Ten Rules of
Fire Endurance Rating

T. Z. HARMATHY
Division of Building Research
National Research Council (Canada)

Fire endurance tests alone cannot supply all the data needed for intelligent appraisal of fire resistant ratings of building elements. There are simply too many different types of assemblies and combinations of materials to classify them all through actual tests. Fortunately, the theory of fire endurance rating is sufficiently advanced to offer guidance in estimating fire endurance ratings. The author sets forth ten rules that may prove useful for quick assessment of the fire endurance of building elements when fire test data on the elements are not available.

It is becoming increasingly evident that all the information necessary for classifying building elements from the point of view of their performance in fire cannot be derived from standard fire endurance tests alone. It is hardly conceivable that all various constructions can ever be subjected to fire tests. Even in those cases where test results are available for more or less similar constructions, the classification may not be immediately apparent. It must be clearly understood that certain variations in the dimensions, loading conditions, materials, or workmanship may markedly affect the performance of the individual constructions, and the extent of such a possible effect cannot be evaluated from the fire test report.

The value of the pieces of information obtained from standard fire tests is very limited without a theory that is capable of cementing the pieces into a consistent unit. Fortunately, the theory of fire endurance rating has already advanced far enough not only to offer some guidance in estimating the effect of certain variables on fire endurance but, very often, even to provide rigorous methods of designing building elements for some prescribed performance.

Although the design for fire endurance, whenever possible, is a fairly complex procedure, involving extensive laboratory investigations and sometimes very laborious heat-flow and stress-deflection analyses, it will always prove of extreme value when developing new building products for
maximum economy. In the case of products already on the market, the problem of economy no longer remains, and the question of whether the product will yield a fire endurance higher than some given value may not deserve an extensive theoretical study.

In this report a number of rules will be discussed which may prove useful in the quick appraisal of the fire endurance of building elements. Some of the rules are concerned with the geometry of the construction, some with the materials. All of them are based on experimentally and theoretically well-founded facts. It is hoped that these rules will provide some guidance to those charged with administering building bylaws, and to those who are engaged in either the design or production of building components. Examples are given to illustrate the wide applicability of these rules.

THE TEN RULES

Rule 1: The "thermal"* fire endurance of a construction consisting of a number of parallel layers is greater than the sum of the "thermal" fire endurance characteristic of the individual layers when exposed separately to fire.

This rule is probably the most important aid in assessment of the performance of building elements in fire, and suggests that the result of fire tests conducted on individual components of building elements, e.g., on gypsum board, plywood, brick veneer, plaster on expanded metal lath, etc., with the purpose of determining their "thermal" performance, may also be of considerable value. It is very convenient to use small-scale specimens for these "nonstandard" informative tests.

Because of the difficulties involved in the analytical treatment of the problem of heat flow through composite slabs, it is not possible, at present, to provide proof of this rule. Nevertheless, its validity has been confirmed by the result of several numerical analyses and small-scale fire tests conducted on both combustible and noncombustible constructions.

There is a special case in which the validity of Rule 1 is immediately obvious, i.e., the case of a "quasi-composite" construction consisting of layers made from the same material. It is known (and can be proved by the method described in Reference 1) that by doubling the thickness of a slab, the fire endurance becomes more than twice the original value. Similarly, for a slab of \( n \) thickness (in other words, consisting of \( n \) identical layers of thickness \( l \)),

\[
t_{n1} > nt_i
\]

where \( t \) is the time of fire endurance and the subscripts denote the thickness of the slabs. This inequality is an expression of Rule 1 for such a "quasi-composite" construction.

*The "thermal" fire endurance is the time at which the average temperature on one side of a construction exceeds its initial value by 250°F when the other side is exposed to a "standard" fire specified by ASTM Method E119.