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Subject: fire resistance

About fire resistance- in the new 2009 IBC book- go to page 126 to find "calculated fire resistance" chart.
Joe T.

TOWARDS INDUSTRY, RESEARCH & DEVELOPMENT...

Fire Resistance Test on a Loadbearing Masonry Wall of 250-mm-thick Adobe Blockwork

TECHNICAL RECORD 490

DECEMBER, 1982

EXPERIMENTAL BUILDING STATION
DEPARTMENT OF TRANSPORT AND CONSTRUCTION
P.O. BOX 30, CHATSWOOD, N.S.W. 2067 AUSTRALIA

By S.M. Byrne •

Report thanks to communication from Stephen Johansson, Wollongong, N.S.W.

PREFACE by
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There has been a long-standing need for a "fire rating" for earthen or adobe walls. Now, this information from our Australian friends has become available, and represents a real step forward. Fire resistance rating tests are expensive to conduct. A test roughly similiar to the one reported here would cost in the $30,000 range if conducted in the United States. Therefore, the value of the information herein is enormous. It gives realtors, contractors and codes people some parameters to go by.

Unless you have brick floors and an earthen barrel vault or dome roof, fire is a serious threat to the adobe home owner. Heat and smoke produced by smouldering or burning possessions is deadly. The contents of an adobe structure will burn as readily as those in any building.

Australian adobe has a fire resistance rating of four hours. Conventional wood-frame construction has a fire rating of one hour. This means that in laboratory tests, adobe walls withstood four hours of exposure to heat and flame before failure, while wood-frame walls would withstand only one hour.

Solaradobe presents a unique problem. The same convection spaces that gently heat the home (or cool it), provide easy avenues through which fire spreads.

Additional tests are needed to determine the fire resistance rating of our American made adobe. Fire command officers depend on accurate information about building materials with which to make life-and death decisions.

1. INTRODUCTION

01 This report describes a fire-resistance test carried out at EBS on a wall built from adobe blocks with manufacturing dimensions of 375 mm by 250 mm by 125 mm. The wall was about 3 m high by 3 m wide and was tested as a loadbearing wall.

02 The object of the test was to establish the fire-resistance rating of a typical loadbearing wall of adobe blockwork and hence to have a basis to estimate the likely fire-resistance rating of similar adobe-block walls, both loadbearing and non-loadbearing.

03 The test was part of a more comprehensive EBS research project[1] in which it was numbered test LB46.

2. EXPERIMENTAL PROCEDURE

01 The test was carried out in accordance with Australian Standard 1530, Part 4-1975, Fire-resistance Test of Structures[2].

02 The specimen was installed in the Station's loading frame[3]. This apparatus can accommodate specimens up to 3 m high by 3 m wide and is so designed that, irrespective of the thermal distortion of the apparatus, the load distribution on the specimen can be controlled and maintained throughout the test.

3. DESCRIPTION OF SPECIMEN

01 The blocks used to build the wall were obtained from Sun Earth Mud Bricks at Mittagong, N.S.W. (fig.1 not avail.) . The blocks were manufactured by the puddled-earth method - the soil was mixed with water and poured into moulds which were stripped immediately leaving the blocks to dry in the open. The manufacturing dimensions of the blocks were 375 mm long by 250 mm wide by 125 mm high. They were cast in mid-April 1982.

02 The soil used in the blocks was clay extracted from the Mittagong area. Figures 4 and 5 show the results of soil tests carried out on samples of the soil.

03 The wall was constructed at EBS in a timber frame about 3 m square. (fig.2 not avail.) . Each course had a length of 7.25 blocks with a mortar joint of about 25 mm between each block. The closing block was located near the centre of each course and was staggered from one course to the next. A bed of mortar about 25 mm thick was placed between each course. The finished wall consisted of 20 courses.

04 The mortar was made by mixing water with a soil local to EBS. No additives were used.

05 The wall was built by a contract block layer who was familiar with the construction of adobe-block walls. Construction commenced on 18th May and completed on 21st May. Six courses were laid on each of the first two days and the last eight courses on the third day. On the final day the wall was bagged on both sides.

06 The finished height of the wall was 2.95 m and the width was 2.905 m. The overall thickness was about 250 mm.

07 Therefore the ratio of effective height to thickness (slenderness ratio) was 8.85 using the definition of effective height contained in the SAA Brickwork Code, AS 1640-1974[4], except that the actual height 'h' was taken to the surface of the supports instead of to their centre-lines as required by the Code.

08 The permissible load on the wall was assumed[5] to be 0.25 MPa. The load at the mid-height of the wall during the test was 0.125 MPa, half the permissible load. This is equivalent to a force of 91 kN of which 53 kN was exerted by the top platen of the loading frame and the top half of the wall. This load was chosen because the results of tests with other types of masonry[1] indicate that the earliest collapse time generally occurs when the applied load is about half the permissible load.

