32/33
450	C17	concrete	over trough	32/33
451	C18	concrete	over crest	32/33
452	C19	middle decking	over trough	32/33
453	C20	decking	over crest	32/33
454	C21	mesh	over trough	32/33
455	C22	mesh	over crest	32/33
456	C23	concrete	over trough	32/33
457	C24	concrete	over crest	32/33
458	C25	NE decking	over trough	32/33
459	C26	decking	over crest	32/33
460	C27	mesh	over trough	32/33
461	C28	mesh	over crest	32/33
462	C29	concrete	over trough	32/33
463	C30	concrete	over crest	32/33
464	C31	SE decking	over trough	32/33
465	C32	decking	over crest	32/33
466	C33	mesh	over trough	32/33
467	C34	mesh	over crest	32/33
468	C35	concrete	over trough	32/33
470	C5/1	column B4 SW flange	mid-height	34-38
471	C5/2	web		34-38
472	C5/3	NW flange		34-38
473	C5/4	NE flange		34-38
474	C6/1	column B3 SE flange		34-38
475	C6/2	web		34-38
476	C6/3	NW flange		34-38
477	C7/1	column B2 SW flange		34-38
478	C7/2	web		34-38
479	C7/3	NE flange		34-38
480	C8/1	column B1 SE flange		34-38
481	C8/2	web		34-38
482	C8/3	NW flange		34-38
483	C8/4	NE flange		34-38
484	C9/1	column A4 SE flange		34-38
485	C9/2	SW flange		34-38
486	C9/3	web		34-38
487	C9/4	NW flange		34-38
488	C13/1	column A1 SE flange		34-38
489	C13/2	web		34-38
490	C13/3	NW flange		34-38
491	C13/4	NE flange		34-38
492	B1/1	beam B4/C4 middle	mid-length bottom flange N	41-44
493	B1/2	web		41-44
494	B1/3	flange/web junction		41-44
495	B1/4	top flange S		41-44
496	B6/1	beam B2/C2 middle	bottom flange N	41-44

497	B6/2	web		41-44
498	B6/3	flange/web junction		41-44
499	B6/4	top flange S		41-44
500	B8/1	beam B1/C1	bottom flange N	41-44
501	B8/2	web		41-44
502	B8/3	flange/web junction		41-44
503	B8/4	top flange S		41-44
504	B9/1	beam A4/B4 middle	bottom flange N	41-44
505	B9/2	web		41-44
506	B9/3	flange/web junction		41-44
507	B9/4	top flange S		41-44
508	B10/1	beam A3.5/B3.5	mid-length bottom flange N	41-44
509	B10/2	web		41-44
510	B10/3	top flange/web junction		41-44
511	B10/4	top flange S		41-44
512	B12/1	5m beam into shaft wall	mid-length bottom flange N	41-44
513	B12/2	web		41-44
514	B12/3	top flange/web junction		41-44
515	B12/4	top flange S		41-44
516	B16/1	beam A1/B1 middle	bottom flange N	41-44
517	B16/2	web		41-44
518	B16/3	top flange/web junction		41-44
519	B16/4	top flange S		41-44
520	B21/1	beam B3/B4	close to connection bottom flange W	41-44
521	B21/2	web		41-44
522	B21/3	top flange/web junction		41-44
523	B21/4	top flange E		41-44
524	B21/5	beam B3/B4	mid-length bottom flange W	41-44
525	B21/6	web		41-44
526	B21/7	top flange/web junction		41-44
527	B21/8	top flange E		41-44
528	B22/1	beam B2/B3	close to connection bottom flange W	41-44
529	B22/2	web		41-44
530	B22/3	top flange/web junction		41-44
531	B22/4	top flange E		41-44
532	B22/5	beam B2/B3	mid-length bottom flange W	41-44
533	B22/6	web		41-44
534	B22/7	top flange/web junction		41-44
535	B22/8	top flange E		41-44
536	B23/1	beam B1/B2	mid-length bottom flange W	41-44
537	B23/2	web		41-44
538	B23/3	top flange/web junction		41-44
539	B23/4	top flange E		41-44
540	B24/1	beam A3/A4	close to connection bottom flange W	41-44
541	B24/2	web		41-44
542	B24/3	top flange/web junction		41-44
543	B24/4	top flange E		41-44
544	B24/5	beam A3/A4	mid-length bottom flange W	41-44

545	B24/6	web		41-44
546	B24/7	top flange/web junction		41-44
547	B24/8	top flange E		41-44
548	B25/1	beam A1/A2	close to connection bottom flange W	41-44
549	B25/2	web		41-44
550	B25/3	top flange/web junction		41-44
551	B25/4	top flange E		41-44
552	B25/5	beam A1/A2	mid-length bottom flange W	41-44
553	B25/6	web		41-44
554	B25/7	top flange/web junction		41-44
555	B25/8	bottom flange E		41-44
556	W1	column C5, i/s of SW flange	500mm from slab, 25mm from flange	39/40
557	W2	column C6, i/s of SW flange	500mm from slab, 25mm from flange	39/40
558	W3	column C7, i/s of SW flange	500mm from slab, 25mm from flange	39/40
559	W4	column C8, o/s of NW flange	550mm from slab 25mm from flange	39/40
560	W5	column C8, o/s of SE flange	550mm from slab 25mm from flange	39/40
561	W6	column C9, o/s of NW flange	550mm from slab 25mm from flange	39/40
562	W7	column C9, o/s of SE flange	550mm from slab 25mm from flange	39/40
563	W8	column C13, o/s of NE flange	550mm from slab 25mm from flange	39/40
564	W9	column C13, o/s of SW flange	550mm from slab 25mm from flange	39/40
565	T1	column C5, o/s of SE flange	300mm below beam, 25mm in	39/40
566	T2	column C6, o/s of SE flange	100mm below deep beam, 25mm in	39/40
567	T3	column C7, o/s of SE flange	100mm below deep beam, 25mm in	39/40
568	T4	column C7, centre of web	100mm below deep beam	39/40
569	T5	column C7, o/s of NW flange	100mm below deep beam, 25mm in	39/40
570	T6	column C8, o/s of NE flange	300mm below beam, 25mm in	39/40
571	T7	column C9, o/s of SE flange	300mm below beam, 25mm in	39/40
572	T8	column C13, o/s of NE flange	300mm below beam, 25mm in	39/40
573	JR1	beam B4, bottom flange S	350mm from flange of beam on g/l C	47/48
574	JR2	beam B4, bottom flange S	450mm from flange of beam on g/l C	47/48
575	JR3	beam B4, bottom flange S	640mm from flange of beam on g/l C	47/48
576	JR4	beam B4, bottom flange S	740mm from flange of beam on g/l C	47/48
577	JR5	beam B4, bottom flange S	1/4 point E	47/48
578	JR6	beam B4, bottom flange S	centre	47/48
579	JR7	beam B4, bottom flange S	1/4 point W	47/48
581	721	F7-C6-A	strain gauge	49/50
583	722	B	strain gauge	49/50
585	723	C	strain gauge	49/50
587	724	D	strain gauge	49/50
589	725	F7-C7-A	strain gauge	49/50
591	726	B	strain gauge	49/50
593	727	C	strain gauge	49/50
595	728	D	strain gauge	49/50
601	D1	N/S CL	1m from g/l C	53
602	D2	N/S CL	2m from g/l C	53
603	D3	N/S CL	3m from g/l C	53
604	D4	N/S CL	4m from g/l C	53
605	D5	N/S CL	5m from g/l C	53

606	D6	N/S CL	6m from g/l C	53
607	D7	N/S CL	7m from g/l C	53
608	D8	N/S CL	8m from g/l C	53
609	D9	centre of deep beam	gridline B	53
610	D10	centre of beam B2/C2	secondary beam	53
611	D11	1m N of previous	slab	53
612	D12	1m N of previous	slab	53
613	D13	1m N of previous	secondary beam	53
614	D14	1m N of previous	slab	53
615	D15	1m N of previous	slab	53
616	D16	1m N of previous	secondary beam	53
617	D17	1m N of previous	slab	53
618	D18	1m N of previous	slab	53
619	D19	centre of beam B3/C3	secondary beam	53
620	D20	centre of beam B1/B2	primary beam	53
621	D21	6m N of previous	primary beam 1250	53
622	D22	3m N of previous	primary beam	53
623	D23	6m N of previous	primary beam 500	53
624	D24	g/l 2, 2.5m W of B2	secondary beam 1250	53
625	D25	panel A NE 1/4 point	slab 500	54
641	D26	panel A SE 1/4 point	slab 500	54
642	D27	panel A centre	slab 500	54
643	D28	panel A NW 1/4 point	slab 500	54
644	D29	panel A SW 1/4 point	slab 500	54
645	D30	panel B NE 1/4 point	slab 1250	54
646	D31	panel B SE 1/4 point	slab 1250	54
647	D32	panel B centre	slab 1250	54
648	D33	panel B NW 1/4 point	slab 1250	54
649	D34	panel B SW 1/4 point	slab 1250	54
650	D35	panel C NE 1/4 point	slab 1250	54
651	D36	panel C centre	slab 500	54
652	D37	panel C SW 1/4 point	slab 500	54
653	D38	panel D SE 1/4 point	slab 500	54
654	D39	panel D centre	slab 500	54
655	D40	panel D NW 1/4 point	slab 500	54
656	D41	panel E NE 1/4 point	slab 1250	54
657	D42	panel E SE 1/4 point	slab 1250	54
658	D43	panel E centre	slab missing	54
659	D44	panel E NW 1/4 point	slab 500	54
660	D45	panel E SW 1/4 point	slab 500	54
661	D46	panel F NE 1/4 point	slab 500	54
662	D47	panel F SE 1/4 point	slab 500	54
663	D48	panel F centre	slab 500	54
664	D49	panel F NW 1/4 point	faulty	54
665	D50	panel F SW 1/4 point	slab 500	54
681	D51	fire wall N	1/4 height	
682	D52	fire wall N	mid-height	
683	D53	fire wall N	3/4 height	

684	D54	fire wall S	1/4 height	
685	D55	fire wall S	mid-height	
686	D56	fire wall S	3/4 height	
687	D57	above D9	4th floor	55
688	D58	above D39	4th floor	55
689	D59	above D27	4th floor	55
690	D60	above D48	4th floor	55
691	D61	above D36	4th floor	55
692	D62	above D19	4th floor	55
693	D63	above D16	4th floor	55
694	D64	above D13	4th floor	55
695	D65	above D10	4th floor	55
701	H1	from hangar roof	6m	46
702	H2	from hangar roof	12m	46
703	H3	from hangar roof	15m	46
704	H4	opposite perspex N	North side	46
705	H5	opposite perspex S	South side	46
706	H6	truss N rear	behind protection	46
707	H7	truss N front	in front of protection	46
708	H8	truss S rear	behind protection	46
709	H9	truss S front	in front of protection	46
710	O1	opposite compartment	1m away	45
711	O2	opposite compartment	2.5m away	45
712	O3	opposite compartment	5m away	45
713	O4	opposite compartment	10m away	45
714	Wall 1	Inside S		
715	Wall 2	outside S		
716	Wall 3	inside N		
717	Wall 4	outside N		



Photograph 6 Large compartment fire test prior to ignition showing crib layout



Photograph 7 Post-flashover fire development – cribs burning individually



Photograph 8 Latter stages of the fire showing deflection of the secondary beams and floor slab



Photograph 9 Deformation and integrity failure of compartment wall – view from inside compartment



Photograph 10 Localised collapse of compartment wall – view from inside compartment



