



NRC Publications Archive Archives des publications du CNRC

Temperature Measurement: Alternate Test of Fire Protection for Structural Steel Columns

Stanzak, W. W.

For the publisher's version, please access the DOI link below./ Pour consulter la version de l'éditeur, utilisez le lien DOI ci-dessous.

Publisher's version / Version de l'éditeur:

<https://doi.org/10.4224/20358792>

Technical Note (National Research Council of Canada. Division of Building Research), 1969-06-01

NRC Publications Record / Notice d'Archives des publications de CNRC:

<https://nrc-publications.canada.ca/eng/view/object/?id=d0a2d514-5014-458d-a98e-f9a937cd804e>

<https://publications-cnrc.canada.ca/fra/voir/objet/?id=d0a2d514-5014-458d-a98e-f9a937cd804e>

Access and use of this website and the material on it are subject to the Terms and Conditions set forth at

<https://nrc-publications.canada.ca/eng/copyright>

READ THESE TERMS AND CONDITIONS CAREFULLY BEFORE USING THIS WEBSITE.

L'accès à ce site Web et l'utilisation de son contenu sont assujettis aux conditions présentées dans le site

<https://publications-cnrc.canada.ca/fra/droits>

LISEZ CES CONDITIONS ATTENTIVEMENT AVANT D'UTILISER CE SITE WEB.

Questions? Contact the NRC Publications Archive team at

PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca. If you wish to email the authors directly, please see the first page of the publication for their contact information.

Vous avez des questions? Nous pouvons vous aider. Pour communiquer directement avec un auteur, consultez la première page de la revue dans laquelle son article a été publié afin de trouver ses coordonnées. Si vous n'arrivez pas à les repérer, communiquez avec nous à PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca.





NATIONAL RESEARCH COUNCIL OF CANADA

DIVISION OF BUILDING RESEARCH

No.

538

TECHNICAL NOTE

PREPARED BY W.W. Stanzak CHECKED BY G.W.S. APPROVED BY N.B.H.

DATE June 1969

PREPARED FOR Inquiry and Record

SUBJECT TEMPERATURE MEASUREMENT: ALTERNATE TEST OF FIRE PROTECTION FOR STRUCTURAL STEEL COLUMNS.

The alternate test of fire protection for structural steel columns (as specified in CSA B54.3-1964¹ and ASTM E119-67²) requires that a sample at least 8 ft long be tested in a vertical position without applied load, and exposed to fire on all sides. This test is applicable only when the protection is not required by design to carry any part of the column load. The applied protection must be restrained against longitudinal thermal expansion greater than that of the steel core. In the CSA Standard, temperatures are measured by at least 3 thermocouples, located at each of five levels (cross-sections). The ASTM Standard requires temperatures to be measured by at least 3 thermocouples at each of four levels. In both Standards the upper and lower levels are 2 ft from the ends of the column and the intermediate levels symmetrically spaced. The test is considered to be successful if the transmission of heat through the protection during the period of fire exposure for which classification is desired does not raise the average (arithmetical) temperature of the steel at any level above 1000°F (538°C), or above 1200°F (648°C) at any one of the measured points.

The question has arisen whether results of tests conducted in accordance with the provisions of the present CSA Standard would differ significantly from results of tests carried out according to the ASTM method. All fire tests carried out in accordance with the CSA Standard have been described³. This note results from an examination of the test records to determine the influence of thermocouple location on the fire endurance time.

L

Typical locations of thermocouples as required by the two test methods are shown in Figure 1. It is significant to note that the upper and lower levels are at the same height in both cases. Thus the CSA provision is essentially a requirement for more thermocouples. The CSA Standard, however, requires measurement at the centre; the ASTM Standard does not. Where protective materials have a modular dimension, e.g., 2 ft, 4 ft, there will be a joint at mid-height. Therefore it is important to measure temperatures at this location, as provided for by CSA. Also, with pin-ended members, the structural failure would occur at the centre. If there were a joint at mid-height, the results of tests according to the CSA Standard could differ significantly from those obtained by the ASTM method.

The tests examined and reported here were on columns whose protection had no joints. Table I shows average temperatures at the various levels at one and two hours. The level at which the temperature first exceeded 1000°F is also indicated. Out of 7 tests, failure occurred at the upper and lower levels in 5 cases. This is partly the result of the particular furnace construction. The burners of the DBR floor furnace are about 29 inches above the furnace floor, i.e., approximately in line with level 5. Previous studies have shown that furnace temperatures are somewhat higher at this level, as would be expected. In furnaces that cause no temperature gradient on the exposed surface, failure would be most likely to occur at the upper level (1).