4. RESULT

01 The fire-resistance test was carried out on 8th July 1982.

02 During the test vertical cracks appeared on the unexposed face of the wall at spacings of about 150 mm to 600 mm. The cracks started to appear at about 15 minutes. By the end of the test the cracks had started to close up again. None of the cracks allowed a clear view into the furnace during the test and so there was no failure under the integrity criterion of the Code.

03 The maximum central deflection of the wall was 24 mm at the end of the test. There was no sign of imminent collapse when the test was stopped.

04 There was no failure during the test under the insulation criterion of the Code. At the end of the test the average temperature rise on the unexposed face of the specimen was 68°C.

05 The furnace was turned off 241 minutes after the start of the test.

06 The specimen was wheeled away from the furnace after the test and allowed to cool with the load still applied. On the following morning an additional load was applied to determine the crushing strength of the wall. This was achieved by gradually increasing the load applied by the top platen of the loading frame. The total applied load at crushing was 248 kN.

5. DISCUSSION

01 The cracking pattern observed on the unexposed face of the specimen during the test was typical for a loadbearing masonry wall in a fire-resistance test. There was never any likelihood of failure under the passage-of-flame criterion.

02 The temperature rise on the unexposed face at the end of the test was well below that required for failure under the insulation criterion. If the test had been continued insulation failure might not have occurred for more than an hour later.

03 The rate of heat transmission compares wall with that for a normal clay-brickwork wall of the same thickness. Tests[6] on such walls indicate an insulation-failure time of about 6 to 7 hours.

04 During exposure to fire a wall expands more on the side adjacent to the fire than on the unexposed side. Therefore the wall tends to bow towards the fire. The amount by which a particular wall bows depends on its height, its thickness, its material properties such as thermal diffusivity and thermal expansion, and the restraints imposed by the boundary conditions.

05 In many cases the load will cause the specimen to collapse during a fire test. The behaviour of the wall is analogous to that of an axially loaded column with initial curvature and therefore may be considered in terms of its slenderness ratio. In general, a slender wall will tend to collapse earlier than a thick one and the magnitude of the load will also affect the time at which the wall collapses[1].

06 For loadbearing walls of normal clay brickwork, EBS recommends that the ratio of effective height to thickness should be limited to a value of 20 to ensure stability of the wall in the fire-resistance test. When making this calculation the effective height is calculated by the method in the SAA Brickwork Code[4], except that the actual height 'h' is calculated to the surface of each support instead of to its centre-line as required by the Code.

07 The ratio of effective height to thickness of the specimen in this test was only 8.85. The small deflections recorded in the test show that this value is well below the critical value for such a wall. It appears likely that the limit on the ratio for an adobe wall would be similar to that for a normal clay-brick wall.

08 The load which caused crushing in the load test after the fire-resistance test was only about 37 per cent higher than the assumed permissible load on the wall before the fire-resistance test.

09 From the results of the fire-resistance test it appears likely that similar adobe walls would easily satisfy the insulation and passage-of-flame criteria of the Code for at least 4 hours.

10 Although the wall did not show any signs of failure under the collapse criterion it is difficult to predict exactly what limit should be placed on the ratio of effective height to thickness for such walls.

11 The estimation of this limit is also complicated by the fact that only one test has been conducted on an adobe-block wall. Research at EBS has shown the magnitude of the applied load has a significant effect on the time of collapse of masonry walls[1].

6. CONCLUSIONS

01 The wall qualified for a fire-resistance rating of 4 h in AS 1530, Part 4-1975[2].

7. REFERENCES

1. BYRNE, S. M. 'Fire Resistance of Loadbearing Masonry Walls'. Fire Technology, Vol. 15, No. 3, August 1979.

2. Methods for Fire Tests on Building Materials and Structures, Part 4 - Fire-resistance Test of Structures (AS 1530, Part 4-1975). Standards Association of Australia, Sydney, 1975.

3. SCHUBERT, T. J. 'New Development in Fire Testing Loadbearing Walls'. Journal of Institution of Engineers, Australia. September-October 1976, pp. 34-35.

4. Brickwork in Buildings (AS 1640-1974). Standards Association of Australia, Sydney, 1974. (SAA Brickwork Code.)

5. MIDDLETON, G. F. 'Earth-wall Construction'. Experimental Building Station, Bulletin No. 5, revised by L. M. SCHNEIDER. AGPS, Canberra, 1981.

6. DAVEY, N. & ASHTON, L. A. 'Investigation on Building Fires. Part V: Fire Tests on Structural Elements.' National Building Studies Research Paper No. 12, Department of Scientific and Industrial Research. HMSO, London, 1953.