Photograph 11 Deformation of compartment wall – view from outside compartment

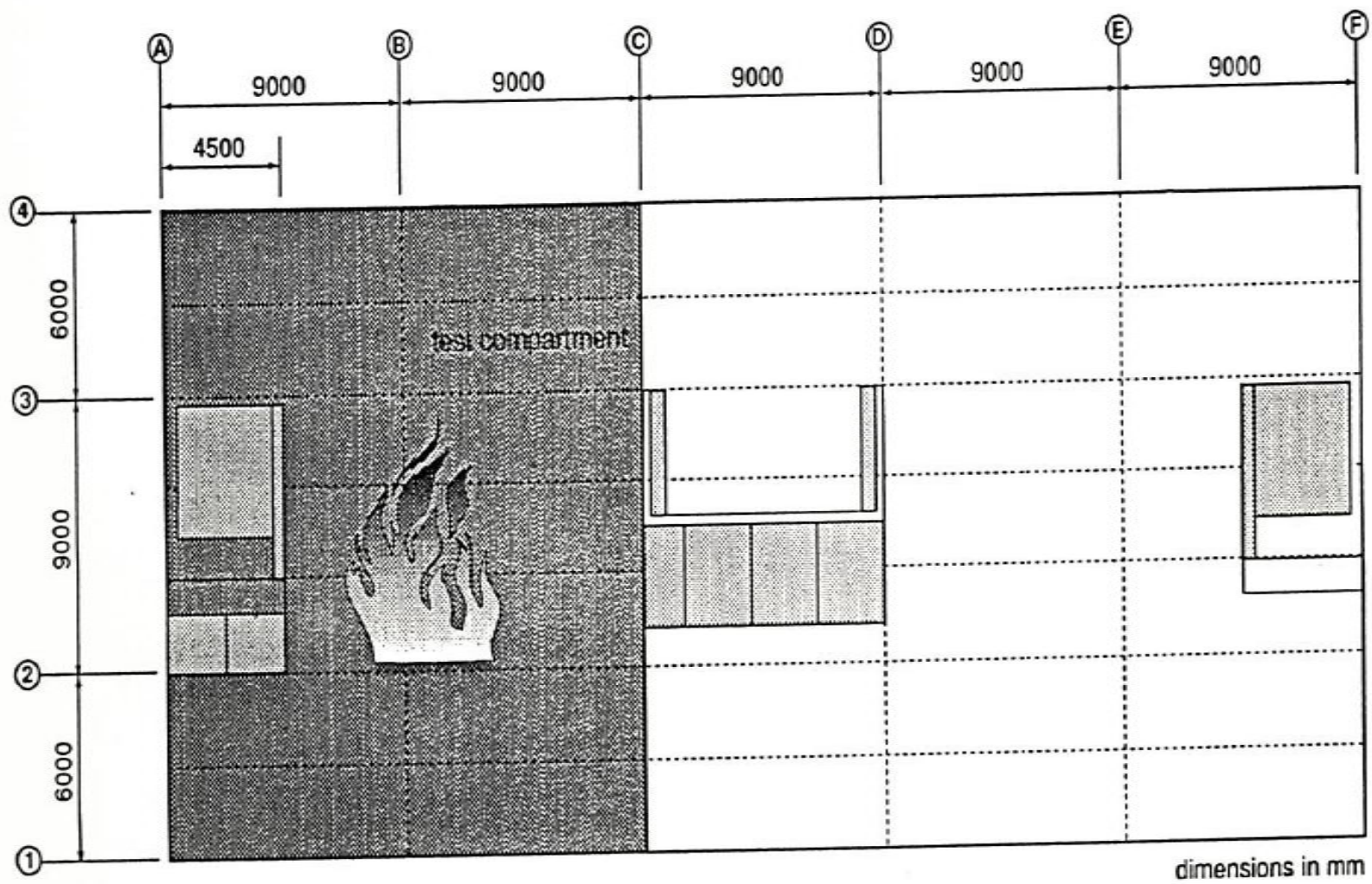


Figure 29 Location of large compartment fire test

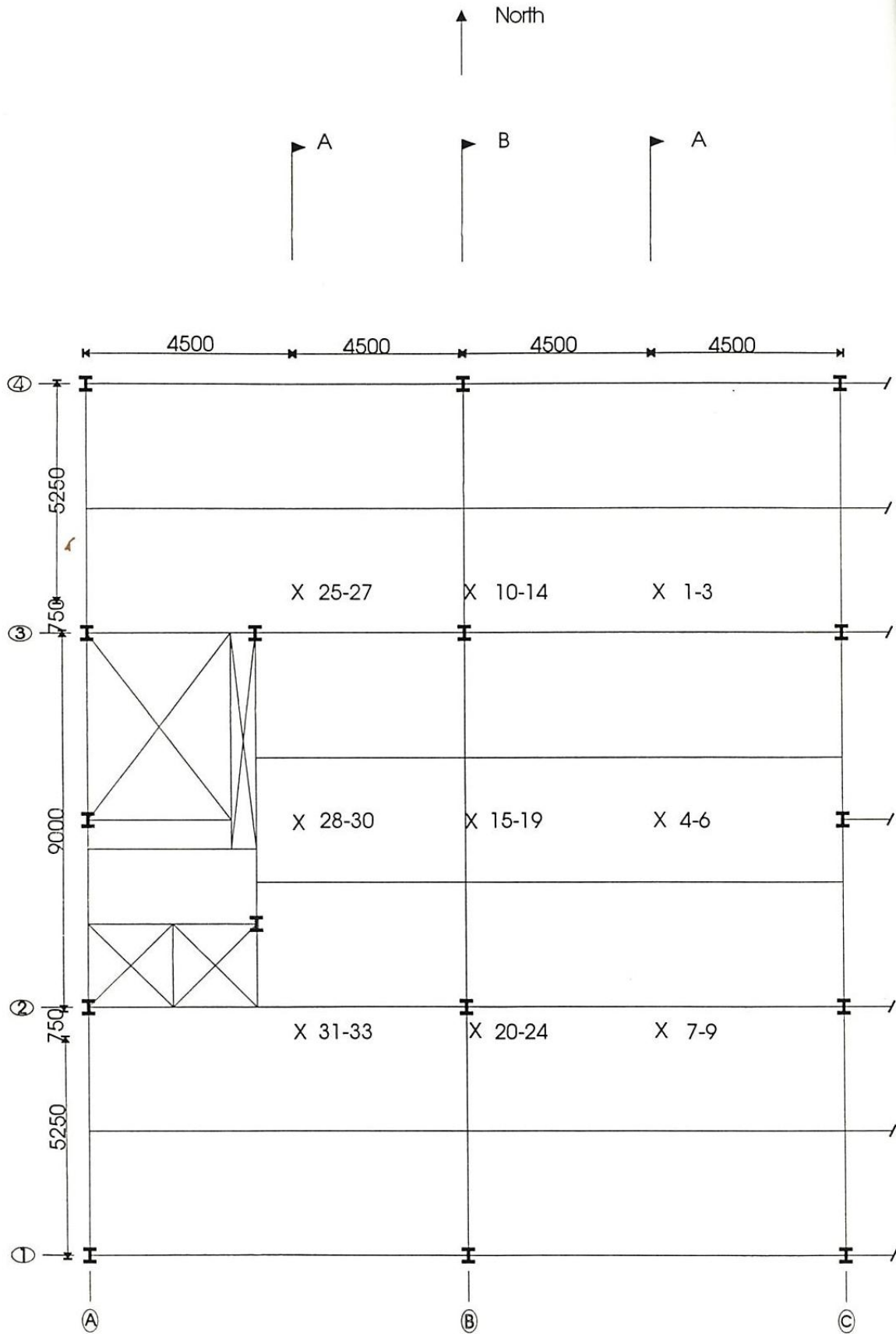
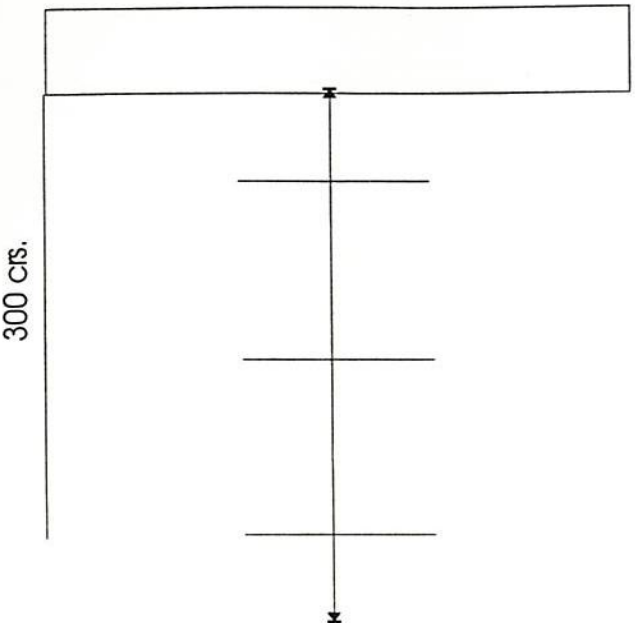


Figure 30 Atmosphere thermocouple locations – associated data file ATMOS.XLS

Section A



Section B

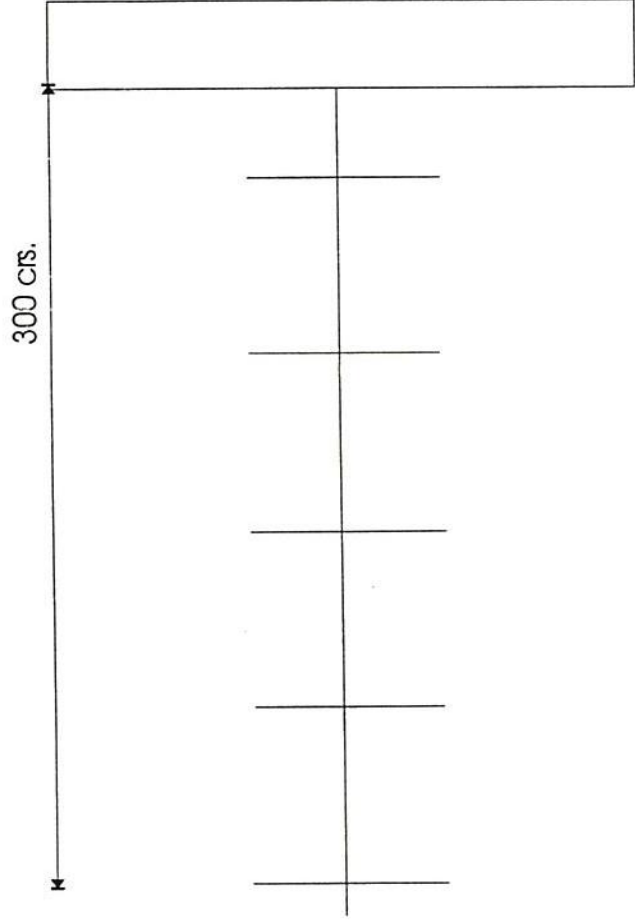


Figure 31 Location of thermocouples from ceiling – elevation – associated data file ATMOS.xls

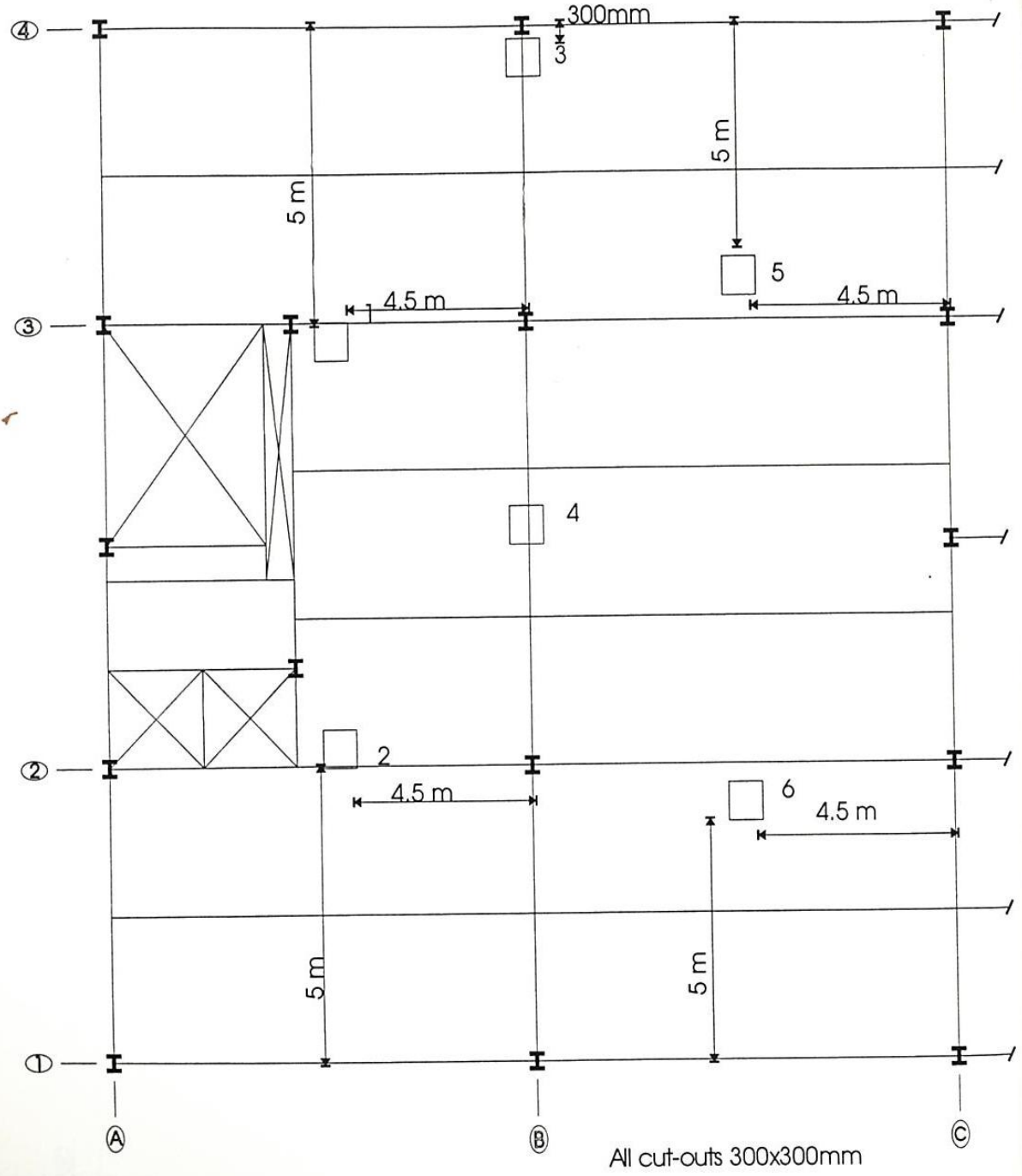
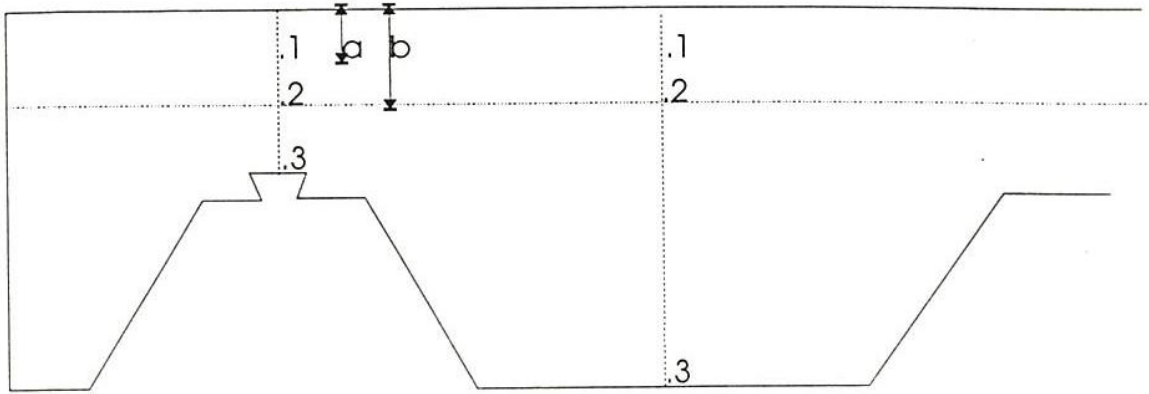


Figure 32 Location of cut-outs in concrete slab – associated data file SLABTEMP.xls



cut-out no.	a (mm)	b (mm)
1	31.5	63
2	35	70
3	21	42
4	27.5	55
5	35	70
6	27.5	55

Figure 33 Concrete slab thermocouple positions – associated data file SLABTEMP.xls

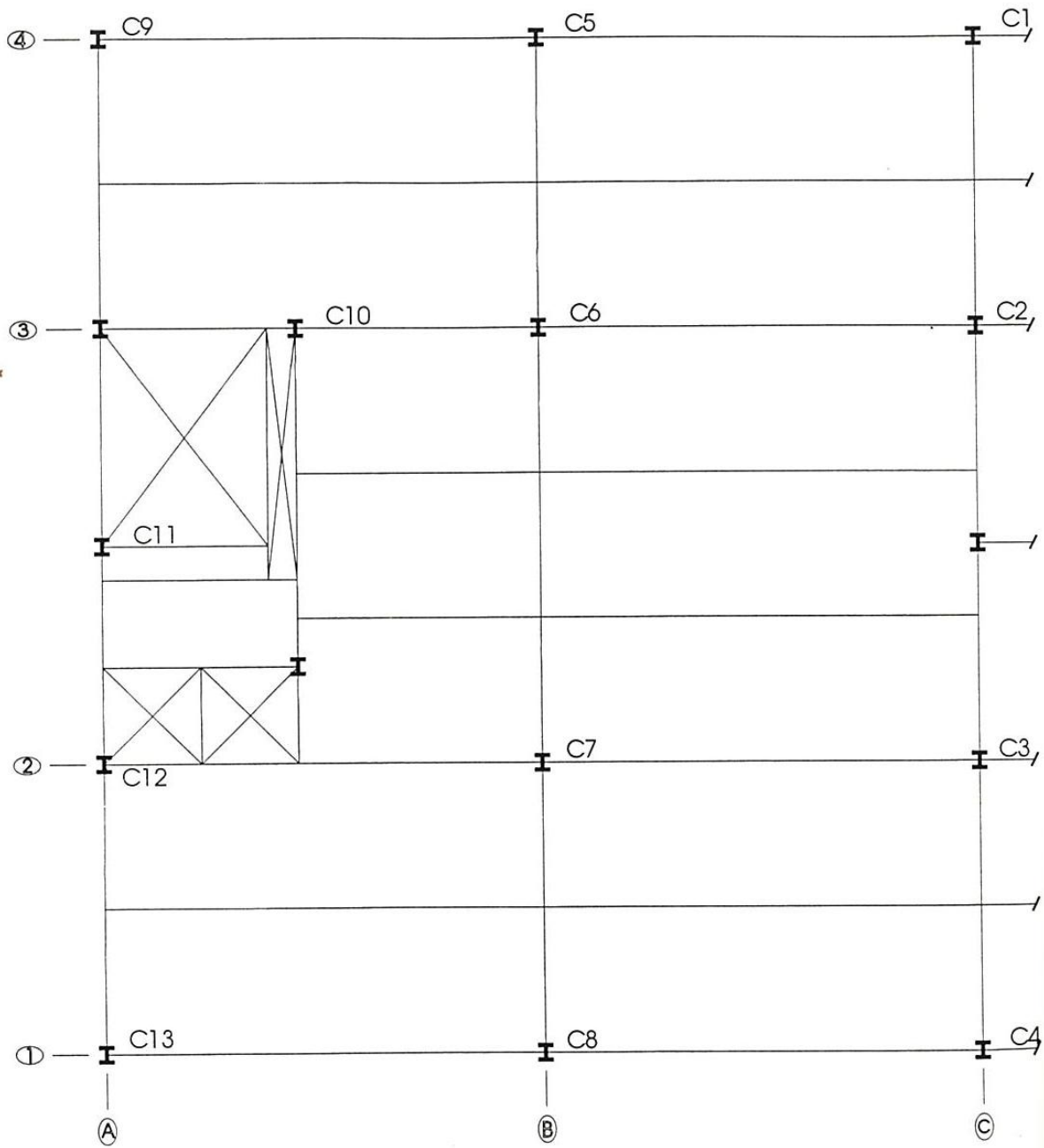


Figure 34 Column identification – associated data files C5TEMP.xls; C6TEMP.xls; C7TEMP.xls; C8TEMP.xls; C9TEMP.xls; C13TEMP.xls

