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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.

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TOWARDS INDUSTRY, RESEARCH & DEVELOPMENT...

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

TECHNICAL RECORD 490

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

DECEMBER, 1982

By S.M. Byrne

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

PREFACE by
RICHARD APGAR
TRAINING OFFICER



ALAMEDA VOLUNTEER FIRE DEPARTMENT
BERNALILLO COUNTY FIRE DISTRICT I
BERNALILLO, NEW MEXICO

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 similar 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 pro-

duced 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 project¹ 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 Structures².
- 02 The specimen was installed in the Station's loading frame³. 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 1640-1974⁴, 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 assumed⁵ 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 plate of the loading frame and the top half of the wall. This load was chosen because the results of tests with other types of masonry¹ 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 plate 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 an hour later.
- 03 The rate of heat transmission compares well with that for a normal clay-brickwork wall of the same thickness. Tests 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.
- 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, 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.

FIGURE 4

GENERAL TEST REPORT SOILS AND GRAVEL

PROJECT		NORTH BYRNE S.B.S.		LAB FILE No		7101/8/82		SUBMITTED BY		MR. L.M. SCHNEIDER		DATE		31/5/82	
Sample No.	995	Location	NITTSBORO	MAXIMUM DRY COMPACTION	STRENGTH	STRENGTH	STRENGTH	STRENGTH	STRENGTH	STRENGTH	STRENGTH	STRENGTH	STRENGTH	STRENGTH	STRENGTH
DRY FIELD NO.	28/82	DRY FIELD NO.	28/82	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE
Description of Sample	SOIL	Description of Sample	SOIL	SPECIMEN NO. 1 = 5270	SPN 1/2 = 1.71	SPECIMEN NO. 2 = 5280	SPN 1/2 = 1.71	SPECIMEN NO. 3 = 5290	SPN 1/2 = 1.71	SPECIMEN NO. 4 = 5300	SPN 1/2 = 1.71	SPECIMEN NO. 5 = 5310	SPN 1/2 = 1.71	SPECIMEN NO. 6 = 5320	SPN 1/2 = 1.71
Unified classification symbol		Unified classification symbol													
Passing 75µ sieve		Passing 75µ sieve													
Passing 37.5µ sieve		Passing 37.5µ sieve													
Passing 15µ sieve		Passing 15µ sieve													
Passing 8.5µ sieve		Passing 8.5µ sieve													
Passing 4.75µ sieve	100	Passing 4.75µ sieve	100												
Passing 2.5µ sieve	29	Passing 2.5µ sieve	29												
Passing 1.18µ sieve	27	Passing 1.18µ sieve	27												
Passing 600µ sieve	86	Passing 600µ sieve	86												
Passing 425µ sieve	70	Passing 425µ sieve	70												
Passing 300µ sieve	59	Passing 300µ sieve	59												
Passing 150µ sieve	44	Passing 150µ sieve	44												
Passing 75µ sieve	36	Passing 75µ sieve	36												
Liquid limit %	29	Liquid limit %	29												
Plastic limit %	15	Plastic limit %	15												
Plasticity Index %	14	Plasticity Index %	14												
Linear Shrinkage %	8.5	Linear Shrinkage %	8.5												
Modified CBR %		Modified CBR %													
Modified CBR 1/2"		Modified CBR 1/2"													
Standard Deviation		Standard Deviation													
Los Angeles Value %		Los Angeles Value %													

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- 02 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.

6. CONCLUSIONS

- 01 The wall qualified for a fire-resistance rating of 4 1530, Part 4-1975.

7. REFERENCES

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

GENERAL TEST REPORT SOILS AND GRAVEL

PROJECT		NORTH BYRNE S.B.S.		LAB FILE No		7101/8/82		SUBMITTED BY		MR. L.M. SCHNEIDER		DATE		31/5/82	
Sample No.	996	Location	NITTSBORO	MAXIMUM DRY COMPACTION	STRENGTH	STRENGTH	STRENGTH	STRENGTH	STRENGTH	STRENGTH	STRENGTH	STRENGTH	STRENGTH	STRENGTH	STRENGTH
DRY FIELD NO.	28/82	DRY FIELD NO.	28/82	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE	AS PER 2 OF T & G TEST PROCEDURE
Description of Sample	SOIL	Description of Sample	SOIL	SPECIMEN NO. 1 = 4940	SPN 1/2 = 1.71	SPECIMEN NO. 2 = 4950	SPN 1/2 = 1.71	SPECIMEN NO. 3 = 4960	SPN 1/2 = 1.71	SPECIMEN NO. 4 = 4970	SPN 1/2 = 1.71	SPECIMEN NO. 5 = 4980	SPN 1/2 = 1.71	SPECIMEN NO. 6 = 4990	SPN 1/2 = 1.71
Unified classification symbol		Unified classification symbol													
Passing 75µ sieve		Passing 75µ sieve													
Passing 37.5µ sieve		Passing 37.5µ sieve													
Passing 15µ sieve		Passing 15µ sieve													
Passing 8.5µ sieve		Passing 8.5µ sieve													
Passing 4.75µ sieve	100	Passing 4.75µ sieve	100												
Passing 2.5µ sieve	99	Passing 2.5µ sieve	99												
Passing 1.18µ sieve	90	Passing 1.18µ sieve	90												
Passing 600µ sieve	95	Passing 600µ sieve	95												
Passing 425µ sieve	88	Passing 425µ sieve	88												
Passing 300µ sieve	77	Passing 300µ sieve	77												
Passing 150µ sieve	66	Passing 150µ sieve	66												
Passing 75µ sieve	44	Passing 75µ sieve	44												
Liquid limit %	29	Liquid limit %	29												
Plastic limit %	15	Plastic limit %	15												
Plasticity Index %	14	Plasticity Index %	14												
Linear Shrinkage %	8.5	Linear Shrinkage %	8.5												
Modified CBR %		Modified CBR %													
Modified CBR 1/2"		Modified CBR 1/2"													
Standard Deviation		Standard Deviation													
Los Angeles Value %		Los Angeles Value %													

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