F.R. Note No. 501

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

FIRE RESISTANCE OF CONCRETE BLOCK WALLS

by

H. L. Malhotra

Summary

Tests have been performed to determine the fire resistance of load-bearing and non-loadbearing walls of concrete blocks, both solid and hollow, made with two types of aggregates. The information from the tests has made it possible to make a more complete assessment of the fire resistance of concrete block walls, but some further work is still necessary, particularly on loadbearing walls.

May, 1962.

Fire Research Station,
Boreham Wood,
Herts.

FIRE RESISTANCE OF CONCRETE BLOCK WALLS

by

H. L. Malhotra

Introduction

Walls, like other structural separating elements of a building, may be required to act as barriers to the passage of fire. Their ability to give protection in this way is measured by the standard fire resistance tests (B.S.476), and is expressed as a time in terms of standard grades varying from a minimum of $\frac{1}{2}$ hour to a maximum of 6 hours, in prescribed steps. The degree of fire resistance required by bye-laws for the various elements of a building depends upon such factors as the size and the location of a building and the purpose for which it is intended. In order to show how these requirements may be complied with, tables have been published giving details of the fire resistance provided by common forms of construction. In the section dealing with walls some information has been provided on concrete blocks, based on results of a few tests performed many years ago and data from American sources. The information was incomplete and with the aim of remedying some of the deficiencies a limited research programme was undertaken in co-operation with the British Cast Concrete Federation who undertook to supply the necessary materials for the test specimens.

Scope of the investigation

Concrete block walls in buildings may be either non-loadbearing or loadbearing. As the fire resistance properties of a wall are influenced by the test conditions, which are required to simulate the actual usage, it was necessary to test both loadbearing and non-loadbearing constructions. Failure of non-loadbearing walls is generally by heat transmission leading to the temperature on the unheated side exceeding the permitted limit, and the performance of walls thinner than test specimens can therefore be calculated. The same method of extending test data is not feasible for loadbearing walls in the absence of precise knowledge of their strength reduction properties at various temperatures, and the likely manner of failure, since they usually fail by lack of stability rather than insulation.

From the point of view of fire protection, concretes are divided into two categories, those made with Class 1 aggregates, consisting in general of artificial materials such as foamed slag, clinker, expanded clay and shale etc., and Class 2 aggregates of natrual origin such as gravel, basalt, granite etc., with the exception of limestone which is included in the first category. In this investigation aggregates were used to represent materials in common usage of each class, those selected being foamed slag and river gravel. The size and the type of concrete blocks used in this investigation are listed below.

TABLE 1

Particulars of blocks used for the test specimens

Specimen No.	Aggregate	Type	Thickness	Loading condition
1	Class 1	solid	6 in	Non-loadbearing
2	Class 2	solid	4 in	Non-loadbearing
3	Class 2	hollow	6 in	Non-loadbearing
4	Class 2	hollow	4 in	Non-loadbearing
5	Class 1	solid	4 in	Loadbearing
6	Class 2	solid	4 in	Loadbearing
7	Class 2	solid	4 in	Loadbearing

Description of specimens

The fire tests were performed on specimen walls 10 ft square built by the staff of the Fire Research Station to the normal trade standards. The non-loadbearing walls were erected in a heavily reinforced concrete frame which applied restraint to the four sides and the loadbearing walls were built on a concrete beam and mounted in the loading frame of the apparatus, which applied a vertical load during the test. One half of each face of the non-loadbearing walls was rendered with a coating of cement/sand plaster to a nominal thickness of $\frac{1}{2}$ in to obtain additional information from the same test on the increase in fire resistance obtainable with a plaster finish. The same technique could not be adopted with the loadbearing walls, as the dissimilarity of the two halves of the wall would influence the integrity of the whole construction by an unknown factor. Hence the tests were performed on loadbearing walls without any finishes. The loads on these walls were calculated in accordance with the Code of Practice on block walls to produce the maximum design stresses. The walls were tested at an age when they had achieved equilibrium moisture conditions with the atmosphere in the laboratory and according to the method described elsewhere(3).