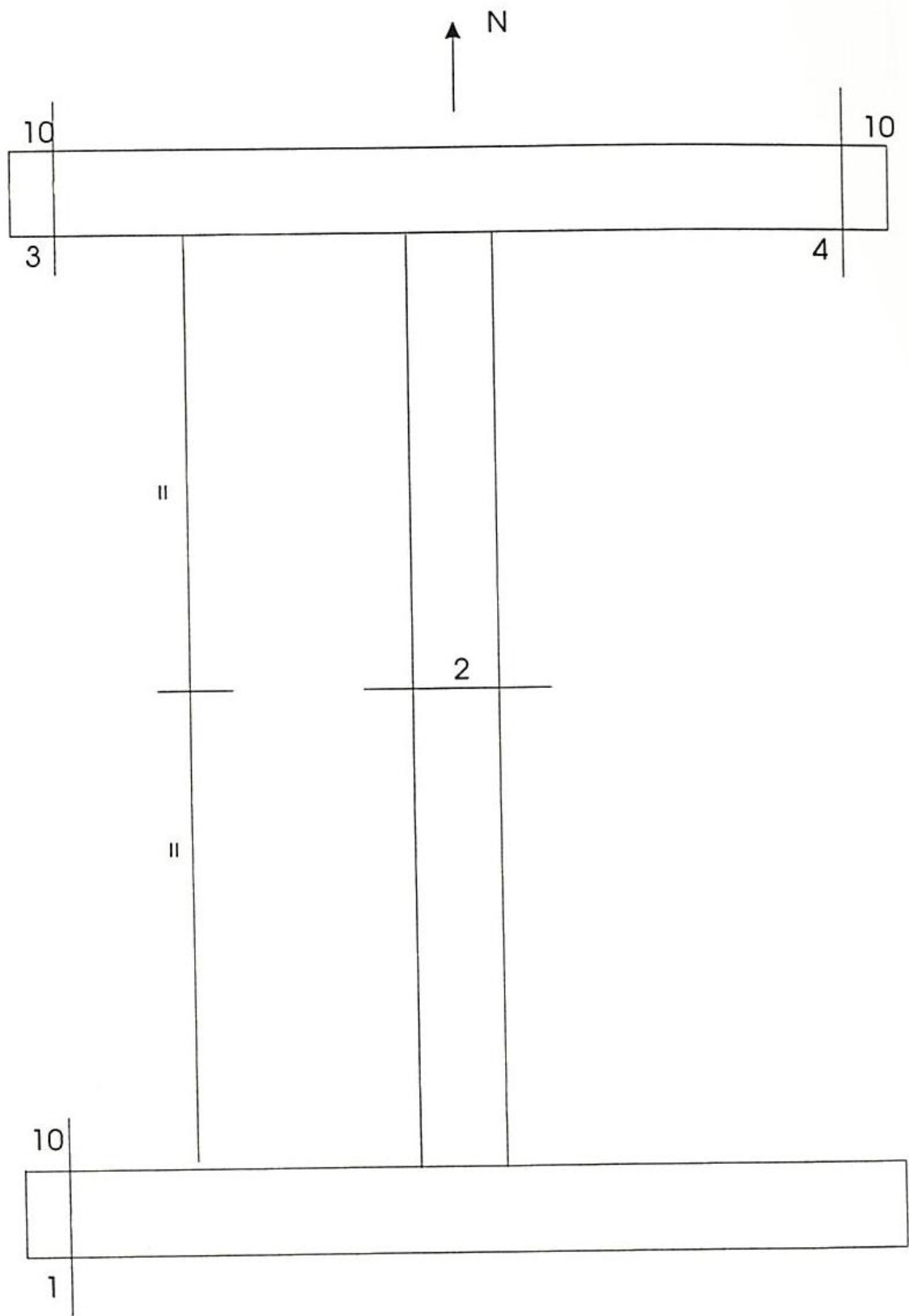


Figure 35 Cross-sectional thermocouple locations column C5 (B4) – associated data file C5TEMP.xls

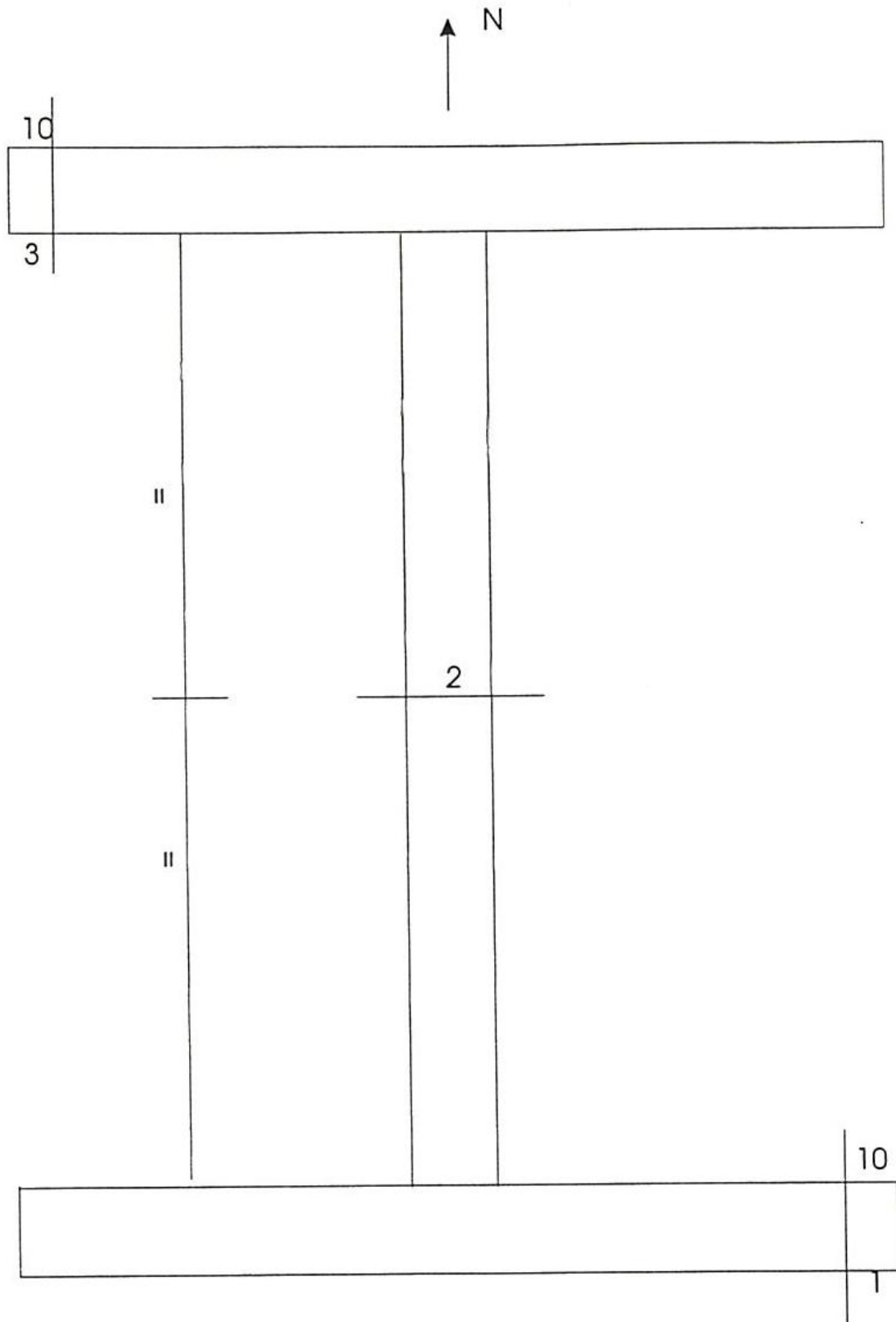


Figure 36 Cross-sectional thermocouple locations columns C6 and C7 (B3&B2) associated data files C6TEMP.xls; C7TEMP.xls

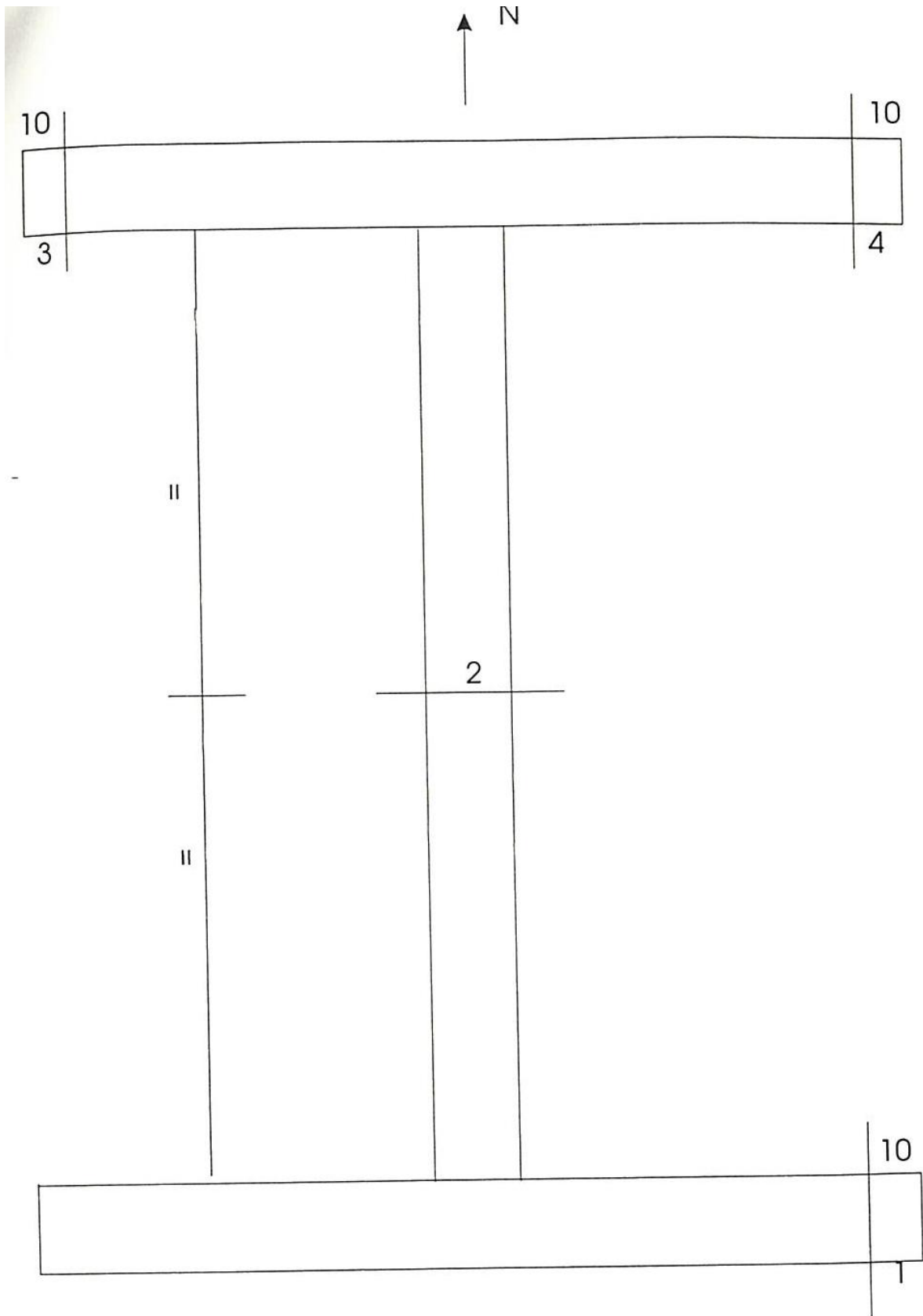


Figure 37 Cross-sectional thermocouple locations columns C8 and C13 (B1&A1) associated data files C8TEMP.xls; C13TEMP.xls