The maximum temperature difference between any two levels after one hour was 100°F, with an average maximum difference of 54°F. After two hours the corresponding differences were 74°F and 42°F. As the thickness of protection was not entirely uniform at all locations, however, a portion of these differences may be attributed to peculiarities of the construction of the protection. This is clear from the fact that failure occurred at levels other than nos. 1 and 5, where it would normally be expected.

The fact that there may be variation in thickness due to workmanship or the design of the particular construction, is an argument in favour of having as many thermocouples as is practical on the column. Where the thickness of protection is uniform, however, one would expect results to be identical by these two methods.

Figure 2 shows typical temperature profiles for columns at one and two hours. Obviously the temperatures between measured levels are unknown. The profile at one hour is more irregular than at two hours. Since the protection on these columns remained intact, this would indicate that heat conduction along the length of the column smooths the temperature profile as the fire test progresses.

The investigations at the DBR/NRC have shown that results of tests conducted in accordance with CSA would be very similar to, but not usually identical with, those obtained using the ASTM method. The exception is where the protective cover has a joint at the centre, which allows additional heat transmission. Clearly, it would be desirable to have thermocouples at the mid-height in this event. Therefore the specification for temperature measurement in the CSA Standard need not be changed.

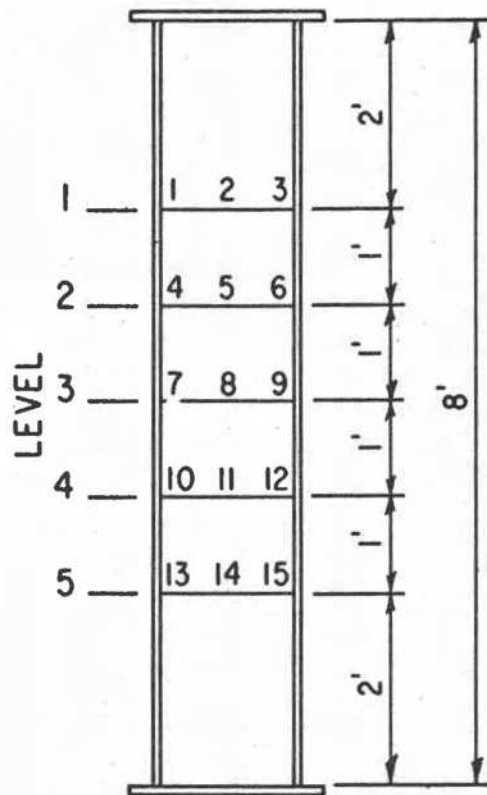
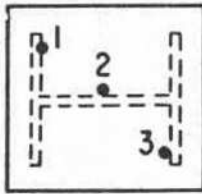
REFERENCES

1. CSA Standard B54.3-1964. Methods of Fire Tests of Walls, Partitions, Floors, Roofs, Ceilings, Columns, Beams, and Girders.
2. ASTM Designation E119-67. Fire Tests of Building Construction and Materials.
3. Stanzak, W.W. Fire Tests of Eight Wide-Flange Steel Columns Protected with Gypsum-Sanded Plaster. National Research Council of Canada, Division of Building Research, Fire Study No. 20, Jan. 1968 (NRC 9768).

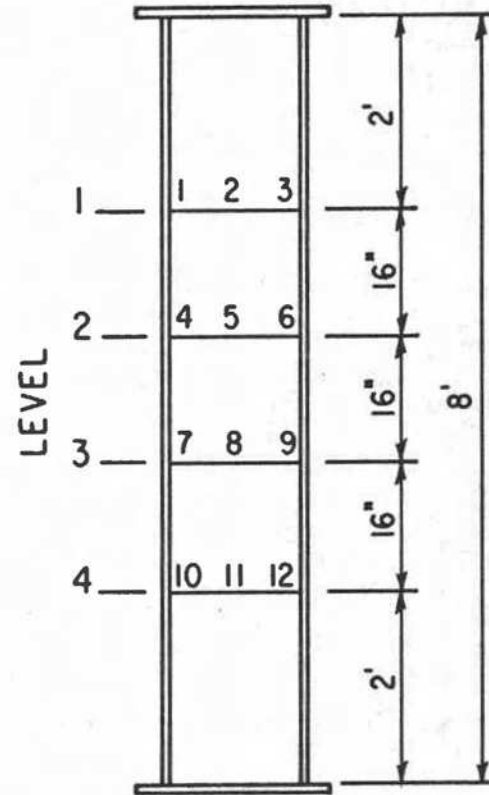
TABLE I

AVERAGE TEMPERATURES ON SURFACE OF STEEL COLUMNS AT ONE AND TWO HOURS

Time Hr	Test Number	Temperature, °F, at Level Number					Level of Failure	Maximum Temperature Difference Between Any Two Levels
		1	2	3	4	5		
1	8	400	388	408	393	411	--	23
	6	465	433	471	463	515	--	82
	5	905	853	867	850	870	1	55
	4	818	778	817	795	820	3	42
	3	580	515	508	480	508	--	100
	2	720	717	730	743	743	5	26
	1	905	900	903	950	950	5	50
2	8	892	900	888	890	870	2	30
	6	988	972	978	972	993	5	21
	3	1022	988	982	948	953	1	74