Test results and discussion

The results of the tests on the seven specimens are summarized in Tables 2 and 3, and the appearance of some typical specimens before and after test is shown in Plates 1 to 5.

The tests have provided data which can be used to enlarge the existing information on the fire resistance of concrete block walls. Using the results of the present tests and existing information Table 4 has been compiled giving the thickness of block walls to provide fire resistance of various grades from $\frac{1}{2}$ hour to 6 hours, both for loadbearing and non-loadbearing conditions, with and without plaster finishes. Existing published tables of fire resistance of walls do not make any distinction between the two types of construction and hence tend to be somewhat conservative for non-loadbearing walls. It has been possible to make some assessments for wall of lesser thickness than those tested. There are however still gaps in the available information chiefly for loadbearing walls where interpolations are not possible at present.

Conclusions

A series of fire resistance tests was carried out on concrete block walls made with two types of aggregate, and tested either loadbearing or non-loadbearing. The tests have provided data on the more important types of wall to supplement the available information on their fire resistance, but some further tests are necessary to provide complete information for the whole range of fire resistance periods for which these walls can be used.

References

1. Fire Tests on Building Materials and Structures. B.S.476 : Part 1 : 1953.

2. Structural recommendations for loadbearing walls. British Standard Code of Practice : CP 111 (1948).

3. DAVEY, N., and ASHTON, L. A. Investigations on building fires Part V Fire tests on structural elements. National Building Studies Research Paper No 12. London 1953. H.M.S.O.

TABLE 2

Results of tests on non-loadbearing walls

Specimen No.	Material	Thickness in	Finish	Duration of test h - min	Mean temperature rise on unexposed face		Fire resistance grading h
					Time h - min	°C	
1	Solid concrete blocks- Class 1 aggregate	6	a) none	7 00	7 00	80	6
			b) cement/sand*		7 00	70	6
2	Solid concrete blocks- Class 2 aggregate	4	a) none	4 20	2 52	139	2
			b) cement/sand*		4 20	140	4
3	Solid concrete blocks- Class 2 aggregate	6	a) none	6 00	5 14	139	4
			b) cement/sand*		6 00	96	6
4	Hollow concrete blocks- Class 2 aggregate	4	a) none	0 25	-	-	-+
			b) cement/sand*				

* $\frac{1}{2}$ in nominal coating of cement/lime/sand rendering on both faces of one half of the specimen

+ Specimen collapsed during the test.

TABLE 3

Results of tests on loadbearing walls

Specimen No.	Material	Thickness in	Load tons	Duration of test h - min	Mean temperature rise on unexposed face		Fire resistance grading h
					Time h - min	°C	
5	Solid concrete blocks- Class 1 aggregate	4	3.75	2 15	2 00	28	2
6	Solid concrete blocks- Class 2 aggregate	4	2.40	2 50	2 50	149	-+
7	Solid concrete blocks- Class 2 aggregate	4	2.40	2 08	2 00	79	2