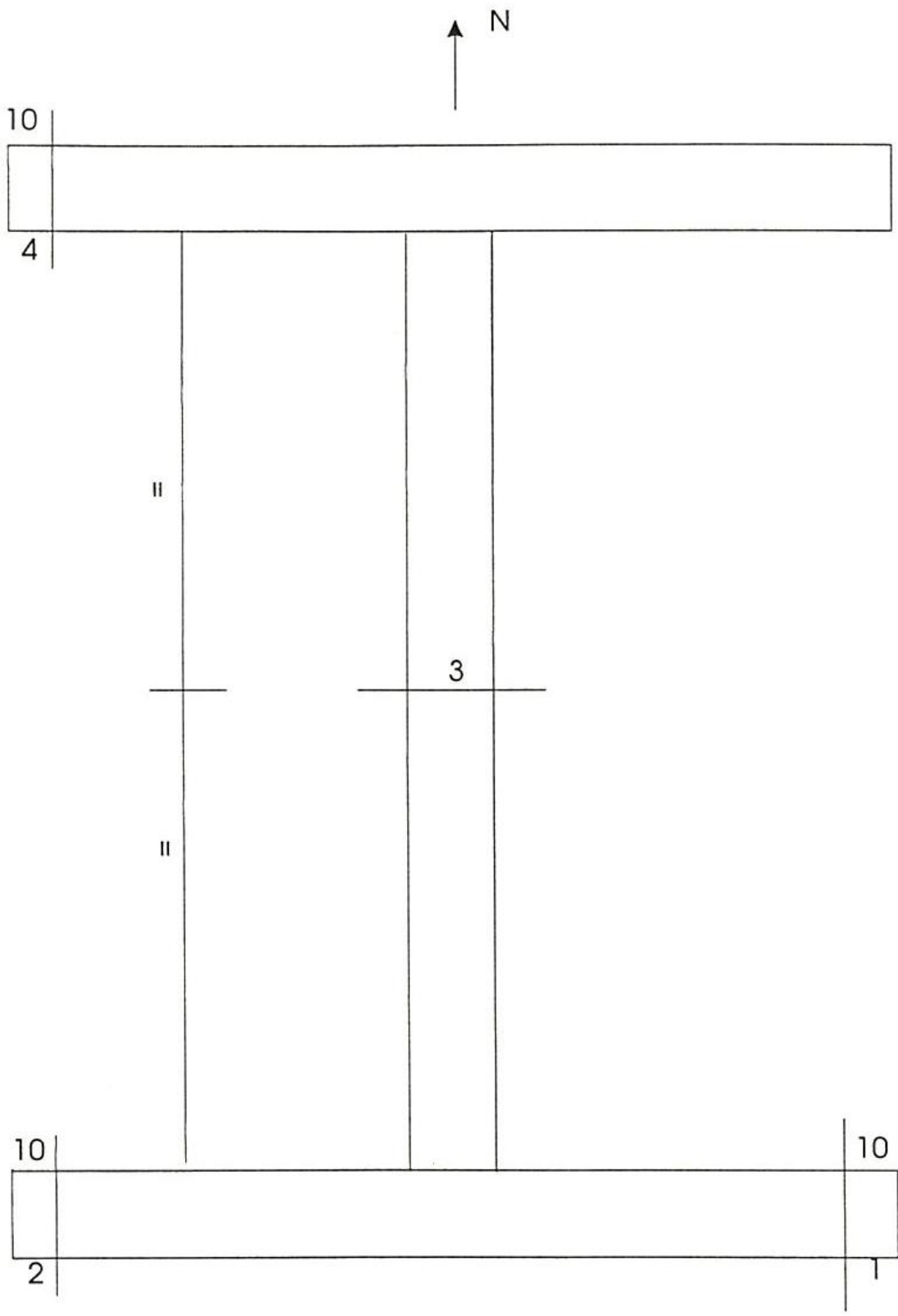
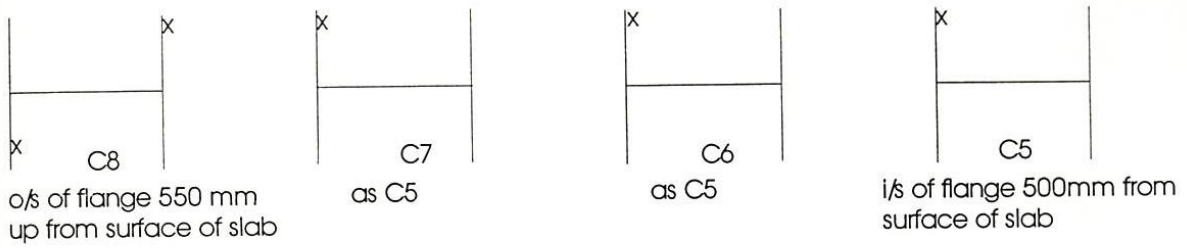
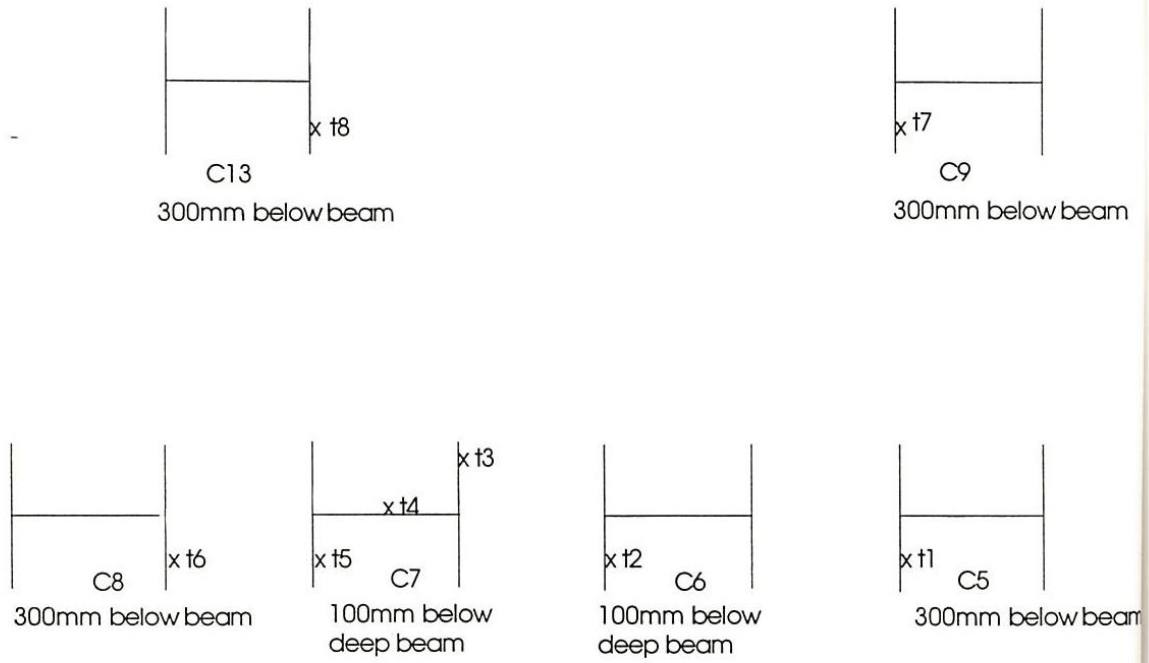


Figure 38 Cross-sectional thermocouple locations for column C9 (A4) associated data file C9TEMP.xls



Note: All thermocouples 25mm in from edge of flange, o/s = outside, i/s = inside

Figure 39 Position of thermocouples associated with weldable strain gauges



Note: All thermocouples on outside of flange 25mm in from edge

Figure 40 Additional thermocouples at top of columns (T1-T8)

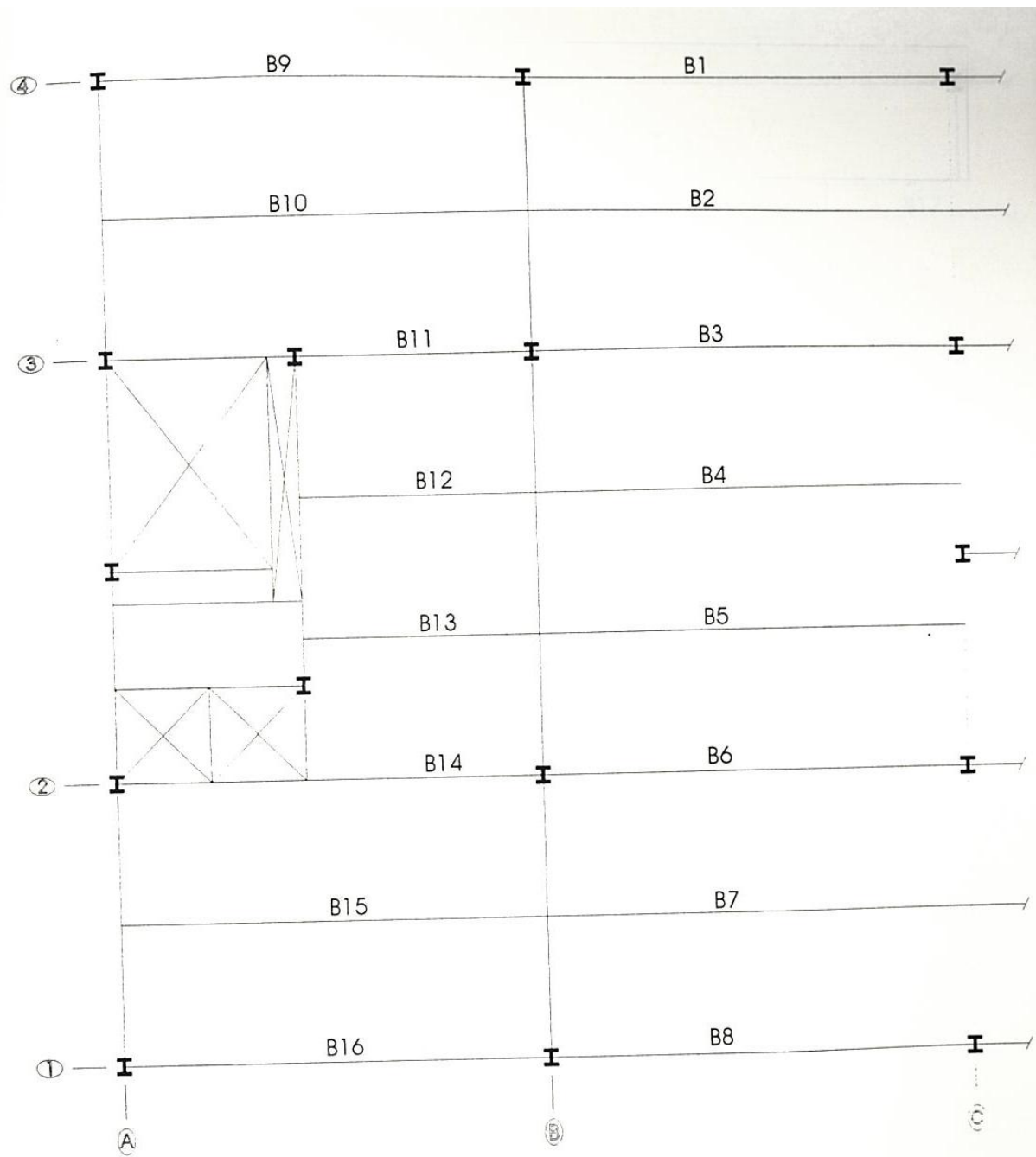


Figure 41 Secondary beam identification

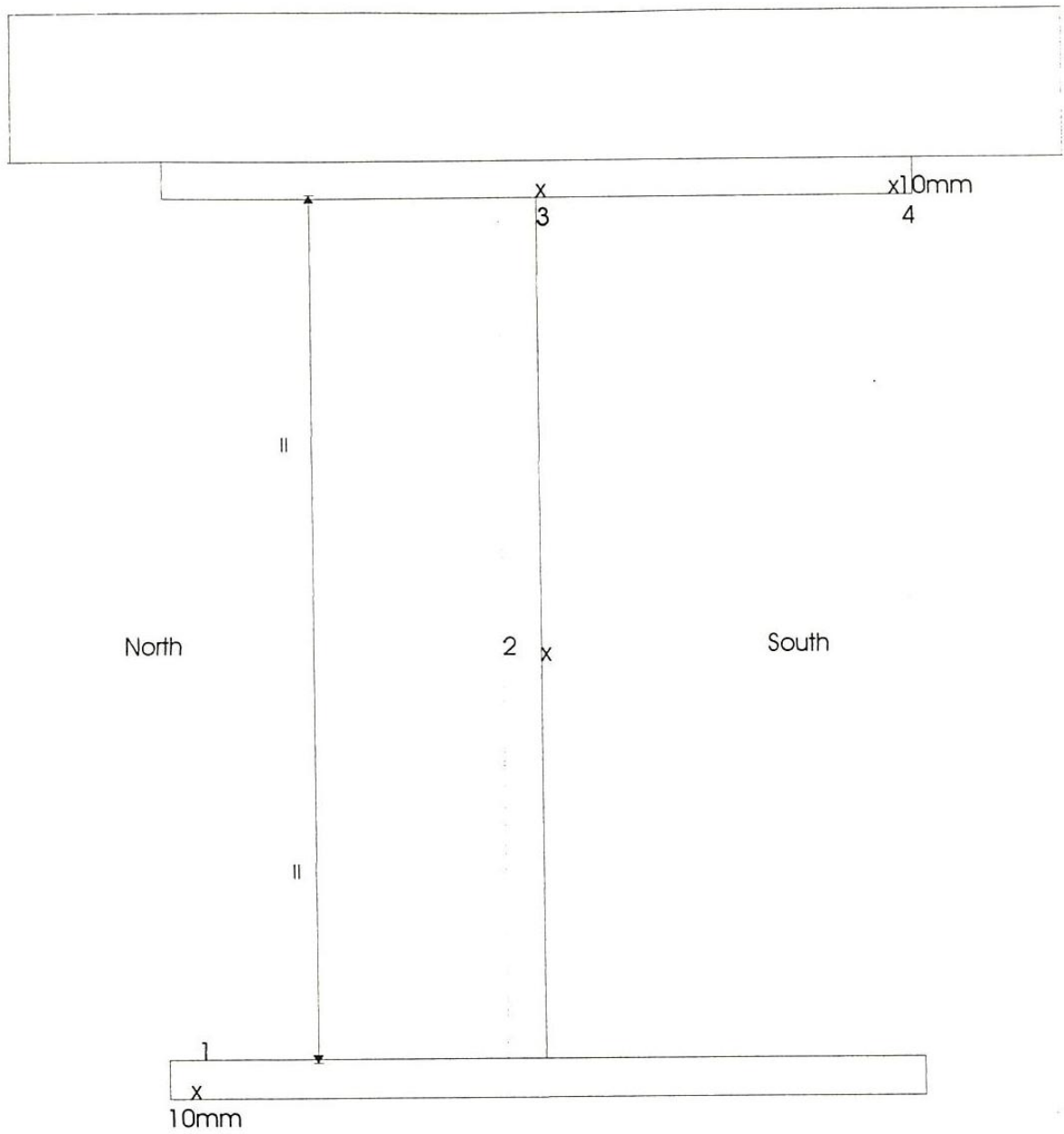


Figure 42 Thermocouple locations for secondary beams B1, B6, B8, B9, B10, B12 and B16 looking east associated data files B1Temp.xls; B6TEMP.xls; B8TEMP.xls; B9TEMP.xls; B10TEMP.xls; B12TEMP.xls; B16TEMP.xls

