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Fire Resistant Study for Long Span Beams Made of FR 490 Steels

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Abstract

Building could be severely influenced by fire and it can be demolished so that the major structural elements such as columns and beams required to be coated by fire protection materials according to each condition. Especially, a steel framed building regarded as a weaken structures when the building is engulfed with a severe fire condition. Therefore, the fire resistant steel (FR 490) has been developed to improve the structural properties of an ordinary structural steels at high temperature. Generally, the fire resistance of structural beam built with a structural steel can be measured by horizontal furnace using a standard testing method by each nation's standard. However, the real length of the beam showed the tendency longer than that of the horizontal furnace. Therefore, it is considered more important to know the real fire resistant performance of structural beams. In this paper, to evaluate the fire resistant performance of long span beams made of the FR 490, the fire engineering method is done using not only materials properties at high temperatures but a heat transfer, a stress theory. The results showed that as the length of beams are longer, the maximum load bearing capacities at high temperatures are lower and the deflections are increased.

Keywords: FR 490, long span beam, fire resistant performance, structural stability at high temperature

1. Introduction

When steel framed buildings are covered with a severe fire, the structural stabilities can be damaged and this can cause a progressive collapse. Therefore, all most of countries require the primary structural elements such as columns, beams, trusses the fire protection according to building situation. In Korea, the fire protection depends on the buildings height and use. The way to satisfy the fire protection is divided into two parts. One is to obey the building regulation and standard, the other is to design with an engineering technique. The last one is known to an advanced engineering design or a performance based fire design. The name can be used differently by nation or by person who uses it. The basic concept of the advanced engineering design consists of a fire scenario and a structural analysis using mechanical properties and heat transfer theory. Until now, the advanced fire engineering method is known to practice to most of countries but not my country. At now, my country is trying to accept the performance-based engineering method in building industry and this paper is one of process to do it.

In general, the structural steel is known as a weaken material when it exposed to a fire. Because the atomic structure is inclined to recede away as the temperature of it is getting high. Therefore, to protect the normal strength of the structural steel at high temperature situation, a proved thickness of passive fire protective materials should be applied. A FR 490 had developed to lessen the tendency to reduce mechanical properties such as yield strength and an elastic modulus at high temperature rather than those of SM 490. The FR 490 has the same mechanical property as the SM 490 has. The purpose of this study is to evaluate the structural stability of long span beams made of the FR 490 at high temperature using mechanical properties and heat transfer and heat stress analysis.

2. Method

The structural stability of long span beam can be measured by vertical furnace in terms of deflection with loading. But the vertical furnace is fixed with a maximum dimension, 4 meters in length and 3 meters in width. But the size of the

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vertical furnace is dependent on each fire facility. Therefore, when the longer beam is required the fire resistance, the furnace is no longer functioned. From middle 1900's, a calculation method started from European nations based on an engineering development and as a reasonable alternative to furnace test.

Until now, Korea didn't utilize the fire engineering method and has used a prescriptive method from early 1970's. Therefore, even though the FR 490 showed a better performance than that of SM 490, the steel construction field not allow the FR 490 as a structural steel. To utilize the better structural steel than SM 490 into the construction market, an analytical evaluation is conducted using mechanical properties with long span beams. Applied mechanical properties are shown in Table 1.

Table 1 Mechanical properties of FR 490

Properties	Temperature (℃)	Regression Equation
Properties	T≤500	Cold value (315 MPa)
	500<T≤900	-0.72T + 674.49
Elastic Modulus	T≤200	Cold value (210 GPa)
	200<T≤900	-211.73T + 254,343

Long span beams consist of 4 types. The basic length of the beam is 4100 mm. This length is standard size in vertical furnace in Korea. The maximum span is reaching to 5000 mm. The analytical parameters are shown in Table 2.

Table 2 Analysis parameters

Section	H-400x200x8x13 Section area(84.12 cm^2)
Support conditions	Simple beam
Span of beam (mm)	4100, 4400, 4700, 5000
Fire curve	Standard fire curve, KS F 2257-1,6

3. Results and Discussion

Based on an one dimension heat transfer theory the surface temperatures of the beam are calculated like Fig. 1. As the beam is not protected any fire protective material, the surface temperature is going up rapidly and after 20 minutes the temperature is similar to standard fire curve.

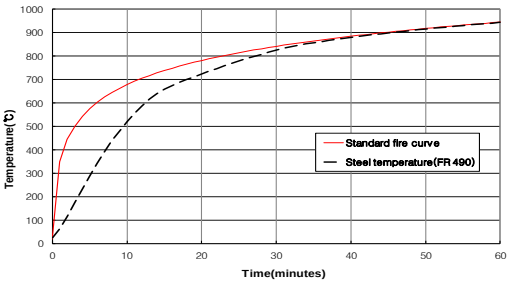

Fig. 1 Steel temperature history versus times

As the surface temperature is going up the maximum load of each beam is going down slowly and it is steep about 300℃. The decreasing patterns of long span beams are shown in Fig. 2. At the table, it is shown as the lengths of beams are longer the reduction ratios are higher.

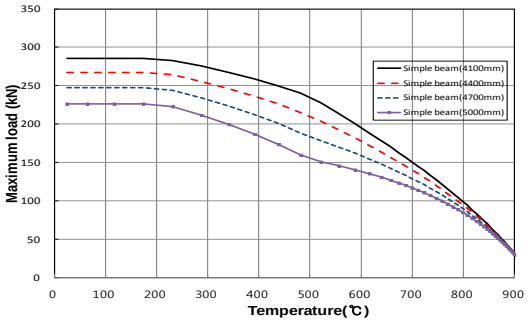

Fig. 2 Maximum loadings versus surface temperatures

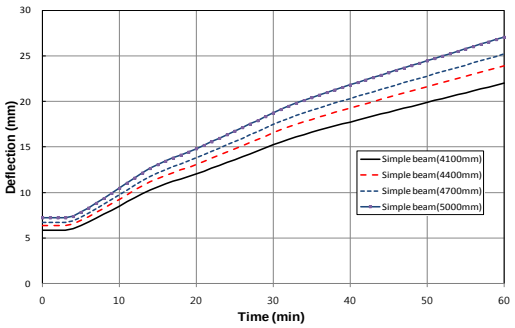

Fig. 3 Deflections versus elapsed times

Deflection is very important factor to recognize the structural stability in beams. As the time is passing, each beam's deflection is shown in Fig. 3. As the time is passing in other words, the surface temperature of each beam is going up, the deflection is larger and the longer the beams are, the larger the deflections are.

4. Conclusions

To know the structural behavior of beams made of FR 490 at high temperature, an engineering method was applied and the followings are obtained.

(1) As surface temperature of beam is going up, the load-bearing capacity is going down.

(2) As the lengths of beams are longer, the maximum load capacities are decreased.

(3) Deflection is increased highly when the surface temperature of beam is going up and the length of beam is longer.

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