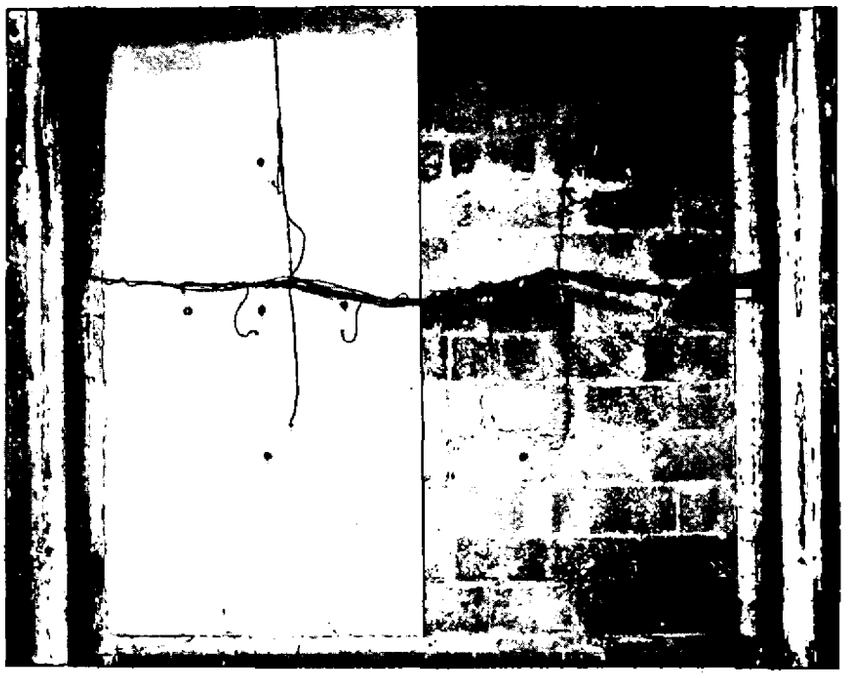
+ The specimen wall failed under the reload test and did not fully comply with the fire resistance requirements

TABLE 4

Fire resistance of concrete block walls

Materials and construction	Minimum thickness in inches excluding plaster for fire resistance of (in hours)				
	6	4	2	1	½
A. LOADBEARING WALLS					
1. Solid blocks - class 1 aggregate					
(a) unplastered or (b) ½ in cement/sand rendering or (c) ½ in gypsum/sand plaster	6	6	4	4	4
(d) ½ in vermiculite/gypsum plaster	-	4	4	4	4
2. Solid blocks - class 2 aggregate					
(a) unplastered or (b) ½ in cement/sand rendering or (c) ½ in gypsum/sand plaster	-	-	4	4	4
(d) ½ in vermiculite/gypsum plaster	-	4	4	4	4
B. NON-LOADBEARING WALLS					
1. Solid blocks - class 1 aggregate					
(a) unplastered	6	6	4	3	2
(b) ½ in cement/sand rendering	-	4	3	3	2
(c) ½ in gyptum/sand plaster	-	4	3	2	2
(d) ½ in vermiculite/gypsum plaster	-	3	3	2	2
2. Solid blocks - class 2 aggregate					
(a) unplastered	-	8	4	3	2
(b) ½ in cement/sand rendering (c) ½ in gypsum/sand plaster	-	7	4	3	2
(d) ½ in vermiculite/gypsum plaster	-	4	3	2	2
3. Hollow concrete blocks, one cell in wall thickness-class 1 aggregate					
(a) unplastered	-	6	5	4	2½
(b) ½ in cement/sand rendering (c) ½ in gypsum/sand plaster	-	6	4	2½	2½
(d) ½ in vermiculite/gypsum plaster	-	6	3	2½	2½
4. Hollow concrete blocks, one cell in wall thickness-class 2 aggregate					
(a) unplastered	-	6	6	5	5
(b) ½ in cement/sand rendering (c) ½ in gypsum/sand plaster	-	6	6	5	4
(d) ½ in vermiculite/gypsum plaster	-	5	4	4	3