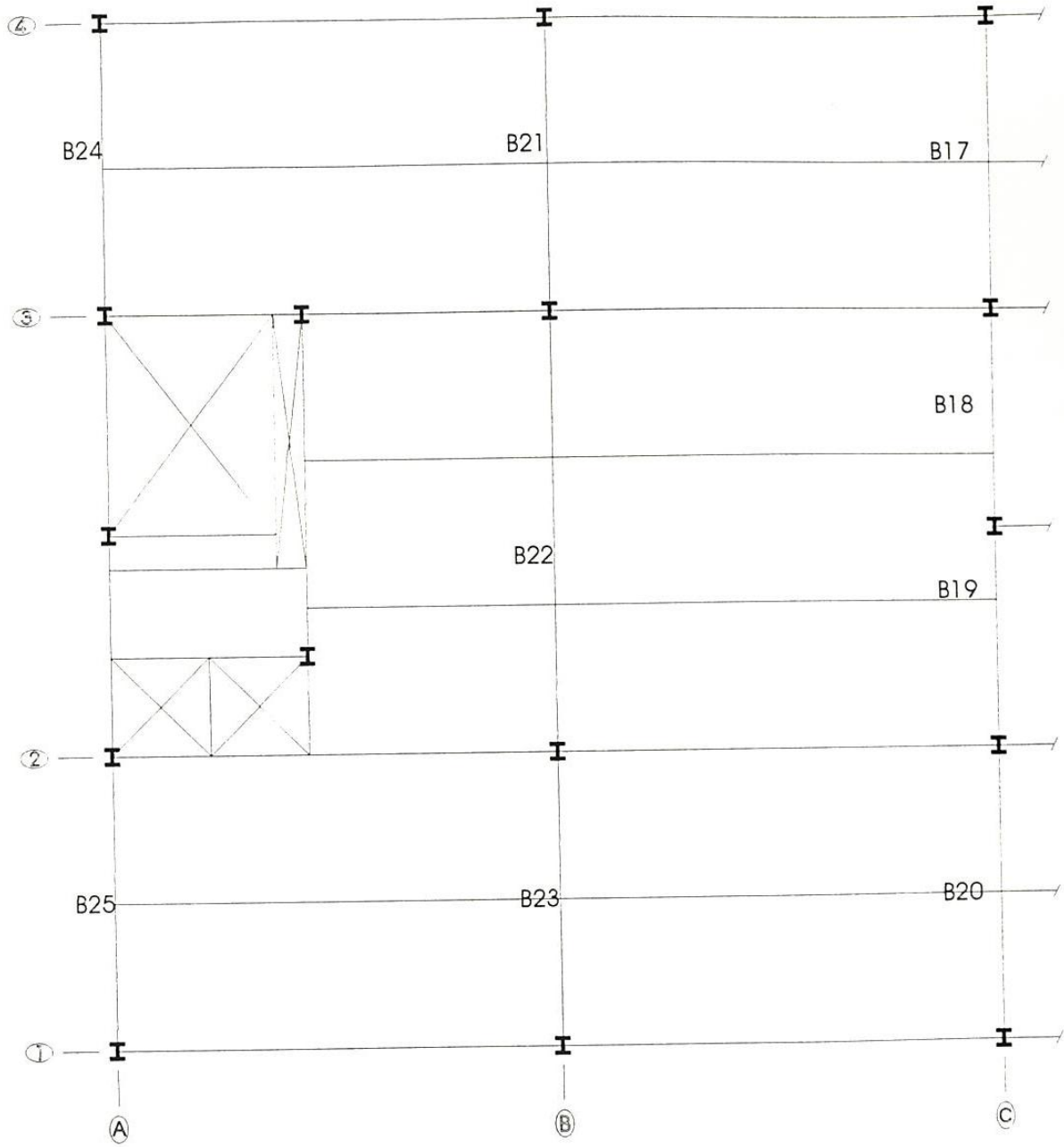


Figure 43 Primary beam identification associated data files B21TEMP.xls; B22TEMP.xls; B23TEMP.xls; B24TEMP.xls; B25TEMP.xls

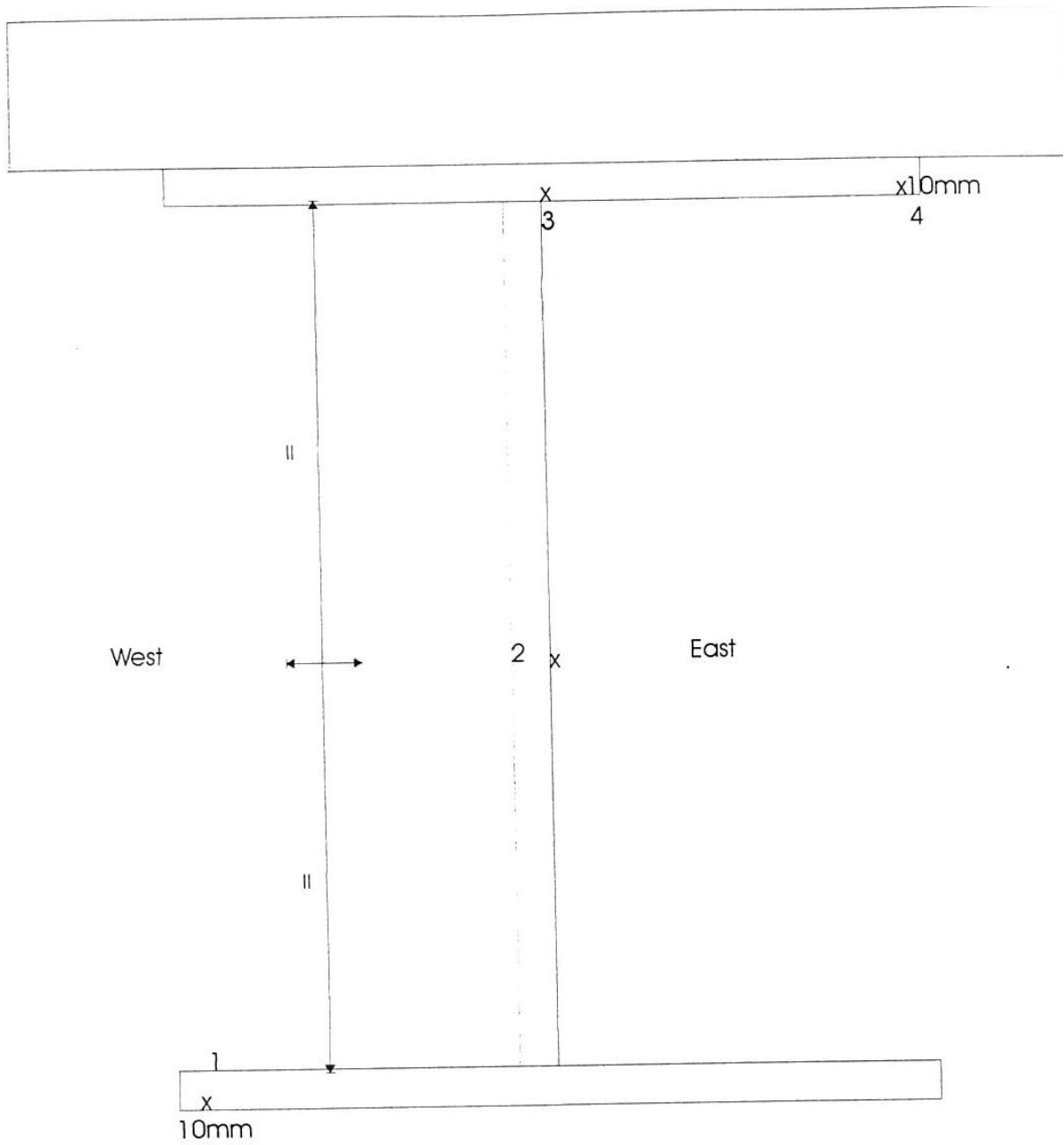


Figure 44 Thermocouple locations for primary beams B21-25 looking north

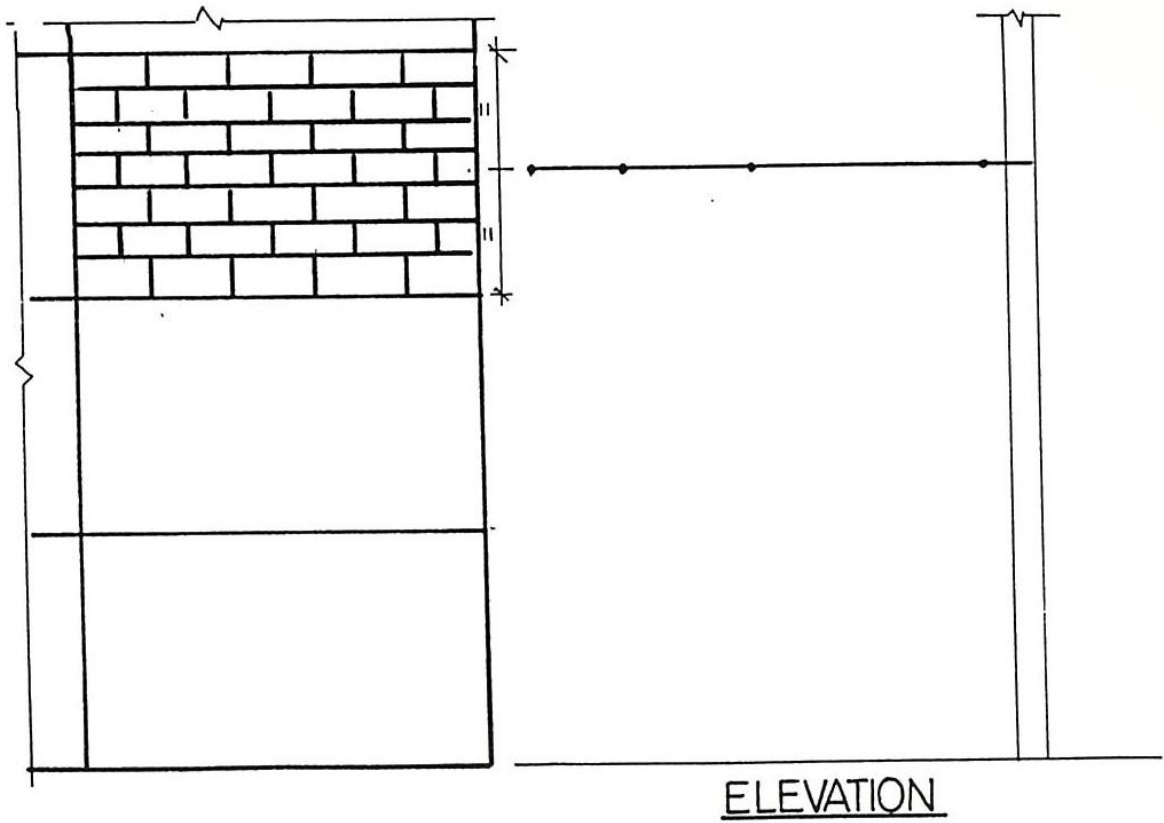
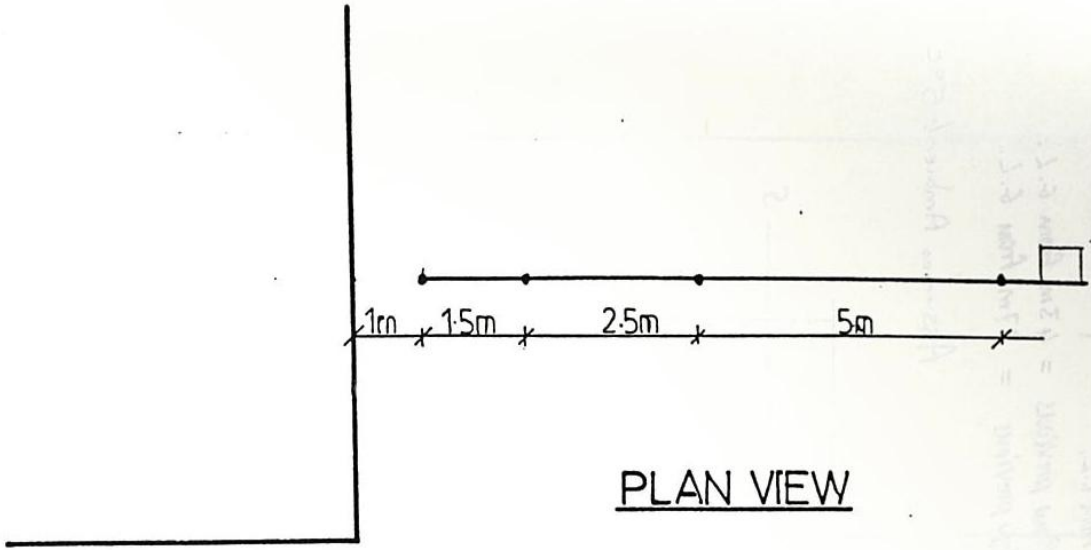


Figure 45 Position of thermocouples opposite the compartment associated data file OPP.xls

4 = opposite top glazing panel, approx. 4.0m. from C.L., 5m. from glazing
 5 = Ditto
 6,7 = In front and behind main steel truss opposite compartment
 8,9 = Ditto

1 = central walkway height above centre of compartment
 4.9m from G.L.
 2 = 6 m. below previous = 43m. from G.L.
 3 = 6m. below previous = 37m. from G.L.

Assumes Ambient 5°C

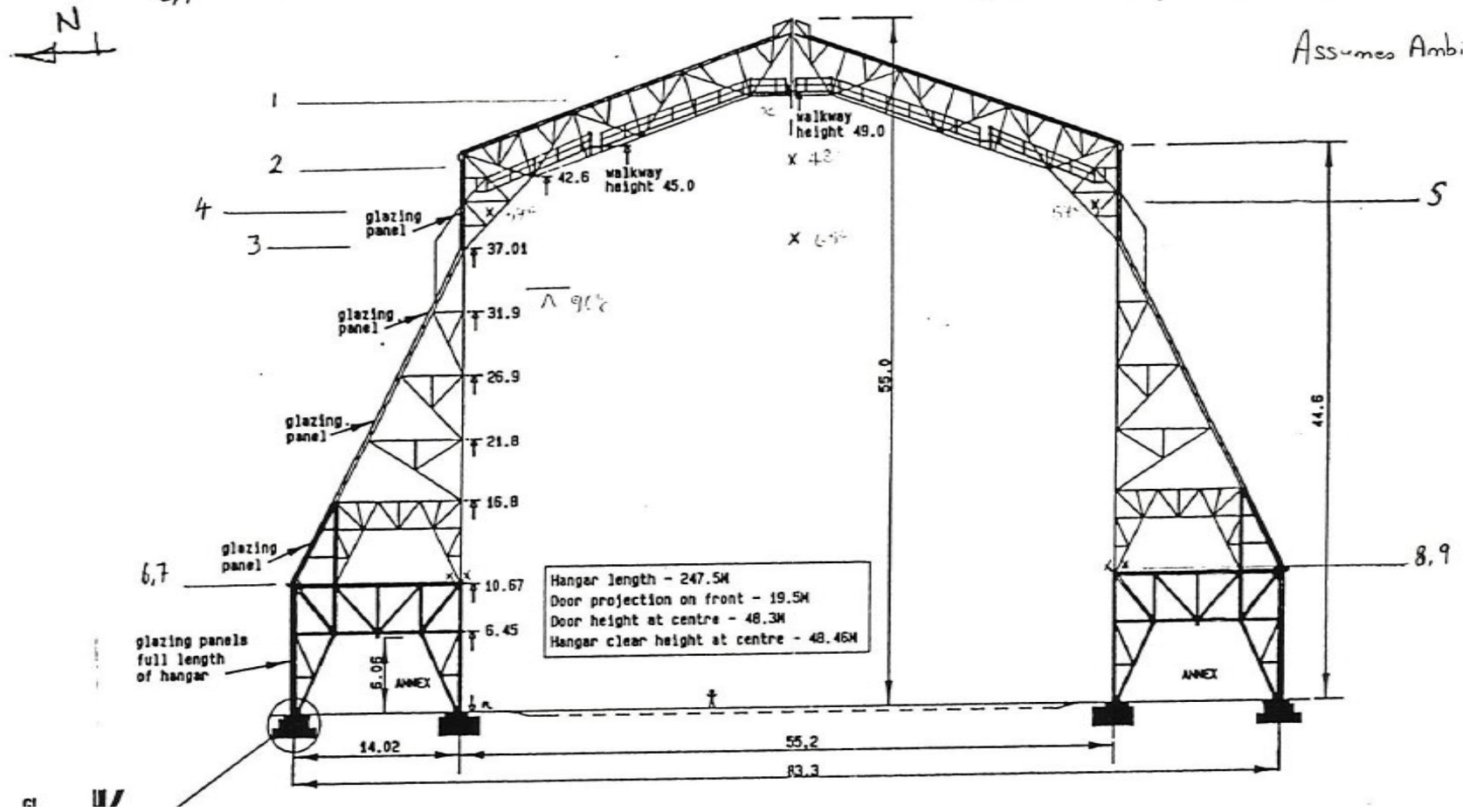


Figure 46 Location of thermocouples used to monitor the response of the hangar associated data file HANGTEMP.xls