CSA



ASTM

FIGURE 1
TYPICAL TEST SECTIONS

094394-1

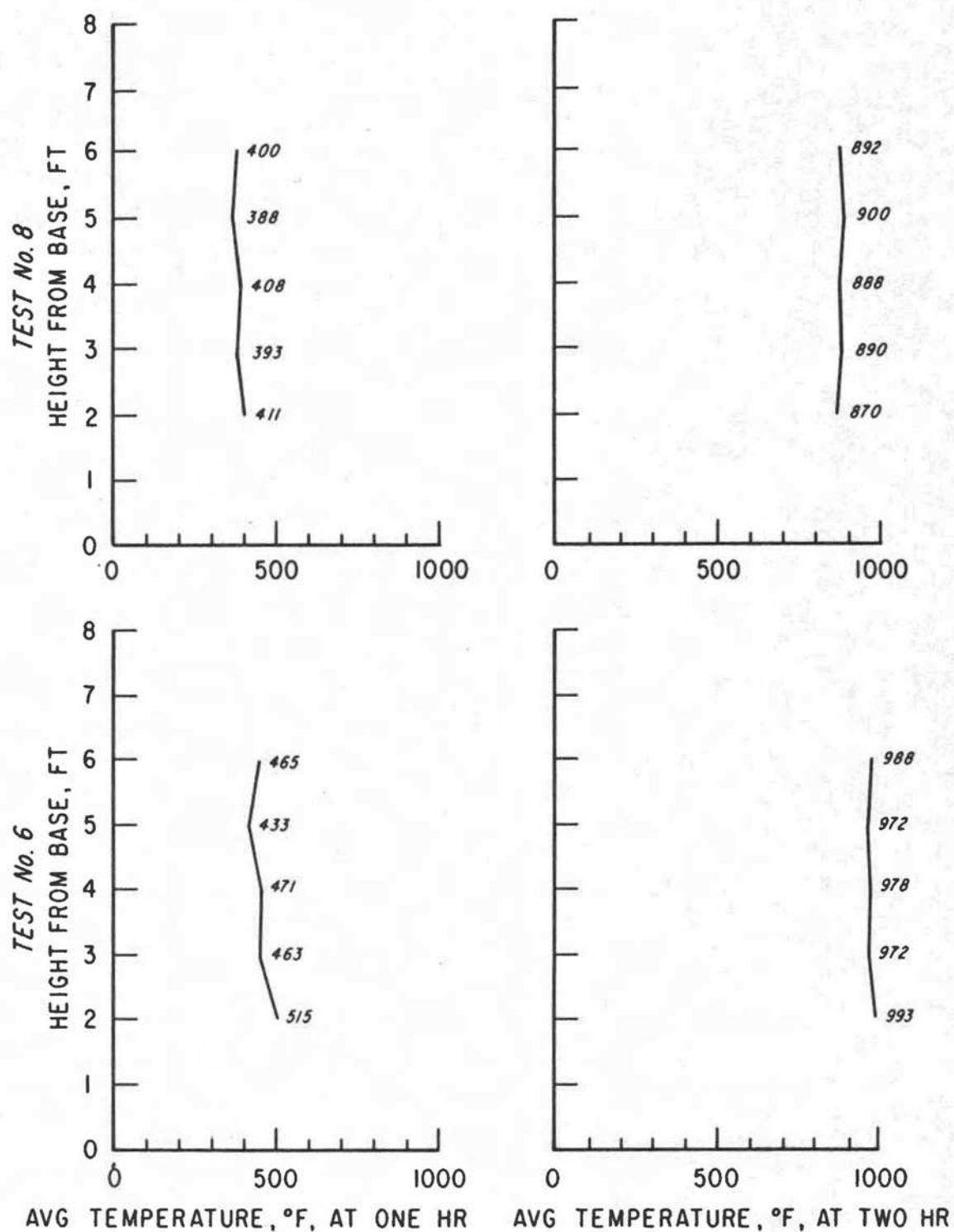


FIGURE 2
TEMPERATURE PROFILES AT ONE AND TWO HOURS