Exposed face after fire test of 7 hr duration

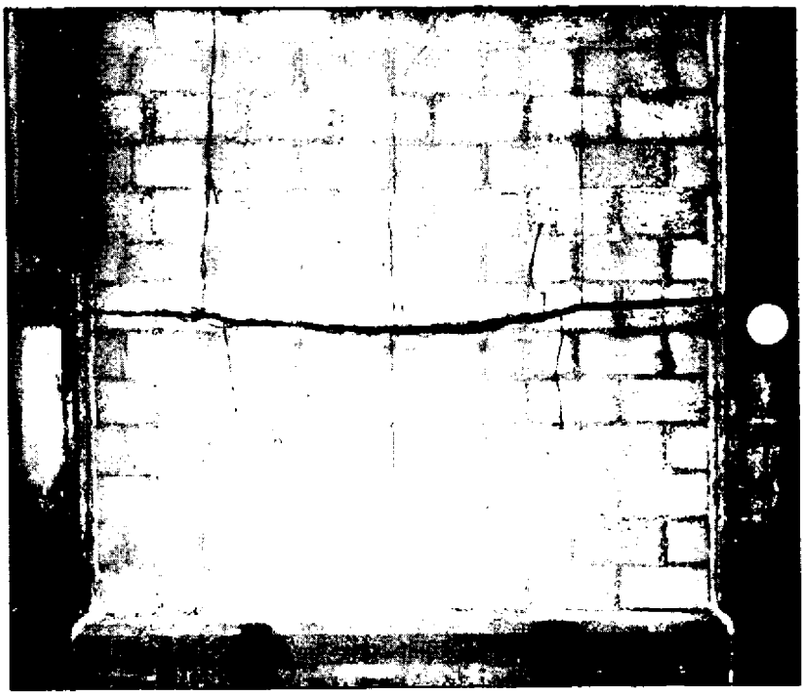


Unexposed face at the end of fire test
(Specimen No. 1)

SOLID BLOCK WALL (NON-LOADBEARING)
CLASS 1 AGGREGATE

Exposed face of 6 in hollow block wall
(non-loadbearing) after 6 hr.

(Specimen No. 3)

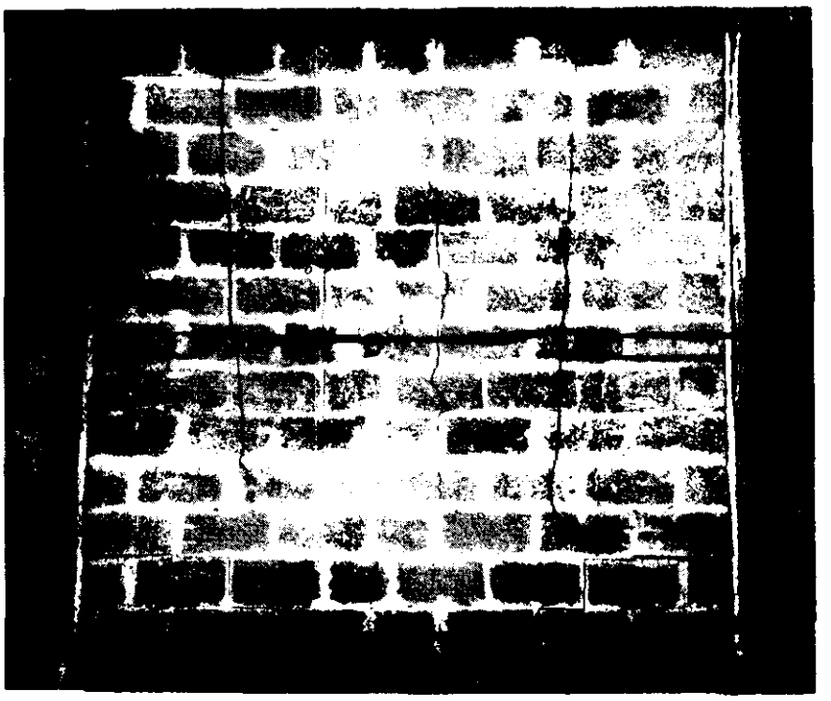


Unexposed face of 4 in solid block wall
(loadbearing) at the end of test

(Specimen No. 7)

TEST WALLS
CLASS 2 AGGREGATE

Exposed face at end of test (2 hr)



Unexposed face at end of test

SOLID BLOCK WALL-LOADBEARING
CLASS 1 AGGREGATE