↳ Either Side of Fire Wall

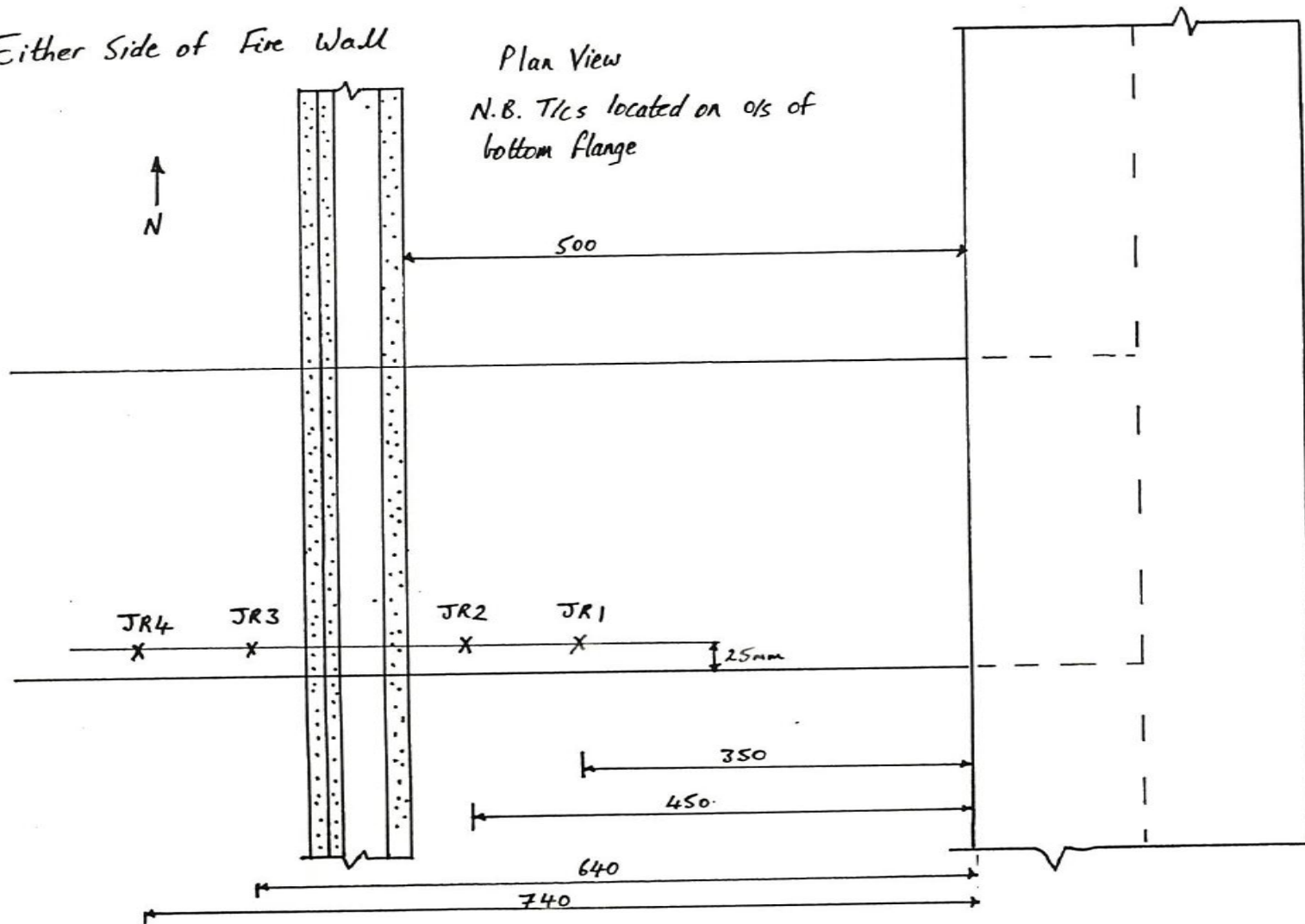


Figure 47 additional thermocouples – Beam B4 between gridlines B and C associated data file JR.xls

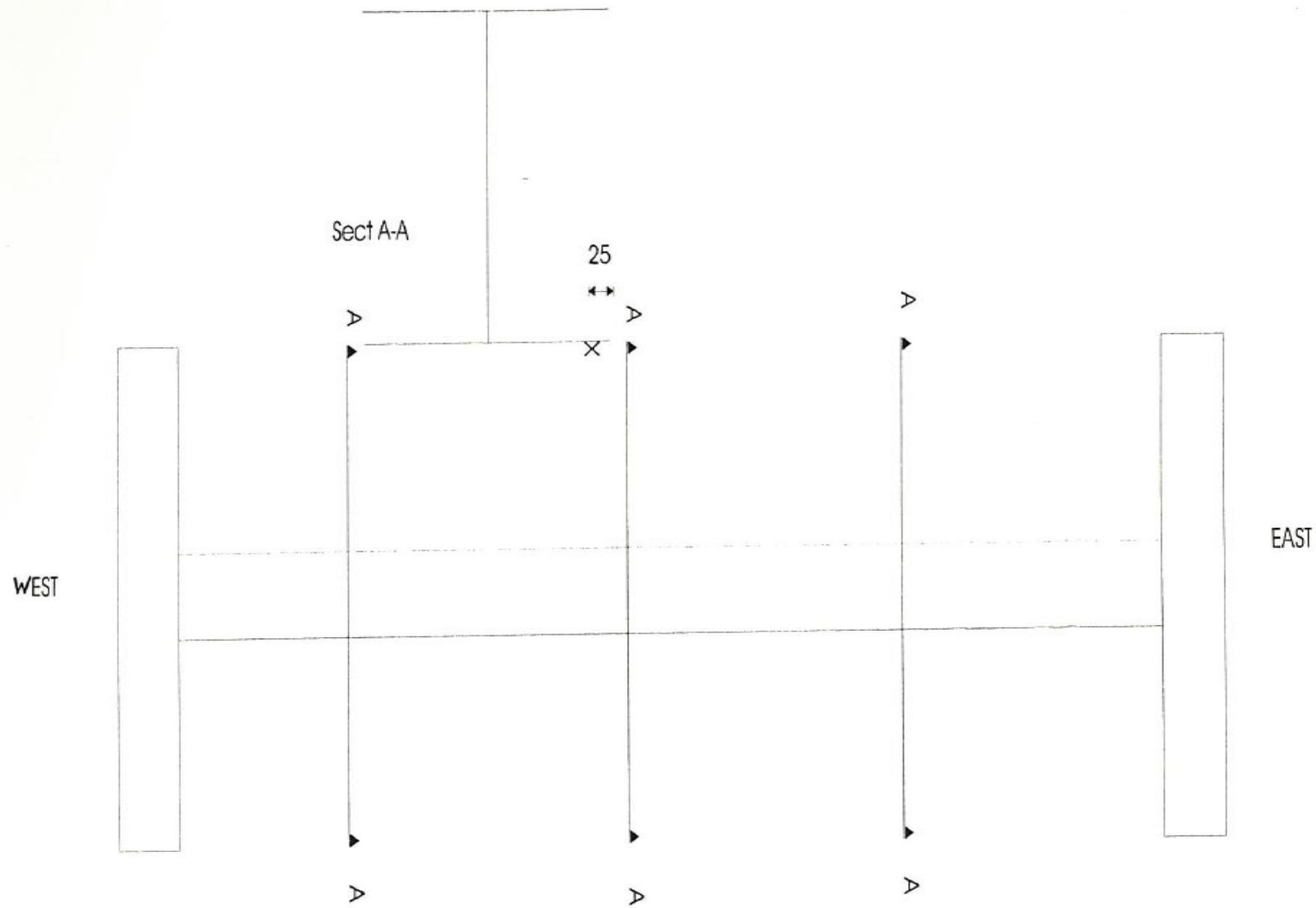
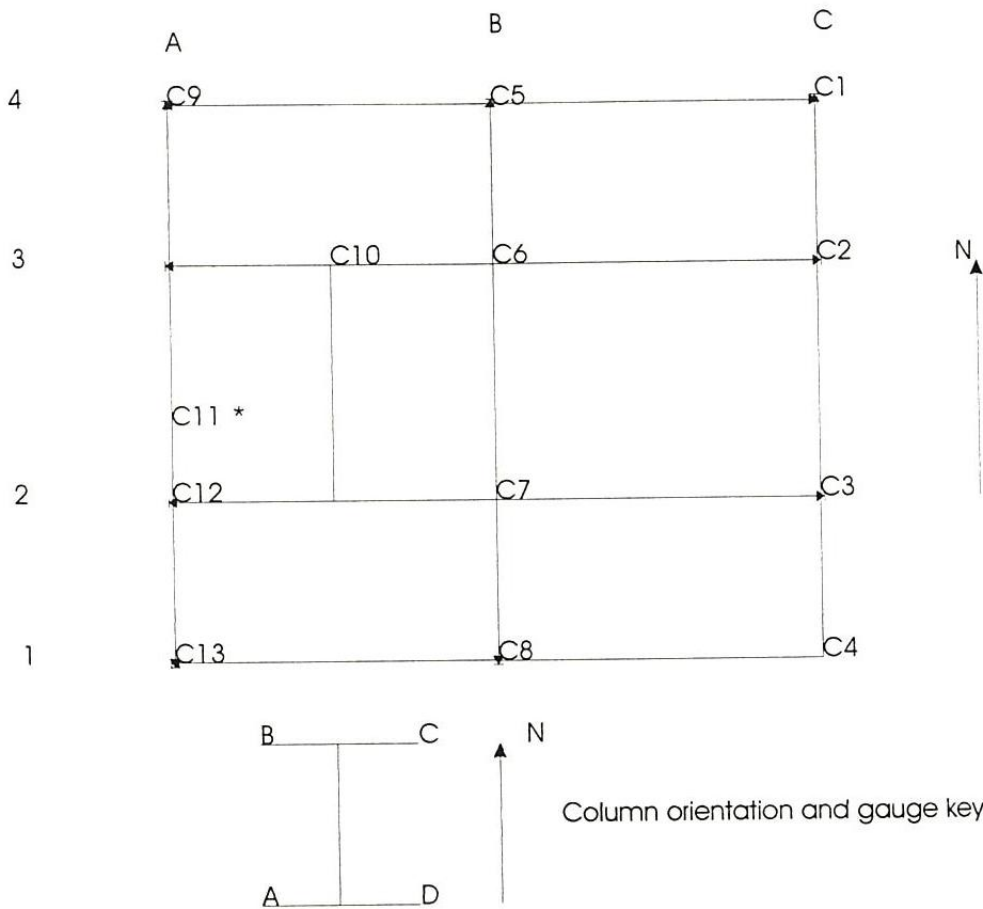


Figure 48 Additional thermocouples beam B4 associated data file JR.xls

* C11 not used



If gauge is located on inside of flange then this will be denoted by a ` alongside cable reference eg. 231

F denotes floor eg. F1 is floor 1, C denotes column eg. C1 is column 1

Figure 49 Column strain gauge layout associated data files FxC1strain.xls; FxC2strain.xls; FxC3strain.xls; FxC4strain.xls; FxC5strain.xls; FxC6strain.xls; FxC7strain.xls; FxC8strain.xls; FxC9strain.xls; FxC10strain.xls; FxC12strain.xls; FxC13strain.xls – where x = 1,2 and 3 additional files on 7th floor F7C6strain.xls; F7C7strain.xls