FIGURE 4

COMMONWEALTH DEPARTMENT OF HOUSING AND CONSTRUCTION MATERIALS LABORATORY

GENERAL TEST REPORT SOILS AND GRAVEL

PROJECT	NORTH RYDE E.B.S.				
LAB FILE No	8701/2/82	SUBMITTED BY	MR. L.M. SCHNEIDER	DATE	31/5/82

Sample no.	995				SPEC
Location	NITTAGONG			MAXIMUM DRY COMPRESSIVE STRENGTH TEST	
BRICK FIELD NO.	SE/82			AS PER B OF T & C TEST PROCEDURE	
Description of Sample	SOIL			SPECIMEN No. 1 = 5910 kPa t/m^2 = 1.7	
					R/C = 9.6
United classification symbol				SPECIMEN NO. 2 = 6240 kPa t/m^2 = 1.7	
% Passing 75mm sieve					R/C = 9.6
% Passing 37.5mm sieve				HYDROMETER ANALYSIS	
% Passing 19mm sieve				D mm	R%
% Passing 9.5mm sieve					
% Passing 4.75mm sieve	100			64	37
% Passing 2.36mm sieve	99			47	32
% Passing 1.18mm sieve	97			33	29
% Passing 600um sieve	86			24	28
% Passing 425um sieve	70			16	26
% Passing 300um sieve	59			12	25
% Passing 150um sieve	44			9	23
% Passing 75um sieve	38			6	21
				4	19
				3	18
				3	17
Liquid limit %	29			1	16
Plastic limit %	15			THE SAND, GRAVEL & GRANULAR MINERAL	
Plasticity index %	14			CONTENT AS PER BULLETIN NO. 5	
Linear Shrinkage %	8.5			EARTH WALL CONSTRUCTION FIRE OR	
Modified OMC %				RAMMED EARTH, STABILISED EARTH.	
Modified CBR %				THE PROPORTION OF CLAY & SILT TO THE	
Soundness (Na2SO4) loss				SAND, GRAVEL & GRANULAR MINERAL	
Los Angeles Value %				IN THE EARTH MIXTURE WAS: 5.2:1.0	
				(34% CLAY & SILT BY DRY VOLUME)	

REMARKS: D mm = DIAMETER OF PARTICLE IN MICROMETERS
R% = PERCENTAGE OF SAMPLE FINER THAN D mm.

REPORT TO MR. L.M. SCHNEIDER K.B.S., N. RYDE. Signed J.E. [illegible] 23/6/82 UNIT LEADER.
Signed [illegible] OMC LABORATORY.

FIGURE 5

COMMONWEALTH DEPARTMENT OF HOUSING AND CONSTRUCTION MATERIALS LABORATORY

GENERAL TEST REPORT SOILS AND GRAVEL

PROJECT	NORTH RYDE E.B.S.				
LAB FILE No	8701/2/82	SUBMITTED BY	MR. L.M. SCHNEIDER	DATE	31/5/82

Sample no.	996				SPEC
Location	NITTAGONG			MAXIMUM DRY COMPRESSIVE STRENGTH TEST	
BRICK FIELD NO.	SE/82			AS PER B OF T & C TEST PROCEDURE	
Description of Sample	SOIL			SPECIMEN NO. 1 = 4840 kPa t/m^2 = 1.71	
					R/C = 11.3
United classification symbol				SPECIMEN NO. 2 = 5830 kPa t/m^2 = 1.70	
% Passing 75mm sieve					R/C = 11.2
% Passing 37.5mm sieve				HYDROMETER ANALYSIS	
% Passing 19mm sieve				D mm	R%
% Passing 9.5mm sieve	100				
% Passing 4.75mm sieve	99			65	39
% Passing 2.36mm sieve	98			46	37
% Passing 1.18mm sieve	95			34	34
% Passing 600um sieve	88			24	30
% Passing 425um sieve	77			16	28
% Passing 300um sieve	66			12	27
% Passing 150um sieve	52			9	25
% Passing 75um sieve	44			6	23
				4	20
				3	19
				3	19
Liquid limit %	29			1	17
Plastic limit %	15			THE SAND, GRAVEL & GRANULAR MINERAL CONTENT	
Plasticity index %	14			AS PER BULLETIN NO. 5 EARTH WALL CONSTRUCTION	
Linear Shrinkage %	8.5			FIRE OR RAMMED EARTH, STABILISED EARTH.	
Modified OMC %				THE PROPORTION OF CLAY & SILT TO THE SAND,	
Modified CBR %				GRAVEL & GRANULAR MINERAL IN THE EARTH MIXTURE	
Soundness (Na2SO4) loss				WAS 6.4:1.0 (38% CLAY & SILT BY DRY VOLUME).	
Los Angeles Value %					

REMARKS: D mm = DIAMETER OF PARTICLE IN MICROMETERS
R% = PERCENTAGE OF SAMPLE FINER THAN D mm.

REPORT TO MR. L.M. SCHNEIDER K.B.S. N.RYDE. Signed J.E. [illegible] 22/6/82 UNIT LEADER.
23 JUL 82 1979 Signed [illegible] OMC LABORATORY.