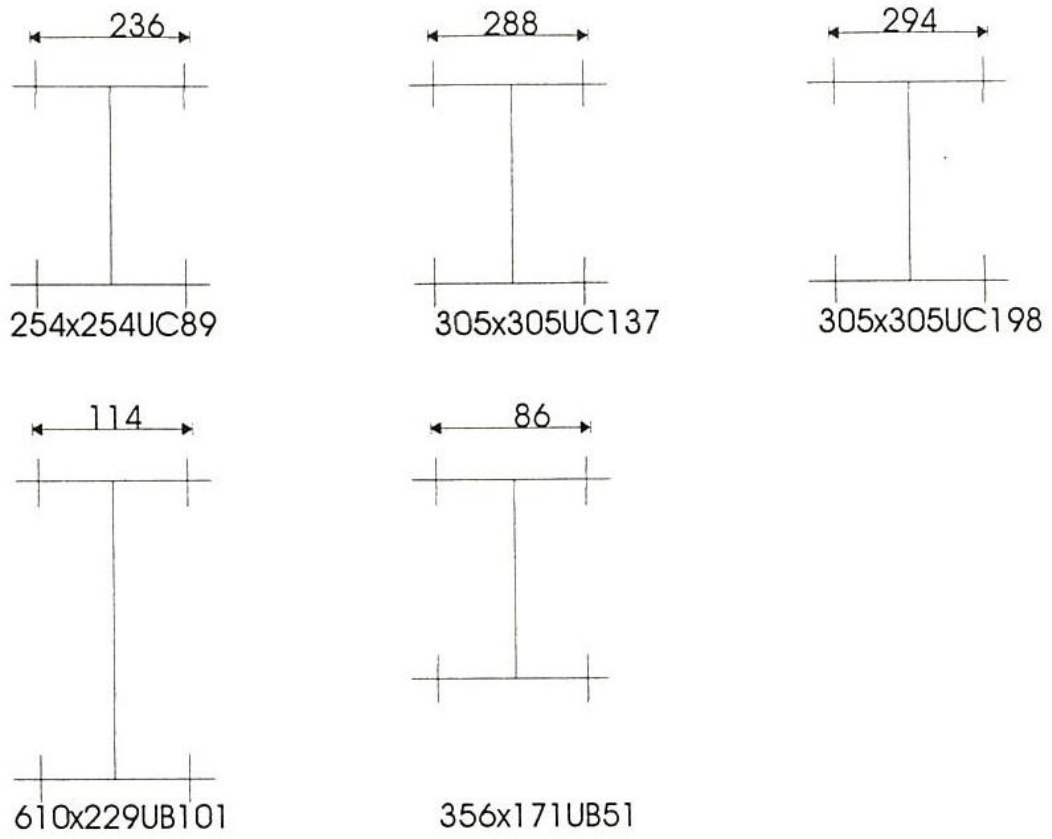


Figure 50 Cross-sectional strain gauge locations

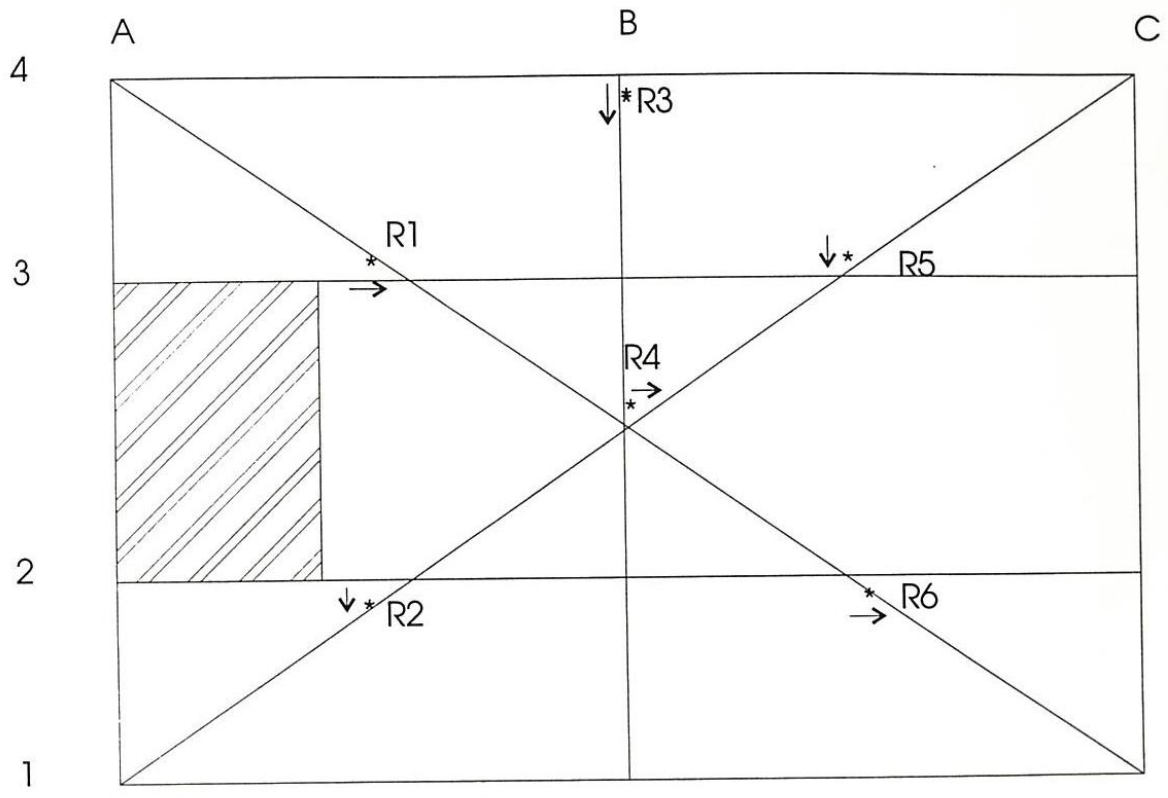


Figure 51 Reinforcement gauge layout 3rd floor associated data file RFSTRAIN.xls

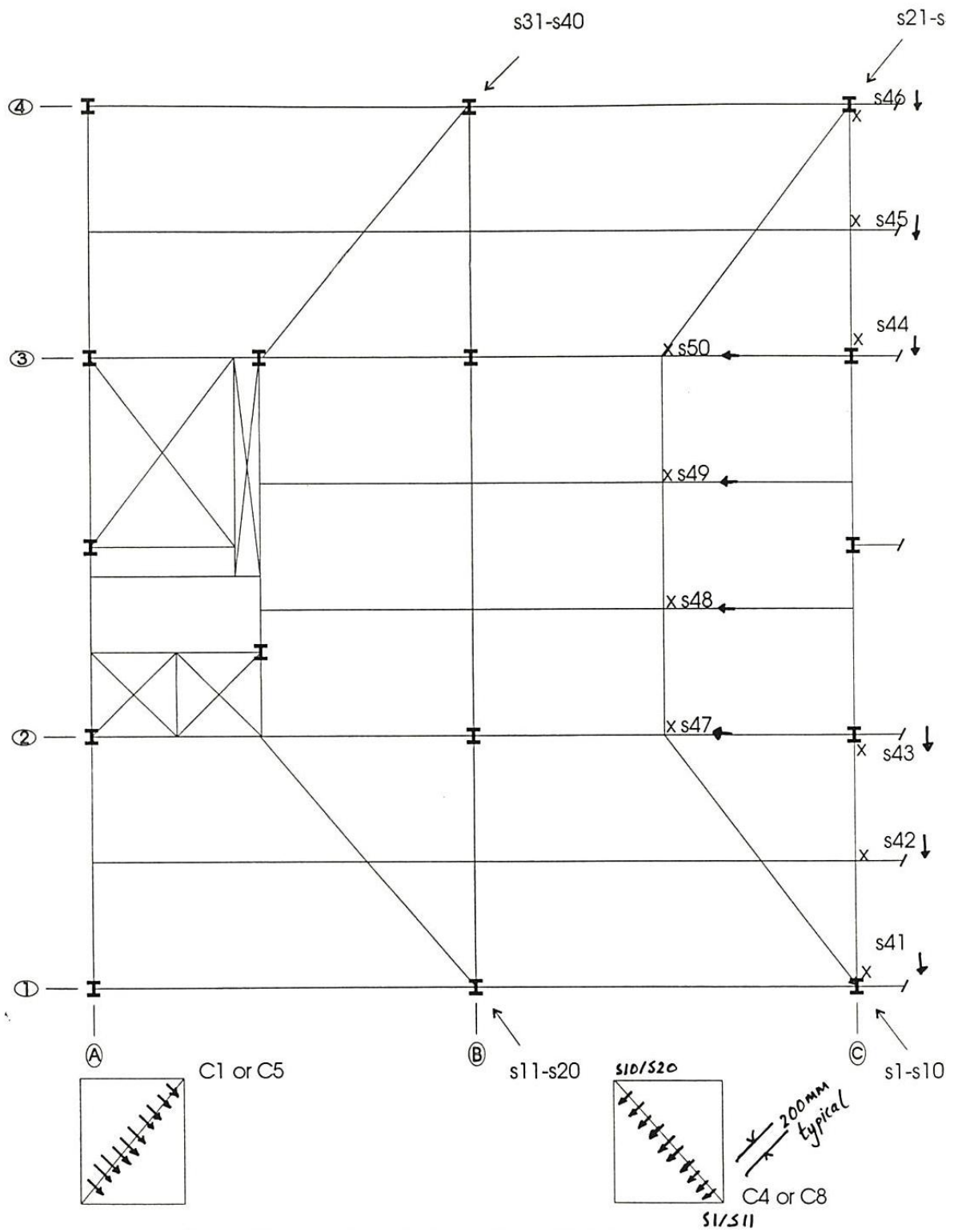


Figure 52 Concrete slab gauge layout 3rd floor associated data file CSSTRAIN.xls

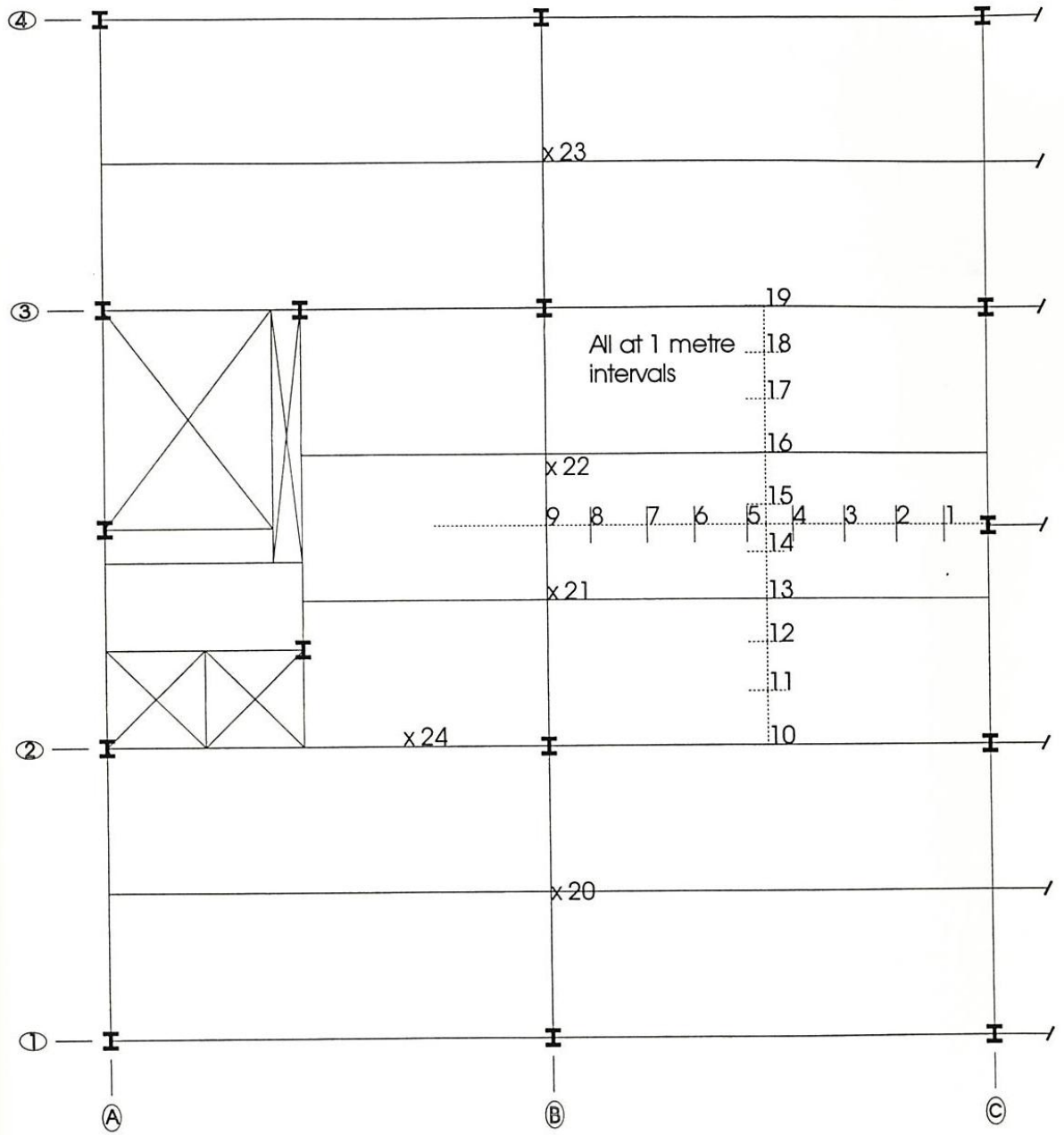


Figure 53 Location of displacement transducers 1-24 associated data file SLABDEF.xls

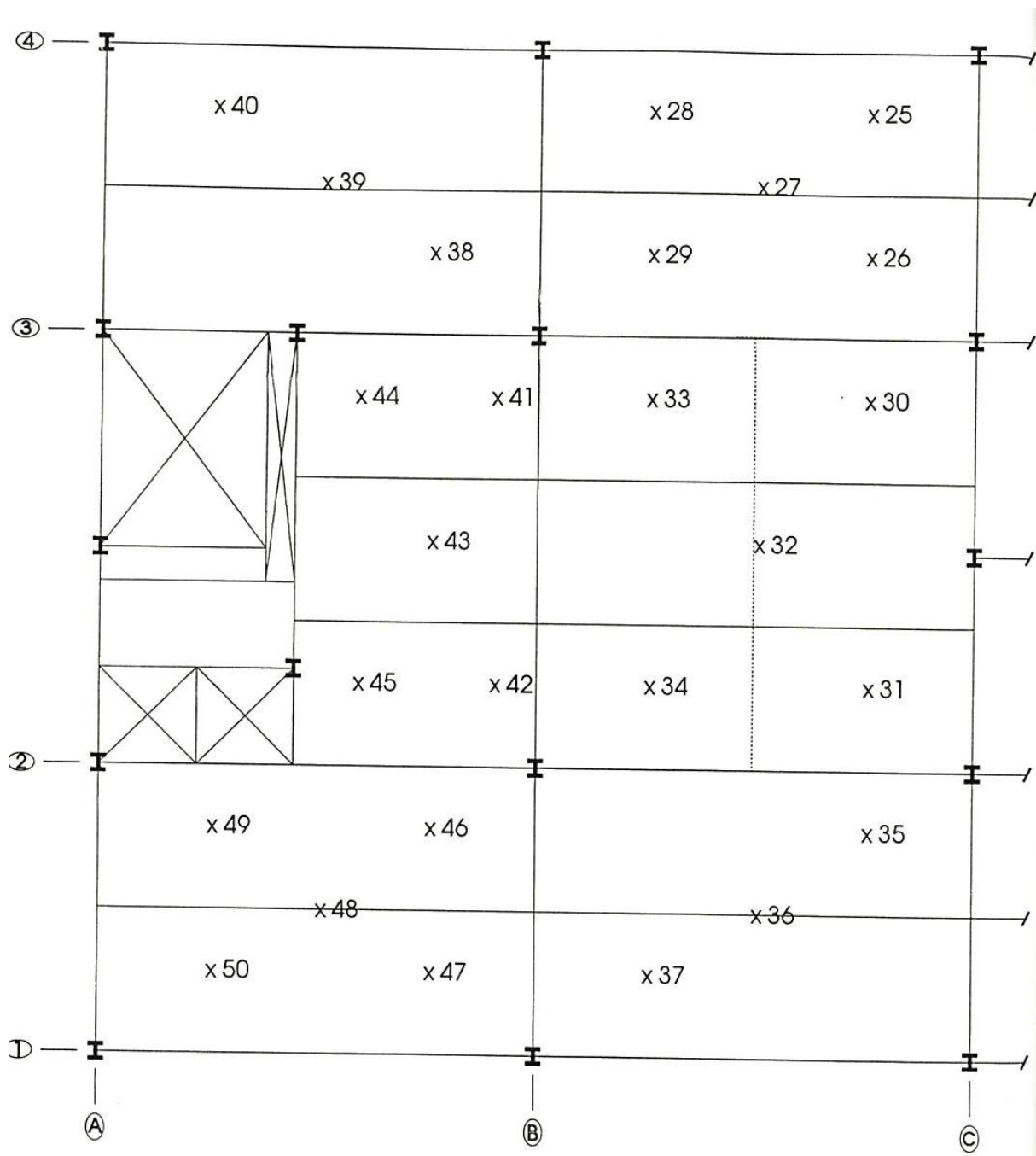


Figure 54 Location of displacement transducers 25-50 associated data file SLABDEF.xls

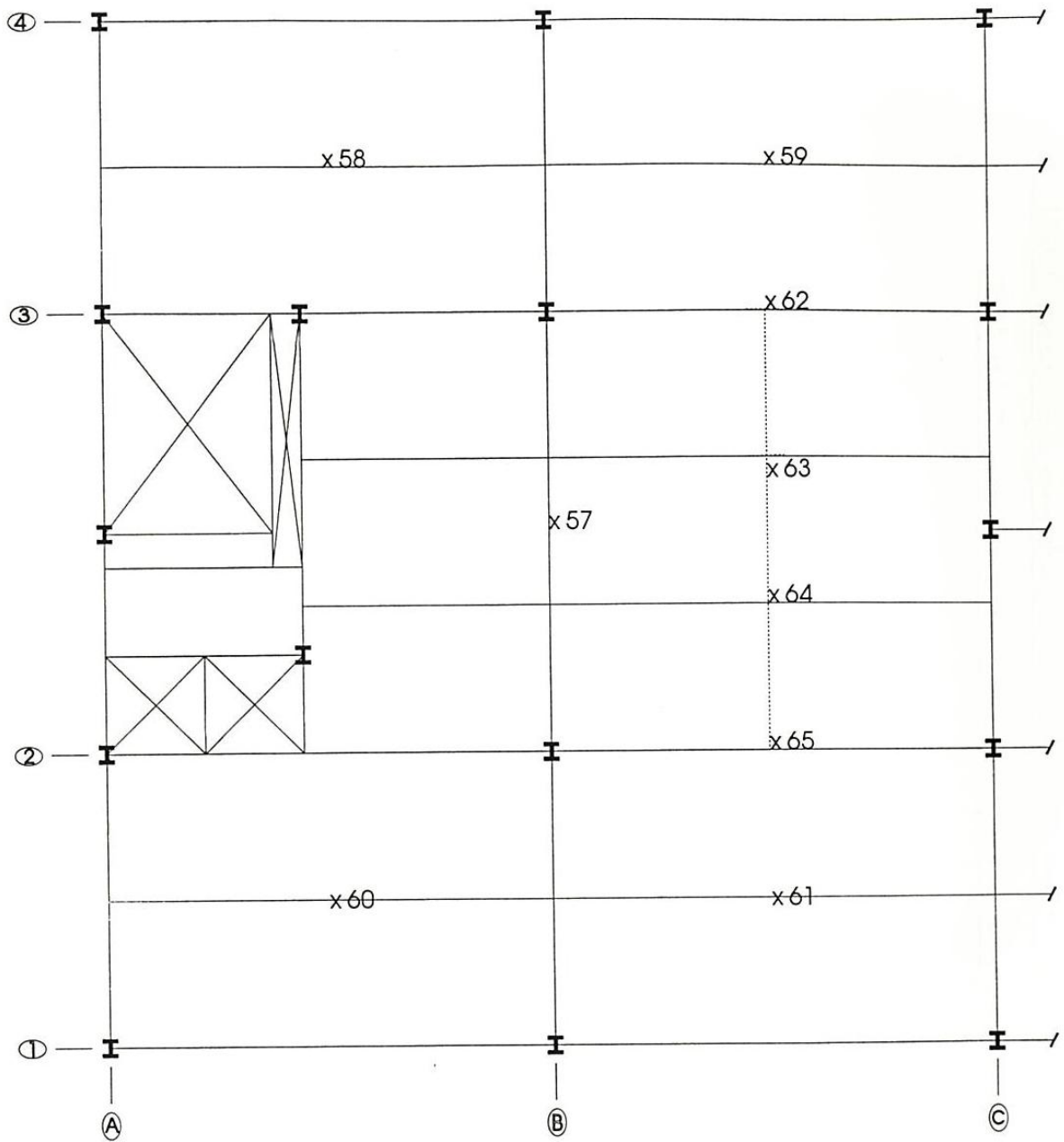


Figure 55 Location of displacement transducers on 4th floor associated data file FLR4DEF.xls

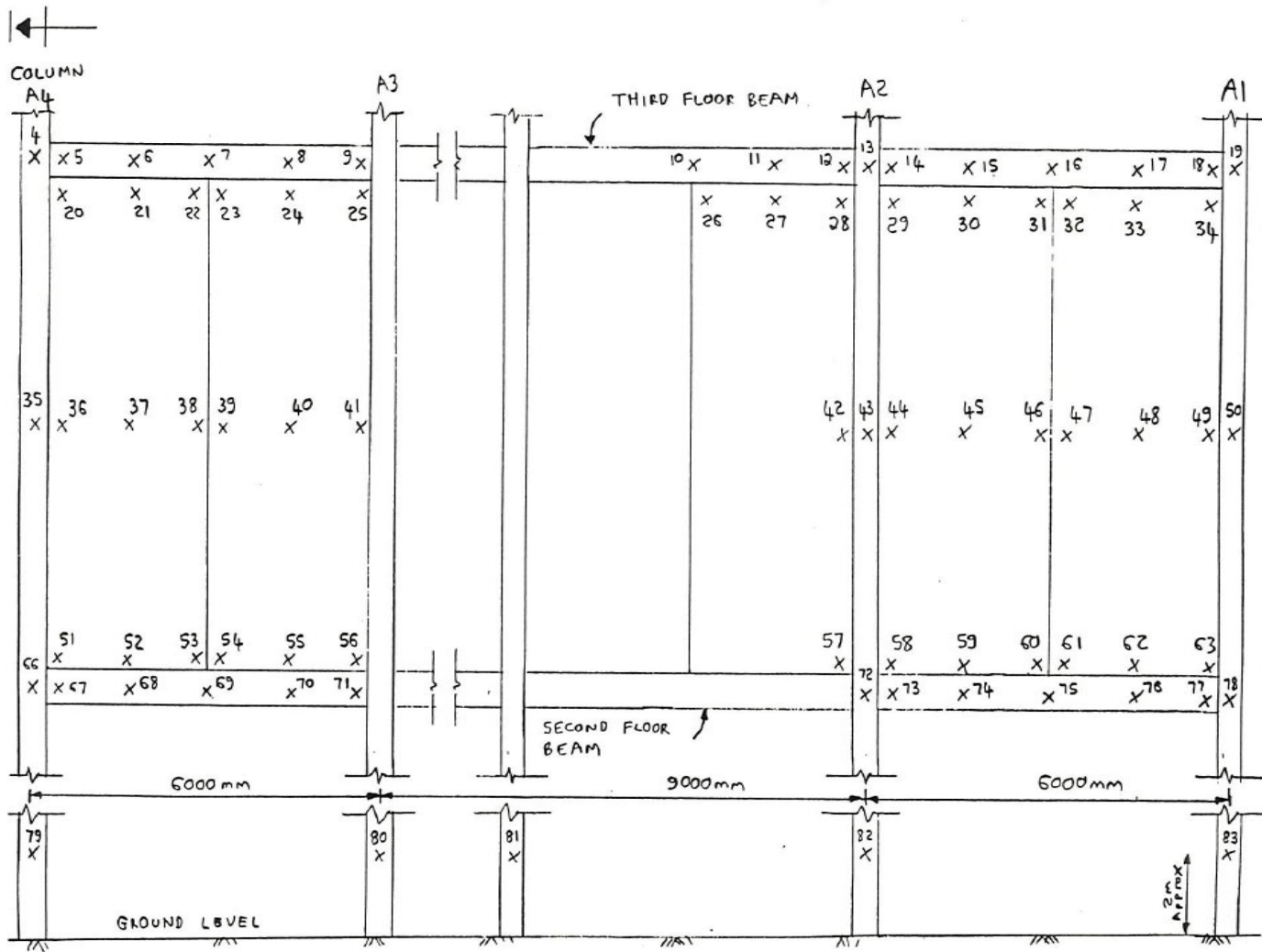


Figure 56 Target positions for 3D- Laser survey system monitoring of west wall movement (Note: target numbers 1,2,3,64,65 not used) associated data file not available

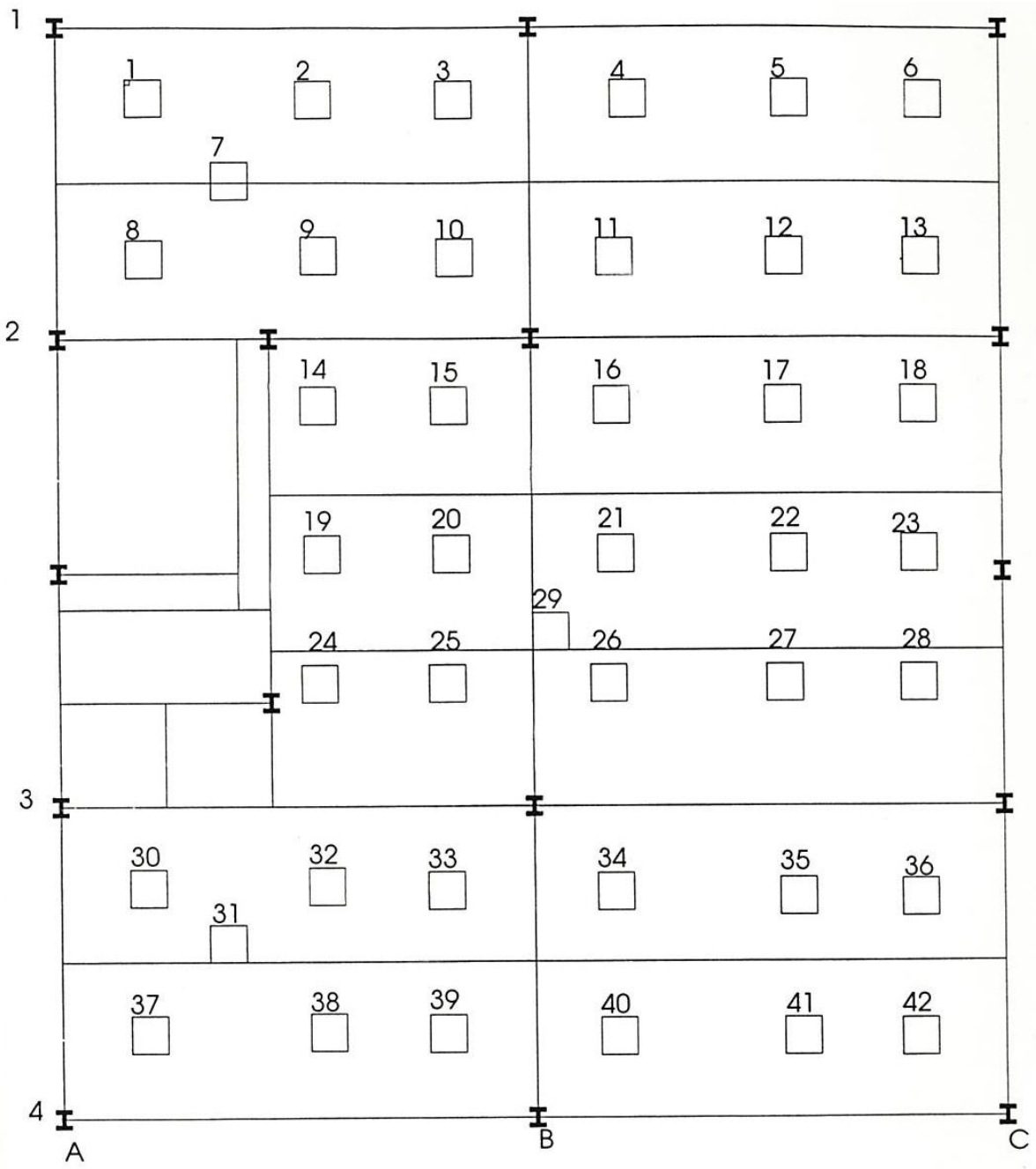


Figure 57 Crib layout for large compartment fire test

Max. Heat Output = 1.7 mW
Time to peak = 20 mins.
Steady burning = 40 mins.

Total mass = 425 kg
Total no. of sticks = 340

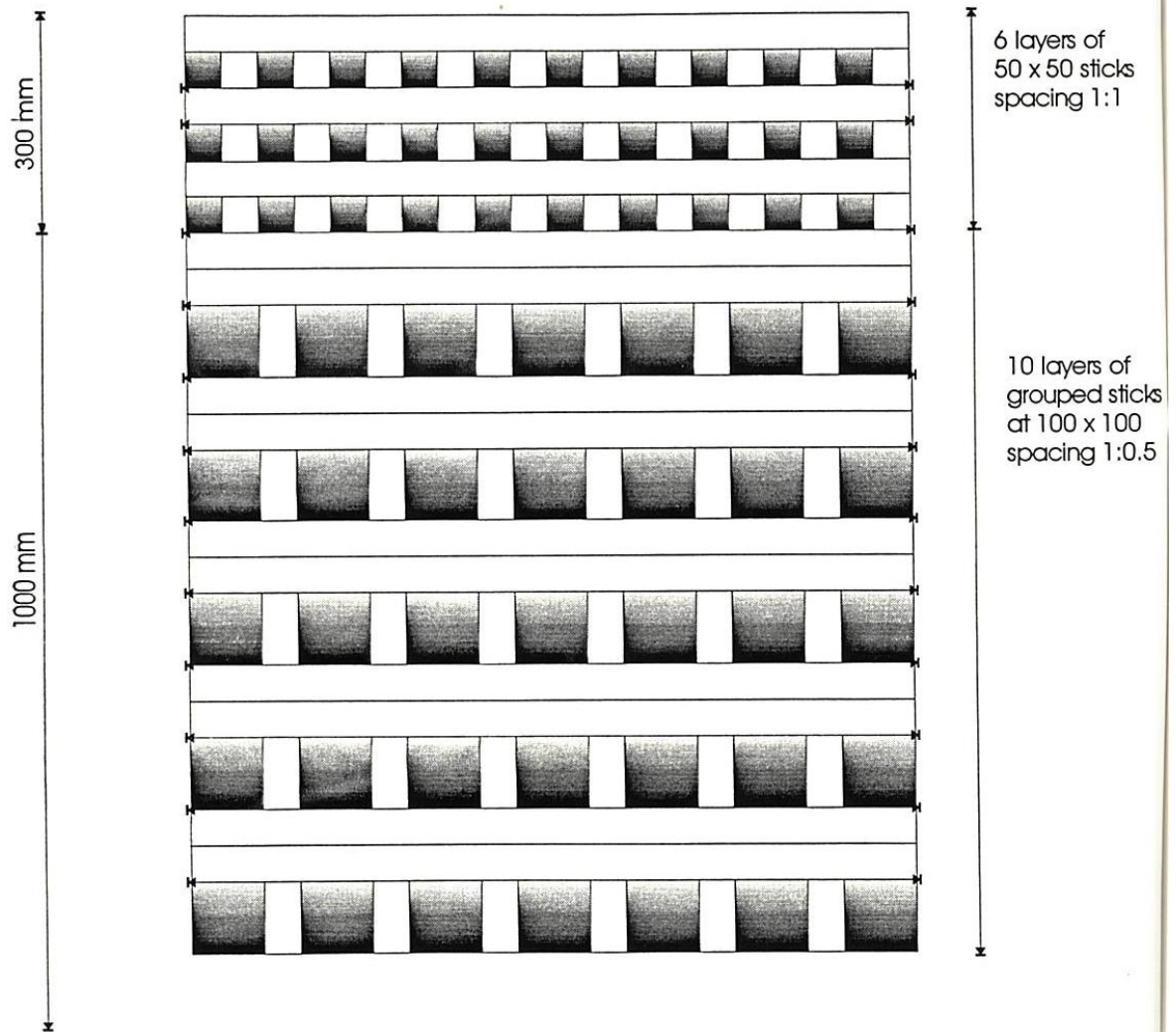


Figure 58 Crib dimensions for large compartment fire test